THE SOCIAL NETWORKS OF EARLY HUNTER-GATHERERS IN MIDCONTINENTAL NORTH AMERICA

by

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As the author of this work, I take full responsibility for what it contains: this includes those parts that the future may show to have merit as well as any inaccuracies, oversights, flaws in method and logic, and misinterpretations that are present. I have attempted to address significant questions using a new approach, and I do not anticipate that my ideas, methods, and results will go unchallenged. While the worth of this work may be ultimately judged based on how much of it is "right", I believe a better metric of its worth may be the frequency, quality, and severity of the arguments which result from consideration of its content.

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ABSTRACT

This dissertation integrates ethnographic information and computational modeling to build theory about hunter-gatherer social networks and the relationships between the characteristics of those networks and patterns of variability in material culture. Key mechanisms of personal network formation (mobility, marriage, and kinship) and social learning are represented in an agent-based model which allows both system-level social networks and large-scale patterns of artifact variability to emerge from the “bottom up” through numerous human-level behaviors and interactions. This model is used to: (1) identify patterned relationships between the human-level behaviors that we can observe ethnographically and the characteristics of the system-level social networks that emerge through those behaviors; and (2) explore how the characteristics of system-level social networks are related to the patterns of variability in items of material culture whose production is mediated through those networks. Comparisons between archaeological artifact assemblages and artifact assemblages produced during model experiments are used to evaluate network-based explanations for the appearance and disappearance of stylistic regions during the Paleoindian and Early Archaic periods (ca. 11,050-8000 radiocarbon years before present) in midcontinental North America. These comparisons suggest that the appearance of stylistic regions during the Middle and Late Paleoindian periods was most likely the result of processes of stylistic drift operating across social networks that were less inter-connected than those of the Early Paleoindian period. Decreasing social connectivity across the midcontinent was probably related to an uneven distribution of population as hunter-gatherer individuals, groups, and systems responded to environmental change at the end of the Pleistocene. Population growth and the emergence of relatively homogenous environments at the beginning of the Holocene (ca. 10,000 radiocarbon years before present) would have increased social connectivity and diminished the capacity of drift processes to produce stylistically differentiated regions.

Chapter 1

INTRODUCTION

The goal of this dissertation is to build our understanding of the characteristics of the social networks of hunter-gatherers and enhance the confidence with which we can recognize changes in prehistoric social networks based on the study of archaeological remains. This work integrates ethnographic data, computational modeling, and archaeological data to construct a framework for building theory and evaluating network-based explanations for changes in material culture within a specific archaeological case: late Pleistocene and early Holocene (ca. 11,050-8000 radiocarbon years before present) hunter-gatherer systems in midcontinental North America.

A social network is defined here as a web of relationships formed by individuals connected to one another by and through social ties. Per this definition, each individual in a network can be connected to every other individual through a path that utilizes one or more social ties. The personal networks of individuals are inter-linked into a larger, system-level "network of networks" that constitutes the social field (Barth 1978:165-166; Boissevain 1974:24, 1979:392; Grønhaug 1978) and "transforms an aggregate of individuals into a group" (Blau and Scott 1962:3), binding individuals into larger cultural systems and channeling information, people, genes, and resources. The extent of a social field or a social system can be defined by the extent of the social network that connects the individuals within it (see Grønhaug 1978).

A system-level social network is a phenomenon that emerges through persistent regularities or patterns of social interactions among individuals and/or groups of individuals. The social behaviors of individuals both produce a system-level social structure and are influenced by it (Barnes 1972; Blau and Scott 1962; Radcliffe-Brown 1940). As emergent phenomena that exist at a level above personal social networks, system-level social networks have a structure with properties and characteristics that can be identified, described, analyzed, and classified (Turner and Maryanski 1991; Maryanski 1996:69; Nadel 1957; Wasserman and Faust 1994:6-7). Following Nadel (1957:8), "structure" is defined here as "an ordered arrangement of parts which can be treated as transposable, being relations invariant, while the parts themselves are variable." Because structure is the *pattern* of inter-relationships, the structural characteristics of a network can be considered without knowing the details of each constituent relationship.

The importance of social networks to all human societies makes them a fundamental and enduring topic of anthropological, archaeological, and sociological interest (see Barnes 1972; Foster 1978; Freeman 1989; Laumann et al. 1989; Nadel 1957; Turner et al. 1989; Turner and Maryanski 1991). While social networks are by no means the only aspects of social structure in which anthropologists are interested, there is no doubt that they are a fundamental piece of the puzzle (Barth 1978; Turner et al. 1989; Turner and Maryanski 1991). If we define "society" as existing by virtue of interactions among humans (Turner et al. 1989:250), we recognize that the social networks which both mediate and are formed by those interactions constitute the basis of human sociality. Social networks form the "backbone" of social structure (Turner and Maryanski 1991:557).

The social networks of hunter-gatherers are of special interest because of the vital role that these networks play in hunter-gatherer systems and the importance of these systems to so many questions of human prehistory: the emergence of language and culture, patterns of gene flow related to the evolution of modern human anatomy, the invention and development of technology, the dispersion of our species from Africa, and the colonization of the New World all occurred while the world was populated by hunter-gatherers. Hunter-gatherer societies formed the foundation from which the institutional and organizational features of "complex" societies (i.e, chiefdoms, states, empires) ultimately developed. This makes understanding the characteristics of the networks of "simple" hunter-gatherers of primary importance.

The characteristics of all human social networks make them a challenging object of study. The relatively large number and variety of dynamic social ties that individual humans form, maintain, and utilize create the potential for a great deal of structural complexity when coupled with the large population sizes of human systems. This complexity makes recognizing, describing, and understanding the implications of variability in the structure of human social networks a daunting task. While the behaviors and social connections of a small number of individuals can be observed, recorded, and analyzed, the large size and structural complexity of human social networks effectively renders impossible detailed, empirical studies of these networks at the level of the “complete” system (Barnes 1972:3). Modern sociological or anthropological studies of living groups can generally be placed into one of two categories: (1) quantitative studies of the aggregate structure or properties of social networks at relatively large scales; and (2) descriptive studies that focus on the formation, maintenance, or effects of a relatively small number of social connections (see Barnes 1972:4; Dunbar and Spoors 1995:275; Marsden 1990).

Studying the system-level social networks of hunter-gatherer populations is rendered even more challenging by the particular characteristics of these systems. Hunter-gatherer systems are often spatially extensive and characterized by low density, mobile populations which depend on face-to-face contact for communication. Ethnographic data illustrate how the human movements that precipitate this contact articulate with a range of person- and group-level behaviors affecting the formation, maintenance, and use of social networks: marriage, kinship, gifting and exchange, and language play important roles in defining relationships between individuals and establishing and maintaining social ties between distant areas (e.g., see Binford 2001; Lee and DeVore 1968; Lewis-Williams 1982; Whallon 2006; Wiessner 1982; Wobst 1974; Yengoyan 1968). Given the large scales of space and long scales of time at which these networks operate, however, it is difficult to imagine how the temporally- and spatially-limited lens of ethnographic observation could, by itself, be used to describe and understand their system-level structure and properties (cf. Barnes 1972; Radcliffe-Brown 1940; Wobst 1978).

The archaeological study of prehistoric hunter-gatherer social networks is further complicated by the necessity that inferences about the characteristics of social networks (and changes in those characteristics) must be based on material culture. This requires understanding how various aspects of social networks affect patterns of variability in material culture at the scales of time and space that we can recover archaeologically. Currently, these inferences depend on the assumptions that: (1) there are relationships between the structure of a social network and the patterns of variability in domains of material culture that are affected by that network; and (2) the relationships between these two phenomena are relatively simple (i.e., we can understand them through the application of simple logic). While the first assumption is warranted by ethnographic data showing how social networks affect social learning (e.g., see Bamforth and Finlay 2008; Berry and Georgas 2009; Coward and Gamble 2008; Minar 2001; Shennan and Steele 1999), the second assumption is much more dubious. Complex systems theory and models indicate that the person-level behaviors in network-mediated, spatially-situated systems like those of hunter-gatherers do not simply “scale up” to patterns that we can observe archaeologically.

Thus we are confronted by a fundamental mismatch between the scales at which we can effectively observe the networks of living hunter-gatherer systems and the scales at which we must interpret archaeological remains. This mismatch in scale is coupled with large gaps in our understanding of (1) how the cultural behaviors that affect the formation and use of social networks at the level of person-person interactions (that we can observe ethnographically) produce the structure and properties of the resulting system-level social networks and (2) how the characteristics of system-level social networks are related to patterns of variability in material culture that we can observe archaeologically.

This work addresses these issues by integrating ethnographic data, computational modeling, and archaeological data to construct a framework for building theory and evaluating network-based explanations for change within a specific archaeological case: late Pleistocene and early Holocene hunter-gatherer systems in midcontinental North America. Ethnographic data are used to understand the kind and range of person- and group-level cultural behaviors that contribute to the formation of social networks and the transfer of information across those networks, as well as the basic ways in which information related to the production of items of material culture (such as stone tools) is transferred through social learning. Agent-based modeling is used to bridge the “scale gap” by representing the human behaviors that we can document ethnographically (such as mobility, marriage, kinship, and social learning) as “rules” for human-level behavior, creating a population of actors who behave and interact according to these rules, setting the system in motion, and characterizing the outcomes in terms of two emergent, system-level phenomena: (1) system-level social networks; and (2) large scale, aggregate patterns of variability in material culture observable at scales comparable to those we can observe archaeologically. Through systematic experimentation, cause-effect relationships between human-level behaviors and emergent, system-level phenomena can be investigated as an empirical problem.

The archaeological record of early hunter-gatherers in midcontinental North America is largely limited to stone tools. During this period, the widespread Early Paleoindian fluted point horizon was followed by regionalized styles of projectile points characterizing the Middle and Late Paleoindian periods. These regionalized technologies were later eclipsed by more-or-less horizon-like successions of Early Archaic point forms. This general sequence of "homogenous-regionalized-homogenous" in eastern North America has been attributed to changes in the scale and structure of social networks as well as the appearance of social boundaries during the Middle and Late Paleoindian periods.

Our current explanations of these archaeological phenomena generally lack two important elements: (1) a sound theoretical understanding of how network structure is related to the transfer of information and archaeologically visible patterns of artifact variability; and (2) an archaeological dataset of sufficient scale, density, and detail to systematically evaluate alternative hypotheses. This study develops both of these elements, building both *general theory* about the operation and properties of hunter-gather social networks and *archaeological theory* about how large-scale patterns in material culture are related to these networks. Model outputs are compared to a large archaeological dataset to systematically evaluate alternative explanations and create a sound basis for interpreting patterns of archaeological artifact variability in terms of the human social networks that mediated their creation. The computational model constructed for the purposes of this dissertation models the formation, change, and material residues of networks of "complete" systems which emerge through person- and group-level interactions. This allows us to link the characteristics of human-level mechanisms to both system-level social networks and the archaeological "footprints" that they produce.

This dissertation is organized in nine chapters. Chapter 2 summarizes the characteristics of human social networks and presents ethnographic data relevant to understanding the mechanisms which contribute to the creation and maintenance of social ties in hunter-gatherer societies. Chapter 3 discusses approaches linking the characteristics of social networks to material culture. Chapter 4 describes the architecture, operation, and validation of the agent-based model that was constructed for this dissertation and used for analysis. Chapter 5 describes a series of experiments exploring relationships between mobility, demography, and the characteristics of social networks in the model. Chapter 6 discusses the late Pleistocene and early Holocene archaeological record of midcontinental North America, providing the context for the specific archaeological case that is addressed here. Chapter 7 describes the archaeological dataset. Chapter 8 presents comparisons between model and archaeological data and evaluates explanatory scenarios for the appearance and disappearance of stylistic regions in early archaeological record of midcontinental North America. Chapter 9 discusses the characteristics of Paleoindian and Early Archaic social networks suggested by archaeological and model data.

Chapter 2

HUNTER-GATHERER SOCIAL NETWORKS

Social networks are an important component of every ethnographically documented hunter-gatherer society (e.g., see Binford 2001; Kelly 1995; Lee and DeVore 1968; Lewis-Williams 1982; Schweizer 1997; Whallon 2006; Wiessner 1982; Williams 1981; Wobst 1974; Yengoyan 1968). As in all human systems, the social ties linking individuals to one another serve as conduits for flows of three kinds of resources: materials, symbols, and emotions (Turner and Maryanski 1991:550). Ties among individuals within local foraging groups, households, and families form the intimate support and security network required for navigating the logistics of everyday life and facilitating the transfer of information between generations. Ties that extend outside the local group are critical to demographic viability, allowing individuals to locate mating partners and groups to relocate during times of resource stress. Networks are formed and maintained in systems with low population densities whose members are spatially dispersed and often very mobile. Face-to-face communication is contingent on group and individual mobility that allows people to come into contact with one another. Kinship, exchange, and language play important roles in defining relationships between individuals and establishing and maintaining social ties between distant areas.

It is impossible to recover “total” network data (i.e., data that include information on the entire egocentric network of every individual in a system) from actual hunter-gatherer populations. This is effectively true of all human systems: the large population sizes of networked human systems and the relatively large number and variety of social ties that individual humans form, maintain, and utilize create the potential for an immense amount of structural complexity. Further, one could argue that the vast majority of the human population of the planet is effectively inter-connected (see Firth 1951:50; Travers and Milgram 1969). Therefore, real human networks must be carefully sampled in order to attempt to capture data relevant to understanding their system-level characteristics without ignoring or excluding the very interdependencies that network studies seek to analyze (Marsden 1990).

Most network studies of actual human systems focus on understanding some aspect of a "partial" network (Barnes 1972; Boissevain 1974). These studies typically collect and analyze data from a defined sub-set of the population or focus on a specific kind of social tie (Wasserman and Faust 1994). The artificial nature of the "boundedness" imposed by these studies make them problematic for understanding the system-level characteristics of networks. As noted by Barnes (1972:3-4), the "social network . . . involving all members of a society, exists independently of any investigator. Although it may remain largely unknown, we cannot assume that the effect of the network on its members is mediated only through those links the investigator is fortunate enough to uncover."

These "partial" studies are useful, however, for understanding the person- and group-level mechanisms that underlie the formation, maintenance, and use of social ties. Ethnographic observation of hunter-gatherers provides us with this kind of information about how social ties are constituted at the level of the individual person and small group. While we cannot recover information on the "total" networks of actual hunter-gatherers, we can use computational modeling to model the network systems that emerge through these person- and group-level behaviors. We can then describe, measure, and analyze the properties of the "total" networks produced by sets of known person-and group-level behaviors.

This chapter presents a basic overview of the characteristics of human social networks in general and hunter-gatherer social networks in particular. I begin by discussing some general characteristics of human social networks and contrasting human social networks with those of non-human primates. I then focus on hunter-gatherer systems, describing variability in the major ethnographically-documented mechanisms for the formation and maintenance of the social ties that constitute the building blocks of social networks in those systems. Finally, I introduce some basic measures and terminology that are used to describe the structure and properties of social networks.

Characteristics of Human Social Networks

Human social networks are characterized by a suite of characteristics that differentiates them from those of other primates: (1) the social networks of humans are relatively large; (2) social relationships are highly variable and complexly organized in a "nested" structure; (3) many social relationships are defined, formed, and/or maintained by symbolic, culturally-defined behaviors (e.g., kinship and exchange). Comparisons between nonhuman primates and humans suggest that the advent of adult male-female pair bonding (i.e., "marriage") and the emergence of the cognitive capacities required for symbolic communication were key factors in the evolution of human social networks (see Chapais 2011; Hill et al. 2011; Maryanski 1992, 1993, 1996; Maryanski and Turner 1992). These developments allowed groups to be composed of stable family units, biological kin to be recognized on both the mother's and father's side, and inter-group relationships to be based on social ties created and maintained through kinship and exchange.

The personal social networks of individual humans are multi-level entities with nested groupings of increasing size: an "ideal" personal social network can be represented graphically as a series of concentric circles of acquaintances and possible acquaintances with ego at the center (Figure 2.1). Each successive circle defines a larger, more emotionally distant level (see Boissevain 1974:46-47; Gamble 1998, 1999; Hill and Dunbar 2003; Stiller and Dunbar 2007; Zhou et al. 2005). "Typical" levels might contain 5, 15, 50, 150, 500, and 1500 individuals (Stiller and Dunbar 2007; Zhou et al. 2005). These are general size tendencies and are somewhat dependent upon how social relationships are defined and quantified: there is great variability in the size of the personal networks of individual humans (e.g., see Bickart et al. 2010; Hill and Dunbar 2003; Killworth et al. 1990; McCarty et al. 2001; Roberts et al. 2009; Stiller and Dunbar 2007). The first four levels define circles of ego's acquaintances. The remaining two levels contain individuals not in ego's personal network.

The innermost two levels of a person's social network (i.e., his "inner circle") are occupied by people with whom ego has close relationships maintained with regular contact (Boissevain 1974; Dunbar and Spoors 1995; Gamble 1998). Personal networks at this level typically contain 10-15 individuals (Dunbar and Spoors 1995; see also Milardo 1992). These network levels contain a high proportion of family members and close friends. The social ties between

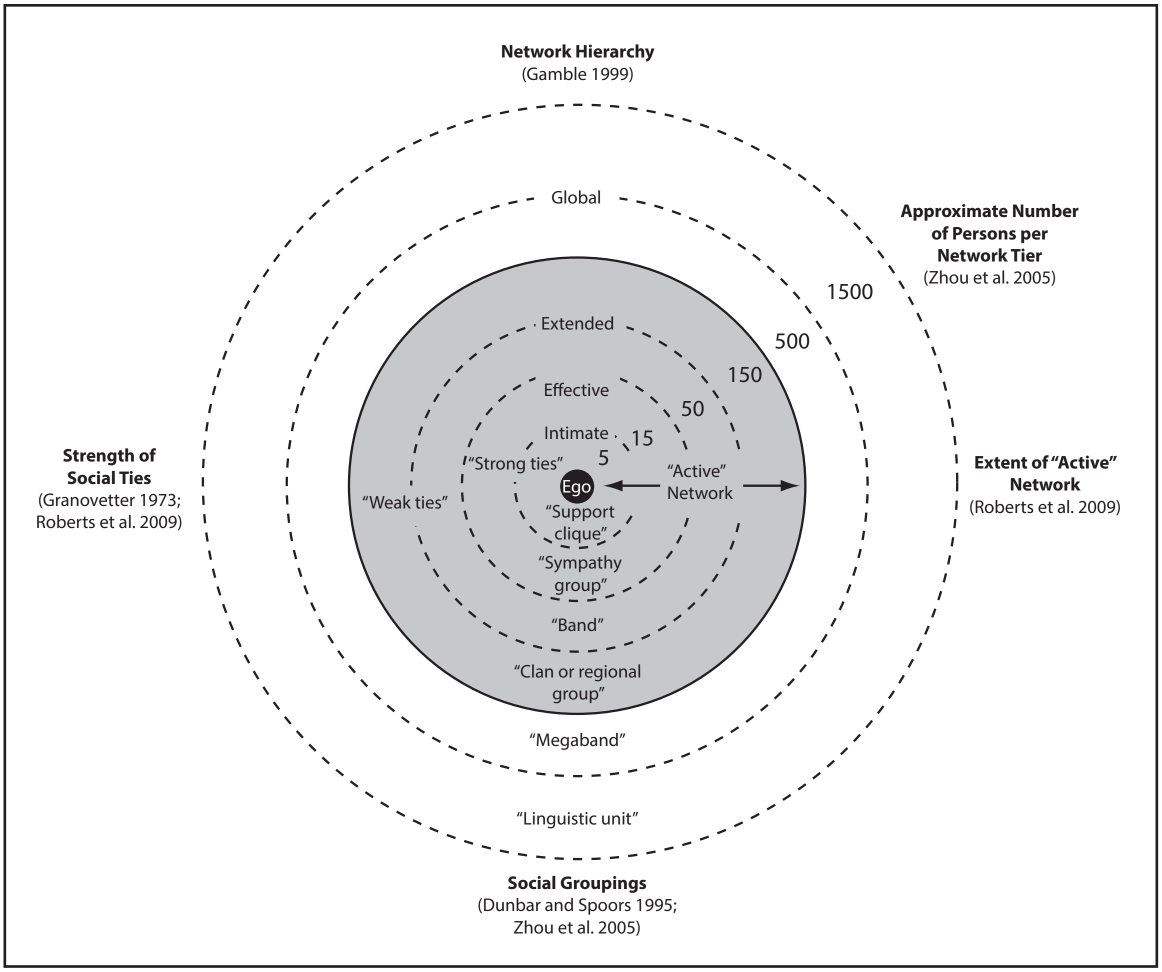


Figure 2.1. Idealized depiction of the nested levels of a personal social network.

an individual and those in his "inner circle" are so-called "strong ties" (Friedkin 1980; Granovetter 1973; Walker et al. 1994). These ties serve as conduits for large amounts of resource flow (Turner and Maryanski 1991:553), linking individuals who provide "extensive emotional, instrumental, and social support" to one another (Roberts et al. 2009).

A high density of ties is expected among the individuals in these innermost levels: most of the ties that *could* exist between individuals other than ego actually *do* exist (Feld 1997; Gamble 1998:434; Granovetter 1973, 1983). Although ties at these levels can diminish in strength and be replaced (see Wellman et al. 1997), the high density of the ties and the presence of culturally-defined expectations about many of these relationships (e.g., "family") probably contributes to high stability in these innermost levels of a person's network relative to the outermost levels (see Burt 2002; Feld 1997).

The “intimate network” described by Gamble (1998, 1999) would be contained within the “inner circle”, as would at least a portion of the “effective network.” Gamble’s (1998:434) “effective network” is equivalent to Milardo’s (1992) “exchange network.”

The 150 level has been argued to represent the approximate mean size of the “active” network that an individual can manage and maintain through personal contact (Dunbar 2003; Hill and Dunbar 2003; Roberts et al. 2009). Gamble’s (1999) “extended network” corresponds to the active network. Boissevain’s (1974:47) “effective zone,” comprised of “strategic” persons with whom ego maintains relations “for economic and political purposes,” appears to correspond to this level as well.

The size of actual networks at this level appear to range widely, but many studies find the mean number to be between about 100 and 300 (see Boissevain 1974:117; Hill and Dunbar 2003; McCarty et al. 2001; Roberts et al. 2009; Stiller and Dunbar 2007). Dunbar (2003) suggests that the size of the active network a person can manage may be constrained by cognitive physiology, as a number around 150 is predicted from the size of the human neocortex based on the relationship between neocortex and group size seen in other primates (see also Bickart et al. 2010). Cultural mechanisms (e.g., technology, material culture, language, and other symbolic systems) may be important in allowing humans to supersede the biological limitations imposed by neocortex size (see Coward and Gamble 2008; de Ruiter et al. 2011).

Social ties with individuals that are within the active network but outside of the two innermost levels of a person’s social circle are likely to be “weak ties.” Weak ties are ties that serve as conduits for small and/or sporadic amounts of resource flow (Granovetter 1973, 1983; Turner and Maryanski 1991:553). While weak ties are less important than strong ties in providing close, frequent support on a day-to-day basis, they are more important for transferring a wide variety of information (Granovetter 1973, 1983; Roberts et al. 2009; Walker et al. 1994) and may serve as “bridges” between subdensities (or “cliques”) within the network (Burt 2002; Turner and Maryanski 1991). Weak ties can be links between a variety of casual acquaintances, kin, or distant family members. Because of the heterogeneity and large number of these weak ties, the density of ties among individuals in a person’s active network tends to be lower than those among acquaintances in the innermost levels of his network. These characteristics contribute to the effectiveness of weak ties as channels for distributing a variety of different kinds of information (Granovetter 1973, 1983; Roberts et al. 2009).

The weak ties in the active network often need to be maintained in order to remain viable channels for obtaining or disseminating information (Burt 2002). Weak ties may decay more rapidly than strong ties because the burden of maintaining them falls solely on the two individuals involved: there is neither a densely interconnected network of co-acquaintances to facilitate the relationship nor the existence of a set of expectations about the nature of the relationship defined by categories such as "family" or "kin" (see Burt 2002; Feld 1997). The behaviors used to maintain weak ties (i.e., exchange of gifts, personal contact, etc.) all have a "cost" to the individuals involved in terms of time, energy, and/or assets (Burt 2002; Roberts 2010). The expenditure of resources to maintain these ties can be viewed as an investment in social relationships with an expected return, such as information or influence (Lin 1999). Thus the formation and maintenance of a large, heterogeneous assortment of weak ties has both costs and benefits. Because the number of ties that a person can actively manage and maintain is constrained by biology (i.e., the ability of the human brain to effectively, simultaneously monitor only a limited number of social relationships), cultural mechanisms, and the finite nature of resources (such as time, personal energy, assets) that can be used to maintain these relationships, an individual must make choices about which relationships to invest in and how heavily to invest in them. This is why the total size of a person's social network often decreases when new, energy-intensive relationships (such as with a marriage partner or a new child) are added (see Roberts 2010).

Weak ties among kin may require less maintenance than non-kin ties for two reasons: (1) because at least some aspects of the relationship are defined by the status of the two individuals as kin, regardless of their personal connection (Barnes 1972; Roberts 2010; Roberts et al. 2009); and (2) because kinship ties are likely to be "reinforced" by other kinship ties extending between kin (Roberts 2010). Relationships defined by kinship "typically have lifelong durability, with ascriptive roles minimally dependent on frequency of transactions" (Barnes 1972:26-20). The estimated proportion of kin in networks varies depending on which parts of a network are the subject of analysis. Dunbar and Spoors (1995) reported about 37.5 percent of the "inner circles" (i.e., sympathy groups) of a modern British population was kin (note that the definition of "kin" used in that study would include immediate family). Kin composed about 55 percent and 40 percent of the "significant other" and "exchange" networks described by

Milardo (1992). Hill and Dunbar (2003) reported a mean proportion of 21 percent kin (also including biological family) within the "active" networks of individuals sending out Christmas cards.

Within a given system, the personal networks of individuals are inter-linked into a larger, system-level "network of networks" that constitutes the social field (Boissevain 1979:392). The system-level network is an emergent phenomenon that has its own set of characteristics that can be measured, described, and analyzed (see below). Persons that are parts of a given system (i.e., have social links that connect them to others in the system) but not part of an individual's active network constitute a population of potential acquaintances. Gamble (1999:51) refers to this as the *global network*. (Note that Milardo [1992:456] uses the term "global network" to refer to all people known to an individual.) Within a given system, there should exist a direct connection or an indirect social path (i.e., a path that involves a series of social connections) between any two individuals. A population of around 2,500 people has been suggested as an upper threshold for the maximum "group" population that has some stability without a formalized governing hierarchy (Gamble 1998:436).

If the size of individual active networks has some central tendency (e.g., because of biological constraints related to cognition and or cultural mechanisms that exert feedbacks on network size), the pool of *potential* acquaintances grows disproportionately in size as population size increases. This is because the number of possible social connections within a given population rises disproportionately to arithmetic increases in population size (see Bossard 1945; Kephart 1950). In a group of 200, for example, each individual may have social connections with exactly 199 other individuals. The addition of one individual to the population increases the number of social connections each person may have by 1. The total number of *possible* social connections within a group containing 200 individuals is 19,900, calculated using the formula N(N-1)/2, where N is group size (Kephart 1950). This number increases by (N-1) each time a person is added, increasing the number of possible social connections disproportionate to the increase in the size of the population. Doubling the population size to 400, for example, quadruples the possible number of connections (79,800). Quadrupling the population size to 800 increases the possible number of connections by a factor of 16 (319,600). Over three million social connections are possible within a population of just 2,500 people.

While human capacities for symbolic behavior are tied to the formation and maintenance of social ties at all levels, the relationship between symbolic behavior and the formation and maintenance of social ties in the extended network is particularly important (Turner and Maryanski 1991:550). These ties, often created and maintained through kinship and exchange, can extend between groups and are significant in facilitating friendly inter-group relationships (see Chapais 2011; Hill et al. 2011). In general, resources used to maintain weak ties are likely to have a stronger symbolic component than those used to maintain strong ties (Gamble 1998:433).

The distinctive aspects of human social networks (size, structure, and dependence on symbolism) are inter-related in a way that is unique among primates. Stable mean group sizes suggest that the social networks of nonhuman primates contain fewer than 70 other individuals (Dunbar 1992; 2003; Beauchamp and Cabana 1990; Hill and Dunbar 2003; Kudo and Dunbar 2001), far smaller than the networks of individual humans. While there is variability in the origin, strength, and maintenance of social bonds among nonhuman primates (Kasper and Voelkl 2009; Lehmann et al. 2010; Maryanski 1987, 1992, 1993, 1996), there have been no suggestions that the social networks of individual nonhuman primates have a strongly tiered, nested structure similar to that of humans. Finally, while many researchers would argue that some higher primates do have some capacity for symbolic behavior and communication (e.g., see Boesch 1991; Box 1984; Matsuzawa 1986), these capacities are in no way sufficient to support the level of symbolic behavior required for the cultural systems of kinship and exchange that are used to create and maintain the extended networks of humans.

Biology probably plays a significant role in constraining the size, structure, and symbolic aspects of nonhuman primate social networks. Correlations between stable group size and neocortex size in nonhuman primates suggests biological limits on the number of social relationships that individual nonhuman primates can simultaneously monitor, maintain, and/or manipulate (Dunbar 1992, 1998, 2003; Hill and Dunbar 2003; see also Sallet et al. 2011). The neocortex is important to many of the behaviors (e.g., grooming, maternal behaviors, and the recognition of faces and vocal calls) that nonhuman primates use to form and maintain social bonds (Kling 1986; Sawaguchi and Kudo 1990) and the size of the brain/neocortex may constrain the “complexity” of social networks that can be formed within primate groups (Lehmann et al. 2010). The lack of language, further, severely constrains the ability of nonhuman primates to exchange information about social relationships without direct interaction (Lehmann et al. 2010). Simply put, biological limitations do not allow nonhuman primates to create and maintain large, tiered, heterogeneous, symbolically-constituted social networks like those that are fundamental to human social structure.

Mechanisms of Social Network Formation and Maintenance among Ethnographic Hunter-Gatherers

The vast majority of studies of social networks have been focused on populations in the industrialized, urban world. While many general, empirically-observed aspects of human social networks appear to be common to all human societies (e.g., see Apicella et al. 2012; Gamble 1998; Zhou et al. 2005), the cultural and behavioral mechanisms that facilitate the formation and maintenance of social ties among hunter-gatherers are somewhat different from those employed by modern urban populations. This is due to the distinctive qualities of hunter-gatherer adaptations: mechanisms for the formation and maintenance of social ties must be compatible with the particular demographic, ecological, economic, and technological aspects of these systems.

Ethnographic data demonstrate that there is a wide range of variability in both the "macro" level organization of hunter-gatherer social networks and the "micro" level rules and behaviors which affect how social ties are formed and maintained. As in all human systems, the "macro" structure of the system-level social networks of hunter-gatherers emerges from numerous interactions and behaviors at the level of the individual or small group. Primary mechanisms for establishing and/or maintaining social ties include descent, kinship, marriage, and exchange. The interactions that facilitate many of these mechanisms involve face-to-face contact between individuals (Coward and Gamble 2008:431). In spatially-dispersed (i.e., non-sedentary) hunter-gatherer populations, group and personal mobility are important in allowing the face-to-face interactions necessary for directly establishing and maintaining social ties as well as exchanging "third party" information about social relationships.

I begin by discussing descent, kinship, and marriage as an inter-linked suite of behaviors that affect the formation and maintenance of social ties. I then discuss the role of exchange in maintaining social ties over periods of time when no face-to-face contact occurs. This is followed by a discussion of the broad parameters of hunter-gatherer mobility that facilitate face-to-face contact. Finally, I integrate these mechanisms for establishing and maintaining social ties with the idealized characteristics of human social networks described above.

Kinship, Marriage, and Descent

Kinship, marriage, and descent form an interlinked set of cultural rules and behaviors by which social relationships are defined and operationalized (Keesing 1975; Lévi-Strauss 1969; Murdock 1965). *Kinship* systems define categories that classify persons into "kin" and "non-kin" and create webs of relationships (Schneider 1961). While many kinship terms specify genealogical relationships, kinship ultimately defines sets of social (rather than strictly biological or genealogical) relationships (Barnes 1972; Beattie 1964; Schneider 1961; see also Read 2001). Kin relationships may exist between pairs of individuals who are biologically related or biologically unrelated. Kinship categories articulate with marriage by identifying which members of society are "too close" to be marriage partners (Farber 1968; Lévi-Strauss 1969). By partitioning the social universe, kinship constitutes an important organizing principle of hunter-gatherers and forms a primary means by which social ties outside the local group are formed (Binford 2001:12; Lee 1984).

Descent rules are generally understood as the social rules which define a line of blood-related kin (Schneider 1961). In general, kinship systems can be differentiated into those with unilineal descent rules and those without (Buchler and Selby 1968; Goodenough 1961). These two "great families" of systems differ with respect to how the partition between kin and non-kin is made, and organize relationships between groups and individuals in broadly different ways (Harris 1987). In non-unilineal systems (also commonly called cognatic and/or bilateral), both male and female parents are used to reckon descent and affinity (Murdock 1965). In unilineal systems (patrilineal, matrilineal), only one parent is used to reckon descent. For simplicity, the term "bilateral" will be used here to refer to non-unilineal systems (but see Goodenough 1961).

In general, bilateral kinship systems create "personal kindreds" as the main kinship unit other than the nuclear family (Murdock 1965). Because descent is reckoned through both parents, each individual is connected to a different array of kin. Other than those of siblings, no two personal kindreds are identical (Buchler and Selby 1968; Farber 1968; Goodenough 1961; Mitchell

1963:244; Murdock 1965). Particular relationships between individuals, rather than between groups, are used to determine the propriety of marriage (Farber 1968:14; Murdock 1965). Related individuals can be judged as “near” or “far,” but there may not be any uniform principles by which to make these judgments (Buchler and Selby 1968; Goodenough 1961; Harris 1987). Murdock (1965) describes personal kindreds as endlessly overlapping and intersecting, noting that a society can never be divided by kindreds into separate, exclusive groups as is possible with divisions made by nuclear family, lineages, clans, or communities.

Unilineal systems, in contrast, are based on an “orderly replacement” that emphasizes “kinship *group* affiliation in determining the range of incestuous marriage” (Farber 1968:13). Unilineal groups are “based on common descent from a real or imaginary ancestor, who remains the fixed point of reference down the generations through time until such time as the group segments” (Goodenough 1961:1343). While personal kindreds may be recognized in unilineal societies, lineages are the primary means of organizing social life (Mitchell 1963; Murdock 1965). It is the lack of pronounced lineal structures in bilateral descent systems, rather than the presence of personal kindreds, that allows unilineal and bilateral systems to be differentiated from one other.

Broad differences are apparent in the structure of social ties created by unilineal and bilateral systems. Bilateral systems create non-exclusive, ego-centric webs of kinship and marriage ties that radiate through both parents. Marriage outside of these kin ties results in connection to a different web of affinal ties through the spouse. In lineal systems, marriage to specific individuals within the lineage is often preferred (e.g., cross-cousin marriage). Lineages are mutually exclusive units that perpetuate themselves by maintaining their distinctness from other lineages (Goodenough 1961). If bilateral systems are horizontal, lineal systems are vertical. If bilateral systems create networks, lineal systems are cellular. While unilineal systems are often associated with corporate groups and corporate ownership of property or control over resources (Farber 1968; Harris 1987; Murdock 1965), the non-exclusiveness of personal kindred systems inhibits the development of these kinds of structures (Farber 1968).

A variety of kinship systems, including both bilateral and unilineal systems, has been documented among living hunter-gatherers (Keesing 1975). Bilateral systems are more common among living hunter-gatherers than lineal systems (Harris 1987; Keesing 1975:134; Lee and DeVore 1968). The common occurrence of bilateral kinship systems suggests that these kinds of systems often “fit” the organizational needs of ethnographic hunter-gatherers for creating and maintaining social networks of appropriate size and density.

Both lineal and bilateral systems can be adjusted to alter the number of available marriage partners by moving the line between kin and non-kin. The complicated section system of the Kariera of northwest Australia (a lineal system), for example, incorporates several levels of marriage proscriptions (Keesing 1975). Yengoyan (1968) argued that these section systems create a vast network of related individuals and groups that allows flexibility of organization and mobility across geographically large areas. The expansion of the section terms allows larger territories to be included within the kinship/marriage system. These elaborate systems have been the subject of debate among anthropologists for over a century (Keesing 1975; Meggitt 1968; Murdock 1965; Yengoyan 1968).

The naming system used by the San (also referred to as the Ju/’Hoansi or the !Kung) may have a similar effect, reducing the number of potential marriage partners and increasing the geographical size of the social network (Lee 1984:68; Lewis-Williams 1982:436). Kinship among the San is bilateral (Harris 1987; Lee 1984) and use an Eskimo kinship terminology (see below) (Lee 1984:66). While there is no “rule” of band exogamy among the San (Keesing 1975:6), marriage is forbidden between members of the same nuclear family, certain close kin, and kin as defined by the naming system.

The so-called Eskimo kinship terminology, common among the Inuit and other hunter-gatherers, reflects an emphasis on bilateral descent and the primacy of the nuclear family as a productive unit (Harris 1987:173-174). The three Central Eskimo societies discussed by Damas (1968) were characterized as bilateral, as were the Taremuit and the Nunamuit of northern Alaska (Spencer 1968). Consistent with the expectations of an open, bilateral system, Damas (1968:111) reports “extensive linking of overlapping kindreds” among the Central Eskimo.

The number of ties created through kin-definition in any given system is often inversely related to the number of potential marriage partners. As membership by kinship increases (i.e., the number of people who are considered “kin” increases), the number of potential marriage partners decreases (cultural rules often – but not always – prevent or discourage marriage between kin). The ultimate “effect” of some ethnographically-documented kinship and marriage systems (such as the lineal Australian section systems) is to reduce the number of possible marriage partners through the incest taboo while increasing the number of kin (Whallon 1989). At the other extreme, bilateral systems can be quite open with regard to potential marriage partners outside the nuclear family.

While marriage rules exist specifying who may and may not marry, however, actual behavior can, and often does, deviate from these rules. Individuals within the system often do not follow the "rules," and rules exist (or can be created) to circumvent the "rules" (Keesing 1975:83; Kelly 1995:286). Keesing (1975:122) sees kinship systems as ultimately epiphenomenal, created through behavior rather than the other way around: descent and marriage rules are a conceptualized system which corresponds to actual behavior in some imperfect way (see also Buchler and Selby 1968; Kelly 1995; Murdock 1965). Ecological, demographic, and economic circumstances can produce different kinship and marriage behaviors within the same set of "rules" (e.g., Keesing 1975:123, 135).

Ethnographic accounts clearly indicate that kinship and marriage systems are mechanisms for the creation and maintenance of inter-group social ties (e.g., Marshall 1976:200) and are understood as such within those societies:

> . . . [I]t is apparent that the North Alaskan Eskimo sought in every way possible to extend the patterns of economic cooperation. Not only is the kin and household unit founded in cooperation but marriage itself was a device which served to extend the forms of cooperation between otherwise unrelated family groupings [Spencer 1968:14].

As noted by Kelly (1995) and Wiessner (2009), specific marriages may occur for reasons other than the establishment of social ties to ensure resource access. Viewed as an aspect of hunter-gatherer infrastructure, however, the pattern of kinship and marriage has to be parsimonious with subsistence and ecology in some fashion. Marriage and kinship can create a web of inter-group ties that can serve as a "safety net" during times of resource stress (e.g., Lewis-Williams 1982:436; Spencer 1968:133; Wiessner 2009:253).

Exchange

Binford (2001:467) states that items exchanged between groups "help maintain social ties over long periods during which no face-to-face contact occurs." This view of exchange as a medium for the maintenance and reinforcement (rather than creation) of reciprocal relations is echoed by Lee (1984), Lewis-Williams (1982:436), and Wiessner (1982, 2009) in regards to the *hxaro* exchange system of the San.

The San *hxaro* system is probably the most well-known system of reciprocal exchange among ethnographically documented hunter-gatherers (see Wiessner 1982, 1983, 1984). The *hxaro* system is a system of reciprocal gift-giving used to create and maintain ties between families and related individuals (Lee 1984; Wiessner 1982:66, 1984:206). Most *hxaro* exchange ties "radiate from the husband-wife relation" (Lee 1984:98) and involve individuals between which there is relatively frequent, if episodic, interaction and some kin relationship (Wiessner 1984:206). Diagrams of the *hxaro* system show gifts moving along both intra- and inter-group ties (Wiessner 1982:69; Schweizer 1997).

The ego-centered nature of the *hxaro* network is congruent with the bilateral kinship system of the San. While the *hxaro* system is often characterized as a mechanism for "circulating" goods (Lee 1984:97), it is not clear how circular it really is. Wiessner (1982:70) notes that the San "cannot trace paths [of hxaro exchange] more than two or three links in either direction." This suggests that goods move through, and out of, the system as viewed from a local vantage point. Schweizer's (1997:751) analysis of the *hxaro* network led him to conclude that

> Reciprocal gift exchange in this society creates a sparse regional network of mutual obligations, which is mainly driven by close kinship; common locality plays only a minor role. Continuous gift giving is used to establish and maintain a personal (ego-centered) network of close associates.

Binford (2001:467) observes that the nature of exchange relationships may co-vary with subsistence: exchange in groups focused on terrestrial animals often occurs between affinal kin (as opposed to consanguineal kin) or between individuals that are not related by kinship, while exchange in plant-dependent groups follows social paths linking kin (rather than non-kin). In both cases, exchange volume is generally low and emphasizes the maintenance of ties rather the exchange of bulk goods (Binford 2001:467).

Mobility, Group Stability, and Group Size

The social networks of non-sedentary hunter-gatherers are both built through and dependent on mobility and fluctuations in group membership to create and maintain social ties. As discussed above, individual humans typically have personal social networks that exceed 100 persons in size. The co-residential groups that are a fundamental unit of spatially-dispersed hunter-gatherer systems throughout all or part of the year, however, are generally much smaller than this. Creating and maintaining the large number of social ties typical of personal networks, therefore, requires mechanisms that allow individuals to regularly interact with a larger number of persons than they co-reside with at any given time. Personal mobility (the movement of individual persons and/or families between foraging groups) allows group membership to fluctuate, providing opportunities for individuals to create new ties and maintain established ties. Group mobility (the movement of co-residential groups of people from one residential location to another) allows for periodic aggregations of multiple groups and re-organization of groups through processes of group fission/fusion. Together these mechanisms allow members of a spatially-dispersed population to build and maintain their personal social networks and transfer information through intermittent or non-permanent contact.

There is a significant amount of variability in the frequency, distance, and kinds of movements in which hunter-gatherers engage. Much of this variability is understood in relation to hunter-gatherer subsistence ecology (see Binford 1980, 1983, 2001; Kelly 1995): mobility must be compatible with the distribution of subsistence resources and the technologies and strategies used to exploit those resources. Mobility serves to bring consumers to subsistence resources or subsistence resources to consumers (Binford 1983).

Mobility also serves to bring people into contact with one another. In some cases, this may be secondary to immediate subsistence concerns. In other cases, however, the primary motivation of some mobility behaviors appears to be explicitly related to the transfer of information and/or the maintenance of social ties. Whallon (2006), for example, argued that personal mobility was sometimes used to establish and maintain social ties over a wide area as a strategy for buffering localized resource scarcity (see also Kelly 1995:153). Periodic regional aggregations of hunter-gatherers facilitate marriage, exchange, information transfer, and a variety of communal activities (see Conkey 1980;

Damas 1968, 2002; Kelly 1995; Walthall 1998). The social networks that are created and maintained by these behaviors serve as a "safety net" to mitigate the risks associated with hunter-gatherer lifeways. Thus it is clear that mobility is often related to both ecology and sociality: however mobility is structured in a given system, it must serve to effectively bring people into contact with both subsistence resources and each other.

The movements of individuals and families between groups has been commonly observed in modern hunter-gatherers and is generally accepted as a common, if not integral, feature of hunter-gatherer life (Binford 2001; Kelly 1995; Lee and DeVore 1968:7; Marshall 1976:179-180; Silberbauer 1981; Turnbull 1968; Woodburn 1968). Among the San, for example, the membership of camps changed in size and composition daily (Lee 1968:31, 1984). Woodburn (1968:105) describes a state of constant flux among the Hadza:

> People do not camp continuously at a particular site for more than a few weeks and they usually move much more often. At the time members of a camp all move, they may go together to a new site; they may split up and form camps at two or more new sites; they may go as a body to join some existing camp, or they may divide, some joining an existing camp and others building a camp at a new site. Even while people are living together in a camp at a particular site, the composition of the site changes: some people move in and some move out.

These inter-group movements are not random, but are conditioned by the existence of social relationships. Generally, the movement of an individual or family from one group to another is dependent upon the existence of a social relationship with an individual in the new group. Wiessner (1982:61) states that "the apparent flexibility of organization among the San is not true flexibility in itself, but the product of a structured system of social relations operating according to certain principles." *Hxaro* exchange takes place in a delayed fashion during visits, and may serve as a pretext for visits (Lee 1984:99).

The amount of inter-group movement or transfer may be quite high. Among the G/wi, for example,

> The gross annual rate of short-term migration is very high, exceeding 200 percent of the membership of some bands in years of good rainfall when there is plenty of food and travel is relatively easy [Silberbauer 1981:142].

While the apparent motives for travel may vary (e.g., Turnbull 1968), every movement that results in the translocation of an individual from one group to another is an opportunity for face-to-face interactions to occur.

The movements of co-residential groups logically affect opportunities for interaction between members of different groups. The spatial proximity of groups logically affects the ease with which individuals may move between groups and/or interact with individuals in other groups. When groups are highly dispersed, it may be more difficult for individuals to travel between groups. When groups aggregate, the cost of travel between groups (and, subsequently, information transfer) is minimal.

There is a large amount of variability in both the scale and frequency of residential mobility among ethnographically-observed foraging groups. Data provided by Binford (2001) and Kelly (1995) suggest that the frequency of residential movement of mobile hunter-gatherers varies continuously from about once per year to once per week (Figure 2.2). The average distance of residential movement varies from less than 5 km to over 70 km (Figure 2.2A), with total (annual) distances moved varying from 0 to about 800 km (Figure 2.2B). The highest total distances moved are associated with groups making a relatively small number of long moves and groups making a relatively high number of short moves.

The size of hunter-gatherer co-residential groups varies both within and between systems. Binford (2001:Table 8.01) provides data from numerous ethnographic cases (Figure 2.3). Some of this variability is the result of the periodic fission and fusion of foraging groups that has been reported for many hunter-gatherer systems in many different ecological settings (see Binford 2001; Lee and DeVore 1968; Kelly 1995; Turnbull 1968). Among mobile (i.e., non-sedentary) hunter-gatherers, the reported size of foraging groups at their most dispersed varies between 5 and 35 (with a single reported case of 1) (Figure 2.3A). In most cases where a “most dispersed” group size is reported, the size of groups at the “most aggregated” phase is less than 100 (Figure 2.3B). Fluctuations in group size allow groups to re-organize and re-combine, providing opportunities for changes in group membership.

Periodic (often seasonal) aggregation of regional populations appears to be a common feature of hunter-gatherer settlement systems (Birdsell 1968a:234; Conkey 1980; Kelly 1995; Walthall 1998). Reasons for aggregations are likely both social and economic (see Conkey 1980; Damas 1968, 2002; Kelly 1995;

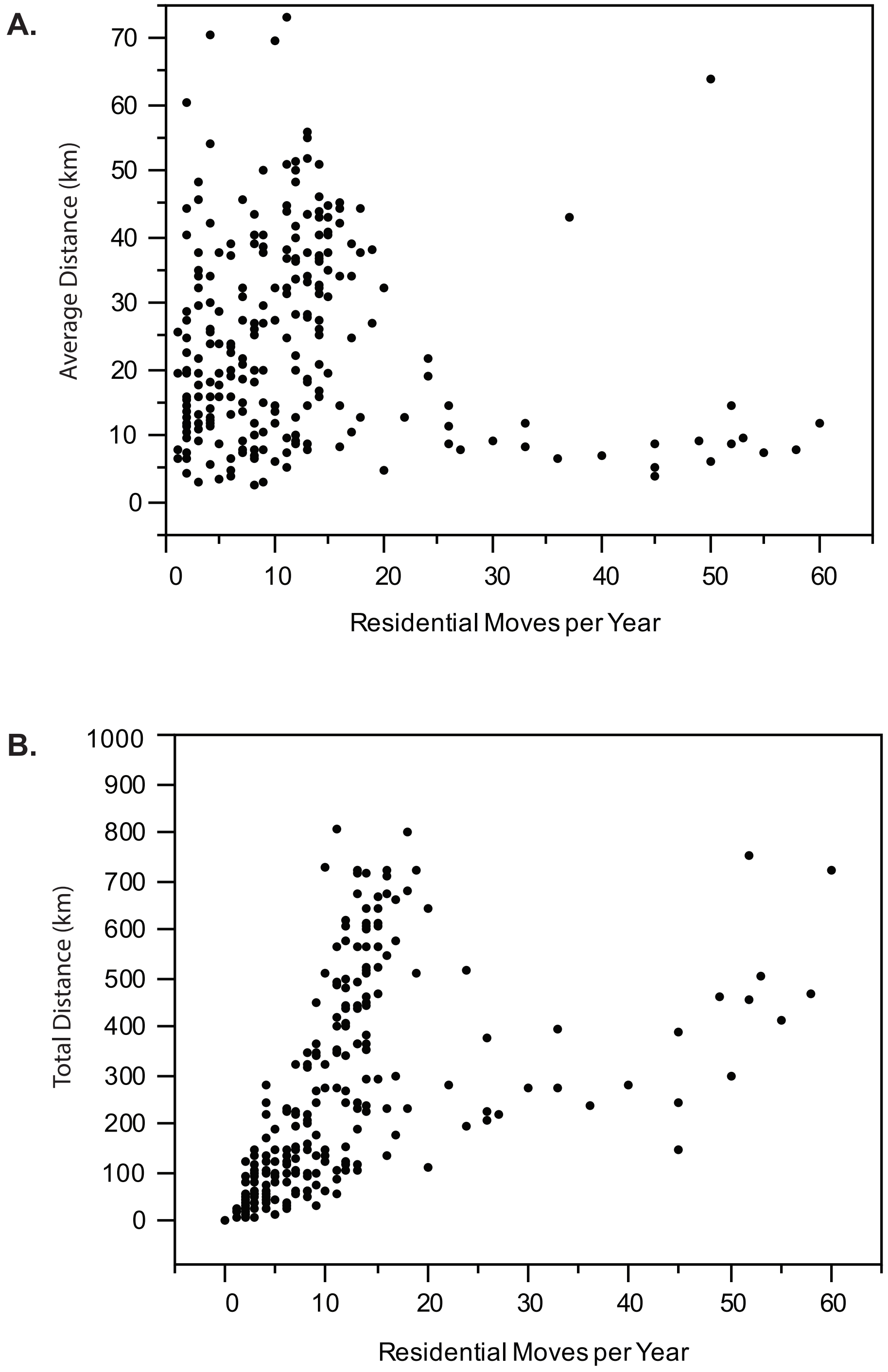


Figure 2.2. Plots of the number of residential moves per year vs. the average distance per movement (A) and the total distance moved (B) among ethnographic hunter-gatherers (*n* = 293 groups). Data from Binford (2001) and Kelly (1995).

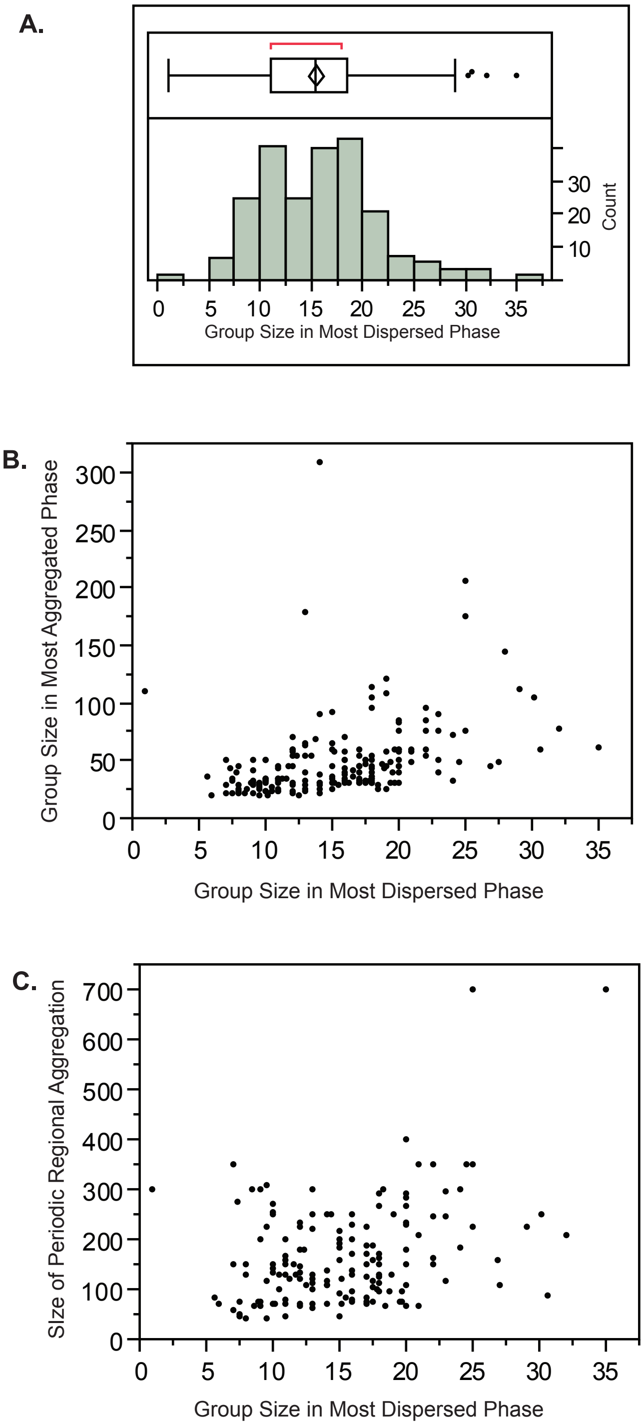


Figure 2.3. Group size among ethnographic hunter-gatherers. (A) Histogram of group size during most dispersed phase among 215 ethnographic hunter-gatherer groups; (B) plot of group size during most dispersed phase vs. group size during most aggregated phase; (C) plot of group size during most dispersed phase vs. size of regional periodic aggregation. Data from Binford (2001).

Walthall 1998). The populations present at these aggregations can be somewhat larger than those associated with individual foraging groups: aggregations between 100 and 300 have been commonly reported among mobile hunter-gatherers (Figure 2.3C). Generally, large population aggregations can only be supported in times and places of relative resource abundance (Walthall 1998). Among the Inuit peoples of the central Arctic, aggregations of as many as 100-200 occurred in conjunction with concentrated resources available at fishing, sealing, and whaling locations (Damas 1968, 2002). Seasonal aggregations of 50 to 300 people lasting less than a few weeks were associated with caribou drives among the Nunamuit (Damas 1968:111). Lee (1984:100) reports gatherings of up to 200 San during the winter. Groups of 100 have been reported for the /Xam (Lewis-Williams 1982:431). Gatherings of up to 270 people have been documented in the deserts of Australia (see Hayden 1980:623).

In summary, social networks are affected by mobility, group stability, and group size because these features of hunter-gatherer systems provide mechanisms that allow members of a spatially-dispersed population to build and maintain their personal social networks and transfer information through intermittent or non-permanent contact. In turn, social networks exert an effect on all these features encouraging or constraining the movements of individuals or groups based on the existing state of social relationships. We may expect, then, that variability in aspects of personal and group mobility, group stability, and group size may be related to the characteristics of the social network that both guides and constrains these characteristics.

Idealized Characteristics of Hunter-Gatherer Social Networks

Information about the particular mechanisms that contribute to the establishment and maintenance of social ties in hunter-gatherer societies can be integrated with the idealized characteristics of human social networks. As discussed above, the personal social networks of individual humans can be represented as a series of nested circles originating from ego, each successive circle containing a greater number of individuals to whom ego is socially linked. The system-level social network emerges from the inter-linking of numerous personal social networks.

In general, weak and strong ties tend to correspond to inter-group and intra-group relations, respectively (Friedkin 1982; Granovetter 1973:1376;

Marsden 1990). Because of their greater number and their role in connecting local groups, weak ties increase structural cohesion and integration of the network as a whole, balancing their individual inefficiency as conduits of information with their greater numbers (Friedkin 1980, 1982). Ties *within* an organizational subsystem (i.e., the primary subsistence unit in the case of hunter-gatherers) are likely to be strong (Friedkin 1982). Cohesion at the group level is conditioned more by strong ties (Friedkin 2004).

A person's intimate network, comprised of about 10-15 people, is likely to be composed largely of co-residential family members and/or friends. Strong ties are established through marriage (husband-wife), biological relatedness (parent-offspring, sibling-sibling) and close contact and are sustained by regular, intimate face-to-face contact and/or by cultural conventions that define their nature. Families and households are generally regarded as relatively stable, "building block" units in hunter-gatherer systems (e.g., Chapais 2011; Helm 1968:121; Johnson 1982; Marshall 1976:168; Maryanski 1992:25).

Gamble (1998:434) defined the "effective" network as "the people who provide the individual with material and emotional assistance during the routines of daily life." In the context of mobile hunter-gatherer systems, a person's effective network would be composed of other members of his/her foraging group. Individuals have frequent, face-to-face contact with other individuals in these small, "on the ground" groupings. As discussed above, the membership of these groups can be more-or-less stable depending on the degree of personal- and family-level mobility, group fission-fusion behaviors, etc. While the size of co-residential groups among spatially-dispersed, ethnographic hunter-gatherers varies greatly under different conditions (see Figure 2.3), a group size of around 25 people is commonly cited as "average" (Kelly 1995:210). A group size of around 25 is thought to be commonly produced by a "compromise between reproductive and economic needs: it is sufficiently large to keep the group demographically viable, yet small enough to prevent rapid depletion of local resources" (Kelly 1995:212; see also Binford 2001; Johnson 1982; Wobst 1974).

It would be expected that all members of a co-residential foraging group would know one another. Thus the density of ties within an individual's effective network would be very high. Interestingly, "close" kin accounted for less than 10 percent of the membership of the sample of hunter-gatherer groups considered by Hill et al. (2011). Thus while descent and kinship play some role in establishing/defining/maintaining the ties in an individual's effective network, many of the ties within these foraging groups are between individuals who are not related by descent or kinship. These ties would likely vary in strength and character. Inter-personal tension and conflict among co-residential individuals is often cited as one reason why groups may fission or individual persons or families may switch groups (e.g. see Johnson 1982; Marshall 1976; Turnbull 1968).

The existence of social ties between individuals residing in different groups is a universal component of hunter-gatherer societies. These ties are a critical part of hunter-gatherer infrastructure, serving as avenues for information exchange, mate location, and resource access (Binford 2001; Lee 1984; Lee and DeVore 1968; Lewis-Williams 1982; Spielmann 1986; Whallon 2006; Wiessner 1982; Wobst 1974). Ties may be formed and defined on the basis of descent, marriage, kinship, previous group-level co-residence, or other cultural mechanisms. They may be maintained by occasional face-to-face contact, cultural proscriptions, and/or exchange. Ties extending between groups are presumed, by definition, to be part of a hunter-gatherer's extended network. The presumed heterogeneity, wide distribution, and relatively low density of these ties are consistent with the characteristics of "weak" ties (Granovetter 1973; Turner and Maryanski 1991).

Kinship ties form a significant component of the extended networks of hunter-gatherers. Several general characteristics of kinship are notable. One is that kinship creates defined social relationships where previously none may have existed: a marriage between two individuals may result in the creation of relationships between otherwise unrelated individuals (e.g., the father of the bride and the father of the groom) or between one of the marriage partners and the relatives of the other marriage partner (e.g., the groom and the bride's mother's brother). These social relationships can be created and defined in the absence of any face-to-face interaction. Two unacquainted individuals who meet can often determine their relationship to one another through kinship (see Marshall 1976:241-242; Read 2001).

Second, not all kin are created equal: culturally-defined obligations may be different between "close" kin and "distant" kin. Even though ties formed on the basis of kinship may originate without face-to-face interaction, they may still need to be maintained. Damas (2002:16), for example, notes that the large aggregations of the central Arctic Inuit provided the best opportunities for renewals of kinship ties beyond those of the family. Kinship ties should not be assumed to be impervious to decay.

Third, by classifying individuals as either “kin” or “non-kin,” kinship systems create webs of defined relationships among individuals that may have a significant effect on the choice of marriage partners (see above). Generally, the greater the number of ties created by kin-definition, the lower the number of potential marriage partners. This potentially affects the spatial structure of social networks by forcing individuals to seek marriage partners in distant areas.

Because kinship systems classify people differently, different kinship systems can be expected to have different effects on the creation of social ties. Descriptions of societies with bilateral kinship often stress the integrative properties of these kinds of “open” systems. Binford (2001:465) sees the existence of open kin networks as basic to the “generic” hunter-gatherer adaptation: “generic hunter-gatherers are integrated into their social world through egocentric, reticulate patterns of extended, kin-based relationships.” Farber (1968:12) describes an idealized “open” kinship system as one that stresses “integration functions” and is “organized to maximize the number of marital liaisons between kin groups.”

The intersecting, overlapping webs of social ties created by bilateral systems are probably more parsimonious with “open” (i.e., unbounded) social networks than closed ones for two reasons: 1) bilateral kinship systems, with their emphasis on the nuclear family and de-emphasis on the kin status of those with more distant genealogical connections, allow for a wide range of marriage options; and 2) the non-exclusive, overlapping nature of the personal kindreds produces an unbounded, continuous social fabric across which an open network can operate. The pool of potential marriage mates can be expanded or narrowed by adjusting the genealogical distance that is considered “too close” for marriage, or by adding other restrictions (such as the San naming system). The “reach” of these kinds of systems, then, can be tuned to a scale appropriate to their ecological requirements. This flexibility may be one reason why bilateral systems are common among highly mobile hunter-gatherers (Harris 1987:167). Keesing (1975:7) remarks that “In such webs of kinship and intermarriage between bands lay potential solutions to new organizational and ecological problems . . .”

In “closed” (i.e., bounded) social networks, by contrast, the maximum number of “distant” social ties could be created and maintained through kinship systems that classify a greater number of people as kin and reduce the number of potential marriage partners. Lineal systems generally do both of these things. “Generic” lineal systems produce bounded groups of kin that are non-overlapping. The closed, exclusive, group-oriented structures of these systems are parsimonious with closed networks precisely *because* they have edges.

The Australian section system is an example of how this kind of system can work in an area of low population density. Population densities in some portions of Australia were as low as 1 person per 90 km^2 (Yengoyan 1968:190), similar to the 1 person per 100 km^2 used in Wobst’s (1976) illustration and below several general estimates of Pleistocene population densities (Binford 2001; Birdsell 1972; Hassan 1981). Both Yengoyan (1968:188) and Birdsell (1968b:246) characterize Australian systems as “tribes” in the sense that they inhabit circumscribed territories with closed boundaries. Social ties are created across the network through both kinship and marriage. Information flows across these ties though mechanisms of fluid group composition and aggregations. The same long-distance mobility behaviors used for extracting resources from the environment function to facilitate communication. “All Australians can walk all the places that they need to walk during the annual cycle” (Birdsell 1968b:246). The small number of “short cuts” required to significantly reduce communication distances across the network may explain why it may be inconsequential in terms of closed network properties if all marriages do not conform to preferences or prohibitions (see Kelly 1995:286).

This is not to say that these two broad forms of descent reckoning are exactly correlated with open and closed social networks, but only to point out that the basic patterns of social ties that each produces may not be equally compatible with both forms. If we accept kinship as a real part of social and economic infrastructure (rather than simply a cognitive framework), we accept that there are articulations between kinship and economic and social realities.

Ties formed between individuals who have lived and worked together in group settings but are not related by descent or kinship also may form a significant part of an individual’s extended network. These ties may be more fragile than ties defined by descent or kinship because they lack a culturally-proscribed set of expectations about their nature or permanence. In the absence of frequent face-to-face interaction, these kinds of “acquaintance” relationships between individuals in different groups are likely to be “weak” ties. As discussed above, these kinds of ties are often numerous, heterogeneous, and maintained through mechanisms such as exchange.

Geographic distance affects the creation and maintenance of non-local ties in several ways. When groups are in close spatial proximity, less effort is required to establish and maintain social ties because travel between groups may be accomplished with relatively little effort. In a study of the social networks of 205 Hadza, Apicella et al. (2012) concluded that the probability of a social tie existing between two individuals decreased with geographic distance and increased with genetic relatedness. These are the general, expected effects of the roles that space and kinship play in discouraging and encouraging (respectively) the creation and maintenance of social ties. Long-distance (i.e., non-local) ties are important to the viability of many hunter-gatherer systems, however, and various mechanisms exist for creating and maintaining these ties (Whallon 2006). Wiessner (2009), for example, describes how some Ju/'hoansi arranged marriages with the specific goal of creating exchange ties over long distances. The Australian section system compels individuals to find marriage partners in distant areas by reducing the number of locally-available marriage partners, thereby increasing the spatial scale of the social network (Whallon 1989; Yengoyan 1968) and presumably affecting its structural characteristics.

In summary, the intimate, effective, and extended networks of individual hunter-gatherers are the product of a suite of mechanisms that create and facilitate the maintenance of social ties. Marriage, kinship, descent, co-residence, personal mobility, group mobility, and exchange all play roles in producing both the nested structures of personal networks that are characteristic of human systems and the system-level social networks that emerge from the inter-linking of numerous personal networks. Following the possibility raised by Friedkin (1980:422), I suggest that hunter-gatherer systems are dependent on a combination of weak and strong ties: “Macro integration can be based on weak ties which permit episodic transmissions of information among groups, while micro integration is based on a cohesive set of strong ties which permit regular transmissions within groups.” The distinctive human behaviors of exchange, inter-group marriage, kinship, and language make possible the creation and maintenance of large social networks that inter-connect dynamically mobile populations distributed sparsely across large spatial areas.

Basic Description of System-Level Social Networks

This section defines and discusses several variables and concepts that are used to describe some basic characteristics of human social networks. These are used in the model description presented in Chapter 4 and the analyses of model outputs discussed in Chapters 5 and 8. Most of these variables and concepts are relatively simple, uncomplicated measures that have been in standard use since the beginning of formal social network analysis in the 1950s (see Mitchell 1974; Wasserman and Faust 1994; Turner and Maryanski 1991). The set of variables and concepts utilized in this dissertation is not intended to be exhaustive.

Describing the structure of a social network (i.e., how the parts of the network are connected together) requires identification of the nodes in the network and the paths between those nodes (Marsden 1990; Turner and Maryanski 1991; Wasserman and Faust 1994). Many of these discussions will reference the illustration in Figure 2.4. This figure is a visual representation of three small networks of nodes (representing individual persons) connected by links (representing ties between persons).

Network Size

The size of a network is simply the number of direct links between individual pairs of nodes (Marsden 1990; Turner and Maryanski 1991). Networks A and B in Figure 2.4 each have five direct links, while network C has 16.

Network Density

Network density is a measure expressing the proportion of links present relative to those possible (Marsden 1990; Turner and Maryanski 1991; Wasserman and Faust 1994). As discussed above, the number of possible links is calculated using the formula N(N-1)/2, where N is the population size. In a network with six nodes, there are 15 possible ties. In a network with 12 nodes, there are 66 possible ties. The density of networks A and B in Figure 2.4 is 0.33 (5/15). The density of network C is 0.24 (16/66).

Node Degree

The *degree* of a node is the number of paths connecting to it (Hackathorn 2003; Wasserman and Faust 1994). In network A in Figure 2.4, nodes 1 and 5

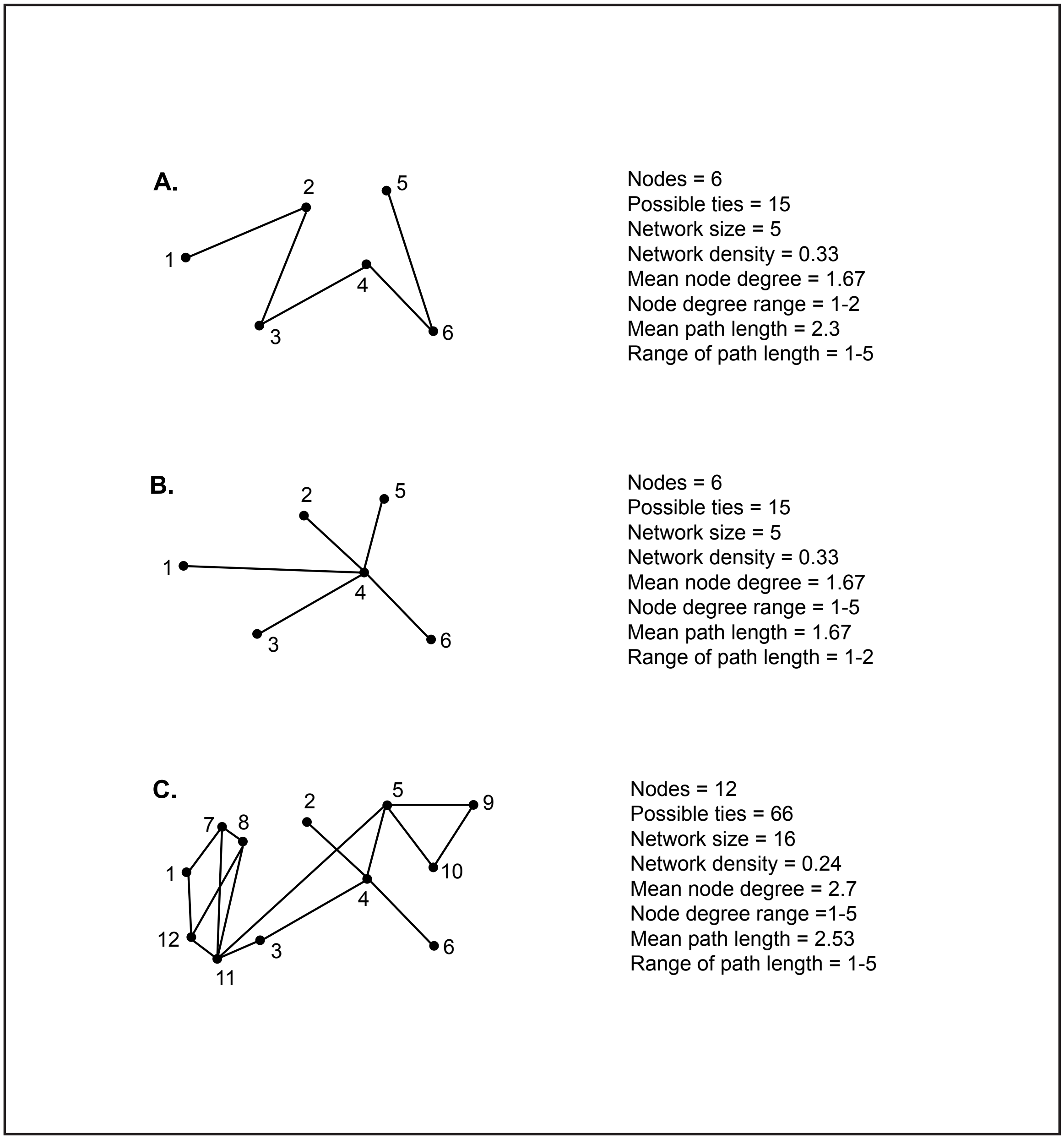


Figure 2.4. Example networks illustrating measurement of network size, density, mean node degree, and mean path length.

have a degree of one and all other nodes have a degree of two. All the nodes in network B have a degree of one except for node 4, which has a degree of 5.

Mean node degree is the average number of links per node. This could also be called “mean links per person.” It is a basic measure of the mean size of individual social networks. In both networks A and B, there are 10 one-way links among six nodes, resulting in a mean node degree of 1.67 in each network (10/6).

Mean Path Length

By definition, any two nodes in a network can be connected by either a direct or indirect social path. The *path length* (or social distance) between any two nodes is the number of links in the shortest route between nodes (Hackathorn 2003). Nodes that are connected directly have a path length of one. In Figure 2.4, the path length between nodes 1 and 2 in network A is one. The path length between nodes 1 and 3 is two.

Mean path length, the mean distance between every possible pair of nodes in a network, is a measure of the inter-connectedness or "closeness" of the entire network (Lovejoy and Loch 2003). An exact calculation of mean path length requires finding the shortest possible path between each pair of nodes. Thus the number of paths needed to calculate mean path length is equal to the number of possible connections in a network. For very small networks (such as those in Figure 2.4), this is not problematic. As the number of paths increases and the structure of connections becomes more complex, however, it becomes more and more difficult.

The structure of a network (how the nodes are connected) affects mean path length. Networks A and B in Figure 2.4 are the same size and the same density. The mean path length of network A (2.3) is greater, however, than that of network B (1.67) because of the structure of the network. The presence of a single, well-connected node (node 4) in network B shortens the mean path length by serving as a hub for inter-connecting all the other nodes. Network C has more nodes, more connections, a higher mean node degree, and a higher mean path length (2.53). Note that it would be possible to re-arrange the structure of the links in any of these networks to alter the mean path length. It would also be possible to find alternative arrangements of links that would yield the same mean path length but differences in other characteristics.

Network Structure and the "Small World" Property

Travers and Milgram (1969:426) used the phrase "small world" to refer to the phenomenon where "social networks are in some sense tightly woven, full of unexpected strands linking individuals seemingly far removed from one another in physical or social space." The experiment described by Travers and Milgram (1969) is perhaps the first and most famous example of a study empirically documenting this phenomenon: an average of only 5.2 intermediaries was required to reach a target person in Massachusetts from arbitrarily-selected individuals in Boston and Nebraska. Other studies have produced similar results, suggesting that about 3-5 links are required to connect random individuals even in large populations (Gamble 1998:436).

Recent analyses of networks (including both social networks and other kinds of networks) have explored the structural characteristics that produce the “small world” property (e.g., Kleinberg 2000; Newman 2000; Watts 2004; Watts and Strogatz 1998). Networks with the “small world” property combine a high density and regular structure of ties at the local level with a small mean path length (at the level of the network as a whole). Experimental data from abstract model networks show how the addition of a relatively few “short cuts” between distant nodes in a regular network produces the small world property (Watts and Strogatz 1998). This is a nonlinear effect: a relatively minor amount of structural alteration has a relatively large effect on the properties of the network. The small world property greatly enhances the speed of communication and synchronizability across the network while preserving local clustering (Watts and Strogatz 1998).

Conclusion

The personal social networks of individual hunter-gatherers are produced through a suite of mechanisms that create and facilitate the maintenance of social ties: marriage, kinship, descent, co-residence, personal mobility, group mobility, and exchange. While mechanisms such as marriage, kinship, and descent are common to all human systems, the distinctive characteristics of mobile hunter-gatherer systems (i.e., small populations spread over large areas, dependence on face-to-face contact for interaction) entail a reliance on personal- and group-level mobility to produce the large number of social connections and nested structures of personal networks that are characteristic of all human social networks.

System-level social networks emerge from the inter-linking of numerous personal networks. As emergent phenomena, these system-level networks have their own set of characteristics and properties that can be measured, described, and analyzed. System-level hunter-gatherer social networks are composed of ties between individuals that vary in strength, character, and the geographic distance they span. Many hunter-gatherer systems utilize cultural mechanisms specifically to establish and maintain social ties connecting geographically-distant individuals. At least some of these ties are likely to serve as “short cuts” or “bridges” (Friedkin 1982; Granovetter 1973:1365-6; Hackathorn 2003; Turner and Maryanski 1991), reducing the mean path length of the social network and producing a “small world.”

Chapter 3

SOCIAL NETWORKS AND PATTERNS OF VARIABILITY IN MATERIAL CULTURE

Social networks articulate with material culture in several ways. The transfer of information related to the production of items of material culture (e.g., stone tools, pottery, textiles, etc.) and the spread of technological innovations take place through social learning, the constituent interactions of which are mediated by social networks. The same between-group movements of peoples that provide a mechanism for the creation and maintenance of social ties in hunter-gatherer systems result in information transfers that allow cultural traditions to develop and persist across spatially-dispersed populations. Material culture is sometimes consciously employed to communicate symbolic information or to recognize, create, or reinforce boundaries or differences within and between societies (e.g. Hodder 1979; Wiessner 1983; Wobst 1977). Ethnographic studies show how multiple, inter-related factors may affect how variability in material culture is generated, perceived, consciously used, and manifest in archaeological assemblages (e.g., Lemmonier 1992; Hodder 1979; Weissner 1983; Wobst 1977) and how the influence of these factors may change through time.

These articulations suggest it is feasible to interpret archaeological remains in terms of the social networks that mediated their creation: artifacts are the material residues of network-mediated systems of human interaction. This is not a new idea. Changes in the scale, structure, or extent of social networks are commonly suggested as possible explanations for archaeologically-visible changes in the patterns of variability in material culture (e.g., see Banks et al. 2009; Conkey 1980; Gamble 1986, 1998; Koldehoff and Loebel 2009; White 2006a; Wobst 1976, 1977). Identifying the presence of social boundaries (i.e., barriers or impediments to social interaction) and understanding their implications has been an ongoing concern of archaeologists around the world (e.g., Englehardt 2010; Green and Perlman 1985; Stark 1998; Williams 1974).

The study of prehistoric social networks through archaeological remains is contingent on accurately identifying and understanding how patterns of network-mediated social interactions are related to patterns of material culture. This requires understanding how patterns of person-level interactions “map up” to patterns we can observe in material culture at archaeological scales. The relationships between patterns at these two levels should not be assumed to be simple. Our existing models, however, depend heavily on logic and intuition to bridge the important gaps between the temporal and spatial scales of human interaction and the archaeologically-visible patterns that we are attempting to interpret.

In this chapter, I discuss: (1) how social learning and cultural transmission articulate with material culture; (2) our existing models for linking the characteristics of social networks and/or social interaction (or changes in those characteristics) to archaeological remains; and (3) the rationale for applying complex systems theory and computational modeling to the archaeology of hunter-gatherer networks. I challenge the usefulness of existing models, arguing that there are both theoretical and empirical grounds for vigorously questioning the assertions and assumptions embedded in these models. I argue that complex systems theory and computational modeling provide an appropriate set of tools for understanding the links between social networks and archaeologically-visible patterns of variability in material culture, both of which are large-scale, emergent phenomena.

Social Learning, Cultural Transmission, and Artifact Variability

Much of human learning is social learning, defined as “learning that is influenced by observation of, or interaction with, another animal (typically a conspecific) or its products” (Heyes 1994:208). Social learning contrasts with “individual” or “asocial” learning in which individuals learn through trial-and-error interaction with the environment (Heyes 1994; Rogers 1988). Novelty and innovations that arise through asocial learning can be subsequently transferred through social learning. Social and asocial learning have different costs and benefits. While social learning is often less “costly” than asocial learning (i.e., the transfer of information is typically simpler than the trial-and-error process necessary to create that same information), for example, a complete reliance on social learning eliminates potentially beneficial information that can be obtained from the trial-and-error process. A mixture of social and asocial learning allows for the cumulative, adaptive characteristics of human culture (see Boyd and Richerson 1988; Mithen 1996; Richerson and Boyd 1992; Steele and Shennan 1996).

In hunter-gatherer societies, social learning occurs in the context of face-to-face interactions among persons who are socially connected to one another (i.e., social learning is not a random phenomenon). Generally, horizontal and vertical learning processes are focused through local interactions in the intimate and effective networks. Persons in the intimate network are typically instrumental in the generational (i.e., “vertical”) transfer of craft traditions in hunter-gatherer societies: parents and related individuals (such as grandparents and other relatives) teach children (Bamforth and Finlay 2008; Berry and Georgas 2009; Coward and Gamble 2008; Minar 2001; Shennan and Steele 1999). The vertical transfer of knowledge and skills between persons is akin to the “guided variation” mode of transmission in cultural transmission theory (e.g., see Mesoudi and O’Brien 2008; Boyd and Richerson 1985).

Given the small size and high density of ties among individuals co-residing in foraging groups, information related to technological innovations or improvements would be expected to spread rapidly among group members through “horizontal” peer-to-peer learning (see Berry and Georgas 2009; Bettinger and Eerkens 1999:237; also Schiffer and Skibo 1987:597). This peer-to-peer transfer of information is the “indirect bias” mode of cultural transmission theory (see Berry and Georgas 2009; Bettinger and Eerkens 1999:237; also Schiffer and Skibo 1987:597). Movements of people between groups, a common feature of hunter-gatherer systems, would facilitate the spread of innovations between groups and, subsequently, across systems. Flux in group membership would also result in changes of the local “pool” that is available to contribute to vertical learning processes.

In all cases, social learning entails the possibility of modification during the learning process. In the context of the production of items of material culture, this is often referred to as “copying error.” Copying error is the product of both inherent constraints in human perception that prevent the detection of slight differences between the attributes of any two objects (shape, size, color, etc.) and variability in the physical abilities of humans to faithfully reproduce what they perceive. The amount of error is relative and is typically thought to be around a maximum of ± 3 to 5 percent based on empirical studies of human perception (e.g., Eerkens 2000; Eerkens and Lipo 2005; Hamilton and Buchanan 2009).

Social learning entails the transfer of information related to both stylistic and functional aspects of artifact variability. Style and function can be regarded as "the fundamental sources of variability in archaeological materials" (Meltzer 1981:313). *Functional variability* is defined here as formal variability related to the operation of an artifact in the material realm: it is what an artifact does and is designed to do (Kamminga 1982; Sackett 1982). Following Sackett (1982), *stylistic variability* is defined here as that portion of formal variability that is not functional in the material realm: function and style together can be assumed to exhaust the majority of formal variability. Observational error (the difference between the measured value of a quantity and its true value) is also a source of variability. This source of variability is typically trivially small and will be ignored in the following analyses.

Functional and stylistic aspects of variability are subject to different sets of conditions which affect how they are transferred and perceived. Because functional variability affects the performance or utility of an artifact, it is conditioned by a selective environment in which the results of design choices are evaluated based on some criterion or criteria of performance (cf. Bleed 1986; Meltzer 1981:314; Schiffer and Skibo 1987, 1997; Shott 1996; White 2008). Design trade-offs may influence how a tool performs various aspects of its intended function: a more robust projectile point may be less prone to breakage on impact but less efficient at cutting/piercing and more difficult to securely haft, for example (e.g., see Bleed 1986; Guthrie 1983). When multiple variables are involved, the "best" solution to a design problem is usually not obvious. Trial-and-error experimentation (i.e., asocial learning) can be employed to evaluate the relative performance of different combinations of attributes. A selective environment constrains variability because not all possible combinations of attributes will allow a tool to be used for its intended purpose.

Stylistic variability, by definition, is *not* constrained by a selective environment related to performance in the material realm. Style includes what Sackett (1982) terms *iconological* and *isochrestic* variability. These two major components of style are sensitive to different processes, especially with regard to the conscious use of some aspects of style as markers of social identity. Under the term *iconological*, Sackett (1982:59) includes only "those aspects of formal variation that artisans purposefully invest with symbolic content reflecting self-conscious social groups." This corresponds to the "active" aspects of style considered by Wobst (1977) and the *emblemic* style of Wiessner (1983). Style in this sense indeed does have a function: to transmit a message about social affiliation to a target population (Wiessner 1983; Wobst 1977:321).

Isochrestic ("equivalent in use") variation, in contrast, can be described as stylistic variability that is produced through processes of social learning *without* the intent to create distinctive markers of group identity. Sackett (1985, 1986, 1990) argued that much of what we perceive as "style" occurs because

> the choices artisans make among the range of options potentially available to them tend to be quite specific and consistent, and that these are dictated largely by the craft traditions within which the artisans have been enculturated as members of social groups" [Sackett 1985:157].

It is the social boundedness of these cultural traditions, not conscious human behavior intended to transmit a message about social affiliation, that passively creates distinctive "styles" of material culture.

The articulation of functional and non-functional variability in social contexts is complicated (Lemmonier 1992; Schiffer and Skibo 1997). "Style" may indeed have a social function, and functionally-equivalent choices may result in different "technological styles." Time adds another dimension to the consideration of these dimensions of variability, as the conscious and unconscious dimensions of material culture variability are not immutable.

> Style can lapse into isochrestic variation if an artifact's symbolic role wanes and stylistic comparison no longer incites social comparison. Likewise, if social meaning becomes attached to different isochrestic forms, isochrestic variation can be activated into style [Wiessner 1985:162].

Wobst (1977) showed how material objects may play a greater role in transmitting messages about group identity as social distance increases. Because symbolism often plays an important role in the negotiation and maintenance of inter-group ties (e.g., see Gamble 1999:51; Minc 1986:73; Wiessner 1982), we may expect that material goods that are exchanged to maintain these ties may exhibit the conscious expression or suppression of stylistic variability (Gamble 1999:51; Wobst 1977).

While these complications warrant some degree of wariness, the central point remains: social learning, cultural transmission, social networks, and artifact variability are inter-related phenomena. Articulations among these phenomena mean that it is feasible to use information about one phenomenon (artifact variability) to make inferences about another phenomenon (social networks).

In most cases involving hunter-gatherers, specific instances of social learning and cultural transmission related to the production of craft items occur at local scales of human interaction and involve only a small number of people. As discussed in Chapter 2, the populations of hunter-gatherer systems are typically dispersed across space in numerous small groups. Social connectivity and information flow across the system is created and maintained through mobility, marriage, kinship, exchange, and language. The transfer of individuals between groups (though marriage, personal mobility, group fission/fusion, etc.) simultaneously (1) contributes to the social connectivity of these systems and (2) transforms social learning and cultural transmission into trans-local phenomena. Each transfer of an individual from one group to another alters the group-level "pools" of individuals that may participate in the transfer of information through social learning. Thus the same mechanisms that produce/reinforce social connectivity allow cultural traditions to develop and persist across spatially dispersed populations (cf. Coward and Gamble 2008).

Existing Archaeological Approaches Linking Social Networks and Material Culture

Patterns of variability in material culture have been used to make inferences about many aspects of social interaction and social networks. The large-scale characteristics of social networks – their extent, structure, and operation – have been invoked to explain archaeological data at many scales (e.g., Anderson and Hanson 1988; Conkey 1980; Gamble 1982). Spatial discontinuities and continuities in stylistic aspects of artifact variability have been used to infer the presence and absence (respectively) of social boundaries and to make statements about the degree of interaction/integration within and between systems (e.g., Englehardt 2010). The distributions of particular kinds of artifacts (as well as rock art and built features such as mounds, enclosures, and mortuary features) have also been used to infer the existence and locations of intentionally created and maintained political, ethnic, or tribal boundaries (e.g., Gamble

1996; O'Shea and Milner 2002). At smaller scales, assemblage variability was important in studies attempting to link marriage patterns to material culture (e.g., see Deetz 1965:2; Leone 1968:1150; Longacre 1970:27; Whallon 1968:229; see also Plog 1978).

The reality of a relationship between social inter-connectedness and flows of information related to social learning is crucial to the idea that patterns of variability in material culture can provide information about patterns of social interaction within and between systems and help identify the presence of barriers or impediments to social interaction. Linking social interaction and social learning at the ethnographic level (i.e., the level we can observe and understand through direct observation) to the system-level patterns in the archaeological data we are trying to interpret requires a model specifying how phenomena at these two different levels are related. Two sets of existing approaches that are used to bridge these levels are particularly relevant to this dissertation: (1) a set of "logical" models that is used to make inferences about the nature and degree of social interactions that produce large-scale patterns of artifact variability; and (2) a body of theory (cultural transmission theory) that specifies a set of relationships between modes of cultural transmission and resulting patterns of artifact variation.

"Logical" Models: Social Boundaries and the Degree of Interaction

Archaeologists often conceptualize prehistoric (modern human) social systems as either "open" (i.e., unbounded) or "closed" (i.e., bounded), following Wobst (1974, 1976). Wobst (1976:52) defined a "closed" mating network as one in which "the participating local groups derive virtually all of their mates from the same set of personnel." In this case, the mating network corresponds in membership to the maximum band, "the highest level of social integration among hunter-gatherers" (Wobst 1974:152). An "open" network, in contrast, is a continuously distributed network of potential mates with no sharp boundaries (Wobst 1976:53). The geographical center of the network shifts with perspective: each group is at the center of its own network.

The demographic or social conditions that may cause or allow social systems to open or close are a matter of some debate (e.g., see Gamble 1996; Hayden 1980; Williams 1974; Wobst 1974, 1976), a full discussion of which is beyond the scope of this dissertation. The important point is that investigating the appearance of social boundaries in prehistory requires that we be able to confidently identify social boundaries based on material remains (see Stark 1998).

Archaeological interpretations related to identifying social boundaries are often justified by a set of statements asserting the nature of the relationships between the degree of social interaction and the degree of similarity in material remains (e.g., Englehardt 2010:59). I refer to these as "logical" models because they employ simple logic to bridge the large gaps between the spatial and temporal scales of ethnographic observation and archaeological interpretation. These models typically include or imply two related assertions: (1) the presence of discontinuities or continuities in stylistic variability across space can be used to infer the presence or absence of social boundaries (Conkey 1980:230; Gamble 1982:102-3, 1986:57, 322, 325-338; Gifford 1960; Meltzer 1989:11; Wilmsen 1973: 24; Wobst 1976:53; Yellen and Harpending 1972:248); and (2) the degree of stylistic difference between groups reflects the degree of interaction between those groups (Braun and Plog 1982:589; Clarke 1978:364; Englehardt 2010:70; Leone 1968:1150; Plog 1978:144-146; Sackett 1990:33; Wiessner 1983:258). The key expectations of these models are summarized in Table 3.1.

Social boundaries may be related to human interaction and material culture in two main ways. First, material culture may be consciously employed to create, maintain, reinforce, or supress a social boundary (see Conkey 1980; Sackett 1982; Wiessner 1983; Wobst 1977). While it is not always explicit which kinds of stylistic behavior are being considered, the logical models all posit that the presence or absence of social boundaries can be inferred from general patterns of artifact variability: "open" and "closed" networks will be associated with continuous (clinal or homogenous) and discontinuous patterns of stylistic variability, respectively.

Wobst (1976, 1977), Conkey (1980), Wiessner (1983), and Gamble (1986) see "active" style (i.e., emblemic or iconological) as being consciously employed to either create and maintain social boundaries or prevent them from forming. This self-conscious use of style is expected to occur when there is

> a need to signal or symbolize ethnicity or group affiliation, distinctiveness from neighbors, and aggression (or suppression of aggression) in interaction contexts involving members of distinct mating networks" [Wobst 1976:53].

In other words, material culture is used to intentionally transmit information about group membership, serving to either differentiate members of one group from members of another (in the case of bounded systems) or to signal commonalities between individuals who may not know each other (in the case of unbounded systems) (Gamble 1982:102, 1986:322).

> Because it carries a distinct message, emblemic style should undergo strong selection for uniformity and clarity (Wobst 1977), and because it marks and maintains boundaries, it should be distinguishable archaeologically by uniformity within its realm of function [Wiessner 1983:257].

According to this model, the scale of discontinuities in emblemic style should indicate the scale at which network closure occurs. Style is both an indicator and reinforcer of social boundaries. Within a closed network, emblemic style is hypothesized to be uniform or vary clinally. According to Conkey (1978, 1980), at least, this kind of stylistic behavior should not occur in the absence of bounded systems (see Gamble 1982:99).

Aspects of style that are consciously used in this way may be subject to selection pressures that constrain variability (i.e., the formal stylistic properties

Table 3.1. Generalized Expectations of the Logical Models with Regard to Relationships between the Presence/Absence of Social Boundaries and the Patterns of Variability in Material Culture.

"Kind" of Style	Network "Type"	Within-Group Variability	Between-Group Variability	Reference(s)
Emblemic	Bounded	Unimodal/uniform	Discontinuous	Wiessner 1983:257; Conkey 1980:230; Wobst 1976:53; Gamble 1986:322; Gamble 1982:102-3
	Unbounded	NA	Clinal	
Isochrestic	Bounded	Clinal(?); Unimodal(?)	Discontinuous	Yellen and Harpending 1972:248; Sackett 1985:157; Sackett 1990:33; Wiessner 1985:163
	Unbounded	Clinal(?); Unimodal(?)	(?)	
Assertive	Bounded	Random to clinal	Dependent on degree of interaction	Wiessner 1983:259
	Unbounded	Random to clinal	Random to clinal	

of the artifact must communicate the intended message about group affiliation in order to serve its purpose). It is the social environment rather than the material realm that imposes these selection pressures, however. Logically, these pressures may serve to reduce within-group variation and heighten between-group variation if the "function" of the artifact is to signal group affiliation.

Second, material culture may reflect the "boundedness" of a social system without being consciously employed as a symbol of group identity. Social systems may be more-or-less "bounded" by a variety of geographic or ecological circumstances that create barriers or impediments to interaction with neighboring systems. In these cases, distinctive styles of material culture may be produced through drift processes operating within cultural traditions maintained by social learning (i.e., isochrestic variation) rather than through conscious symbolism.

The expected within- and between-group patterns of variation associated with isochrestic variation are, according to Sackett (1990:33), similar to those of iconological/emblemic style.

> Hence each social group or unit of ethnicity tends to possess its own distinctive style, and the overall degree of stylistic similarity represented by two groups' material cultures taken as wholes can be regarded as a direct expression of their ethnic relatedness [Sackett 1990:33].

While Sackett maintains that "active" intentionality need not be present to generate these patterns of formal variability that we identify as "style" (conscious vs. unconscious), he assumes a similar set of relationships between "style" and "group." Wiessner (1985:162-3) argued that the different mechanisms involved in the transmission of isochrestic "style" should result in different patterns of variation: isochrestic style should be stable, varying around a single mean, and not be affected by social interaction.

Finally, Wiessner (1983:258) defines a category of "assertive style" that consciously or unconsciously expresses individual identity, rather than group identity, through the formal properties of items of material culture. Because assertive style does not function as an "active" marker of group identity, it can diffuse across boundaries between groups and provide a complement to emblemic style in identifying the nature of these boundaries. The idea that variability in this dimension of style provides "a measure of interpersonal contact for archaeologists" (Wiessner 1983:258) is similar to what Braun and

Plog (1982:509) term the “social interaction theory of stylistic variation” which assumes that “stylistic characteristics will diffuse or be shared among social entities to an extent *directly proportional* to the frequency of interactions between these entities” (emphasis added) (see also Hodder 1979; Leone 1968; Longacre 1970; Plog 1990; Whallon 1968). The expected within-group distribution of assertive style is hypothesized to range from random to clinal depending on a variety of factors (Wiessner 1983:259).

In summary, the “logical” models assert that: (1) discontinuities in style (whether actively or passively produced) reflect discontinuities in interaction, while continuities in style reflect continuities in interaction; and (2) the degree of difference in style is inversely proportional to the degree of interaction. These assertions both ultimately stem from the assumptions of what Binford (1972:197) terms the “aquatic view” of culture:

> culture is transmitted between generations and across breeding populations in inverse proportion to the degree of social distance maintained between the groups in question. . . . Spatial discontinuities in the distribution of similar formal characteristics are perceived as . . . the result of natural barriers to social intercourse [Binford 1972:197].

In other words, culture spreads until it reaches a boundary that prevents it from spreading further. Thus social and stylistic boundaries are assumed to be isomorphic and the strength of social interaction is assumed to be proportional to the degree of stylistic similarity.

Cultural Transmission Theory: Modes of Learning and Artifact Variability

Cultural transmission theory is a theoretical framework, developed within selectionist archaeology, that is concerned with “the details of how technological skills, knowledge, and practices were passed from individual to individual and from group to group in prehistoric populations” (Mesoudi and O’Brien 2008:628).

Cultural transmission theory describes several different “modes” of learning and connects these modes to different patterns of artifact variation

> In *guided variation*, individuals acquire new behaviors by directly copying other social models and subsequently modifying these behaviors to suit their own needs by individual trial-and-error

> experiments. . . . In *indirect bias*, on the other hand, individuals acquire complex behaviors by choosing a single social model on the basis of a trait that is deemed to index general proficiency in the activity to which the desired behavior is related [Bettinger and Eerkens 1999:237].

Guided variation and indirect bias generally correspond to “vertical” (parent-to-offspring) and “horizontal” (peer-to-peer) modes of transmission. According to this body of theory, these modes of transmission produce distinctive statistical signatures in the resulting artifact assemblages: the latitude in design possibilities offered by guided variation will result in variables that are much less correlated than those produced by indirect bias, where designs are acquired as a “package” (Bettinger and Eerkens 1999:237; Mesoudi and O’Brien 2008).

Current approaches to studying cultural transmission and its material correlates generally fall at either end of a “micro” to “macro” continuum of temporal and spatial scales of analysis/interpretation (Stark et al. 2008). Cultural transmission among living populations is, necessarily, studied at the small scales of time and space that are possible using ethnographic methods of direct observation (e.g., see Minar and Crown 2001; Stark et al. 2008). Archaeological studies, conversely, are dominated by the use of equation-based models to interpret long-term changes in artifact variability (e.g., Bentley and Shennan 2003; Eerkens and Lipo 2005, 2008; Hamilton and Buchanan 2009; Neiman 1995).

Equation-based models used to investigate cultural transmission often make assumptions that individuals interact randomly (i.e., “panmixia”) or that individuals can more-or-less accurately copy the mean of a large population. These assumptions ignore any possible effects that may be produced by the network-mediated (i.e., non-random) interactions that characterize social learning in human systems and assume a simple correspondence between micro-level behaviors and macro-level patterns. The mode of cultural transmission within groups is assumed to result in identical patterns of variability across time and space at any scale these patterns are viewed.

Some recent studies have embedded representations of cultural transmission into spatial frameworks to attempt to understand how the spatial scale of social learning affects cultural diversity (Premo and Scholnick 2011) and how mobility behaviors affect rates of cultural transmission (Perreault and Brantingham 2011).

Critique of Existing Approaches

When summarized, the approaches discussed above assume or assert relatively simple, direct correspondences between (1) discontinuities in interaction and discontinuities in style and (2) the degree of interaction and the degree of stylistic similarity. These assumptions and assertions can be challenged on both theoretical and empirical grounds. The theoretical challenges discussed here are based on studies that suggest that relationships between patterns of social interaction and patterns of artifact variability are likely to be neither simple nor proportional in spatially-situated, networked systems like those of hunter-gatherers. These theoretical challenges are based mostly on studies within the broad tradition of complex systems theory, discussed further below. Empirical challenges are based on the existence of ethnographic studies that demonstrate that the expectations of the “logical” models are often not supported in real-world cases.

Theoretical Challenges

Hunter-gatherer social systems are like other human social systems in numerous, general ways. They are somewhat distinctive from most contemporary human social systems, however, in terms of the role that space plays in the formation and maintenance of social ties. No existing models represent the particular mechanisms of network formation that are present in hunter-gatherer systems. While spatial proximity and the structure of connections are recognized as important variables in the spread of information and disease in both real and theoretical networked systems (e.g., Nelson and Wright 1992:1936; Newman et al. 2002; Cabrer-Borrás and Serrano-Domingo 2007), the interactions of agents in most of these models do not take place in a geographical space that is representative of that occupied by hunter-gatherer systems. Patterned relationships between the characteristics of networks and their properties have been observed in many different kinds of networked systems, however, both real and model. Because it is often the structure of connectivity that determines behavior rather than the details of the particular system (e.g., see Klemm et al. 2003; Newman 2000; Watts 2003, 2004; Watts and Strogatz 1998), insights from these studies are potentially applicable to a wide variety of systems, including hunter-gatherer social systems.

Studies of simple model systems suggest that the structure of interaction can have important effects on the spatial organization of variability. Axelrod's (1997) adaptive culture model demonstrated how polarized cultural regions can develop even though the only mechanism for interaction in the model is one of convergence (i.e., agents can only become more, not less, like their neighbors). Interactions in this model were local, occurring only between spatially adjacent neighbors. Klemm et al. (2003) implemented Axelrod's (1997) model using a variety of "complex" networks to structure interaction. The alteration of the local-interaction structure by the addition of a few non-local connections (e.g., to produce the small world property), favored the creation of a homogenous state rather than a regionalized state. Both kinds of networks (local-only and local with a few non-local connections) are "open" in the sense that there were no barriers to interaction: it is the difference in the structure of connections that creates a qualitative difference in the spatial patterns that are produced.

Schelling's (1978) self-forming neighborhood model demonstrated how relatively small preferences about the characteristics of ones' neighbors can result in complete segregation of neighborhoods. Again, interactions in this model are local: actors make decisions based on their immediate surroundings. Schelling's model (originally implemented using coins and graph paper) showed how individual behaviors based on local information could produce larger scale patterns in the absence of any intent or control.

These simple models challenge the notion that distinctive regionalized patterns of variability can arise *only* in the presence of boundaries to interaction, showing that macro-scale regionalization can be produced by unbounded interaction at the local level. In Axelrod's (1997) model, the addition of relatively few non-local pathways for interaction produces a homogenous, rather than a regionalized, state. This suggests that relatively small alterations to the structure of interaction can have significant impacts on the behavior of the system, both in terms of information flow and spatial patterning.

The second main tenet of the "logical" models is that there is a direct, proportional relationship between the degree of interaction and the degree of similarity in material culture. Assertions that "rates of cultural change may be directly related to rates of social interaction" (Binford 1972:204) or that "assertive style . . . gives a measure of degree of contact across boundaries" (Wiessner 1983:259) assume linear relationships between the amount of interaction and the degree of difference: this assumption can be questioned given what we know about the nonlinear behavior of networked systems.

Network studies show that information flow is often a threshold or a phase phenomenon: some critical value of connectivity marks a point below which the network suddenly "breaks" and no longer permits the continuous flow of information (e.g., see Achlioptas et al. 2009; Chen et al. 2007; Moore and Newman 2000). The point of criticality is related to the kind and number of connections (see Moore and Newman 2000; Newman et al. 2002). The addition of non-local connections to local-only networks has been shown to lower this threshold, and the relationship is not linear (e.g., see Newman et al. 2002: Figure 3). These characteristics are relevant to understanding under what conditions we can infer the presence or strength of a social boundary. When boundaries to information transfer are present, network theory suggests that the relationship between the "strength" of the boundary and the degree of artifact differences across this boundary is not likely to be simple.

Similar to the logical models, equation-based models of cultural transmission typically do not consider how the structure of interactions between and among individuals and groups might affect the archaeological patterns that are ultimately produced by these interactions. Cultural transmission theory generally focuses on micro-level, within-group behaviors, and interprets different archaeological patterns of variation as a direct representation of different underlying, within-group cultural transmission processes (e.g., Bettinger and Eerkens 1999). Intervening network processes (i.e., the network-structured interactions among individuals and groups) which might affect the archaeologically-visible patterns are not considered.

In contrast to many studies of cultural transmission, the study by Premo and Scholnick (2011) considers a spatial component to social learning. Although they do not explicitly consider the role of network structure, their results are consistent with the general idea that the spatial extent of interaction affects variability produced through social learning processes: localized cultural transmission produces greater diversity.

Empirical Challenges

Network studies make it clear that the properties of social networks have potentially significant effects on the macro-scale patterns of artifact variability that are produced as processes of social learning play out across time and space. This means that we should not necessarily expect simple relationships between the characteristics of the person-level interactions in any given system and the patterns of artifact variability that are observable at larger scales. The lack of simple correspondence between these levels was pointed out by Yellen and Harpending (1972:251) in their consideration of the San:

> It needs to be emphasized that our description of local !Kung structure, which deals with cultural micro-variation, has no necessary implications about structuring within a larger area. If a non-nucleated society like !Kung were extended over a very large area, one would expect a slow increase in variability measures as the size of the study area increased, just as in genetic theory (Wright 1951). But in fact societies seem always to be fragmented when very large areas are considered. . . . The genesis of this macro-fragmentation is an intriguing question, but separate from those we have been discussing.

Other ethnographic cases are also concordant with the idea that caution is in order when interpreting macro-scale artifact patterns in terms of patterns of social interaction or the presence/absence of social boundaries. Hodder (1979), for example, describes how patterns of inter-group social/economic tension or competition may be associated with discontinuous distributions of some aspects of material culture even when there is a great deal of social interaction across those “boundaries.” Barth (1969) notes that ethnic boundaries do not typically arise because of a lack of communication, but in fact require communication to be maintained:

> First, it is clear that boundaries persist despite a flow of personnel across them. In other words, categorical ethnic distinctions do not depend on an absence of mobility, contact and information . . . Secondly, one finds that stable, persisting, and often vitally important social relations are maintained across such boundaries, and are frequently based precisely on the dichotomized ethnic statuses [Barth 1969:9-10].

Thus ethnographic data indicate that (1) the existence of social boundaries need not correlate with either discontinuities in material culture or a lack of interaction and (2) discontinuities in material culture may be produced by processes other than the appearance of social boundaries. This is discordant with the two principal assertions of the logical models: social boundaries do not equate with discontinuities in material culture and the degree of social interaction does not equate with the degree of similarity in material culture.

Summary

In summary, ethnographic data and simple, generalized model and network studies suggest that the basic assumptions and assertions of existing approaches linking social networks to patterns of variability in material culture should be regarded with skepticism. Contrary to the "logical models," a high degree of boundary impermeability and/or a conscious intent to signal group affiliation may be required to produce sharp discontinuities in stylistic aspects of material culture. In the first case, a near total lack of interaction would allow divergence in multiple aspects of material culture (as well as language and biological variation) through drift in isochrestic variability. In the second case, social groups may be intentionally differentiating themselves *without* a concurrent reduction or cessation of social interaction. Regionalized patterns of variability may be a "natural" outcome of social learning processes mediated through open, local-only networks (e.g., the macro-fragmentation described by Yellen and Harpending [1972]).

We are left with the suggestion that discontinuities in material culture may be produced by conscious symbolic behavior, a near total lack of interaction, and/or local-only interactions transpiring across an open network. Given these multiple potential sources of discontinuities, the non-isomorphic spatial distributions of different aspects of language, ethnicity, material culture, and biological variation that are commonly noted in ethnographic cases are not surprising (e.g., Barth 1969; Boas 1911; Childe 1951:38-41; Clarke 1978: 303-304, 365; Haaland 1977; Hodder 1979; Hymes 1967; Lemmonier 1992; Welsch and Terrell 1998; Williams 1974).

Complex Systems Theory and Agent-Based Modeling as Tools for Understanding Hunter-Gatherer Social Networks

The problem of understanding dynamic cultural systems through the lens of static material residues has been a core concern of processual archaeology (e.g., Binford 1981; Gamble 1986:30). The existing models and frameworks discussed above rely on assumptions of general, logical correspondences in character between patterns of social interaction and patterns of artifact variability that result from those interactions. Consideration of network studies and ethnographic data provides ample reason to question those assumptions.

Complex systems theory and agent-based modeling offer a set of tools appropriate to understanding the characteristics of hunter-gatherer social networks. The term “complex system” here refers to any system with the particular suite of characteristics where system-level behavior can be understood as emerging “bottom up” from the interactions of individual agents. A complex system, in general, has three basic characteristics: (1) it consists of a relatively large number of interacting agents; (2) it exhibits emergent behavior (self-organizing, collective behavior difficult to anticipate from knowledge of the individual agents’ behavior); and (3) this emergent behavior does not result from central control (Boccara 2004:3). Hunter-gatherer societies are complex systems in that they are composed of numerous individuals who act, react, and interact on local scales.

System-level social networks that are produced through the “lower level” interactions among individuals are emergent phenomena, as are the large-scale patterns of variability in artifacts that are produced by these social systems. The structure of a system-level hunter-gatherer social network emerges through numerous person- and group-level interactions and behaviors as individuals form and maintain their own personal social networks (see Chapter 2). While individuals make decisions regarding their own personal social networks, the system-level social network that incorporates these person-level social networks exists independently of any one person (cf. Barnes 1972:3-4). The large-scale patterns of variability in material culture that we recognize archaeologically, likewise, are produced at temporal and spatial scales much greater than those encompassed by the life experience of any one individual. These static patterns emerged from numerous interactions and behaviors involving social learning and the manufacture and discard of artifacts. Questions about emergent phenomena are questions about how individual behavior aggregates to collective behavior (Watts 2003).

The existing approaches discussed above link these two “system level” phenomena (social networks and patterns of variability in material culture) without an understanding of how both emerge from “the bottom up” through individual interactions and behaviors. These approaches rely heavily on logic and intuition to bridge important gaps between (1) the temporal and spatial scales of human interaction (i.e., the scales that we can observe ethnographically) and (2) the system-level social networks that we seek to understand and the archaeologically-visible patterns that we are attempting to interpret.

Agent-based modeling provides a tool for understanding and building theory about complex systems. Agent-based modeling is a “bottom up” form of modeling where the behavior we can observe at the system level is “generated from the bottom of the system by the direct interactions of the entities that form the basis of the model” (Miller and Page 2007:66; see also Gilbert 2008; Kohler and van der Leeuw 2007). Actors are modeled as discrete entities which interact according to parameters and rules. This allows agents (which, in the case of the modeling efforts here, represent individual people) to be heterogeneous.

An agent-based model (ABM) provides a tool for allowing us to understand the behavior of a complex hunter-gatherer system because it can bridge the “gap” between the small scales of human behavior that we can observe ethnographically and the large scales of system-level behavior which we seek to understand. We can represent the relevant human behaviors that we can document ethnographically (such as mobility, marriage, kinship, and social learning) as operational “rules” for individual-level behavior, create a spatially-situated system of actors who interact according to these rules, set the system in motion, and characterize the behavior of the system in terms of aggregate patterns observable at scales of time and space comparable to those we can observe archaeologically.

Through systematic experimentation with model systems, cause-effect relationships between behavior at lower levels (i.e., the person, family, or group level) and the characteristics that emerge at the system level can be investigated as empirical problems. Modern computer power allows numerous representations of person-level social interactions and behaviors to play out at scales of time and space commensurate with those that we can consider archaeologically. Systems can be created and set in motion repeatedly utilizing different parameters and monitored to understand how and if differences in lower-level behavior rules “map up” to differences in the system-level patterns or behaviors that emerge through these interactions, allowing identification of cause and effect and analysis of process. Agent-based modeling also requires a level of specificity about variables and conditions that renders “black box” causal explanations impossible.

Agent-based modeling is used in the following chapters to build both (1) *general theory* about the formation, operation, and properties of hunter-gather social networks and (2) *archaeological theory* about how large-scale patterns in material culture are related to these networks. An agent-based model representing key aspects of hunter-gatherer behavior related to the formation of social networks is described in Chapter 4. This model is used to explore how parameters of population density, group and personal mobility behaviors, and marriage practices affect the characteristics of emergent social networks (Chapter 5). Based on general modeling results and a consideration of existing interpretations, specific alternative scenarios explaining the patterns of variability in material culture evident in the dataset from an archaeological case (late Pleistocene/early Holocene hunter-gatherers in the North American midcontinent – Chapters 6 and 7) will be constructed and represented in model experiments (Chapter 8). Comparisons between archaeological and model data will be used to evaluate the plausibility of the proposed scenarios. Finally, interpretations of the characteristics of the social networks of early hunter-gatherers in the North American midcontinent will be advanced (Chapter 9).

The approach taken here attempts to utilize the capabilities of agent-based modeling as a “third way” of doing science, incorporating elements of both deduction and induction, theory and experiment (Axelrod 1997). Agent-based modeling is used as a tool for exploring how system-level characteristics, observable (patterns of variability in material culture) and non-observable (social networks), both relate to one another and to the human-level behaviors and interactions which ultimately generate them. Agent-based modeling lets us build models of human social systems from the bottom up according to rules and parameters informed by ethnographic data. We can perform experiments on these systems to understand cause and effect in a way that is impossible with either ethnographic or archaeological data. This lets us determine whether a certain set of processes can produce a particular outcome from a given set of initial conditions, giving us some basis for evaluating whether a particular explanation is sufficient or plausible. This is a central methodological goal of archaeological systems theory (cf. Clarke 1968; Flannery 1968; van der Leeuw 1981:232).

Chapter 4

AN AGENT-BASED MODEL OF NETWORKED HUNTER-GATHERER SYSTEMS IN MIDCONTINENTAL NORTH AMERICA

The computational model constructed and employed here (named ForagerNet2) is an agent-based model that includes representations of relevant aspects of hunter-gatherer social, technological, and demographic phenomena: birth, death, marriage, group and personal mobility, network formation and maintenance, information transfer, and the production and discard of artifacts. Ego-based social networks are formed and maintained through a combination of descent, marriage, and opportunities for person-to-person interaction affected by group and personal mobility. Group residential mobility is structured around a seasonal pattern of aggregation and dispersal. Network-structured interactions among individuals mediate the transfer of information related to the production of artifacts. This information transfer is subject to human error, which produces variability in artifact assemblages. System-level social networks and patterns of artifact variability are allowed to emerge from the "bottom up" through numerous person-, family-, and group-level behaviors and interactions. This makes it feasible to use this model to explore how both (1) person-, family-, and group-level behaviors and (2) patterns of variability in material culture are related to the characteristics of system-level social networks.

The ForagerNet2 model attempts to represent neither the distribution of subsistence resources in the environment nor the exploitation of those resources. Rather than generating mobility from resource exploitation, basic aspects of person- and group-level mobility (i.e., the frequency and distance of movements) are controlled by probability-based parameters that are set in the model. This allows the effects of changes in the parameters affecting mobility to be examined as causal variables without the unnecessary step of modeling the distribution and exploitation of subsistence resources.

ForagerNet2 was built using Repast J. Repast (Recursive Porous Agent

Simulation Toolkit) is a free, open-source agent-based modeling and simulation toolkit that was created at the University of Chicago in collaboration with Argonne National Laboratory (North et al. 2006). It is one of several available agent-based modeling toolkits (e.g., see Gilbert and Bankes 2002; North et al. 2006; Tobias and Hofmann 2004). It was chosen for this work because of its suitability for representing the system under consideration and because it is supported by the Center for the Study of Complex Systems at the University of Michigan. Documentation of Repast can be found at www.repast.sourceforge.net.

This model is not intended to exhaustively represent all details of any given hunter-gatherer system. The exclusion of extraneous detail is a purposeful strategy to aid in constructing a model whose structure and behavior are understandable. While this model is intended to be specifically applicable to midcontinental North America, many of the representations in the model are generic and broadly applicable to a variety of hunter-gatherer systems. In the terminology of Gilbert (2008), ForagerNet2 is a “middle range” model. Middle range models “aim to describe the characteristics of a particular social phenomenon, but in a sufficiently general way that their conclusions can be applied” to many examples of the same phenomenon (Gilbert 2008:42). This use of the term “middle range” should not be confused with Binford’s (1977, 1981) “middle-range theory”.

Description of the structure and operation of a model such as this one is challenging because of the nature and number of articulations between various components of the model. The first section in this chapter describes the representations that constitute the “building blocks” of the model. This section focuses on describing representations of the spatial and temporal environment and the entities (people, places, things) that inhabit that environment. The second section describes the “rules” that determine how the various entities in the model behave and interact with each other within the parameters of the model world. The third section discusses how the model operates and how data are collected from the model. The fourth section discusses some basic aspects of the model’s behavior that suggest the model is a valid representation of the systems it is intended to represent. Ethnographic data that guided construction of the methods and settings used in the model are discussed in the course of the narrative as well as in Chapters 2 and 3.

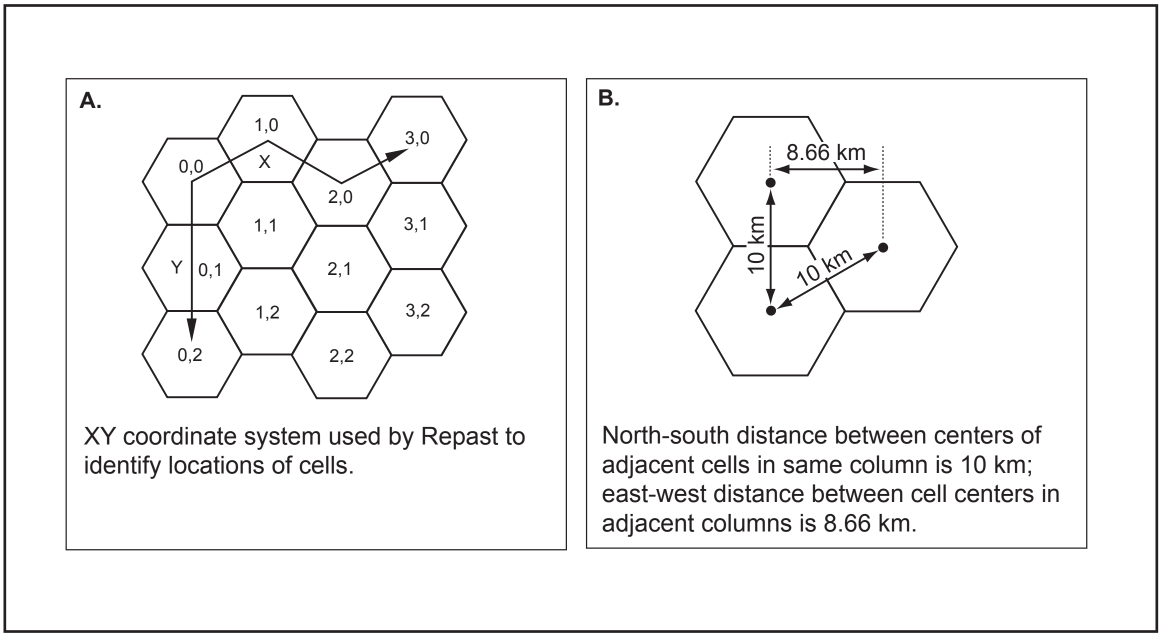
Description of Model Representations

The representations in the model can be placed in three classes: (1) the physical space in which the agents in the model interact; (2) the passage of time; (3) the people, social groupings, social links, and artifacts that exist and interact in the model.

Physical Space

The “world” of the model represents a physical space in which hunter-gather groups, families, and persons move and interact. The spatial environment is composed of a grid of hexagonal cells. Each cell within the grid represents a discrete, hexagonal parcel of land with a diameter of 10 km and an area of approximately 86.6 km^2. Each cell is assigned an XY coordinate by the model as shown in Figure 4.1. Because of the way the hexagonal cells are oriented in the grid, east-west distances between the centers of columns of cells are less than the north-south distances between cell centers: each row of cells adds 10 km to the north-south dimension of the world, while each column adds 8.66 km to the east-west dimension of the grid (Figure 4.1B).

The advantage of using a hexagonal grid rather than a square grid is that all the cells in the ring surrounding any given cell are equidistant from the center



XY coordinate system used by Repast to identify locations of cells.

North-south distance between centers of adjacent cells in same column is 10 km; east-west distance between cell centers in adjacent columns is 8.66 km.

Figure 4.1. Explanation of XY coordinate system used in the model.

cell. This means that a movement from a cell to any of the six neighboring cells represents the same geographic distance, unlike in a square grid where diagonal movement to one of the cells at the “corner” of the local neighborhood of eight cells represents a move of a longer geographic distance than a movement to one of the four cells located directly to the north, south, east, or west of the center cell.

The model was configured to operate at four different geographic scales, designated Scale 1, Scale 2, Scale 3, and Scale 4 (see below). At Scale 3 (the scale used for the majority of the experimentation), the spatial world of the model represents a 1200 km x 1200 km (1,440,000 km^2) area that includes most of the midcontinental United States and portions of Ontario, encompassing an area extending south from the southern boundaries of Charlevoix, Cheboygan, and Presque Isle counties, Michigan, east from the eastern boundaries of Adams and Hancock counties, Illinois, north from the southern boundaries of Lawrence and Morgan counties, Alabama, and west from Bradford County, Pennsylvania. Operation at Scale 3 utilizes a grid that is 120 cells (north-south) by 138 cells (east-west) to represent a 1200 x 1200 km area.

The cells in the grid are the minimal units of movement and spatial differentiation. The XY grid system is used in the model when movement or searching of a defined area is required. This allows use of pre-existing Repast methods for generating lists of neighboring cells based on the XY coordinate system.

The model creates a “parcel” of land to occupy each cell. This parcel is a stationary object which holds information about its location in terms of UTM coordinates, its permanent status as land or water, the identification of lithic sources within it, whether or not it currently serves as an aggregation site, what region it is in, and whether or not it is currently occupied by a group. The variables associated with parcels are presented in Table 4.1.

The model calculates the UTM coordinates of the center of each parcel based on the XY coordinates of the parcel, the size of each parcel, the “packing” of the hexagonal grid, and the UTM coordinates of the starting point of the grid. Each parcel stores its UTM coordinates and provides them when requested. When an artifact is discarded, for example, the location of discard is recorded as a UTM northing and easting (rather than an XY coordinate used by the model). This simplifies comparison of model outputs with archaeological data.

The UTM coordinates of major bodies of water (i.e., the Great Lakes, the

Table 4.1. Variables of the Parcel Class.

Variable	**Type**	**Description**
parcelId	integer	Unique identifier for each parcel
occupied	Boolean	Occupation status (true = currently occupied by a group)
water	Boolean	Whether or not parcel is located in body of water (true = water)
region	integer	Identifier of region in which parcel is located (1 or 2)
x, y	integers	XY location in the world
utmN	integer	UTM northing of parcel
utmE	integer	UTM easting of parcel
aggSiteId	integer	Identifier of aggregation site (if any) which currently utilizes parcel

Atlantic Ocean, and the Gulf of Mexico) were determined using GIS. When the model environment is being built at the beginning of a run, the model compares the UTM coordinates of each parcel with a list of “water” parcels and stores the status of the parcel in a Boolean variable. The presence of water in a parcel prohibits group/person movement into that parcel and prohibits an aggregation site from being placed in that parcel.

Selected real-world lithic raw material sources within the portion of the landscape corresponding to the archaeological dataset are represented in the model. Variables associated with lithic sources are given in Table 4.2. Each lithic source is a stationary object that occupies a single parcel. The UTM coordinates of the approximate center of the Wyandotte, Cobden/Dongola, Attica, Holland, Upper Mercer, Burlington, and Bayport source areas were determined using GIS. The model determines the parcel with the center closest to the location of each of these sources and creates a lithic source within that parcel (Table 4.3).

The status of a parcel as an aggregation site is held by the variable *aggSiteId*. If the value of this variable is 0, no aggregation site is present. A value other than 0 constitutes the unique identification number of a particular aggregation site.

The parcel holds information about whether or not it is currently occupied by a group using the Boolean variable *occupied*. This variable is used when groups are searching the local area to determine which parcels within their mobility range are currently unoccupied and, therefore, candidates for occupation.

The model includes methods for dividing the physical world into two geographic regions (Region 1 and Region 2) defined by UTM coordinates. Each parcel that is north of UTM N4390700 and east of UTM E290600 is in Region 1.

Table 4.2. Variables of the LithicSource Class.

Variable	Type	Description
lithicId	integer	Unique identifier for each lithic source
utmN	integer	UTM northing of lithic source
utmE	integer	UTM easting of lithic source
rmGroup	integer	Raw material group to which lithic source belongs

Table 4.3. Identification, Raw Material Group, and UTM Coordinates of Lithic Sources Represented in the Model.

Lithic Source	lithicId	rmGroup	UTM Easting	UTM Northing
Wyandotte	1	1	562425	4226290
Cobden/Dongola	2	1	300206	4136352
Attica	3	2	476970	4458994
Upper Mercer	4	3	926494	4473784
Holland	5	3	505843	4234470
Burlington	6	4	181017	4342347
Bayport	7	5	760292	4878693

All other parcels are in Region 2. The variable *region* holds the identifier of the region in which a parcel is located.

Regions 1 and 2 correspond approximately to the two major stylistic regions (roughly defined by the distributions of Hi-Lo and Dalton points) that are apparent during the Late Paleoindian period in the midcontinent (see Chapters 6 and 7). These regions are used to construct experiments investigating the effects of impediments to interactions of persons and groups that are resident in different regions. Interaction between regions is affected by the parameter *pBoundaryCross*, which specifies the probability that an interaction (e.g., marriage, the movement of persons from one group to another, the fusion of groups) can occur between the two regions. If the value of *pBoundaryCross* = 0, there is no chance of interaction. If the value of *pBoundaryCross* = 1, the presence of the regions has no effect on interactions. In this model, Regions 1 and 2 are imposed on the social/physical landscape as an experimental condition. The strength of impediments to inter-regional interaction (controlled by the parameter *pBoundaryCross*) can be varied to observe its effect on the characteristics of both emergent social networks and large-scale patterns of artifact variability.

Time

Time passes in the model in the form of discrete steps, each representing one week (5200 steps representing 100 years). At each model step, the model goes through a sequence of operations (see below). A week was chosen as the minimal unit of time in order to allow the representation of hunter-gatherer systems employing a high frequency of residential mobility. Data provided by Binford (2001) and Kelly (1995) suggest that in only a very few ethnographic cases (n = 5 cases out of 311) have hunter-gatherers been observed to make more than 52 residential moves per year.

The model also maintains a cyclical clock that resets to 0 at the beginning of every 52-step cycle. This clock is used to increment the ages of persons and households on a yearly basis as well as to guide the seasonal movements of groups moving towards or away from their aggregation sites (see below). Season 1 in the model encompasses ticks 0-21 on the cyclical clock. Season 2 encompasses ticks 22-51. Season 1 (the season during which groups move away from their aggregation site) was set to be shorter than Season 2 because of the probabilistic component to group movement: when the seasons are the same length, it is possible for a group to move far enough away from its aggregation site that it does not make it back in time to meet up with other groups. The use of probabilistic group movements was a simplification for modeling purposes.

Persons

Each agent in the model represents an individual person. The variables and lists that are associated with each person are summarized in Table 4.4.

Each person has variables to store his/her age, sex and physical location in the world, variables to track various statuses (live/dead, married/unmarried, producer/non-producer, household and group to which the person currently belongs, etc.) and status changes (age at death, age at marriage), and lists to store the identities of persons related by descent (grandparents, parents, siblings, half-siblings, children) and related through co-residence in a household unit (husbands and wives, co-wives, stepchildren, etc.). Each person maintains a list of all persons with whom marriage to him/her is prohibited. Each person has a list to store information about each social link that he/she has to another person in the world. Adults also keep lists containing information about which

Table 4.4. Variables of the Person Class.

Variable	Type	M	F	Description
id	integer	X	X	Unique identifier for each person
currentParcel	Parcel	X	X	Current Parcel of person
currentGroup	Group	X	X	Current Group of which person is a part
currentHousehold	Household	X	X	Current Household to which person belongs
father	Person	X	X	Biological father of person
mother	Person	X	X	Biological mother of person
x, y	integers	X	X	XY location in the world
age	integers	X	X	Age of person (in years)
sex	integer	X	X	Sex of person (0 = male, 1= female)
live	Boolean	X	X	Life/death status (true = alive, false = dead)
birthWeek	integer	X	X	Week of birth; used for incrementing age
previouslyMarried	Boolean	X	X	Marriage status (true = person has been previously married)
ageAtMarriage	integer	X	X	Stores age at which person was first married
ageAtDeath	integer	X	X	Stores age at which person died
producer	Boolean	X	X	Economic production status (true = producer)
pregnancyWeeks	integer		X	Tracks the progress of a pregnancy in weeks
toolProductionLearned	Boolean	X		Whether or not person has learned how to make tools
wifeList	List (Person)	X		Wives (including deceased) of an adult male
husbandList	List (Person)		X	Husbands (including deceased) of an adult female
childList	List (Person)	X	X	Biological offspring (including deceased and/or no longer in same household)
familyList	List (Person)	X	X	Individuals related by descent (parents, grandparents, children, siblings, half-siblings)
siblingList	List (Person)	X	X	Blood-related siblings
coResidentList	List (Person)	X	X	Individuals residing in same household but not related by descent (e.g., affines, step-parents, co-wives, children of step-parents, etc.)
acquaintanceList	List (Person)	X	X	Non-family, non-co-residential individuals that have been in the same Group as person
incestList	List (Person)	X	X	All persons with whom marriage is prohibited (includes all family and co-residents as well as some affines)
potentialBrideList	List (Person)	X	X	Females that individual knows about which are or might be eligible for marriage
localList	List (Person)	X	X	All individuals within the foraging radius of the person's currentGroup (including those persons in the currentGroup)
toolList	List (Artifact)	X		All tools currently in the possession of the person
personLinkList	List (Link)	X	X	All current social links to other people in the world
meanVarA (B, C, etc.)	double	X		Mean value of a particular variable within person's tool assemblage
meanPoint1x (1y, 2x, 2y, etc.)	double	X		Mean value of landmark coordinate within person's tool assemblage
signalReceived	Boolean	X	X	Used to track the spread of information through the population during experimentation

other persons are in their local area and which female members of the population are potentially eligible for marriage.

Adult males keep lists of the tools in their possession and have an extra set of variables to hold the mean values of the attributes of tools that they create. They have a variable that records whether or not they have learned to make tools.

Adult females have a variable to track the length of a pregnancy so that infants are born 40 weeks after conception.

An initial population of persons is created at the start of a model run. All subsequent persons are created through procreation within households. When a person is created through birth, it is added to the current group and household of its parents and added to the family lists of parents, grandparents, siblings, and half-siblings. The child adds these same individuals to its own family list. Co-residents (non-descent-related individuals within the household into which the person is born) are added to the child's co-resident list and the child is added to the lists of co-residents. Two-way social links (e.g., one link for a connection between a child and his mother and one link for the corresponding connection from mother to child) are created at this time (see below).

Persons move physically in the world through mechanisms of personal and group mobility (see below). The model-level parameter *personMobility-RadiusCells* determines the radius of a "local neighborhood" about which persons may gather information related to the locations of other groups (which affects person- and group-level movements), gather and transfer information about potential brides, and engage in marriage with local partners. For all runs discussed in this dissertation, the value of *personMobilityRadiusCells* was set to 2.

Households

Households are co-residential groupings that are comprised mainly of persons related through affinity, descent, or marriage to a common partner (in the case of polygyny). Households constitute important, indivisible social units in the model. They are loci of reproduction, parent-child learning, and production/storage of assets used for marriage. Households are the basic units of production and reproduction in the model. Households also constitute social units relevant to mobility: groups fission along household lines, and households may move from one group to another under the parameters of individual mobility when the person moving is the head of a household. The variables and lists associated with each household are summarized in Table 4.5.

The household is the locus of production and reproduction. A new household is created through the marriage of a male and a female. The founding adult male of the household is considered the "head." The size and composition of a household may change by three main mechanisms: marriage, procreation, and mortality (discussed below). The dependency ratio of a household (ratio of the number of consumers to the number of producers, *aka* the CP ratio) is a key factor in probability-based, household-level decisions in all three areas. A dependency ratio of 1.75, considered "typical" of hunter-gatherers (Binford

Table 4.5. Variables of the Household Class.

Variable	**Type**	**Description**
id	integer	Unique identifier for each household
currentGroup	Group	Current group of which household is a part
head	Person	Person that is the "head" of the household (adult male founder)
birthWeek	integer	Week of origin of the household; used for incrementing year
year	integer	Year of the household's existence (first year is "year 1")
size	integer	Current number of members of household
x, y	integer	XY location in the world
cPRatio	double	Current consumer:producer ratio
currentSurplus	double	Amount of surplus (or deficit) production for the most recent completed year
householdAssets	double	Assets in the "bank" of the household
lifespan	integer	Total length in years of a household's existence
peakSize	integer	Greatest size of the household during its existence
peakCPRatio	double	Highest consumer:producer ratio during the household's existence
peakWives	integer	Greatest number of simultaneous wives during the household's existence
peakProducers	integer	Greatest number of simultaneous producers during the household's existence
peakDependents	integer	Greatest number of simultaneous dependents during the household's existence
lifespanSurplus	double	Cumulative surplus (or deficit) during the household's existence
surplusYears	integer	Cumulative number of years of surplus production
deficitYears	integer	Cumulative number of years of deficit production
memberList	List (Person)	All current members of household

2001:230), was used to perform economic calculations.

Households are productive units. A measure of the productive capacity (surplus or deficit) of each household is converted to abstract “assets” each year by multiplying the number of producers by 1.75 and then subtracting the number of consumers. This calculation assumes that each producer in the household is capable of producing 1.75 “units” and each member of the household (producers and consumers) consumes 1.00 “units.” The assets created through production each year are added to the cumulative assets of the household (or subtracted in a deficit year). These units are an abstract currency created to allow operation of feedbacks related to household productive capacities. In this model, household-level assets are relevant to marriage in situations where marriage entails exchange of assets between the bride’s and groom’s households (see below).

If the head of the household dies, the female and any children or other members of the household remain in the household until some subsequent event causes membership to change (i.e., the female re-marries, children come of age and marry, mortality, etc.).

The mobility of households is affected by group and personal mobility as well as by group fission/fusion (see below).

Groups

Groups are co-residential groupings of persons and/or households representing “on-the-ground” cooperative foraging units. Group membership is defined by spatial proximity: all persons and households in the same cell are, by definition, in the same group. While there are likely to be relationships of descent and/or affinity among the persons and households in a given group, these relationships are not required. The variables and lists associated with each group are summarized in Table 4.6.

Each group has an aggregation site. This site is a coordinate on the physical landscape. The direction of group movement with respect to a group’s aggregation site is affected by the seasonal clock: during Season 1, groups move away from their aggregation site; during Season 2, they move toward it.

The frequency and distance of group movement is affected by two model-level parameters (see below). Group size is affected by model-level minimum and maximum group size values. Groups that are smaller than the minimum will attempt to fuse with another group. Groups that are larger than the maximum will

Table 4.6. Variables of the Group Class.

Variable	***Type***	***Description***
id	integer	Unique identifier for each group
currentParcel	Parcel	Current parcel in which group is located
x, y	integer	XY location in the world
aggSiteId	integer	Identifier of aggregation site to which group returns
aggX, aggY	integer	XY location of aggregation site
groupDistFromAgg	double	Current distance from group's aggregation site
otherGroupsInRange	Boolean	Whether or not other groups are close enough to permit transfer of members through personal mobility (true = within range)
occupantList	List (Person)	All persons currently in the group
householdList	List (Household)	All households currently in the group

fission into two groups (see below).

Groups have a foraging radius (set as a model-level parameter). For the runs discussed here, the group foraging radius (*groupForagingRadiusCells*) is set at 1 (groups "forage" within the six hexagonal cells bounding their current location). The foraging radius defines the area within which groups obtain "local" knowledge.

Aggregation Sites

An aggregation site is a parcel to which groups of the same band return on a yearly basis. The close spatial proximity of multiple groups created by these seasonal aggregations allows for between-group transfers of information (i.e., about potential brides) and people (through personal mobility, group fission/ fusion, and/or marriage). Note that aggregation sites do not exist as a distinct class of object, but exist as a property of a parcel. The model includes methods for adjusting the locations of aggregation sites based on the proximity of adjacent aggregation sites (see below).

Social Links and Marriage Prohibitions

Social links are ties between living persons. Links are formed based on relationships of descent (family links), co-residence in a household (co-resident links), marriage (marriage links), kinship (kin links), and occupancy in the same group (acquaintance links). Family links indicate a consanguineal (i.e., blood descent) relationship. Kinship links are links of affinity (i.e., created through marriage). Co-resident links are established between individuals that co-reside in a household but qualify for neither family nor kin status as defined here. Acquaintance links are based merely on occupancy within the same group. Variables associated with links are summarized in Table 4.7. Link types and sub-types are described in Table 4.8.

The creation of a social link between two people (e.g., Person 1 and Person 2) results in the creation of two directional links: Person 1 → Person 2 and Person 2 → Person 1. This allows the relationship between Person 1 and Person 2 to be asymmetrical. If Person 1 is the parent of Person 2, for example, information flows related to learning are not likely to be equal in both directions. There are always twice as many social links as there are social relationships between people.

There can only be one pair of links defining the relationship between any two people, and each of the links in this pair must be of the same class. It is impossible, for example, for the link from Person 1 to Person 2 to be a family link while the link from Person 2 to Person 1 is an acquaintance link.

Figure 4.2 illustrates how relationships of descent and affinity translate into the link types created by the model. The link type connecting each pair of individuals in the family tree is determined by the rules written into the model (explained below). Links are created or changed to the appropriate type when individuals are born, married, change household, or change group. A change in the nature of the relationship between two persons will trigger a change in the class of the links that connect the two persons. Many of these changes are unidirectional: when two persons who are acquaintances based on co-residence in the same group are married, for example, their acquaintance links are

Table 4.7. Variables of the Link Class.

Variable	***Type***	***Description***
linkID	integer	Unique identifier for each link
linkType	integer	Type of link: 1=family; 2=co-resident; 3=marriage; 4=kin; 5=acquaintance
linkSubType	integer	Subtype of link (see Table 4.8)
fromPerson	Person	Person from which link originates
toPerson	Person	Person to which link goes
distance	double	Straight line distance (in kilometers) spanned by the link

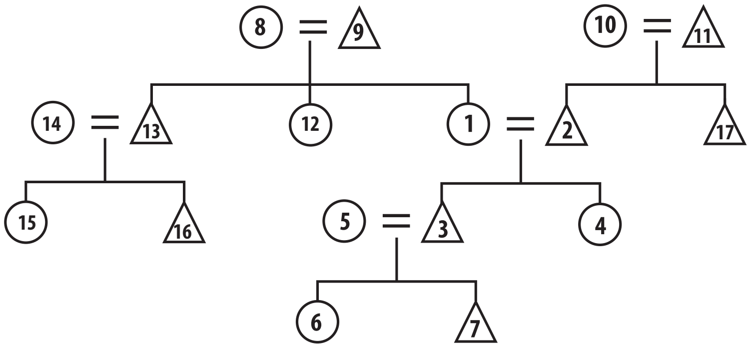
Table 4.8. Definition and Marriage Prohibitions of Types and Sub-Types of Social Links.

linkType	linkSub-Type	Directional Relationship	Marriage prohibited	Can be changed to these other linkTypes
Family	1	parent to child grandparent to grandchild	Yes	None
	2	child to parent grandchild to grandparent	Yes	None
	3	sibling to sibling	Yes	None
Co-Resident	-	household resident to household resident	Yes	Family, Kin
Marriage	-	spouse to spouse	-	None
Kin	1	parent to daughter-in-law parent to son-in-law	Yes	None
	2	husband to mother-in-law wife to father-in-law	Yes	None
	3	aunt/uncle to niece/nephew	Yes	None
	4	niece/nephew to aunt/uncle	Yes	None
	5	cousin to cousin	No	Marriage, Co-Resident
	6	husband/wife to sibling-in-law	No	Marriage, Co-Resident
	7	aunt/uncle-in-law to niece/nephew-in-law	Yes	None
	8	niece/nephew-in-law to aunt/uncle-in-law	Yes	None
Acquaintance	-	group member to group member	No	Kin, Marriage, Co-Resident

converted to marriage links and will never again be anything *but* marriage links. Some changes are prohibited by methods in the model. It is impossible for two individuals connected by any kind of family link to be married, for example. Pairs of social links are dissolved as a result of the death of one of the persons.

The notation (i) after the link type in Figure 4.2 signifies that marriage is prohibited between that pair of individuals. Marriage is prohibited between all pairs of individuals connected by family links. Marriage is prohibited between any two individuals related as aunt/uncle – niece/nephew. Marriage is also prohibited between any two persons who have previously co-resided in the same household, whether related as family or not. Marriage is prohibited among many, but not all, pairs of individuals connected by kin ties. Note that marriage is *not* prohibited between cousins or between a husband and his wife’s sisters or a wife and her husband’s brothers. This is consistent with the occurrence of these kinds of marriages in many hunter-gatherer societies.

The physical distance (in km) spanned by a social link (*linkDistance*) is



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
2	M															
3	F(i)	F(i)														
4	F(i)	F(i)	F(i)													
5	K(i)	K(i)	M	K												
6	F(i)	F(i)	F(i)	K(i)	F(i)											
7	F(i)	F(i)	F(i)	K(i)	F(i)	F(i)										
8	F(i)	K(i)	F(i)	F(i)	-(i)	-	-									
9	F(i)	K(i)	F(i)	F(i)	-(i)	-	-	M								
10	K(i)	F(i)	F(i)	F(i)	-(i)	-	-	-	-							
11	K(i)	F(i)	F(i)	F(i)	-(i)	-	-	-	-	M						
12	F(i)	K	K(i)	K(i)	-	-	-	F(i)	F(i)	-	-					
13	F(i)	K	K(i)	K(i)	-	-	-	F(i)	F(i)	-	-	F(i)				
14	K	-	-	-	-	-	-	K(i)	K(i)	-	-	K	M			
15	K(i)	K(i)	K	K	-	-	-	F(i)	F(i)	-	-	K(i)	F(i)	F(i)		
16	K(i)	K(i)	K	K	-	-	-	F(i)	F(i)	-	-	K(i)	F(i)	F(i)	F(i)	
17	K	F(i)	K(i)	K(i)	-	-	-	-	-	F(i)	F(i)	K	K	-	-	-

Figure 4.2. Diagram showing how biological, marriage, and affinal relationships translate in the social link types used in the model. The numbers on the top and left side of the table identify the individuals designated in the diagram. Link types between individuals are denoted as follows: "M" = marriage link; "F" = family link; "K" = kin link; "-" = no link; (i) = marriage between these two individuals not allowed because of incest prohibition.

calculated based on the straight line distance between the parcels currently occupied by the two linked persons.

Artifacts

Artifacts are objects representing stone tools, specifically hafted bifaces (projectile points). The size and shape attributes of each artifact are defined by a series of variables (Figure 4.3 and Table 4.9). The lettered variables (*varA*, *varB*, etc.) correspond to a set of metric attributes that overlaps with that used to characterize the archaeological samples (see Chapter 7). The values of most of these metric variables are constrained by model-level minimum and maximum values that correspond to those of the archaeological dataset discussed in Chapter 7.

The landmark variables (*point1X*, *point1Y*, etc.) denote the X and Y coordinates (in millimeters) of landmarks used to calculate the metric variables. The metric variable *varA* (basal width), for example, is calculated by finding the difference between the values of *point1X* and *point2X*. The labels used to identify these landmarks correspond to those used to calculate metric variables from artifact images in the archaeological sample (see Chapter 7). When new artifacts are manufactured in the model, it is the X and Y coordinates of the landmarks that are subject to copy error (see below).

The variables *rmSourceId* and *rmGroup* hold information about the specific raw material of the artifact (see Table 4.3). If the artifact was created from a raw material other than those represented by specific lithic sources in the model, *rmSourceId* and *rmGroup* will both have a value of 0. The variable *sourceDiscardDistance* holds information about the artifact's distance from its raw material source (in km) when it was lost or discarded. The variable r*emainingUseLife* holds information about the degree of "use" of the artifact. The identification of the person who made the artifact is stored by the variable *maker*. The owner of the artifact is stored in the variable *owner*. (Because artifacts are

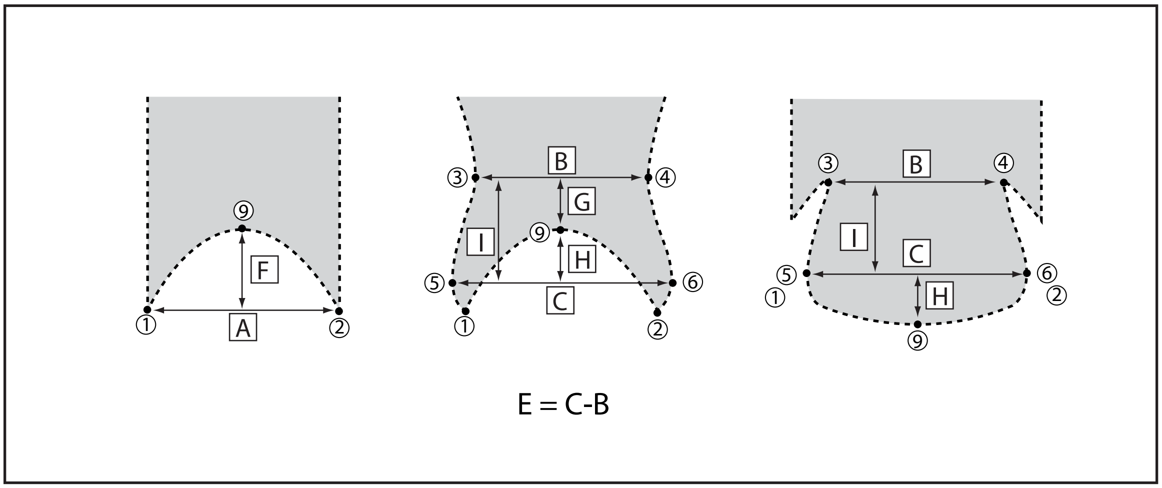


Figure 4.3. Locations of landmarks and associated metric variables used to define morphometric attributes of artifacts in the model.

Table 4.9. Variables of the Artifact Class.

Variable	**Type**	**Description**
artifactId	integer	Unique identifier for each artifact
maker	Person	Person who made the artifact
owner	Person	Person who possesses the artifact
x, y	integer	Artifact's XY coordinates in space (not set until artifact is lost or discarded)
discardUTMN	integer	UTM northing of location of artifact discard/loss
discardUTME	integer	UTM easting of location of artifact discard/loss
remainingUseLife	integer	Remaining use life of artifact; a new artifact has a *remainingUseLife* of 10; *remainingUseLife* is decremented by 1 each time an artifact is used; artifacts with *remainingUseLife* of 0 are automatically discarded
discarded	Boolean	Whether or not an artifact has been discarded/lost
sourceDiscardDistance	double	Distance (km) from artifact's lithic source of origin to its location of loss/discard.
point1x, point1y; point2x, point2y; point3x, point3y; point4x, point4y; point5x, point5y; point6x, point6y; point9x, point9y	double	Coordinates used to designate location of specific morphometric landmarks on a 2D grid; these coordinates are used to calculate metric variables and should not be confused with cell coordinates that specify physical locations in the world of the model.
varA	double	(*point2x*) - (*point1x*)
varB	double	(*point4x*) - (*point3x*)
varC	double	(*point6x*) - (*point5x*)
varE	double	(*varC*) - (*varB*)
varF	double	(*point9y*) - ((*point1y* + *point2y*)/2); if (*point9y* < *point1y*), *varF* = 0
varG	double	((*point3y* + *point4y*)/2) - (*point9y*)
varH	double	((*point5y* + *point6y*)/2) - (*point9y*)
varI	double	((*point3y* + *point4y*)/2) - ((*point5y* + *point6y*)/2)
haftWidth	double	*haftWidth* = *varB* when (*varE* > 0); otherwise haftWidth = *varA*
thickness	double	Thickness of artifact
rmSource	LithicSource	lithicSource where artifact was manufactured.
rmSourceId	integer	Identifier of lithicSource where artifact was manufactured.
rmGroup	integer	Identifier of raw material group of lithicSource (see Table 4.3).
stepDead	integer	Step at which artifact is lost or discarded.

not exchanged in this version of the model, the maker and owner will be the same).

Functional constraints on artifact variability are represented in the model by imposing selection on certain variables: haft width, thickness, the ratio of haft width to thickness, and the degree of haft constriction. The choice of these variables as functional variables is discussed in Chapter 7 in regards to the archaeological dataset. Representation of functional selection is discussed further below.

Model Methods and Structure

This section describes the methods and inter-relationships between methods that affect the behaviors and interactions of the entities in the model. Methods are named sections or “chunks” of Java code that perform operations when called under specific circumstances. When the marriage methods are called for a particular person, for example, a series of operations is initiated which results in a determination of whether or not that person will marry during that particular step.

Methods are inter-related through a variety of feedbacks and effects, a schematic illustration of which is shown in Figure 4.4. Methods originate at different “levels” of the model: persons, households, groups, bands, and the “world” call methods to perform various operations. Marriage methods originate at the level of the individual person, for example, because marriage is a person-level behavior. The operations performed by the methods are affected by person-level variables (e.g., the number of potential brides that the male “knows” about, which is affected by information transfer related to mobility), family-level variables (the dependency ratios of the current families of the male and female, which are affected by marriage, reproduction, mortality, fertility, etc.), and, potentially, system-level variables (the current bride price). Each of these variables is, in turn, affected by other methods in the model.

The behavior of the model is also affected by model-level parameters which establish values for key aspects of the system (see Figure 4.4). The values of these parameters do not change as a result of the dynamics of the model, but can be changed mid-run to observe the effects of a change.

The major methods of the model are representations of rules about group mobility, band aggregation, group fission/fusion, personal mobility, household-level production, transfer of information about potential brides, marriage, reproduction, mortality, learning, artifact creation and discard, and the creation of social links. The operations associated with these methods, feedbacks between them, and the role of model-level parameters will be described, referencing the alpha-numeric designations in Figure 4.4. Variables in this figure are enclosed by

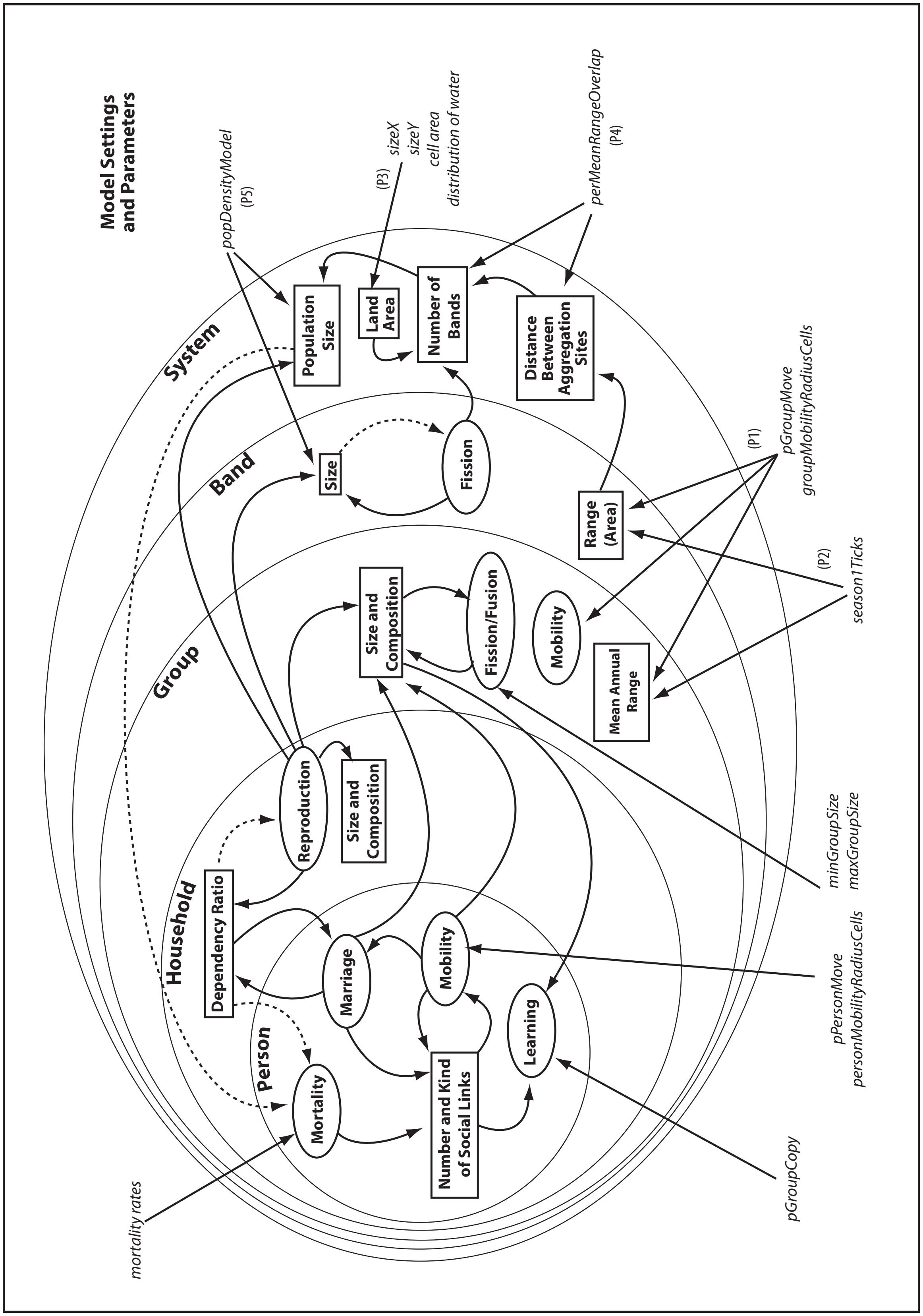


Figure 4.4. Schematic illustration of inter-relationships between levels, methods, and key parameters of the ForagerNet2 model.

rectangular boxes, while methods are enclosed by ovals.

Group Mobility

Group mobility is the primary mechanism by which agents move across the landscape of the model. The movement of groups in the model represents residential (as opposed to logistical) mobility. Patterns of group mobility in the model represent a regular, seasonally-scheduled cycle of dispersion and aggregation: residentially-mobile foraging groups radiate outward from a specific (i.e., "band-level") aggregation site during the first portion of the year and then move towards that same site during the second portion of the year. This pattern of group mobility and seasonal dispersal/aggregation is a simplified, regularized representation of a pattern that is common among ethnographic hunter-gatherers (see Binford 2001; Kelly 1995) and is thought to have been prevalent throughout much of prehistory among hunter-gatherers in eastern North America (Walthall 1998).

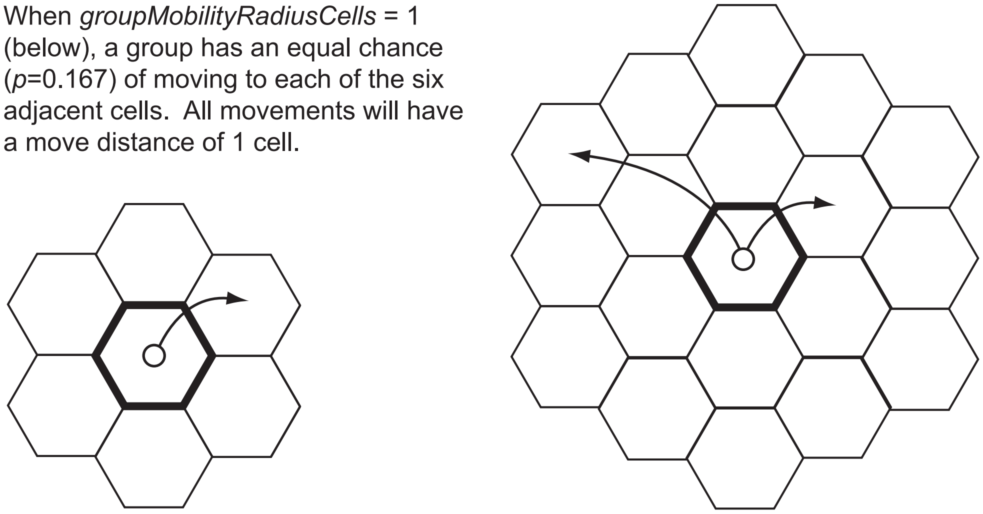
The frequency and distance of group movements are controlled by two model-level parameters: *pGroupMove* and *groupMobilityRadiusCells* (P1 in Figure 4.4). Values for these parameters are set prior to the initiation of a model run. The values of these parameters can be changed during a model run, but do not change as a result of behavior within the model (i.e., there are no feedbacks that alter the values of these parameters). All groups in a given run have the same values of these parameters. Group mobility parameters are also used by the model at startup to determine the initial number and placement of aggregation sites.

The frequency of group movement is controlled by the parameter *pGroupMove*, which can be set to any probability between 0 and 1. A random number between 0 and 1 is generated for each group at each step and compared to the value of *pGroupMove* in the model. If the value of *pGroupMove* is 0.5, for example, a group will attempt to move if it generates a random number less than 0.5. A *pGroupMove* value of 0.5 means groups will move, on average, every other step. A *pGroupMove* value of 1.0 means groups will move every step.

The maximum distance a group can move in a single step is controlled by the variable *groupMobilityRadiusCells*, also set in the model. This variable describes the radius of group movement that is possible in terms of the number of tiers of hexagonal cells that the group may move from its current location.

When this variable is set at 2, for example, a group can move up to two cells (20 km) away from its current location. Because each successive tier of hexagonal cells contains 6 more cells than the previous tier, the probabilities associated with choosing a cell from any given tier are not equal when the number of tiers of possible movement is greater than 1 (Figure 4.5). If the radius of movement is two tiers of cells, a group could move to one of the six adjacent cells in the first tier or one of the 12 cells in the second tier. The chance of choosing one of the first tier cells is 33 percent (6/18) and the chance of choosing one of the second tier cells is 67 percent (12/18). This results in a mean move distance of 1.67 cells (0.33 * 1 + 0.67 * 2). The estimated mean move distances associated with different values of *groupMobilityRadiusCells* are given in Table 4.10.

When a group attempts to move (based on *pGroupMove*), it first compiles a list of all the parcels of land within its movement radius. If it is currently Season 1, the group then assembles a list of those parcels that are farther from



When *groupMobilityRadiusCells* = 1 (below), a group has an equal chance (*p*=0.167) of moving to each of the six adjacent cells. All movements will have a move distance of 1 cell.

When *groupMobilityRadiusCells* = 2 (above right), a group has an equal chance (*p*=0.056) of moving to each of the 18 cells in the two rings that surround the central cell. This will result in a mean distance moved of 1.67 cells: there is 33 percent chance the group will move to a cell in the first tier and a 67 percent chance the group will move to a cell in the second tier.

Figure 4.5. Illustration of differences in mean movement distance when *groupMobilityRadiusCells* is equal to 1 and 2.

Table 4.10. Mean Number of Cells per Move Associated with Different Values of *groupMobilityRadiusCells.*

groupMobilityRadiusCells	**Number of Cells within Move Radius**	**Mean Number of Cells Per Move**
1	6	1
2	12	1.67
3	18	2.33
4	24	2.84
5	30	3.66
6	36	4.37

its aggregation site than its current parcel. If it is currently Season 2, the group assembles a list of those parcels that are closer to its aggregation site. The Boolean variable *interBandSteering* determines whether groups will “steer” towards groups from different bands (i.e., groups that aggregate at different aggregation sites) if they are within range. If *interBandSteering* is on and there are groups from other bands present within the *personalMobilityRadius*, the moving group will move towards one of those groups as long as it moves in the “correct” direction based on the current season. If *interBandSteering* is off or there are no groups from other bands within range, the group will move to a currently unoccupied parcel that has the lowest density of other groups within a *foragingRadius* of the parcel. *InterBandSteering* was set to “on” for all runs considered in this dissertation. When a group moves, all the households and individuals in the group move with it.

An estimation of the mean annual distance that groups move during a given run (*meanAnnualRange*) is calculated by multiplying *pGroupMove* by the mean move distance (from Table 4.10) and the number of steps in Season 1 (P2 in Figure 4.4). This calculates an average distance (in cells) that a group moves from its aggregation site during Season 1, assuming the group moves directly away from the aggregation site during each movement. Because movements with some lateral component are equally as likely as movements directly away from the aggregation site, this calculation of mean annual travel distance will tend to over-estimate the mean distances that groups travel annually from their aggregation sites. If the mean move is 1.67 (as above), *pGroupMove* is 0.5 (groups move approximately every other step), and Season 1 is 22 steps, *meanAnnualRange* will be 18.37 cells.

Number, Placement, Range, and Population of Bands

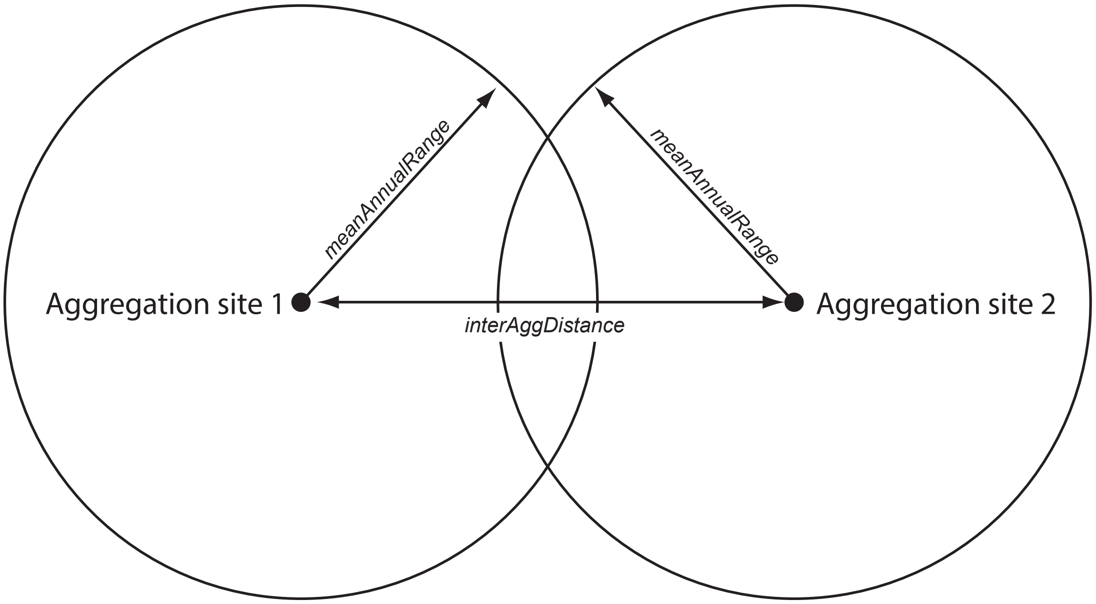
As discussed above, “bands” are conceived here as supra-group social formations, the existence of which allows for the regular transfer of people and information between groups. The groups in a given band aggregate at the same location every year. Groups in the model are bound into bands simply by virtue of this behavior: the “band” level in the model is little more than a mechanism representing the spatial anchoring and organizing of group movements facilitating the inter-group transfer of information and persons. The group mobility settings discussed above, together with model-level parameters specifying the amount of overlap in the ranges of adjacent bands and the initial population density, affect the initial number, placement, range and population size of bands.

The model calculates the *bandRange*: the area (in km^2) that will be used by a single band composed of multiple groups annually radiating from and returning to an aggregation site. The *meanAnnualRange*, a straight-line distance (see above), is converted to km (*meanAnnualRangeKM*) by multiplying it by the diameter of one of the hexagonal grid cells. The value of *bandRange* is calculated assuming a circle with a radius of *meanAnnualRangeKM*. Following the example above, a *meanAnnualRange* of 18.37 cells (183.7 km) will translate into a *bandRange* of 106,015 km^2.

To place band aggregation sites on the landscape, the model first calculates the amount of land (in km^2) available for occupation by multiplying the number of non-water parcels by the area of a 10-km-diameter hexagonal cell (86.6025 km^2) (P3 in Figure 4.4). When the model is operating in Scale 3, this figure equals 1,321,381 km^2.

The parameter *perMeanRangeOverlap* controls the percentage of overlap in the *meanAnnualRange* of adjacent bands (P4 in Figure 4.4). A value of 0.10 indicates that the most distant 10 percent of a group’s mean range will overlap with 10 percent of the mean range of groups from at least one other adjacent band. The distance between adjacent aggregation sites (*interAggDistance*) is calculated as shown in Figure 4.6. A 10 percent overlap in the ranges of groups from two adjacent bands will result in aggregation sites placed 34 cells (340 km) apart when the *meanAnnualRange* is 183.7 km (i.e., when *pGroupMove* = 0.5 and *groupMobilityRadiusCells* = 2).

The model calculates the number of aggregation sites to attempt to place in the world by dividing the amount of available land by *bandRange* and



meanRangeOverlap = *meanAnnualRange* * *perMeanRangeOverlap*
interAggDistance = 2 * (*meanAnnualRange* - *meanRangeOverlap*) + *meanRangeOverlap*

If *meanAnnualRange* = 18.37 and *perMeanRangeOverlap* = 0.10,
meanRangeOverlap = 1.837
interAggDistance = 34.9 cells (the model converts this to an integer and rounds down to 34 cells)

Figure 4.6. Calculation of distance used to place aggregation sites on the landscape of the model.

multiplying by 6. The multiplier of 6 is used to ensure that the landscape is "packed" with as many aggregation sites as possible no matter what the degree of overlap between adjacent ranges. The actual number of aggregation sites that are placed will depend on the amount of overlap between adjacent sites and an element of randomness built into the algorithm that the model uses to place aggregation sites. The model begins by generating a list of all the parcels that are suitable for the placement of aggregation sites, the only stipulations being that these parcels must be at least one *meanAnnualRange* distant from the limits of the world and must be on land. One of these parcels is randomly selected as the location for the first aggregation site. Based on the XY coordinates of this first aggregation site, the model generates a list of all parcels that are within *interAggDistance* + 1. Parcels that are too close to the limits of the world, on water, or too close to the first aggregation site are eliminated from the list. One of the remaining parcels is randomly selected and becomes the location of the second aggregation site. The model then repeats this procedure: (1) a list all parcels that are within *interAggDistance* + 1 of the first two aggregation sites is generated; (2) parcels are eliminated from this list if they are too close to the limits of the world, are on water, or are too close to the locations of either of the first two aggregation sites; (3) a parcel is randomly selected from the remaining parcels to become the location of the third aggregation site. This is repeated until there is no more room left for additional aggregation sites. Note that this algorithm does not ensure even "packing" of band ranges, but does ensure that each band range will have a certain degree of overlap with at least one other band range.

Continuing the example, the model attempts to place 74 aggregation sites in a landscape with 1,321,381 km^2 of land when *bandRange* equals 106,015 km^2 (i.e., *pGroupMove* = 0.5 and *groupMoveRadiusCells* = 2). When *perMeanRangeOverlap* = 0.10, the number of aggregation sites actually placed under these conditions will vary between 5 and 11. Other group mobility settings will be discussed in Chapter 5. All other things being equal, a lower *meanAnnualRange* will result in a greater number of aggregation sites being placed in the world.

The size of the initial population in the world is determined by calculating the sum of the areas of all the band ranges (number of aggregation sites multiplied by *bandRange*) and multiplying it by a *popDensityModel*, a parameter expressing the number of persons per km^2 (P5 in Figure 4.4). When *bandRange* = 106,015 km^2, a *popDensityModel* value of 0.002 persons/km^2 produces a population size of 2,120 people when there are 10 aggregation sites. The model records the initial mean number of persons per aggregation site (*personsPerAgg*, in this case 212) and uses this value in a probabilistic calculation that regulates the size of aggregation site populations (see below). If the calculated value of *personsPerAgg* is less than the minimum group size (*minGroupSize*) set in the model parameters, the value of *personsPerAgg* is set to equal *minGroupSize*. This ensures that groups of at least a minimum size will be able to form under certain conditions of low population density and low mobility.

Band Population Fission and Aggregation Site Proximity

Once per model year (i.e., every 52 steps) the model checks the populations of bands (multiple groups using the same aggregation site). If the population of a band (*aggPop*) is more than twice the value of *personsPerAgg* stored by the model, the model calls a method to split the band into two bands. A new parcel in close proximity to the current aggregation site is selected as the location of a new aggregation site, and a portion of the population (randomly selected along group lines) begins using the new aggregation site. If the population using an aggregation site drops to 0, the aggregation site is deleted.

Once per year the model also checks the proximity of aggregation sites to one another. The model first recalculates the *meanAnnualRange* and *interAggDistance* values based on *pGroupMove* and *groupMobilityRadiusCells* (in case these variables were changed in mid-run as part of an experiment). For each aggregation site, the model calculates the distance to every other aggregation site to determine if at least one other site is within the required *interAggDistance*. If the site is not close enough to any other aggregation sites (i.e., the distance to the closest other aggregation site is > *interAggDistance* + 1), it is added to list of aggregation sites that need to move closer to their nearest neighbor. If the site is too close to one or more other aggregation sites (i.e., the distance to another aggregation site is < *interAggDistance* – 1), it is added to a list of aggregation sites that need to move farther from their nearest neighbor. Aggregation sites are moved 1 to 3 cells (randomly determined) in both the X and Y directions, either towards or away from their nearest neighbor as required.

When a band fissions, the location of its initial aggregation site will be too close to the aggregation site of the original band under most mobility conditions explored using this model. This will cause the sites to move apart from one another the next year. These movements may cause other bands to adjust their aggregation locations in the following year. Likewise, when an aggregation site is deleted because of zero population, the spatial gap that results may cause other bands to adjust their aggregation locations. Thus, together, these methods for fission (and deletion) and controlling proximity of aggregation sites provide mechanisms for regulating the size and spacing of bands. If model settings affecting group mobility or population size feedbacks (e.g., carrying capacity) change mid-run, the system in the model will respond accordingly.

Group Size and Fission/Fusion

Group size (the number of individuals in a group) is affected by person-level, household-level, and group-level methods. Personal mobility (discussed below) allows individuals and their households (if applicable) to move between groups, altering the size and composition of groups. Reproduction (discussed below) also alters the size and composition of group through the addition of new persons. Marriage (discussed below) may or may not alter group size and composition, depending on whether or not the female is in the same group as the male before they marry. Minimum and maximum group size are regulated by methods for group fission (when one group splits to form two groups) and fusion (when two groups combine to form one group). Model-level parameters establish values for minimum group size (*minGroupSize*) and maximum group size (*maxGroupSize*). In the runs discussed here, minimum group size (*minGroupSize*) is set at 10 and maximum group size (*maxGroupSize*) is set at 40. This range approximately mirrors the range of group size reported by Binford (2001:Table 8.01) for the "most dispersed" phase of ethnographic hunter-gatherers.

A model-level parameter (*foragingRadiusCells*) establishes the "foraging radius" of groups. This radius (in cells) defines the spatial extent of the "local neighborhood" around a group at any given time. A group has information about the locations of all other groups that are within this radius. A value of 1 for *foragingRadiusCells* (the default setting for the runs discussed here) means that a group knows about the existence of all other groups that are in the first tier of cells surrounding its current location.

Each step, a group compares its current size to the values for minimum and maximum size set in the model. When a group is below the minimum group size, it will search within its foraging radius for other groups that are below the maximum size. If such groups are present, it will choose one randomly and fuse with it to create a single group that is above the minimum size. The group that is initiating the fusion will become part of the group it is fusing into (i.e., it will adopt the aggregation site of the group it is fusing into, if different). If no groups suitable for fusion are present, the group does nothing.

When a group is above the maximum group size, it will fission into two distinct groups. Fission occurs along household lines (i.e., when a portion of the group leaves to create a new group, the new group will be composed of complete households). Both groups maintain the same aggregation site as the original group. One group maintains the same group identification, while the other group creates a new group identification and moves into an adjacent, unoccupied cell.

Personal Mobility

Personal mobility allows individuals and households to move between groups, providing a mechanism to represent flux in group membership that is typical of many hunter-gatherer systems (see Chapter 2). In this model, only males at or above reproductive age may initiate person-level movement between groups. Persons who are the heads of households move the members of their household with them. Factors affecting personal mobility include two model-level parameters, the spatial proximity of groups to which the person could move, and the presence of individuals in those groups with which the person has social links. Personal mobility contributes to the formation of new social links and the transfer of information about potential brides (see below).

The model-level parameters affecting personal mobility (*pPersonMove* and *personMobilityRadiusCells*) are similar to those affecting group mobility. Values for these parameters are set prior to the initiation of a model run and do not change as a result of behavior within the model (i.e., there are no feedbacks that alter the values of these parameters). All applicable persons in a given run have the same values of these parameters.

The frequency of personal movement is controlled by the parameter *pPersonMove*, which can be set to any probability between 0 and 1. A random number between 0 and 1 is generated for each adult male at each step and compared to the value of *pPersonMove* in the model. If the random number is lower than the value of *pPersonMove*, the individual attempts to move. He first compiles a list of all groups within the value of *personalMobilityRadiusCells*, a variable expressing the maximum radius (in terms of the number of tiers of hexagonal cells) that a person can move. He then compiles a list of all the groups within range that contain individuals to whom he is linked. If linked persons are identified within the groups within range, he randomly selects one of these groups as a destination. The person then physically moves to his new group and becomes a part of that group. If the person is the head of a household, co-resident members of his household move with him.

Household-Level Production

The dependency ratio and productive capacity of households affects methods related to marriage, mortality, and reproduction. The current dependency ratio (*cPRatio*) of a household is calculated (whenever called) by dividing the number of consumers (the total number of people in the household) by the number of producers (the number of people in the household who are at or above the *ageOfProduction* set in the model).

Once per model year (when *seasonTick* = 0), each household calculates its productive capacity based on the numbers of consumers and producers. As discussed above, "assets" are added and subtracted from households each year assuming that each producer producers 1.75 units and each member of the family consumes 1.0 units. In a family of 4 with 2 producers, for example, 3.5 units are produced and 4.0 units are consumed, resulting in a deficit of 0.5 units. In a family of 5 with 3 producers, 5.25 units are produced and 5.0 units are consumed, resulting in a surplus of 0.25 units.

"Assets" are cumulative. They are stored until they are used for marriage. When the head of the household dies, assets disappear (i.e., in this model there is no mechanism for transfer of accumulated assets between generations).

Transfer of Information about Potential Brides

Both males and females of reproductive age participate in the transfer and "correction" of information related to potential brides (i.e., unmarried females of marriageable age) in the population. Each person (male or female) has a *potentialBrideList* in which to store information about females in the population who are potentially eligible to be married. Beginning at reproductive age, persons begin to fill and adjust this list each step. In this model, this is accomplished through the gathering of "firsthand," local knowledge by individuals and the transfer of this knowledge to others through face-to-face interaction. Note that a person's *potentialBrideList* is simply a list of females whom ego has been told or knows to be marriageable. Females keep a *potentialBrideList* in order to participate in the transfer of information about marriageable females. In addition to this, a male of marriageable age uses his *potentialBrideList* as a list of potential brides for himself (see below). In a system of reasonable size, no single person will have complete, accurate information about every marriageable female in the population.

Information about marriageable females in the population is gathered and transferred through a series of steps. First, each person corrects and/or adds to his *potentialBrideList* by collecting firsthand information about all persons in his group and some (or all, depending on the number) persons from other groups that are within the local area of his current group. The person first creates a *localList* and adds to it all persons in his group. Then he generates a list of all the other groups that are within his group's local area. As discussed above, the extent of the "local area" of a group is defined by the foraging radius (*foragingRadiusCells*). If other groups are present in the local area, he randomly selects one group to "visit" and adds all the people in that group to his *localList*.

The person then culls the *localList* to generate a list of all local, reproductive-aged females, both married and unmarried. He then compares each female on this list to the females on his *potentialBrideList*. If the female is already on his *potentialBrideList* but is now married, he removes her from his *potentialBrideList.* This is a mechanism for correcting information through firsthand observation. If the female is unmarried and is not on his *potentialBrideList*, he adds her. The firsthand information that a person collects in this way is accurate.

Then, each person transfers information about potential brides from others in his group. He or she cycles through each of the occupants of the group in turn, asking each reproductive-age person to transfer information about a percentage (determined by the model-level parameter *brideInfoTransferPercent*) of the females on his or her *potentialBrideList*. The giver of the information shuffles his *potentialBrideList* and offers information on the requested percentage of females on the list. The females that are not already on the recipient's *potentialBrideList* are added to it. Note that the information added to the *potentialBrideList* in this way is not necessarily accurate: females that were added to the giver's list during previous steps may have been married in the interim, for example, by the time the information is passed on.

Marriage

Marriage is the mechanism of household formation, one of the mechanisms (along with mortality and reproduction) for changing the size and composition of households, and one of the mechanisms (along with mortality, reproduction, and mobility) for changing the size and composition of groups and bands. In this model, females may have only a single husband while males can have multiple wives. This structural asymmetry is meant to produce the forms of marriage that are most commonly found in hunter-gatherer societies (i.e., monogamy and polygyny) (see Binford 2001).

Marriage methods are affected by a variety of factors, including the availability of information about potential marriage partners, the spatial proximity of potential marriage partners, probabilistic economic calculations performed by both males and females, the availability of productive “assets” that must be transferred between families at the time of marriage, and a model-level parameter (*pInterBandMarriage*) specifying the probability that a male will purposefully seek a bride from a band other than his own. All males and all unmarried females of reproductive age (16) are eligible to marry each step. The operations of the basic methods associated with marriage are summarized as a flow chart in Figure 4.7.

The operations of the marriage methods are initiated by each male of reproductive age at each step (the order in which males initiate the marriage methods is randomized). The male first determines if marriage is possible by checking to see if there are potential brides on his *potentialBrideList*. If the list is empty (i.e., he knows of no potential brides), his marriage methods terminate.

If his *potentialBrideList* is not empty (i.e., he knows of at least one potential bride), he evaluates his current economic situation to determine the probability that he will attempt to find a marriage partner. If he is independent of his parents (i.e., he is already married or has been married in the past), the probability he will seek to add a wife is conditioned by a calculation expressing the difference between the dependency ratio in his current family (*currCPR*) and the dependency ratio if he adds a wife (*condCPR*) as a percentage of his current dependency ratio: (*currCPR* – *condCPR*) / *currCPR*. The addition of a single adult will always lower the dependency ratio if it is above 1. The results of this formula are illustrated in Figure 4.8. This simple calculation captures two key aspects of the economics of polygyny: (1) wives are more likely to be added when the addition is of greater economic benefit; and (2) as family size increases, each additional wife has progressively less impact on the dependency ratio, all other things being equal. If a male of reproductive age is currently unmarried, he will always attempt to marry.

If a male decides to attempt to marry, a probabilistic determination is made as to whether he will seek a “local” female or pursue marriage with a female from a different band. This determination is made based on the value of the model-level parameter *pInterBandMarriage*, which can be set between 0 and 1. When the value of *pInterBandMarriage* is 0, all marriages will be

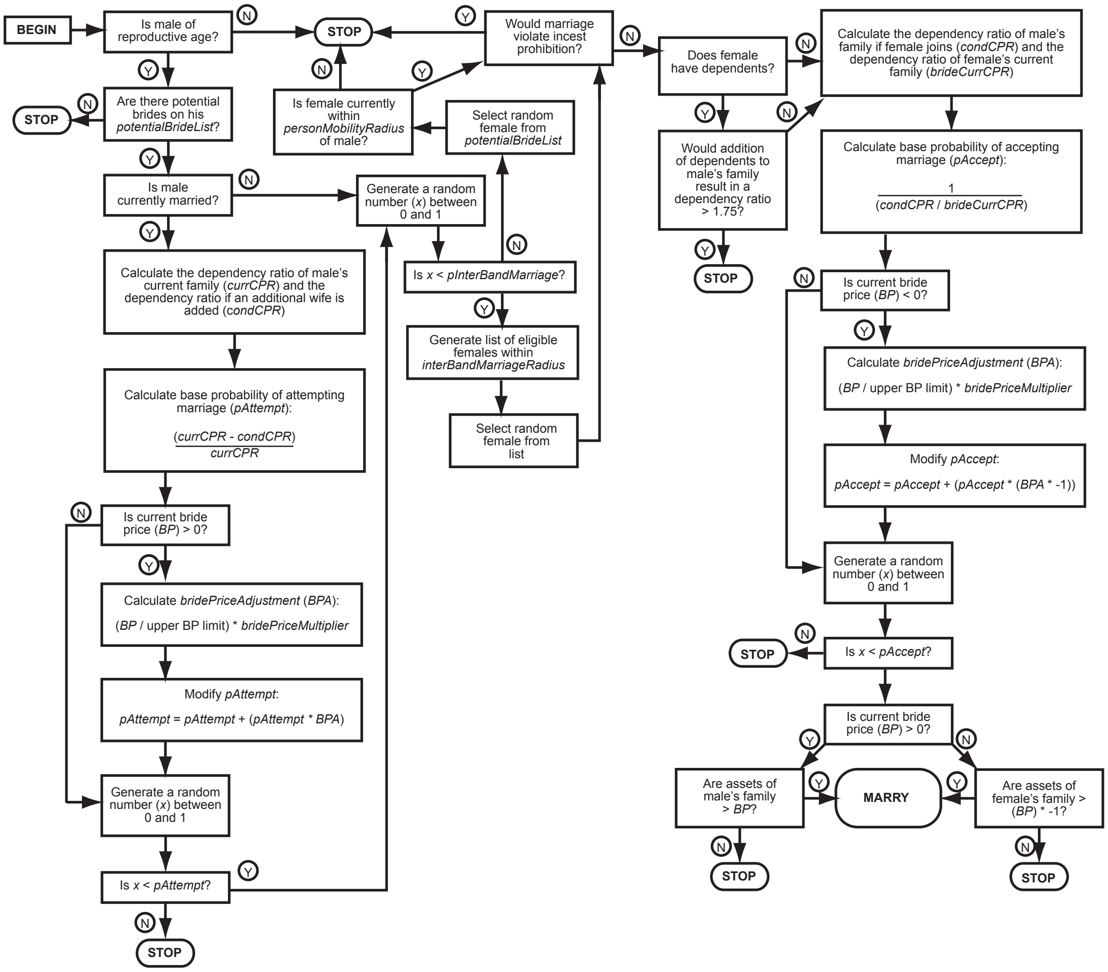


Figure 4.7. Schematic illustration of methods associated with marriage in the ForagerNet2 model.

between individuals who are in close spatial proximity (i.e., within the value of *personMobilityRadiusCells*) to one another at the time of the marriage. When the value is 0.10, about 10 percent of marriages will be between individuals who reside in different bands.

If a local marriage is pursued, the male randomly selects a female from his *potentialBrideList*. If this female is currently located within the personal mobility radius of the male (defined by the model-level parameter *personMobilityRadiusCells*), the male checks to confirm that marriage to

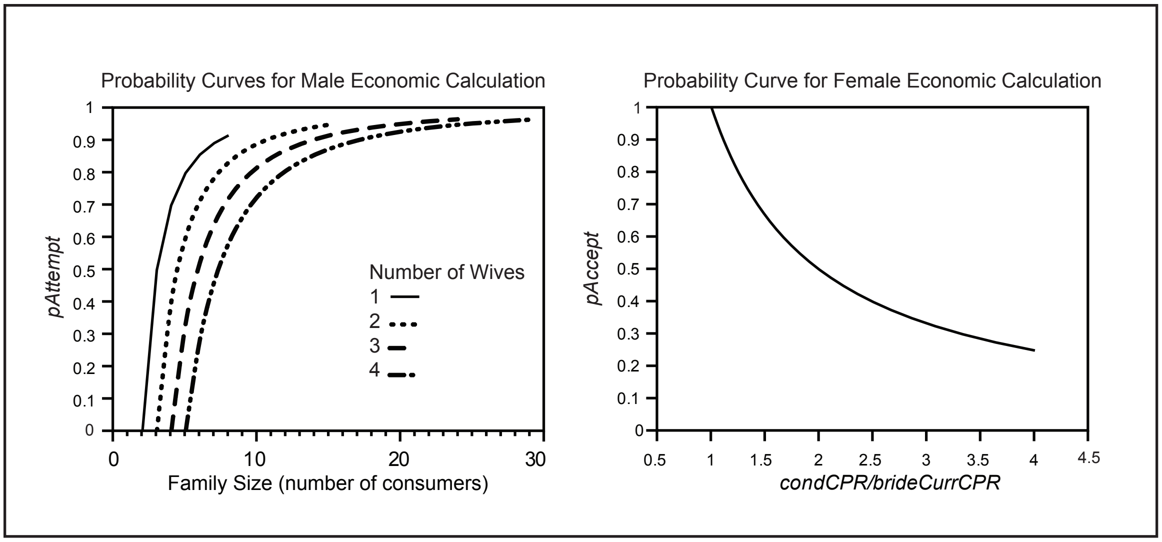


Figure 4.8. Probability curves for marriage-related economic calculations made by males and females in the ForagerNet2 model.

her would neither violate basic incest prohibitions (see below) nor create an economically unviable family (e.g., if the female has many dependents from a previous marriage where the husband has died). If these conditions are met, the probability that the female will accept the marriage is calculated by comparing the dependency ratio within the potential bride's current family (*brideCurrCPR*) with the dependency ratio of the family she would join (e.g., as a second wife) or form with the male (*condCPR*). The probability of her accepting the marriage is calculated as 1 / (*condCPR* / *brideCurrCPR*). The results of this formula are illustrated in Figure 4.8. Thus there is a 50 percent chance that a female will enter into a marriage that will put her in a situation where the dependency ratio is twice as high as in her current situation.

If the female agrees to the marriage, the model checks to see if sufficient assets are available to cover the "cost" of the marriage. Each step, the model calculates a population-level "bride price" statistic that reflects the relative scarcity (or abundance) of females eligible for marriage. This statistic is adjusted each step by comparing the current ratio of available males : available females to the same ratio during the previous step. If the ratio has increased (i.e., potential brides have become more scarce), bride price changes by a randomly generated number between 0 and +1. If the ratio has decreased, bride price changes by a randomly generated number between 0 and -1. When bride price is > 0, getting married entails a cost to the male side. When bride price < 0, the cost of marriage shifts to the bride's family. If bride price is at +2 and the male's family (his parents' family if unmarried, his own conjugal family if married) has "assets" of only 1.5 units, the marriage will not take place. For the runs considered here, bride price is capped at limits of +/- 10 (without these limits, populations can go extinct when the price moves too high or too low and the system cannot compensate in a timely fashion).

If sufficient assets are available, the marriage moves forward. If the female is currently in a group other than the male's group, she moves to the male's group. If the male is previously unmarried, a new household is formed. If the male has already been married or is currently married, the female is added to the male's household. Any children of the female from a previous marriage that still reside with her also move to the male's group and are added to his household. The changes in residence and relationships triggered by a marriage results in the creation or modification of a variety of social links and additions to social lists (see below).

If the male pursues a marriage with a female of a different band (i.e., based on *pInterBandMarriage*), he generates a list of all eligible females within a specified radius (*interBandMarriageRadius*) that reside in groups that aggregate at an aggregation site other than his own. The value of *interBandMarriageRadius* determines the size of the neighborhood that can be searched for potential brides of a different band. In most cases during the experimentation reported here, *interBandMarriageRadius* was set to either *meanAnnualRange* or twice *meanAnnualRange*. Once a list of potential inter-band brides is generated, the male randomly selects one and attempts to marry her. The remaining operations associated with inter-band marriage are identical to those of local marriage.

Reproduction

Each married, non-pregnant female of reproductive age goes through the reproduction methods (Figure 4.9) each step. At the core of these methods is a probability of reproduction calculated by dividing a model-level maximum fertility rate (*maxFertility*) by the length of the female reproductive span. For the runs discussed here, the maximum age at which females can reproduce (*reproductiveMax*) was set at 35 and the minimum age (*ageAtReproduction*) was set at 16, resulting in a reproductive span of 19 years (988 steps). The value of *maxFertility* was set at 10. Thus the "base" probability of reproduction each

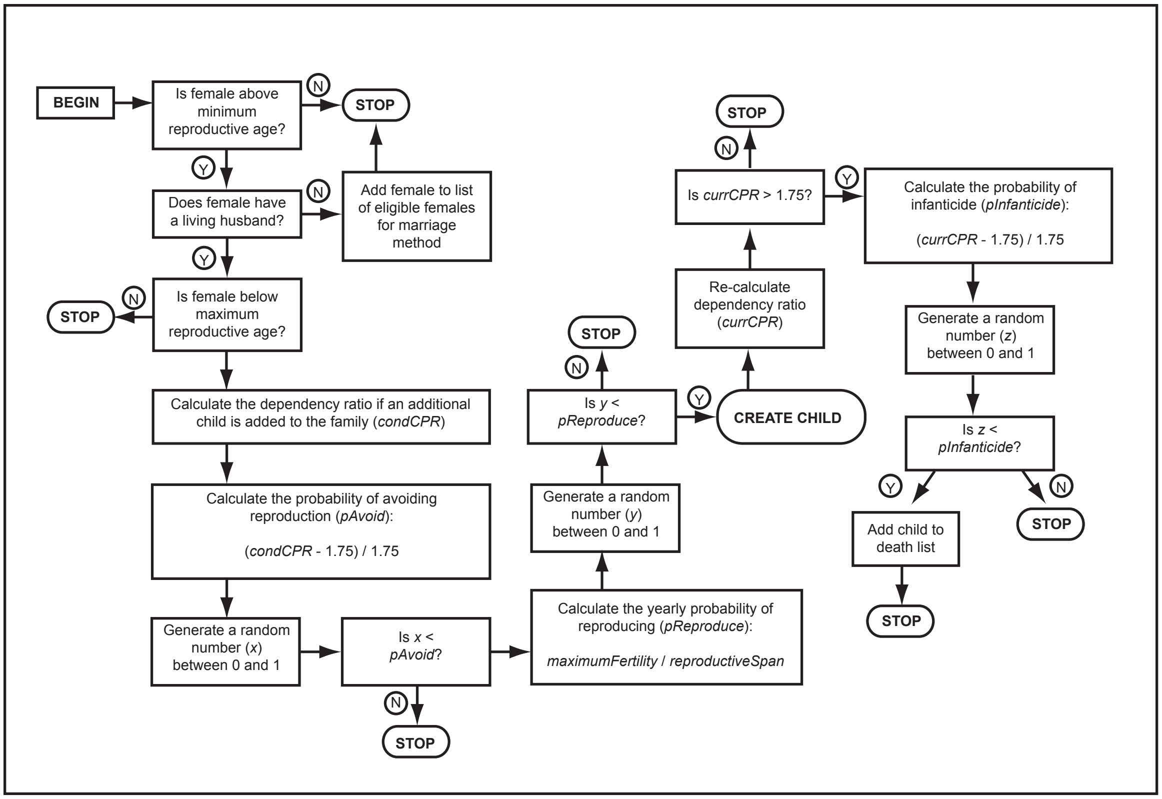


Figure 4.9. Schematic illustration of methods associated with reproduction in the ForagerNet2 model.

step is 0.01012 (10/988). Note that the year-to-year probability of reproduction is constant, rather than variable as in actual human populations. This is a simplification for the purposes of modeling.

When a female becomes pregnant, a count begins to track the length of the pregnancy (*pregnancyWeeks*). This count is incremented at each step until it reaches 40. Successful reproduction results in the creation of child of random sex who is then added to the household, the “world,” and all applicable lists.

The model incorporates mechanisms for both avoiding procreation and terminating the life of a newborn infant (i.e., infanticide). Avoidance serves to lower the total fertility of the population by reducing the number of children that are born. Infanticide serves to raise infant mortality rates. Both mechanisms incorporate calculations about how the addition of a new child would affect the current dependency ratio of the household. The chance of avoiding procreation is determined by calculating how much above 1.75 the dependency ratio would rise if another child were to be added and taking this amount as a percentage of 1.75 (e.g., the chance of avoidance is 100% if another child would raise the dependency ratio to 3.5). If procreation is not avoided, infants are exposed to risk of mortality through infanticide. The chance of infanticide is calculated the same way as avoidance. In this model, the sex of a child does not affect the probability of infanticide.

Mortality

Each person is exposed to a risk of death at each step during a model run (Figure 4.10). Adults are those persons that are at or above the *ageAtReproduction*. If a person reaches a maximum age (*maxAge*, set in the model), death is automatic. Below this maximum age, the probability of an adult dying is determined by dividing a yearly adult mortality rate (*adultMortality*) by the number of steps in a year. Sub-adults are exposed to a risk of death at each step through a mortality rate calculated by dividing a total childhood mortality rate (*childMortality*) by the number of years in a childhood by the number of steps in a year. For the model runs discussed here, *adultMortality* was set at 0.02 (2

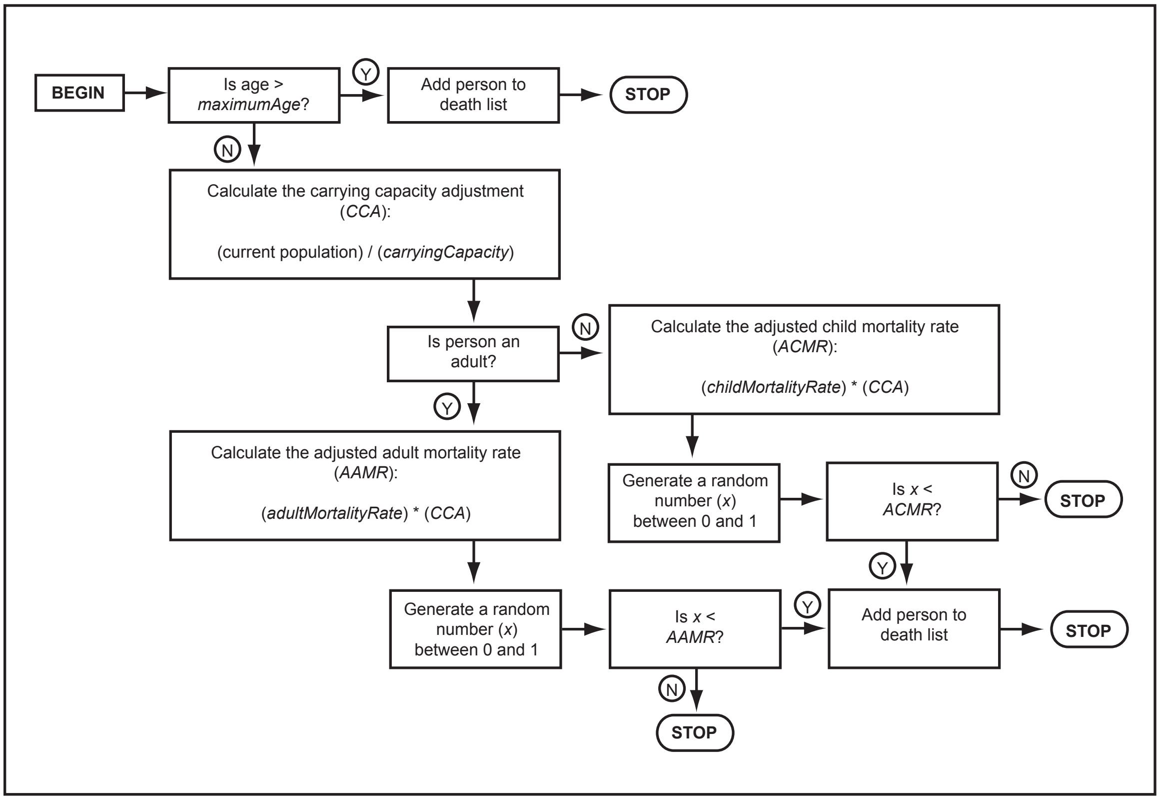


Figure 4.10. Schematic illustration of methods associated with mortality in the ForagerNet2 model.

percent chance of death per year) and *childMortality* was set at 0.40 (2.5 percent change of death per year when the age of adulthood is defined as 16).

The "base" adult and child mortality rates are adjusted yearly based on the difference between the current population size and the specified "carrying capacity" of the world. The model-level parameter *carryingCapacity* is set during start-up to the size of the initial population placed in the world. Populations in excess of the carrying capacity are subject to higher mortality rates while those below carrying capacity are subject to lower mortality rates. This is a feedback mechanism to provide some degree of stability in population size during runs. As discussed below, a "carrying capacity" of 1000 does not mean the population is always 1000: it simply means that mortality rates are positively or negatively adjusted based on whether population size is above or below 1000. Adjustment of the value of *carryingCapacity* during a run provides a simple, system-level way to strengthen or relax constraints on population growth.

As discussed above, infants are subject to an added risk of mortality through infanticide. Infanticide methods are initiated at the household level and only consider the dependency ratio of the particular household, rather than the total system-level population size.

Social Link Formation

Social links of various types (see Table 4.8) are formed as a result of marriage, birth, co-residence in a household, or acquaintance by virtue of being in the same group.

All persons residing and travelling in the same group are connected by (minimally) pairs of acquaintance links. Each step, the model checks for an existing link between each pair of persons in a group. If no link exists between the pair, acquaintance links are created. This is done each step because group membership can change through marriage, birth, personal/household mobility, and group fission. Acquaintance links are the most "basic" class of links and indicate that two persons are acquainted with each other but there is no other relationship (i.e., they are not affines, family, kin, or household co-residents).

Marriage triggers the creation of a pair of marriage links between the husband and wife and the creation of a suite of kin links (or the change of existing links to kin links) between each member of the conjugal couple and the parents, siblings, and children of siblings of the other member. These methods effectively define mothers-, fathers-, brothers-, and sisters-in-law as “kin” as well as the children of brothers- and sisters-in-law. If the male or female involved in the marriage has living children from a previous marriage, pairs of family links are created between parents and these step-children when the bride moves to the groom’s household. Co-resident links are created between any pairs of individuals in the household who are not related by descent or marriage (e.g., co-wives, children with different sets of parents, etc.).

The birth of a child triggers the creation of family, kin, and (sometimes, depending on household composition) co-resident links. Pairs of family links are created between the child and its mother, father, and maternal and paternal grandparents (assuming the father and grandparents are still alive). Pairs of family links are also formed between the child and all other living children of both the mother and father. Pairs of kin links are formed between the child and any siblings of the mother or father as well as between the child and its first cousins (any children of the mother’s or father’s siblings). Co-resident links are formed between the child and any individuals in the household that are not related by descent. This includes children of other wives in the household who have a different father (i.e., from a previous marriage).

All social links pointing to or originating from a person are nullified upon that person’s death.

Social Link Maintenance

The model as currently implemented contains no methods for adjusting the strength of social links. The decay and maintenance of social links can be represented in a future version of the model.

Social Learning

This model is primarily focused on understanding the links between social network structure and variability in a specific class of artifact: formal chipped stone hafted bifaces. Creation, use, and discard of artifacts are represented as male activities in the model.

When a male reaches productive age (typically set at 14 during the runs discussed in this dissertation), he “learns” to make hafted bifaces. The attributes of hafted bifaces are defined by a number of continuous metric variables, the maximum and minimum values of which are constrained by model-level settings (discussed below). Each of these metric attributes is calculated from the coordinates of landmarks that specify the locations of specific points on an artifact. When a male learns to make hafted bifaces, he copies the mean coordinates of these landmarks from one of two sources: (1) the current head of the household that the male is in (likely to be the male's father); or (2) all toolmakers currently in the male's foraging group. The likelihood that a male will learn from all toolmakers in the group is controlled by the value of the model-level parameter *pGroupCopy*.

The male creates the tools (*n* = 10) in his initial toolkit one at a time, copying the mean values of his example person (i.e., the head of his household) or population (the toolmakers in his current group). The methods associated with tool manufacture are described below. Tools with combinations of attributes that fall outside the range of what the model considers functionally "viable" are not accepted into the person's initial toolkit.

After a male has produced his first assemblage of hafted bifaces, the Boolean variable *toolProductionLearned* is set to "true."

Tool Manufacture, Use, Loss, and Discard

All males that have learned tool production go through a series of methods each step to that allow them to use, discard, lose, and manufacture tools. The methods for tool use, discard, and loss (Figure 4.11) come first in the sequence. Methods of tool use represent the limited use-life of stone tools: a tool is automatically discarded when the value of its *remainingUseLife* = 0. For the experiments in this work, a tool was considered "used up" after 10 uses. The probability of "loss" of each tool in a person's inventory at each step (*toolLossProb*) was set to 0.01 (i.e., one percent).

Together, tool use, discard, and loss are mechanisms that result in the deposition of tools on the landscape of the world and depletion of a person's tool inventory. Tool "loss" can be assumed to include both accidental loss of a tool during use or transport or breakage of a tool during use. Data about tools that are lost or discarded can be preserved by the model if desired. For most of the experimental runs discussed here, data on a small percentage (i.e., < 5 percent of the tools of a known raw material source) of the lost/discarded tools was sufficient for comparison with archaeological data.

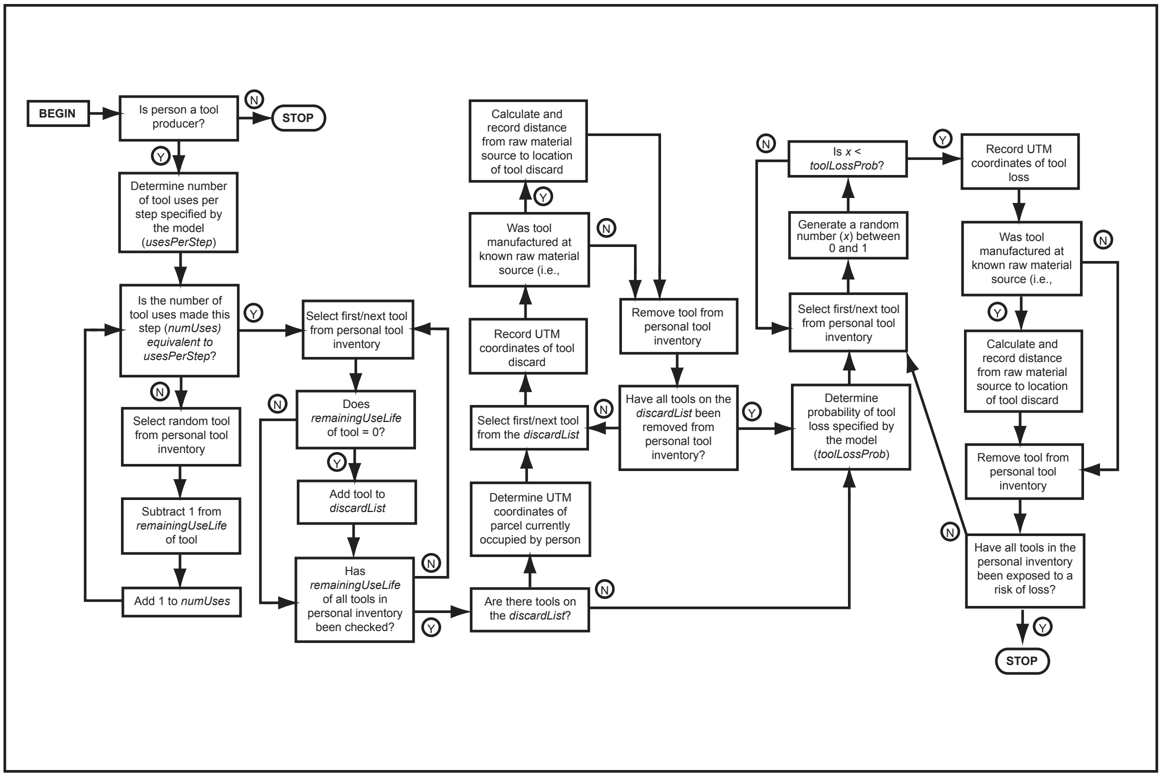


Figure 4.11. Schematic illustration of methods associated with artifact use, loss, and discard in the ForagerNet2 model.

Following methods for tool use, discard, and loss, each tool producer determines the number of tools that he must manufacture to replenish his inventory (Figure 4.12). The number of tools in a “normal” personal inventory is specified by the model-level parameter *toolInventorySize*. The parameter *toolProdMultiplier* allows the model to specify the degree to which tool inventories are “over-stocked” when the toolmaker is in close proximity to a named raw material source. The parameter *rmProcurementRadius* specifies the radius (in terms of tiers of cells) within which a person will produce tools from a named raw material source. When this parameter is set to equal the value of the *personMobilityRadiusCells*, raw materials are procured only within the radius of what is considered “normal” personal movement (typically 1 or 2 tiers of cells). Higher values of this parameter allow the model to represent a higher degree of mobility associated with “logistical” trips to procure raw materials. When the value of *toolProdMultiplier* is 2 and *rmProcurementRadius* is 4, for example, a sufficient number of new tools will be created to enlarge the person’s toolkit to twice the size specified by *toolInventorySize* when the person is within four

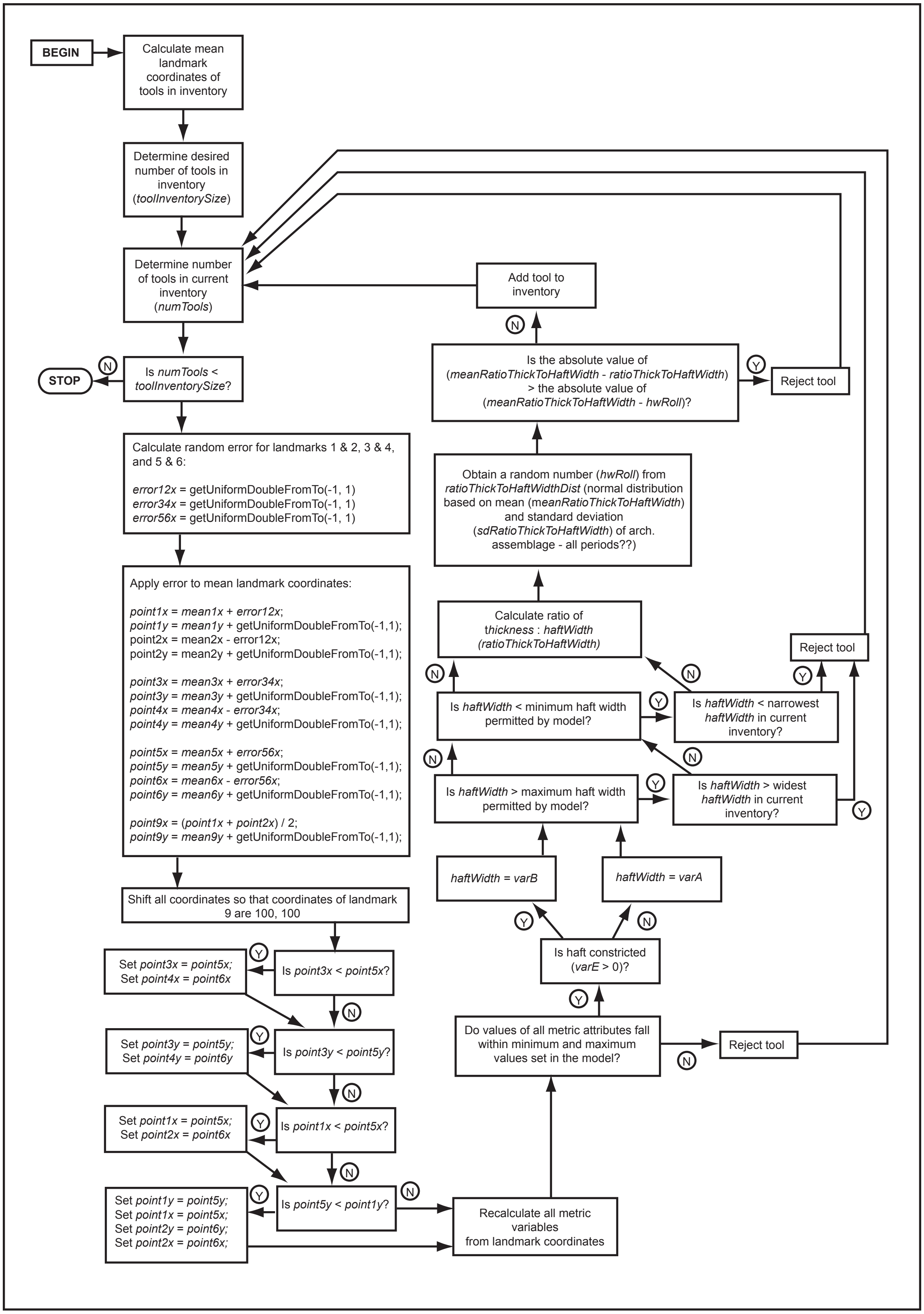


Figure 4.12. Schematic illustration of methods associated with artifact production in the ForagerNet2 model.

cells of a named raw material source. This would represent logistical mobility to overproduce tools from named sources. When *toolProdMultiplier* is 1 and *rmProcurementRadius* is set to equal the personal mobility radius, all raw material procurement is local and no “extra” tools are produced from named sources.

After a person determines the number of tools he would like to have in his inventory, he compares that number to the number of tools in his current inventory. He then produces the required number of new tools, one tool at a time. As shown in Figure 4.12, the tool manufacture process starts by generating a random error within ± 1 mm to add to the mean landmark coordinates of tools in the person’s existing inventory. Representing copying error in this way and applying it at the level of landmark coordinates allows the locations of landmarks to drift independently of one another. When proportional copying error (e.g., ±5 percent) is applied at the level of the metric variables (i.e., as in many studies of cultural transmission), values of metric variables can approach and then become fixed near zero. If the depth of the basal concavity (*varF*) is allowed to vary between 0 and 10 mm, for example, repeated application of proportional copying error will tend to decrease the value of this measurement until it approaches zero. After a measurement reaches zero it can no longer change (a 5 percent error of zero is zero). This is problematic in the framework used here because several of the metric variables (e.g., *varH*) can have positive or negative values depending on the vertical relationships of landmarks.

Error is applied symmetrically to the X coordinates of landmarks 1 and 2, 3 and 4, and 5 and 6. As an example, a single copying error term is generated for the X coordinates of landmarks 1 and 2. Suppose this error term is 0.25 mm. This error term is added to the X coordinate of landmark 1 (*point1x* + 0.25 mm) and subtracted from the X coordinate of landmark 2 (*point2x* – 0.25 mm). Thus the landmarks “move” by an identical amount in opposite directions. A single error term is generated and applied to the Y coordinates of landmarks 1 and 2 (landmarks 1 and 2 will always have identical Y coordinates). This same procedure is followed for landmarks 3 and 4 (which define the width of the most constricted area of the haft) and for landmarks 5 and 6 (which define the maximum basal width).

The X coordinate of landmark 9 is placed midway between the X coordinates of landmarks 1 and 2. Error is applied to the Y coordinate of landmark 9, allowing it to move up and down.

After copy error is applied to all the landmark coordinates, the model shifts the coordinates of each landmark by the same amount so that the XY coordinates of landmark 9 are 100, 100. This is to create a standard so that the mean landmark coordinates of the tools in a person's inventory are meaningful statistics.

The model then checks for and corrects "impossible" relationships between the coordinates of landmarks. The X coordinate of landmark 3 (*point3x*) cannot be less than the X coordinate of landmark (*point5x*), for example, as this would mean that the points of maximum constriction are farther apart than the points of maximum basal width. Similarly, the points of maximum constriction (landmarks 3 and 4) are not allowed to be proximal (i.e., lower in the vertical plane) than the points of maximum basal width, and the most proximal points of the base (landmarks 1 and 2) are not allowed to be farther apart or more distal than the points defining maximum basal width (landmarks 5 and 6). When these conditions occur, the model adjusts the locations of landmarks as shown in Figure 4.12.

Proportional copying error (± 5 percent, uniformly distributed) is applied to *meanThickness*. This 5 percent figure is based on empirical studies of human perception (e.g., Eerkens 2000; Eerkens and Lipo 2005; Hamilton and Buchanan 2009). A uniform distribution of error was used to prevent the large errors (i.e., > 5 percent) that would occur in the tails of a normal distribution.

The model then calculates the values of the metric variables from the coordinates of the landmarks and compares the metric variables to the minimum and maximum values permitted by the model. If the value of any metric variable falls outside the range permitted by model, the tool is rejected and the manufacture process starts over (tools rejected in this way are not deposited in the "world" of the model and cannot become part of an assemblage that is later analyzed).

If all the metrics of the point are within the permitted range, the model then applies selection to the point. This selection operates on two functional variables: haft width and the ratio of thickness : haft width. The model first calculates four numbers: (1) the mean of the range of haft width permitted by the model; (2) the difference between the haft width of the point and that mean; (3) the maximum haft width of all the points in the person's current tool inventory; and (4) the minimum haft width of all the points in the person's current tool inventory. If the haft width of the point is greater than the maximum haft width permitted by the model but closer to the mean haft width permitted by the model than the widest point in the person’s current tool inventory, the point is not rejected. If the haft width of the point is less than the minimum haft width permitted by the model but closer to the mean haft width permitted by the model than the narrowest point in the person’s current tool inventory, the point is not rejected. This part of the selection process allows points to “survive” that are either within the range of the minimum/maximum constraints imposed by the model *or* bring the overall characteristics of the person’s tool inventory closer to the constraints imposed by the model. This is important for allowing point metrics to change in response to changes in functional constraints that are imposed as part of a model run. Without this mechanism for accepting a new point as an improvement even if it does not fully satisfy new functional criteria, the imposition of new functional constraints can effectively end a model run by halting the production of new tools.

The model evaluates the ratio of thickness : haft width of a point by comparing it to a normal distribution generated by the model. This distribution is based on the mean and standard deviation of the ratio of thickness to haft width from archaeological data (see Chapters 7 and 8). The model calculates the difference between the mean of this distribution and the ratio of thickness : haft width of the particular point under consideration. The model also draws a random number from the distribution and calculates the difference between that number and the mean of the distribution. If the point under consideration is farther than the random number from the mean of the distribution, the point is rejected. This way of applying selection to the thickness : haft width ratio produces a distribution of this ratio with an approximately normal distribution.

If the selection criteria are satisfied, the new tool is added to the person’s inventory. The person continues to attempt to manufacture new tools until his inventory reaches the correct number.

Model Startup, Operation, and Data Collection

This section summarizes how the model is built at the beginning of a run, how the model operates during a run, and how data from a run are collected and saved for analysis. Default values for parameters of experimental model runs are summarized in Appendix A.

Build Model

Prior to the start of each run, the model goes through a series of operations to construct the spatial environment (parcels, water, and lithic sources), create the people that constitute the initial population, create the initial tool assemblages produced by each applicable person, and consolidate the population into groups clustered around aggregation sites. Table 4.11 lists the operations of the *buildModel* method in the order they are executed.

Some aspects of the spatial environment are determined by the values of settable parameters and some are determined by sections of code. The size of the world and the size of individual hexagonal cells, for example, are controlled by parameters. Raw material sources and bodies of water are represented in the world by virtue of code that converts the UTM coordinates of these features into the XY coordinate system of the model. The four different geographic scales at which the model was configured to operate are summarized in Table 4.12. The majority of experiments were performed at Scale 3. The final experiements discussed in Chapter 8 were performed at Scale 4.

As described above, the initial number and arrangement of aggregation sites is conditioned by model-level settings controlling group-level mobility and the amount of overlap between the ranges of groups from adjacent aggregation sites. Because the location of the first aggregation site that is placed in the world is randomly determined, runs with identical settings will have different spatial arrangements, and often different numbers, of aggregation sites.

The size of the initial population of the world is determined by multiplying the value of the parameter *popDensityModel* (the density of people per km^2) by the area of the world that is occupied. The occupied area of the world is estimated by simply multiplying the number of aggregation sites in the world by the area of a circle with a radius equal to the mean annual range of a group. The calculated number of persons is then created. These persons are of random sex and have random ages between 16 and 20 (i.e., they are in their early reproductive years). Initial tool assemblages, each containing 10 tools, are created by each male. The metric attributes of tools in these initial assemblages are determined by adding a random copy error (within ± 5 percent) to the mean startup values supplied to the model for *varA* (20.9), *varF* (4.4), *varH* (-1.7), *varI* (5.5) and *thickness* (7.4). These startup values correspond to the mean values of the sample of early fluted points used in the archaeological analysis (see Chapter

Table 4.11. Operations in the BuildModel Method.

Operation	**Description**
Create world	A rectangular "world" of hexagonal grid cells measuring *sizeX* * *sizeY* is created.
Create parcels	One parcel per grid cell (i.e., n = *sizeX* * *sizeY*) is created, added to the *parcelList*, and placed in the world.
Calculate parcel UTM coordinates	The UTM coordinates of the center of each parcel are calculated based on the parcel's XY coordinates, the UTM coordinates of the NW corner of the world, and the size of each grid cell.
Add water	The UTM coordinates of each parcel are compared to a table to determine if the parcel should be coded as "water" (i.e., Great Lakes, Atlantic Ocean, Gulf of Mexico).
Create regions	If the creation of regions is specified (i.e., *regionsOn* == true), two regions are created; Region 1 = all parcels north of UTM 4390700N and east of UTM 290600; Region 2 = all parcels not in Region 1.
Add lithic sources	The location of each lithic source is specified as UTM coordinates; these UTM coordinates are used to identify the parcel that is closest to the UTM position of the lithic source; the lithic source is placed in this parcel and "adopts" the XY and UTM coordinates of the parcel.
Initialize population parameters	Calculate the total area (in km^2) of "land" (i.e., not "water") parcels in the world; calculate mean annual range (in km) of groups based on group mobility parameters; pack aggregation sites into world based on mean annual range and value of *perMeanRangeOverlap* parameter; estimate occupied area of world (in km^2) by multiplying number of aggregation sites by the mean annual range; calculate initial number of persons to create by multiplying the occupied area of the world by the value of the parameter *popDensityModel*, which specifies initial population density in terms of number of persons per km^2.
Create initial population	Create the specified initial population, composed of males and females (randomly determined) between the ages of 16 and 20; add persons to *personList*.
Create initial tools	Create tool assemblages to fill the inventories of all males of tool-making age; dimensions of these initial tools are within +/- *copyError* of metric variables corresponding to midpoints of fluted point sample (*varA* = 20.9; *varF* = 4.4, *varH* = -1.7, *varI* = 5.5, *thickness* =7.4); calculate coordinates of landmarks and values of remaining metric variables
Add people to world	Randomly assign each person to an aggregation site and place that person in the world in a cell (randomly chosen) within 1 tier of aggregation site; set person's XY coordinates and *currentParcel*; set occupied parcel's status to "occupied."
Create initial groups	Create a group to include the persons in each occupied parcel and place that group in the world; set group's XY coordinates and *currentParcel*; add group to *groupList*; set group's aggregation site to be the closest aggregation site; add the occupants of the group to the group's *occupantList* and set the group to be the *currentGroup* of each occupant.

Table 4.12. Spatial Characteristics of ForagerNet2 World when Operating at Scales 1, 2, 3, and 4.

Scale	**Represented Dimensions (km)**		**Represented Area (km^2)**	**Begin UTM (NW corner)**		**Grid size (cells)**		**Number of parcels**
	E-W	**N-S**		**Easting**	**Northing**	**X**	**Y**	
1	2800	2800	7,840,000	-500000	5450000	323	280	90,440
2	2000	1500	3,000,000	-490000	5000000	230	150	34,500
3	1200	1200	1,440,000	160000	5000000	138	120	16,560
4	1700	1700	2,890,000	-340000	5500000	196	170	33,320

7). The coordinates of the landmarks used to define these metric variables are then computed from the metric variables. Each tool is then evaluated to ensure that it falls within the constraints imposed by the model and passes the functional selection test.

Persons are randomly added to the parcels containing aggregation sites and the parcels immediately adjacent to aggregation sites. Initial groups are then created consisting of the persons in each populated parcel. Each group records its occupants, its current parcel, and the identification of the closest aggregation site.

Operation

After the model is built, a run is started. Runs last for a specified number of steps, each of which represents one week. The model performs a sequence of actions each time it takes a step (Table 4.13).

Some actions were performed only once per model year: calculation of yearly household production and updating of household-level statistics; deletion of aggregation sites with a population of zero; fissioning of aggregation sites based on over-population; and adjustment of locations of aggregation sites based on spatial proximity to other aggregation sites.

Some actions were performed only during periods of data collection (see below). These include calculation of link distances, calculation of mean path length, and calculation of network density. The calculation of mean path length is a computationally-expensive operation that has a significant effect on the speed with which the model operates.

Table 4.13. Operations of the Step Method.

Operation	**Description**
Clear lists	Clear lists that are refreshed each step; reset variables that are calculated each step
Calculate carrying capacity adjustment	Divide population size by carrying capacity
Shuffle lists of persons and groups	Shuffle *personList* and *groupList* (random without replacement).
Update clock	Update seasonal clock to reflect current season (season 1 or season 2)
Fission groups	Check the size of each group; if size of group exceeds maximum group size specified by model (set at 40), fission group along household lines
Fuse groups	Check the size of each group; if size of group is less than minimum group size specified by model (set at 10), search for other groups within radius defined by *groupMobilityRadiusCells*; if neighboring groups are available and fusion with one of those groups would create a new group with size < maximum group size, fuse groups
Purge vacant groups	Delete groups that have a size of 0 ("empty" groups can be created through group fission/fusion methods)
Group mobility methods	Each group has an opportunity to move subject to *pGroupMove*; distance of move affected by *groupMoveRadiusCells*; direction of move affected by season, location of aggregation site, and presence of other groups
Determine if groups are in range prior to initiating personal mobility methods	For each group, determine if there are other groups within range for transfer of individuals through personal mobility (radius determined by value of *personMobilityRadiusCells*)
Person mobility methods	Each male of reproductive age (and associated household, if applicable) has an opportunity to move subject to *pPersonMove* and the presence of groups within the personal mobility radius (determined by *personMobilityRadiusCells*)
Calculate mean tool variables for region	Recalculate the mean landmark coordinates for tools by region; only called if *regionCopyO*n = true
Person tool use methods	Methods to use, lose, and discard tools
Person calculate mean tool variables	Recalculate the mean landmark coordinates for each person's current tool inventory
Person step methods	Initiate step method for each person; includes methods for reproduction (for females) and tool learning/manufacture (for males)
Add new people	Add persons born in current step to the world
Tally infanticides	Record data on persons terminated through infanticide; remove those persons from world (dissolve social inks, etc.)
Calculate marriage ratios and bride price	Calculate the ratio of eligible males to eligible females; adjust *bridePrice* according to whether ratio has increased or decreased since last step
Correct local bride information	Person-level methods to collect and update "firsthand" information about eligible brides within personal foraging radius (*foragingRadiusCells*)
Transfer bride information	Person-level methods to transfer "secondhand" information about eligible brides between individuals in same group

Table 4.13. Operations of the Step Method (continued).

Operation	**Description**
Determine marriage order	Create random order in which males will initiate marriage methods
Marriage methods	Initiate person-level methods for marriage
Death methods	Initiate person-level methods for mortality
Remove dead people	Remove dead persons from lists tracking household and group membership, potential bride list (if applicable); record data on age at death; remove social links to and from person; record data about age, sex, marital status, number of children for use in demographic statistics; add person to list of dead people (*deadPersonLis*t); remove person from world
Purge people	Remove persons from *deadPersonList* after they have been on it for 7281 steps
Orphan methods	Check to see if each person is an "orphan" (a person younger than *ageAtProduction* living in a household with no individuals older than *ageAtProduction*; re-house orphans with relatives or other group members
Add acquaintance links	Create acquaintance links between unlinked individuals that are co-resident in a group
Spread signal	If in data recording period, spread the "signal" through face-to-face interaction
Purge dead households	Delete households that have a size of 0
Check household age	Increment the age of a household every 52 steps (i.e., once per year)
Update household statistics	Calculate the productive surplus/deficit for the household for the year (only occurs when *seasonTick* = 0);
Delete null aggregation sites	Delete aggregation sites that have a population of 0 (only occurs once per year when *seasonTick* = 0)
Check aggregation site population	Check the population size of each aggregation site; if population of aggregation site is twice the size of *personsPerAgg*, call methods to fission the population of the aggregation site into two populations, create a new aggregation site for the fissioned population (only occurs once per year when *seasonTick* = 0)
Adjust aggregation site locations	Check proximity of each aggregation site to neighboring aggregation sites; move location of aggregation site to try maintain appropriate distance (determined by settings controlling mean annual group range and the percentage of range overlap between bands) from other aggregation sites (only occurs when *seasonTick* = 0)
Check tick count	Compare current step to the stop/start values of T1, T2, and T3; call appropriate methods to collect data or change variables as specified in experimental settings for run

Experimental Structure and Data Collection

The model was designed to collect various kinds of data during experimental runs. Runs lasted for different numbers of steps depending on the goals of the experiment. An experimental run incorporating two time periods (T1 and T2) lasted a total of 31,200 steps (i.e., 600 years in model time) (Figure 4.13). An experimental period of this length is divided into four parts. The first 5200 steps (100 years) of each run constitute a “burn in” period that allowed time for the system in the model to develop demographic and social network characteristics that are a result of model operations. The next 10,400 steps (200 years) constitute the T1 period, during which aggregate summary data are collected on a variety of demographic and network variables. Midway through T1 (at step 10,400), data are recorded on the age, sex, and number of social links of each currently living person. Immediately following the T1 period, any desired changes are made to system-level parameters. This change in parameters is followed by a 5200-step period of time during which the system responds to the change in parameters. This is followed by the 10,400 step T2 period during which aggregate summary data are again collected. As in T1, cross-sectional demographic data are collected midway through T2. Many of the runs used to produce the data in Chapter 5 were 15,600 steps long (i.e., contained only T1).

The summary data file (SummaryData.txt) produced at the end of a run includes all the aggregate data recorded during T1 and T2 as well as the values

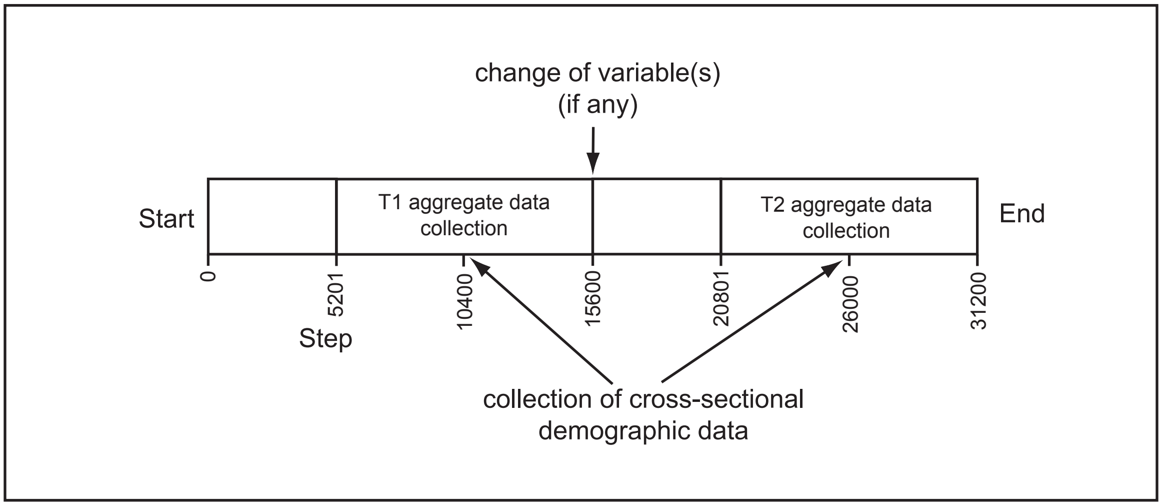


Figure 4.13. Structure of a basic experiment using two time periods (T1 and T2) with a change of variable(s) between T1 and T2.

of key parameters during both of these periods. Cross-sectional demographic data are compiled in a separate text file (DemographicData.txt). Data on the metrics, raw material, manufacturer, and raw materials of individual artifacts that were lost and discarded during T1 and T2 are compiled in another file (ArchToolData.txt). Finally, another file (LinkNumberData.txt) reports the number of links, persons, groups, and aggregation sites at each step of each run. This last file was used to monitor the progress of long runs and provide a check on the data compiled in the summary data file.

Mean path length (or *MPL*, the average number of social steps between any two persons) was calculated at several points during an experimental run. Because this was a very computationally expensive calculation to perform, it was not performed at every step or for every possible pair of persons. Instead, the model was configured to calculate *MPL* probabilistically during 1 percent of the steps during the T1 data collection period (i.e., about 104 times during a 10,400 step period). Each time *MPL* was calculated, the path length between 2000 random pairs of persons was calculated and averaged.

The *MPL* calculation begins by first generating two randomly-ordered lists of persons, each list 2000 long (note that persons can be included on these lists more than once). The path length between the first person on one list (person1) and the first person on the other list (person2) was then determined. First, the model compiles a list of all the persons to which person1 is directly linked. If person2 is on this list (i.e., the two persons are directly linked), the path length between them is 1. If person2 is not on this list, the model adds to the list all the persons who are linked to persons already on the list. If person2 is on this expanded list, the path length between person1 and person2 is 2. This process continues until either a social path is found between person1 and person2 or 60 social “tiers” from person1 have been searched. The model adds the values of all the successful path length calculations and calculates *MPL* by dividing this number by the number of successful path length calculations. The model also reports the number and percentage of unsuccessful path length calculations. These numbers are used to evaluate the degree of connectedness of the population in the model run.

The model includes a mechanism for generating data about the speed of information flow through the population of the model during a run. At the beginning of T1, a random person is chosen from the population to receive a “signal.” The next step, each person who is in face-to-face contact (i.e., occupies the same parcel) with the original signal bearer acquires the signal. The signal is further transmitted each time a person who has acquired the signal comes in contact with a person who has not acquired the signal. The model tracks and reports the number of steps it takes for the signal to reach 50 percent, 75 percent, and 95 percent of the population. The model also tracks and reports the step at which the highest percentage of the population has received the signal.

Model Validation

The validity of a model (how well the model represents what it is intended to represent) can be evaluated by comparing the behaviors of the model with the known behaviors of the real world systems it purports to represent (see Gilbert 2008). For obvious reasons, the behaviors that are the subject of this comparison can be neither those behaviors that are directly programmed into the model nor those behaviors that constitute the emergent phenomena we are trying to investigate. We can, however, make comparisons between data from real world hunter-gatherer systems and corresponding aspects of the model system that are the result of the dynamics of the model. These comparisons allow us to assess the degree to which the internal dynamics of the model match those of the system it represents.

Methods in the ForagerNet2 model that are associated with reproduction, mortality, and marriage are based on those used in the FamilyNet2 model (White 2012). An examination of the behavior of the FamilyNet2 model demonstrated that the systems in that model were similar to ethnographic hunter-gatherer systems in several key aspects. While many of the core “rules” guiding/constraining individual- and family-level behaviors are the same, there are several important differences between the two models. First, interactions in the ForagerNet2 model are mediated by social networks that are situated in a spatial environment. In the FamilyNet2 model, in contrast, interactions had no spatial or network component. Second, the ForagerNet2 model represents two levels of social groupings above that of the family (the foraging group and the band) that are not represented in the FamilyNet2 model. These differences potentially affect demographic aspects of the systems that emerge from the model.

Table 4.14 presents a summary of ethnographic data on hunter-gatherer fertility, infant mortality, marriage age, and mean family size. Summary data

Table 4.14. Summary of Ethnographic Data on Hunter-Gatherer Fertility, Mortality, and Marriage Age.

Variable	**Range**	**Approximate mean**	**Reference(s)**
Reproductive span	8 – 22 years	15 years	Kelly 1995:Table 6.7; Pennington 2001:Table 7.4
Total fertility rate (TFR)	2.6 – 8.0 births	5.4 births	Hewlett 1991:Table 2; Pennington 2001:Table 7.2
Inter-birth interval (IBI)	2.5 – 4.0 years	-	Kelly 1995:Table 6.7; Pennington 2001:Table 7.4
Intensity of polygyny	0 -10 wives	-	Betzig 1986; Keen 2006
Infant mortality	10 – 30 percent	20 percent	Hewlett 1991:Table 3; Kelly 1995:Table 6.9
Childhood mortality	20-50 percent	43 percent	Hewlett 1991:Table 3; Kelly 1995:Table 6.9
Female age at marriage	5 – 22 years	14 years	Binford 2001:Table 8.07
Male age at marriage	12 – 35 years	21 years	Binford 2001:Table 8.07
Female age at first birth	16-23 years	20 years	Kelly 1995:Table 6-7; Pennington 2001:Table 7.4

from several groups of experiments used in the comparisons in Chapter 5 (Table 4.15, Figure 4.14) demonstrate that the model produces values for mean family size, infant mortality, fertility, and mean male and female ages at marriage that fall within ethnographic ranges. There is a relatively low amount of variability among the results from the various experiments. This is consistent with the model settings used in these runs: none of the primary parameters that would affect the calculations and behaviors influencing family-level economics (i.e., marriage, infanticide, reproduction, etc.) were varied in these runs. The settings for *ageAtProduction* (14) and *bridePriceMultiplier* (0) used in these runs would be expected to produce systems with relatively low rates of fertility and small mean family sizes based on results from the FamilyNet2 model (White 2012).

Data about the age and sex of individual persons midway through T1 can be used to characterize the age structure of the populations within the model systems. Figure 4.15 shows example age structure diagrams (i.e., population pyramids) produced from data collected during one step (step 10,400) midway through T1 in four groups of experiment runs. The shapes of these diagrams are generally similar to “expansive” population pyramids characteristic of populations with high rates of both fertility and mortality. While there is little consensus as to what the age structure diagrams of prehistoric hunter-gatherer populations might have been like, the shape of the age structure diagrams produced by model

Table 4.15. Summary of Settings and Mean Results from Experiments Used in Validation of Model.

Exp. ID	Group Mobility Settings	Pop. Density Model	*n* runs	Means during T1				
				TFR	Infant Mortality (percent)	F. Age at Marriage	M. Age at Marriage	Family Size
21-22-09	B	0.001	20	4.3	21.7	18.0	18.7	3.3
05-35-05	D	0.002	17	4.8	22.2	16.7	17.9	3.5
14-56-17	E	0.003	12	4.8	22.1	16.8	18.6	3.5
05-39-15	F	0.002	15	4.3	21.7	18.1	18.9	3.3
21-50-30	G	0.001	20	4.4	21.7	17.7	19.0	3.4

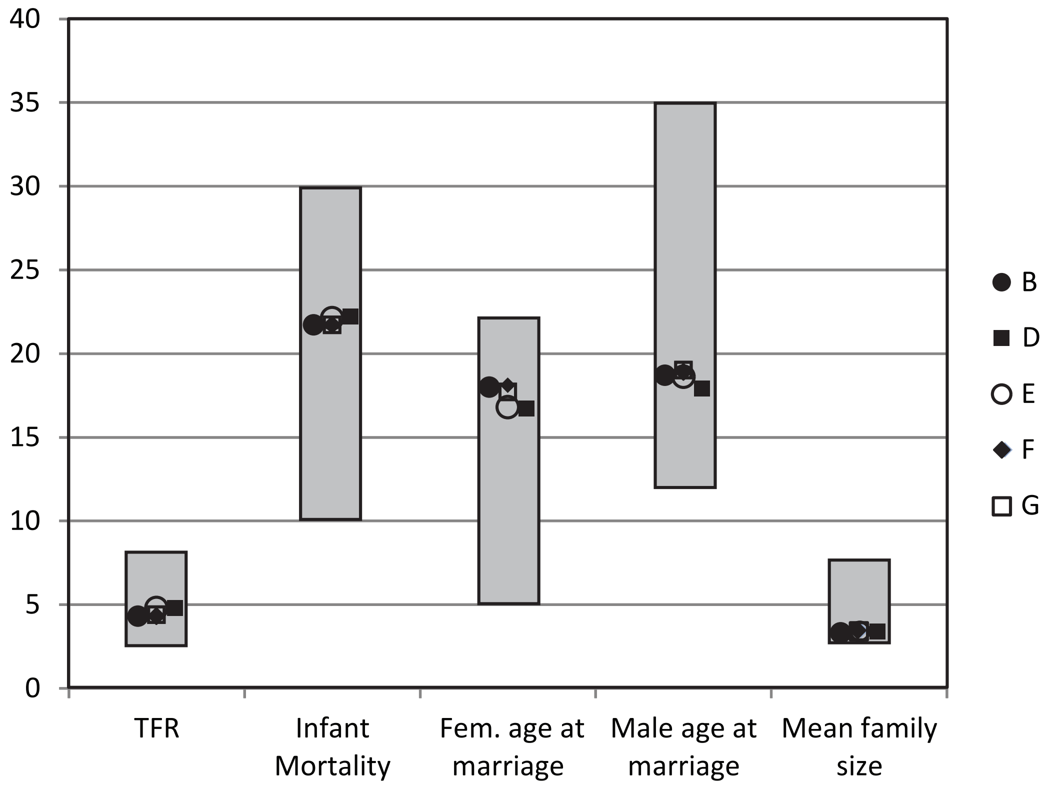
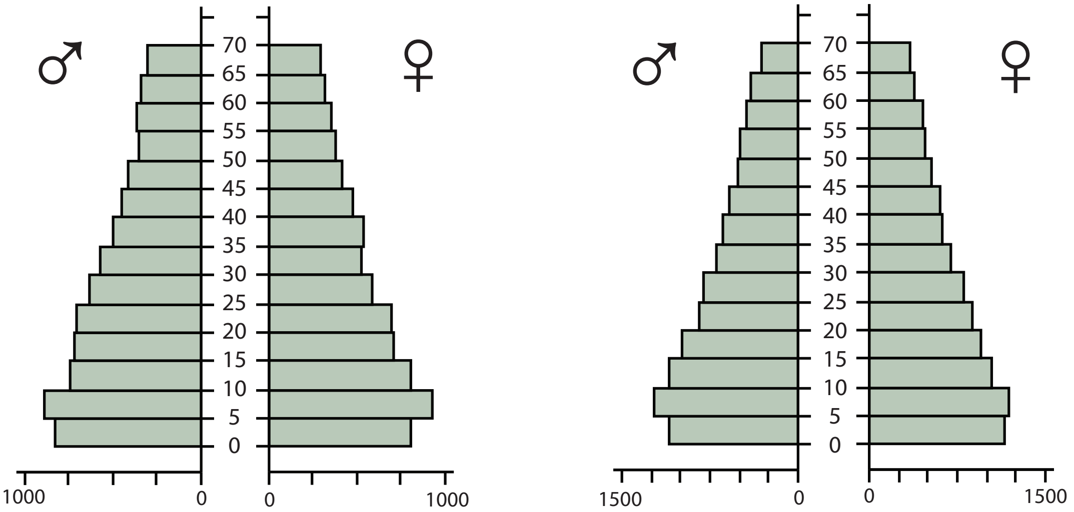
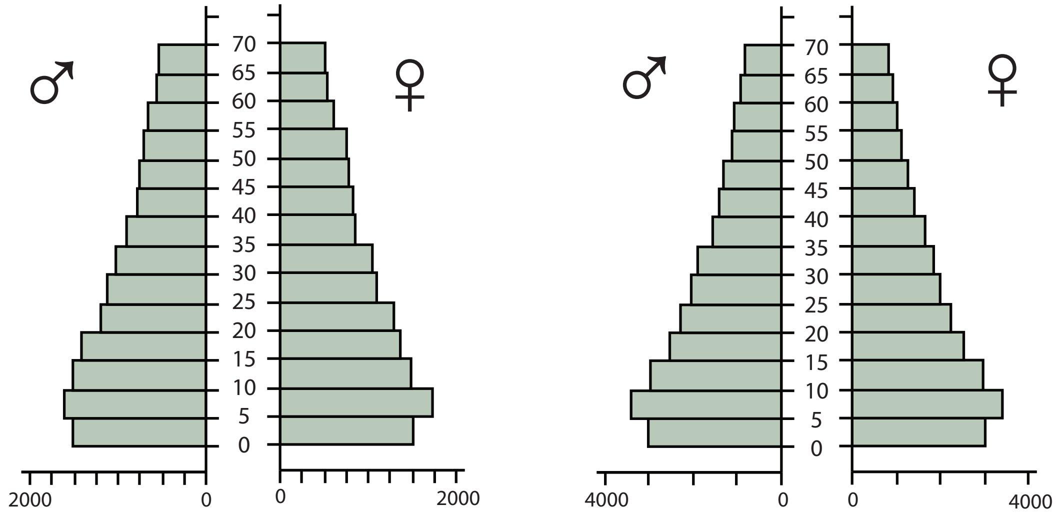


Figure 4.14. Comparison of results from Forager2 model with ranges of ethnographic data. Icons B, D, E, F, and G are model results; ethnographic data range shown in grey boxes. All model results fall within ranges reported from ethnographic hunter-gatherer studies.



Group Mobility Setting B
popDensModel = 0.001
Exp. 21-22-09
Aggregate of 20 runs
Total population = 15, 563

Group Mobility Setting G
popDensModel = 0.001
Exp. 21-50-30
Aggregate of 20 runs
Total population = 20,265



Group Mobility Setting F
popDensModel = 0.002
Exp. 05-39-15
Aggregate of 15 runs
Total population = 28,725

Group Mobility Setting E
popDensModel = 0.003
Exp. 14-56-17
Aggregate of 12 runs
Total population = 52,738

Figure 4.15. Sample age structure diagrams produced by model runs.

systems fall within the general range of those associated with human systems.

Figure 4.16 shows mean trends of change in family size and dependency ratio compiled from data on over 7500 families during the T1 period of four experimental runs (using the same settings as Experiment 21-22-09, see Table 4.16). The expected increases in family size (Figure 4.16A) and dependency ratio (Figure 4.16C) during the expansion phase (i.e., approximately years 0-15) are followed by decreases during the dispersion phase (i.e., approximately years 15-30). Mean family size increases after about year 35. This increase corresponds to a peak in the coefficient of variation (CV) of family size (Figure 4.16B).

This pattern is attributable to the potential for significant variation in family size and composition in the developmental trajectories of “mature” families in the

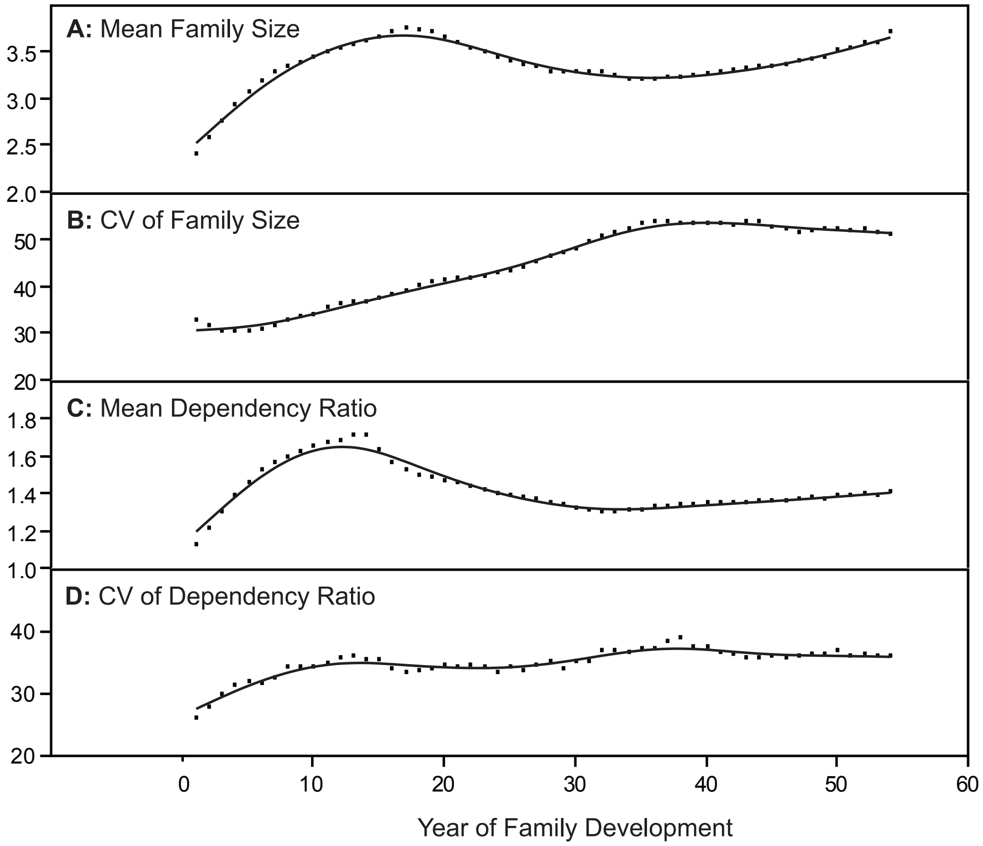


Figure 4.16. Mean changes in family size and dependency ratio through the family-level developmental cycle in model experiments. Points represent mean values calculated from about 7,700 families in four experiments.

model. Figure 4.17 shows that, while polygyny (i.e., the taking of multiple wives) is possible even in very new families, the greatest intensities of polygyny are associated with more mature families (Figure 4.17A). The mean and maximum numbers of wives increase steadily through most of the developmental cycle (Figures 4.17A and 4.17B), concordant with the additive nature of this aspect of family building. Note, however, that families with more than one wife are relatively rare at the default settings used in the experiments considered in this dissertation (Figure 4.18). Polygynous families (i.e., families with more than one wife) occurred in approximately 7.4 percent of the 167,163 family-years used to produce Figures 4.16 and 4.17. Families with more than two wives occurred in less than 1 percent of the cases. There is a single case (i.e., a single family in a single year) of a family with 6 wives.

Change in the mean number of non-producing children (Figure 4.17C)

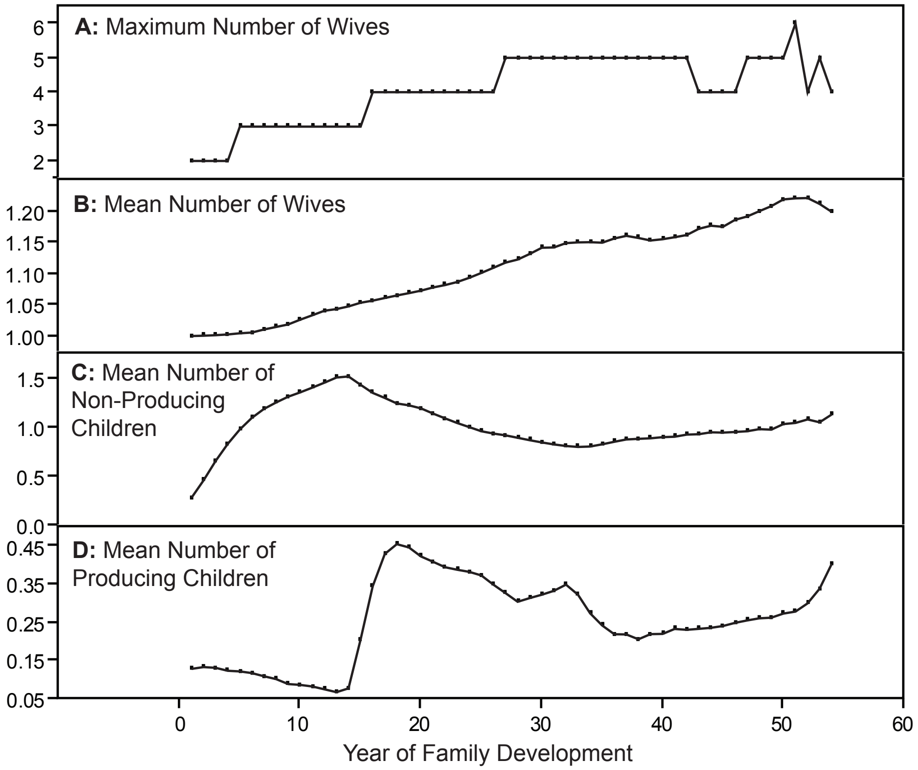


Figure 4.17. Mean changes in the maximum and mean number of wives, the mean number of non-producing children, and the mean number of producing children through the family-level developmental cycle. Points represent mean values calculated from about 7,700 families in four experiments.

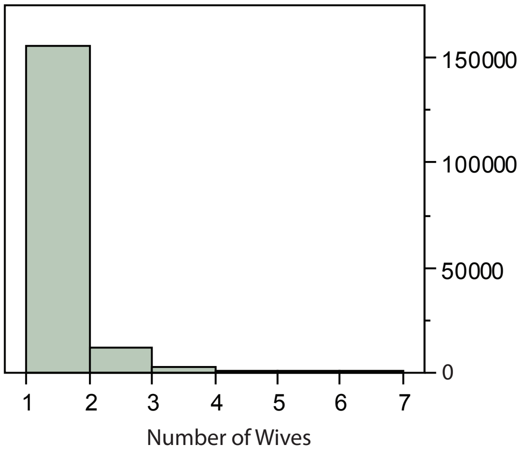


Figure 4.18. Histogram of the number of wives recorded for families in the validation experiment data shown in Figures 4.15 and 4.16.

follows a pattern very similar to that of family size, reflecting the importance of non-producing children in limiting the size of an economically-viable family. The mean number of producing children increases rapidly after year 14 (Figure 4.17D) because *ageAtProduction* is set at 14 in these runs (note that the low mean numbers of producing children prior to year 14 is attributable to mechanisms that allow women to re-marry if the husband dies, creating "new" families that may contain a woman's as-yet-unmarried offspring from a previous marriage). Variability in the timing of reproduction, the death/marriage of offspring, the death of one or more parents, and the addition of wives combine to produce the greatest amount of variability in family size and dependency ratio in mature families.

Finally, the model produces systems with numbers and distributions of social links per person that are concordant with those of real human systems. Figure 4.19 plots the mean, maximum, and standard deviation of number of social links in the same four groups of example runs shown in Figure 4.15. The general pattern is similar in all four examples: the mean, maximum, and standard deviation of the number of links per person increases from birth through about age 30, then is relatively stable. The exception to this is in Experiment 14-56-17, where there is a rapid increase in the maximum number of links following birth and the standard deviation of the number of links decreases after about age 10. In all four examples, the mean number of links of adult persons is between

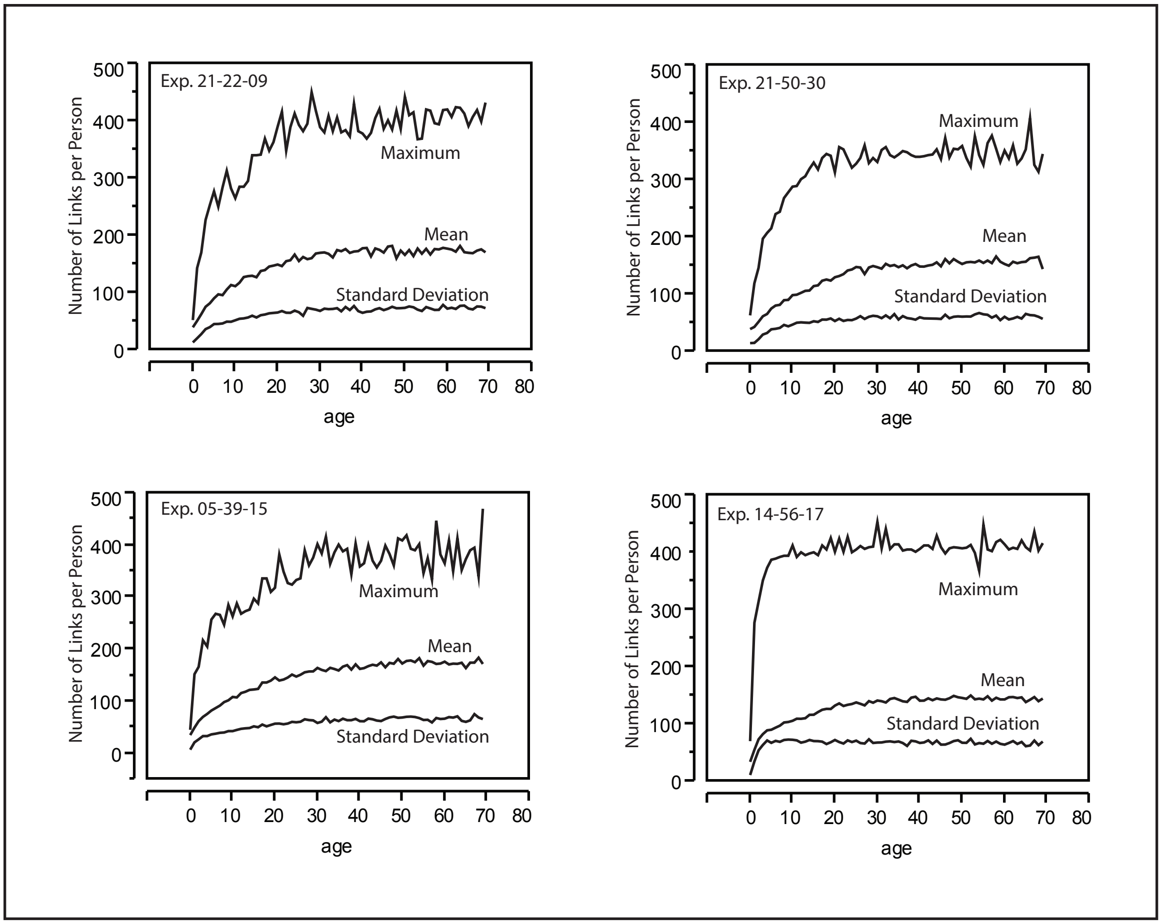


Figure 4.19. Diagrams of the mean, maximum, and standard deviation of the number of social links per person by age in four batches of model experiment runs.

100 and 200. This is concordant with what has been observed in human systems (see Chapter 2).

Distributions of the number of social links per person are right-tailed (Figure 4.20). While some of the variability in the number of links per person is attributable to age (older persons tend to have more social connections), the scatterplots on the right side of Figure 4.20 show that age is not the only factor affecting the number of social links that a person has. The number of possible links increases rapidly with age in all four examples, and there is a wide spread of numbers of links in all age categories. Differences in how the numbers of social links are distributed and how those distributions correspond to age may be connected to the different mobility, marriage, and population density settings of the experiments used to generate these data.

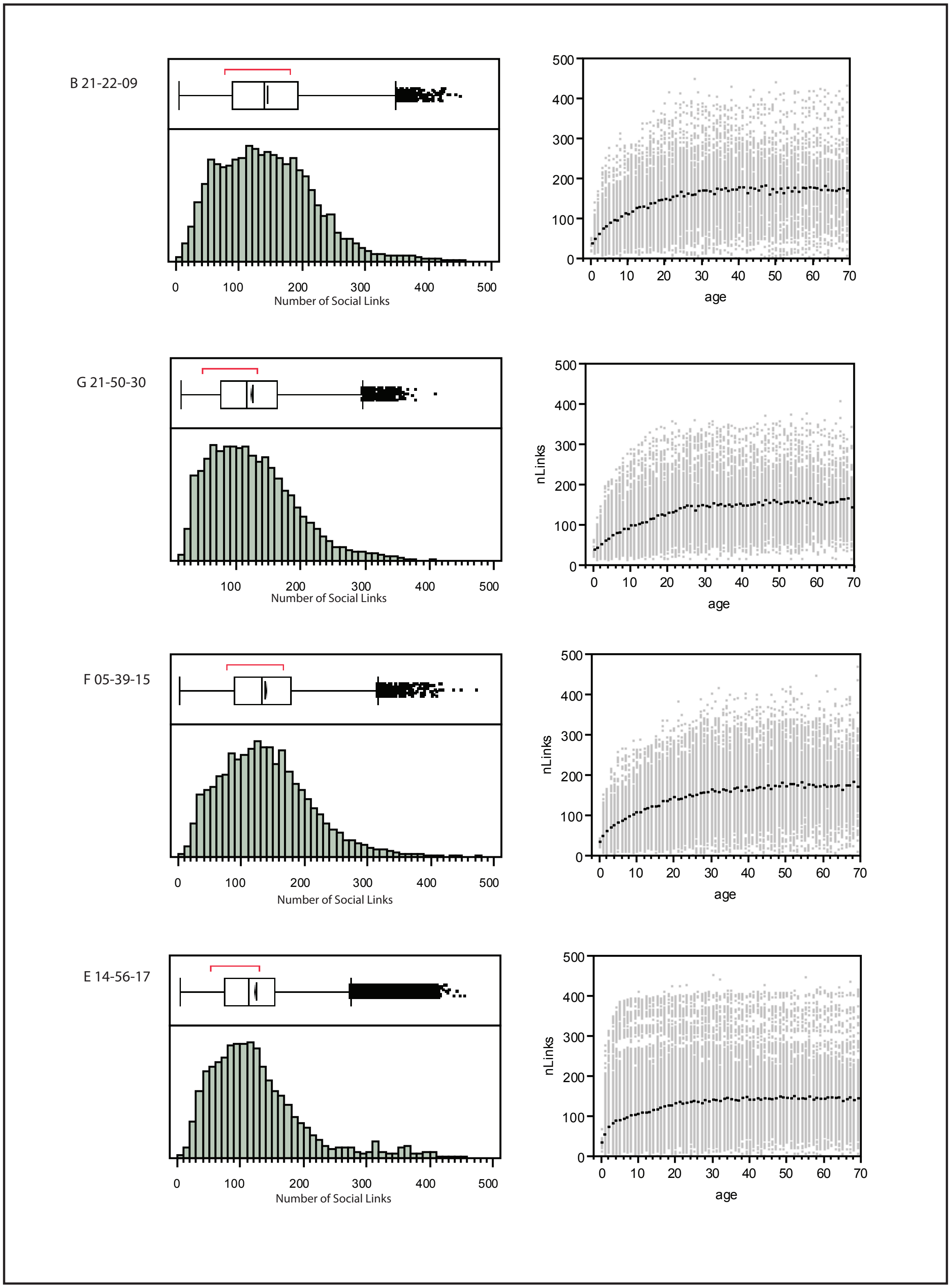


Figure 4.20. Number of links per person from model experiments. Histograms of the number of links per person in batches of four experimental runs (left); all data points of these runs plotted by age (right). The black lines in the charts on the right are the mean numbers of links per person.

In summary, these results suggest the systems in the model produce rates of fertility, infant mortality, and polygyny within the range of those of ethnographic hunter-gatherer systems. Mean family sizes and male and female mean ages at first marriage are also within ethnographic ranges. Patterns of change in family size, composition, and dependency ratio through the developmental cycle match those observed in actual human systems. The model is also capable of producing systems with realistic numbers and distributions of social links. All of these are system-level characteristics that are the result of person-, family- and group-level “rules” and constraints that influence productive, reproductive, and social behavior. Along with age profiles similar to those of real populations, these results suggest that the model reasonably captures key demographic and social dynamics of hunter-gatherer systems and is therefore a valid tool for investigating cause-effect relationships in hunter-gatherer systems.

Chapter 5

MOBILITY, DEMOGRAPHY, MARRIAGE, AND THE CHARACTERISTICS OF SOCIAL NETWORKS IN THE MODEL

A series of experiments was used to explore how parameters of population density, group and personal mobility behaviors, and marriage practices affect the characteristics of social networks formed in the ForagerNet2 model. The purpose of these experiments was to both (1) build understanding of the relationships between the settings of these parameters and the characteristics of the social networks that emerge through the behaviors affected by these parameters and (2) identify combinations of settings that produce model systems with interconnected social networks like those of actual human populations in terms of the numbers of social connections.

This chapter is organized in three parts. First, I define and describe the model parameters of group and personal mobility, population density, and inter-band marriage with reference to the hunter-gatherer ethnographic record. Second, I analyze experimental results to explore relationships between the values of these parameters and the characteristics of the model social networks which they affect. Third, I identify and discuss combinations of settings which reliably produce interconnected, “realistic” social networks and the characteristics of those networks in terms of information transmission. These combinations of settings form the basis for the experimentation discussed in Chapter 8.

Parameters of Mobility, Population Density, and Inter-Band Marriage

Ethnographic data demonstrate that hunter-gatherer systems vary widely in terms of basic factors of mobility, demography, and inter-band marriage that affect the formation of social networks. While these are not the only factors that affect social networks in real hunter-gatherer systems, they are the focus of the analysis here because they constitute basic, general axes along which hunter-gatherer systems vary and can be described. As described in Chapter 4, each of these factors is represented in the ForagerNet2 model. This section describes how settings of model parameters are used to represent variability among hunter-gatherer systems documented ethnographically.

Mobility

There is a large amount of variability in both the scale and frequency of residential group mobility among ethnographically-observed foraging groups (see Chapter 2). Two parameters affect the scale and frequency of residential group mobility in the model: *pGroupMove* (the probability that a group will move each step) and *groupMobilityRadiusCells* (the maximum number of cells that a group can move). Different combinations of values of these two parameters were used to produce eleven different group mobility settings that fall within the range of the ethnographic data provided by Binford (2001) and Kelly (1995) (Table 5.1, Figure 5.1). Not all possible combinations of the scale and frequency of group movement have been observed ethnographically.

Mean annual group ranges associated with each mobility setting are calculated by multiplying the probability of group movement each step by the mean distance that will be moved (see Chapter 4, Table 4.10) by 22 (because one step represents one week of time and groups move away from their aggregation site during the first 22 steps of each year). The areas shown in the column “approximate band range” in Table 5.1 are calculated based on the total land area that would fall within a circle having a radius equal to the mean annual group range. In other words, these areas would correspond to a circular “range” area encompassing the annual movements of many groups that periodically aggregate in the center of the range. The representation of band ranges as relatively circular is a simplifying assumption. At some mobility settings (e.g., A, H, I) this calculation produces “band ranges” that are very large. These settings were not used in the modeling efforts reported here. The “approximate band range” associated with mobility setting B is marginally smaller than the area encompassed by the state of Ohio. This is not completely unreasonable for some estimates of Early Paleoindian mobility based on raw material transport patterns (see below), even given the simplifying assumption of circular ranges.

Relatively few data exist quantifying the scale and frequency of person-

Table 5.1. Parameters and Resulting Characteristics of Mobility Settings.

Mobility setting	***pGroup-Move***	***group-MoveRadius-Cells***	**Mean group move distance (km)**	**Mean *n* annual group moves**	**Mean annual group distance moved (km)**	**Mean annual group range (km)**	**Approximate band range (km^2)**
A	1.0	2	16.7	52	868	367	424,061
B	0.5	2	16.7	26	434	183	106,015
C	1.0	1	10.0	52	520	220	152,053
D	0.5	1	10.0	26	260	110	38,013
E	0.25	1	10.0	13	130	55	9,503
F	0.25	2	16.7	13	217	92	26,503
G	0.1	6	43.7	5	219	96	29,037
H	0.25	6	43.7	13	568	240	181,483
I	0.35	6	43.7	18	787	336	355,708
J	0.1	1	10.0	5	50	22	1,521
K	0.75	1	10.0	39	390	165	85,530

Mean annual group distance moved = (mean group move distance) * (mean *n* annual group moves)
Mean annual group range = (*pGroupMove*) * (mean group move distance)* 22
Approximate band range = (mean annual group range)^2 * pi

and family-level movements between groups. As discussed in Chapter 2, ethnographic accounts indicate that the amount of movement between groups may be very high. For this reason, the probability of person- and family-level movements between groups was treated as a continuous variable. As with group-level mobility, person- and family-level mobility is controlled by the value of two parameters: *pPersonMove* (the probability that a person or family will attempt to move each step) and *personMobilityRadiusCells* (the maximum number of cells that a person can move to switch groups). The value of *personMobilityRadiusCells* was set at 2 for all the experiments discussed here.

Population Density

As with mobility, population density within hunter-gatherer systems varies greatly. The distribution of population densities for 59 hunter-gatherer groups reported by Kelly (1995:Table 6-4) are shown in Figure 5.2A. These density estimates, which vary from 0.002 to 0.65 persons/km^2, are based on the area within the annual range of a group or groups. The distribution is right-tailed, with population density in 48 of the 59 groups falling below 0.1 persons/km^2.

Binford (1983:42-43) draws a contrast between population densities

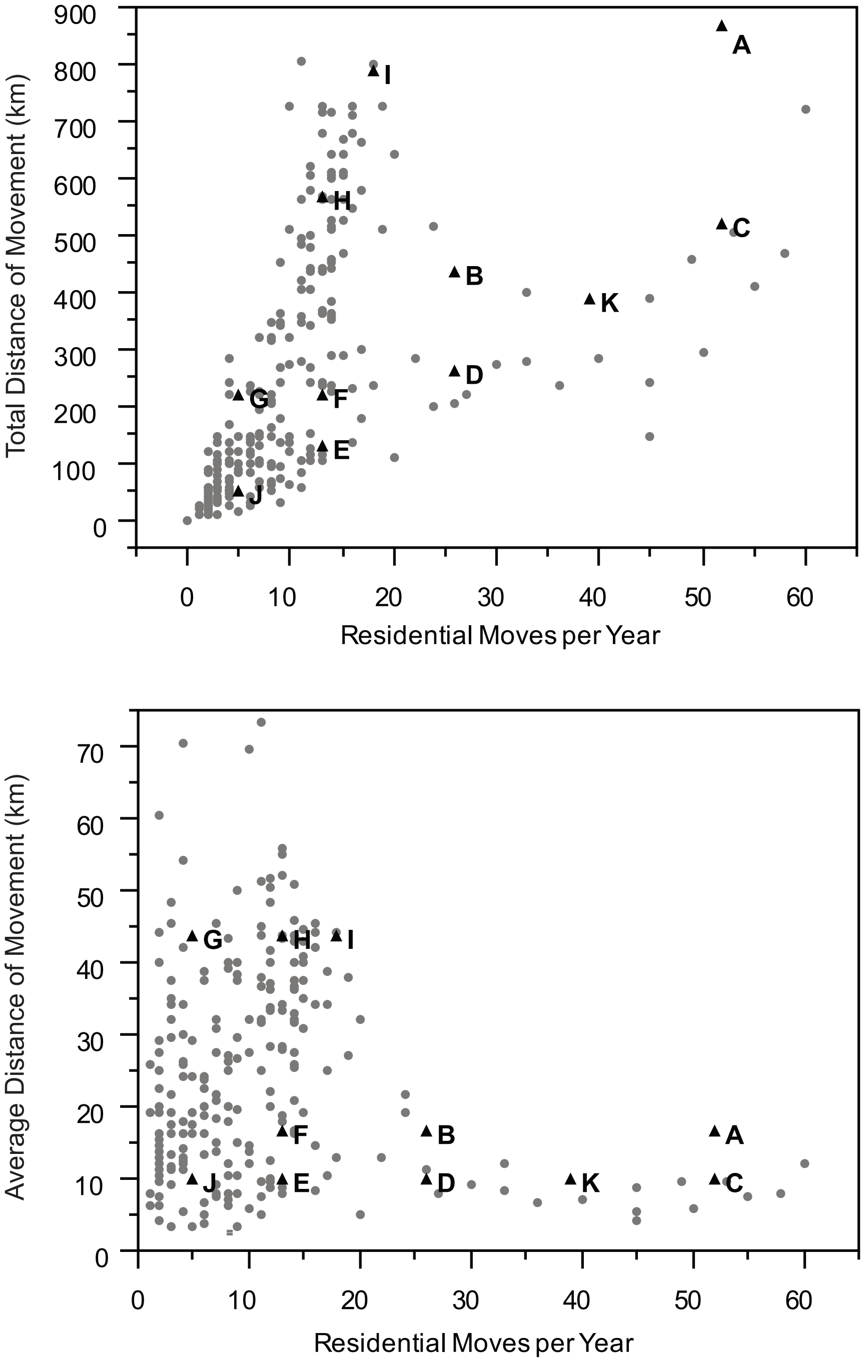
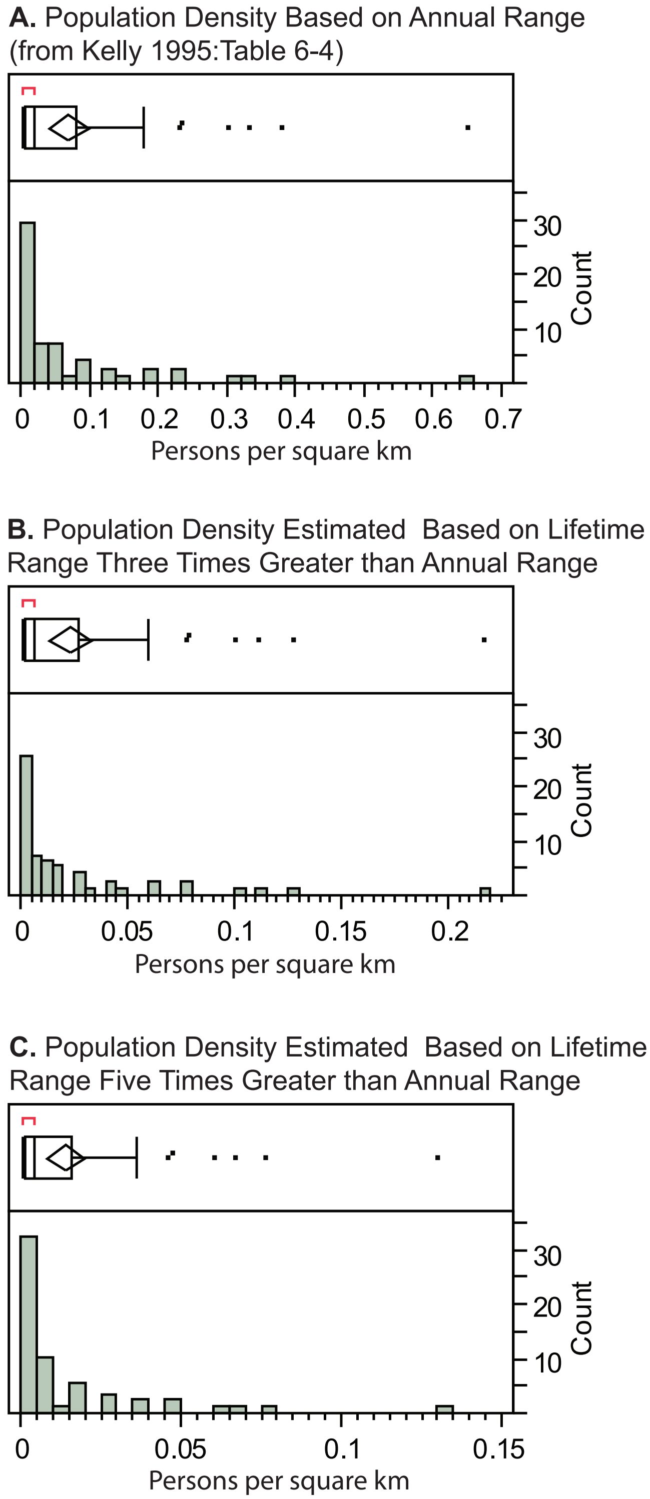


Figure 5.1. Characteristics of model mobility settings plotted against ethnographic mobility data. Ethnographic data from Binford (2001) and Kelly (1995). Data on Montagnais and Ngadadjara provided by Kelly (1995:Table 4-1) excluded.



A. Population Density Based on Annual Range (from Kelly 1995:Table 6-4)

B. Population Density Estimated Based on Lifetime Range Three Times Greater than Annual Range

C. Population Density Estimated Based on Lifetime Range Five Times Greater than Annual Range

Figure 5.2. Population density estimates for ethnographic hunter-gatherer groups. Based on data from Kelly (1995: Table 6-4).

calculated within an annual range and population densities within the full extent of a “lifetime” range, defined as the larger area utilized by a group over the course of many years. In the case of the Nunamiut, for example, the population density calculated using the annual range is about 5 times higher than that calculated when the “lifetime” range is included (0.0058 persons/km^2 for the annual range, 0.0012 persons/km^2 for the lifetime range).

Population densities for the systems created in the ForagerNet2 model are calculated based on the number of persons per total land area occupied over the course of hundreds of years. These density estimates are more similar to the “lifetime range” population densities discussed by Binford (1983) rather than population densities estimated based on an annual pattern of movement.

The bottom two histograms in Figure 5.2 show the data provided by Kelly (1995:Table 6-4) adjusted assuming “lifetime range” population densities are three times (Figure 5.2B) and five times (Figure 5.2C) lower than population densities based on the annual range. When lifetime range population densities are assumed to be three times lower than population densities based on annual range, about half of the cases (28 of 59) fall below 0.006 persons/km^2. When lifetime range population densities are assumed to be five times lower than population densities based on annual range, about half of the cases (29 of 59) fall below 0.004 persons/km^2.

These data suggest that most ethnographic hunter-gatherer groups operate at “lifetime range” population densities below about 0.005 persons/km^2. Population densities in this range are reasonable estimates for late Pleistocene and early Holocene hunter-gatherer systems in eastern North America, which are generally thought to have been characterized by low population densities relative to the systems which followed.

The density of the initial population created at the start of a model run is controlled by the parameter *popDensityModel* (see Chapter 4). For the experiments discussed here, the value of *popDensityModel* was set at 0.001, 0.002, 0.003, 0.004, or 0.005 persons/km^2. After the model calculates the total “occupied” area (in km^2) based on the number of bands placed in the model world and the range of each band, the number of persons in the initial population is determined by multiplying the value of *popDensityModel* by the occupied area. The value of *carryingCapacity* is then set to equal the initial number of persons. Deviations of the size of the population from the value of *carryingCapacity* result in positive or negative feedbacks to probabilities associated with mortality.

Inter-Band Marriage

Marriage is a primary mechanism of establishing social links between hunter-gatherer groups/bands. The ethnographic record details numerous ways in which marriages are arranged and executed. According to Wiessner (2009), all first marriages among the San are arranged by parents. A significant portion of these first marriages were arranged to create ties to distant groups. Creating ties for exchange was the specific reason given for marriage arrangements in 12 percent of all the cases considered by Wiessner (2009:255).

In the ForagerNet2 model, the creation of marriages between individuals that are residents of different bands (i.e., whose current foraging groups use different aggregation sites) is affected by the parameter *pInterBandMarriage* (see Chapter 4). This parameter specifies the probability that a male will seek a bride from a band other than his own. Based on data from several Australian hunter-gatherer groups, Lasker and Crews (1996:236) suggested that about 12-13 percent of marriages were "intertribal." Because few data exist suggesting upper or lower limits on the percentage of inter-band marriage in hunter-gatherer systems, this parameter was treated as a continuous variable to be investigated.

The search for a potential bride from another band is constrained by the variable *interBandMarriageRadius*, which specifies (in cells) the spatial radius within which potential brides from other bands can be identified. For the experiments discussed here, this parameter was set to multiples of the *meanAnnualRange* of groups. At 1x the *meanAnnualRange*, males seek out potential brides from other bands within an area defined by a radius of one *meanAnnualRange* from their current location. At this setting, inter-band marriages are limited to neighboring bands. At 2x the *meanAnnualRange*, the radius could include individuals from non-neighboring bands when groups are at their farthest distance from their aggregation sites. Representations of kinship and marriage/incest taboos remained the same in all model runs (see Chapter 4 for a description).

Experimental Results

The results discussed here are drawn from a total of 3,440 experimental runs conducted at Scale 3 utilizing six of the mobility settings: B, D, E, F, G, and J. These experiments were intended to produce data useful for (1) exploring the relationships between the "causal" variables that affect the formation of social networks in the model (i.e., group mobility, personal mobility, population density, and inter-band marriage) and (2) identifying combinations of settings of group mobility, personal mobility, population density, and inter-band marriage that reliably produce "viable" social networks that are reasonably like those of actual human systems.

The definition of a "viable" social network used here is based on two simple criteria. The first criterion of viability is that the social network that emerges from the interactions of persons in the model must be inter-connected: social paths linking individuals who are not directly tied to one another must be present and discoverable. The threshold for classifying a network as sufficiently inter-connected was set at 90 percent: a network that allows social paths to be identified between any two randomly-selected individuals 90 percent of the time is defined as inter-connected. Search for social paths to calculate the mean path length (*MPL*) of a network was conducted each step during T1 with a probability of 0.01 (i.e., 1 percent of the time). Each time mean path length was calculated, search for a social path was conducted on 2000 random pairings of individuals.

The second criterion of viability is that the mean number of social links per person in the system must be between 100 and 200. This range was chosen to correspond approximately to the approximate mean size of the "active" personal networks that individual humans manage and maintain through personal contact (e.g., see Boissevain 1974:117; Dunbar 2003; Hill and Dunbar 2003; McCarty et al. 2001; Roberts et al. 2009; Stiller and Dunbar 2007). While the personal social networks of individual humans vary greatly in size, the idea that there are general upper and lower limits to the mean size of personal networks within a system is a reasonable one that is supported by empirical data. A relatively broad range of "acceptable" mean links per person was chosen because the model does not represent several factors that are potentially important to both increasing and decreasing the sizes of personal networks (e.g., the time-dependent decay of social contacts, variability in kinship practices). The 100-200 range is thought to be a reasonable filter for rejecting as unrealistic social networks that are characterized by either very high or very low mean numbers of links per person.

The number of aggregation sites placed in the world varies as a function of group mobility parameters (Table 5.2, Figure 5.3). At settings with a greater

Table 5.2. Initial Number of Aggregation Sites and Mean Persons per Aggregation Site Associated with Mobility Settings at Different Population Densities (Scale 3).

Mobility Setting	Initial Number of Aggregation Sites	Mean Persons per Aggregation Site during Experimental Runs at Population Density . . .				
		0.001	**0.002**	**0.003**	**0.004**	**0.005**
B	5-11	94	188	-	-	-
D	22-33	34	74	-	-	-
E	108-125	8	17	28	39	-
F	33-45	23	51	-	-	-
G	29-40	26	55	-	-	-
J	680-718	2	3	4	6	8

mean annual range than B (i.e., A, C, H, and I), the number of aggregation sites that “fit” in the world at Scale 3 ranges from 1 to 6. These settings were not systematically investigated because it was doubtful that the behavior of systems with such a small number of aggregation sites would convey useful information about the relationships between mechanisms of social tie formation and the characteristics of the resulting social networks. These settings can be investigated at larger spatial scales in the future. Mobility setting K was not investigated due to lack of time.

The relationships between population density, personal mobility, inter-band marriage, and the formation of viable social networks will be discussed in turn for group mobility settings B, D, E, F, G, and J. Not all population densities were explored equally for all mobility settings. Emphasis was placed on determining the minimum population densities at which various combinations of settings would reliably produce viable social networks.

Mobility Setting B

The highest degree of group residential mobility investigated here is represented by mobility setting B. At this setting, groups move (on average) every other step and can move a distance of up to 2 cells. At the scales represented in the model, this results in mean annual group movements of over 400 km and a mean group annual range of about 180 km. Between five and 11 aggregation sites are placed on the landscape. At a population density of 0.001 persons/km^2, this results in a mean of 94 persons per aggregation site. At a population density of 0.002 persons/km^2, the mean number of persons per

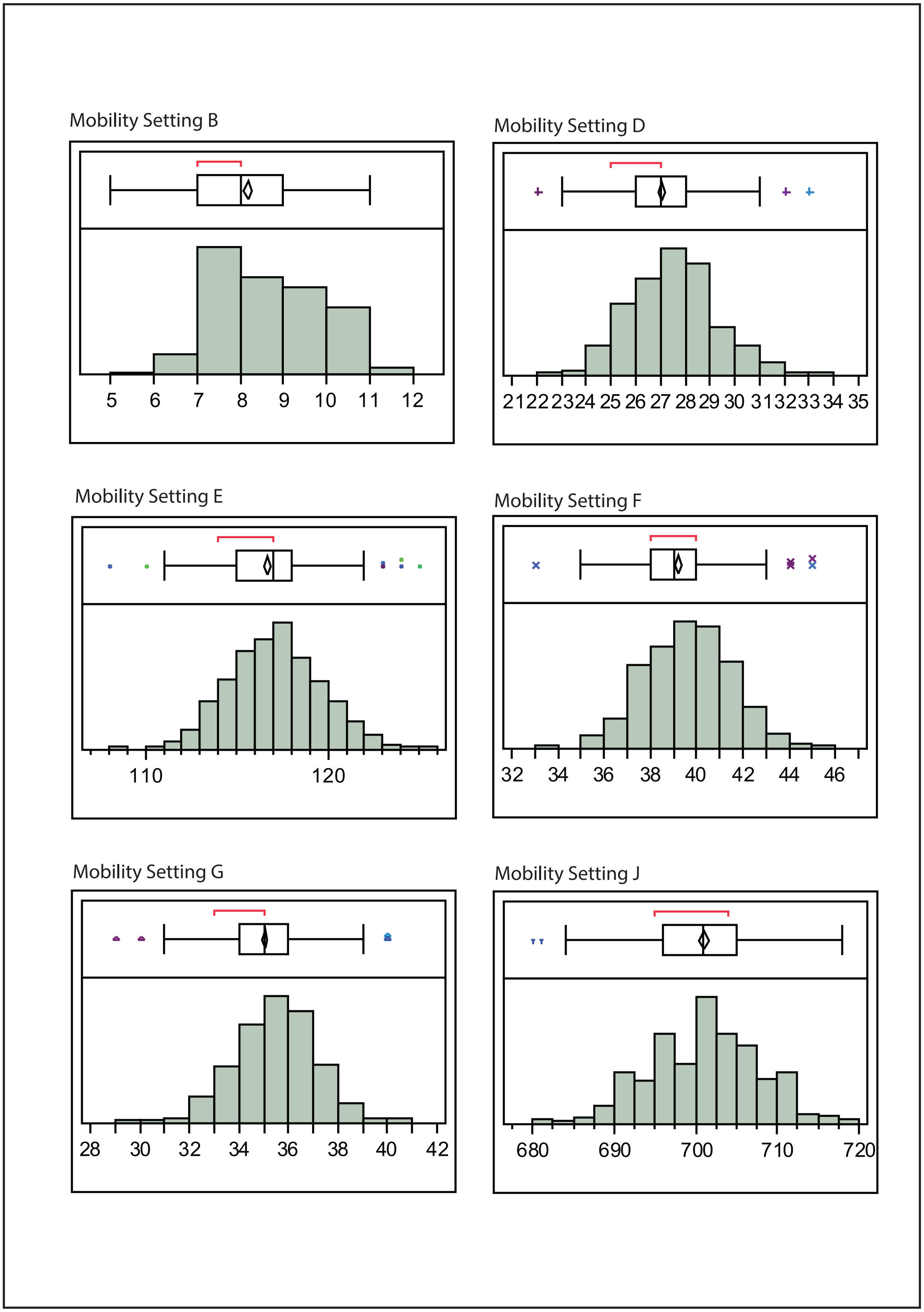
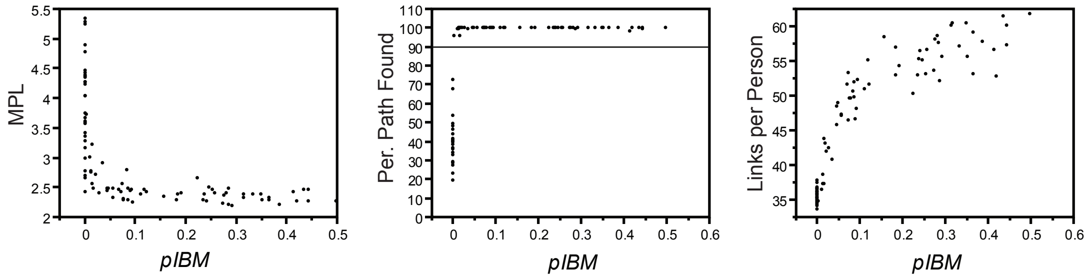


Figure 5.3. Histograms of the number of aggregation sites in the world at different mobility settings (Scale 3).

aggregation site is 188.

Figure 5.4 shows the relationship between the probability of males seeking marriage with a bride from another band (*pInterBandMarriage*, or *pIBM*) and mean path length, percentage of paths found, and mean number of links per person when the value of *popDensityModel* is set to 0.001 (Figure 5.4A) and 0.002 (Figure 5.4B). The value of *pPersonMove* is 0 in these runs (i.e., there is no person-level mobility independent of marriage). At both settings of population density, the relationship between *pIBM* and both mean path length and the percentage of paths found is strongly nonlinear: small increases in *pIBM* over zero result in large decreases in mean path length and highly inter-connected networks. While the value of *pIBM* is related to the mean number of links per person, none of the runs produces a mean number of links per person near 100,

A. *popDensityModel* = 0.001 person/square kilometer,
radius of inter-band marriage = 18 (1x mean annual range)



B. *popDensityModel* = 0.002 person/square kilometer,
radius of inter-band marriage = 18 (1x mean annual range)

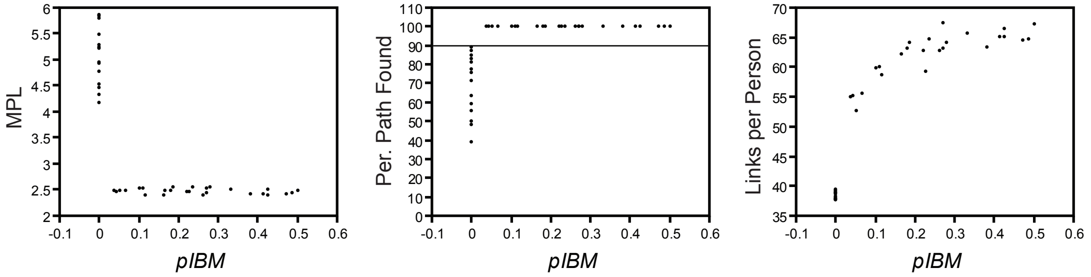


Figure 5.4. Relationship between probability of males seeking marriage with potential bride from a different band (*pIBM*) and mean path length, the percentage of social paths found, and mean number of links per person at population densities of 0.001 persons/km^2 and 0.002 persons/km^2 in mobility setting B.

the lower threshold of the range that is considered “realistic” here.

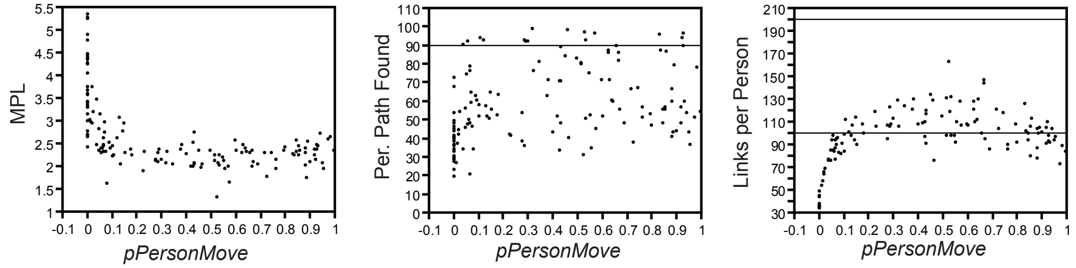
Relationships between the probability of person-level inter-group movement (*pPersonMove*) and mean path length, the percentage of social paths found, and the mean number of links per person are shown in Figure 5.5 for three cases at *popDensityModel* 0.001: (A) where the probability of inter-band marriage is 0; (B) where the value of *pIBM* is 0.10 and males search for potential brides from other groups with a radius of 18 cells (1x the mean annual group range); and (C) where the value of *pIBM* is 0.10 and males search for potential brides from other groups with a radius of 36 cells (2x the mean annual group range). A constant value of *pIBM* of 0.10 was chosen based on the experimental results show in Figure 5.4: it is clear that the primary effects of increasing *pIBM* over zero are realized at low values.

Nonlinear relationships between *pPersonMove* and mean path length and *pPersonMove* and the mean number of links per person are clear in Figure 5.5A: the mean path length rapidly decreases and the mean number of links per person rapidly increases as the value of *pPersonMove* increases. Most of the runs where the value of *pPersonMove* exceeded 0.10 had a mean number of links per person between 100 and 200. The relationship between *pPersonMove* and the percentage of paths found is not as clear. While the lowest percentages of paths found are associated with very low values of *pPersonMove*, increases in the value of this parameter do not strongly affect the percentages of paths found.

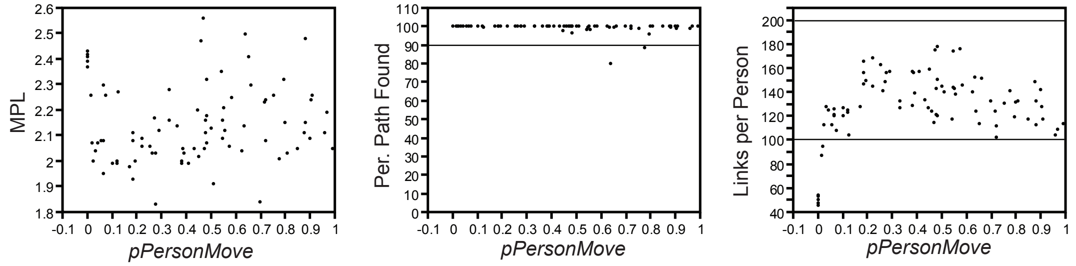
When the probability of inter-band marriage is set to 0.10 (Figures 5.5B and 5.5C), nearly all runs were characterized by inter-connected networks (i.e., networks where the percentage of paths found exceeded 90). As in Figure 5.5A, the mean number of links per person is clearly related to the value of *pPersonMove*. A nonlinear relationship between *pPersonMove* and mean path length is not present, however. The high mean path lengths associated with very low values of *pPersonMove* are not present. As shown in Figure 5.4, this is a result of effects of setting *pIBM* to greater than zero. The differences between the results when the radius of inter-band marriage search is set to 1x or 2x the mean annual range are slight.

Some notable differences are present in the results of runs when the value of *popDensityModel* is set to 0.002 (Figure 5.6). As in the *popDensityModel* = 0.001 runs, the value of *pPersonMove* is related to the mean number of links per person in all three sets of runs and inter-connected systems are reliably produced when *pInterBandMarriage* = 0.10 (Figures 5.6B and 5.6C). Many of

A. Probability of inter-band marriage = 0,
Radius of inter-band marriage = NA



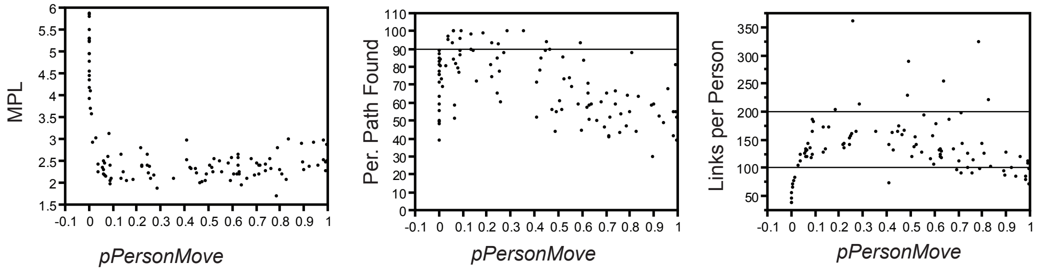
B. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 18 (1x mean annual range)



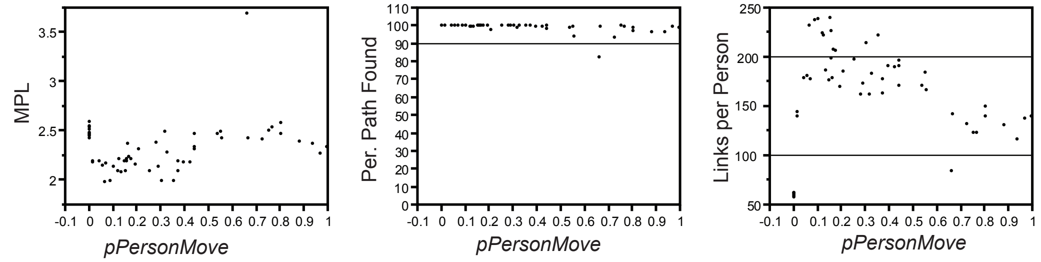
C. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 36 (2x mean annual range)

Figure 5.5. Relationship between value of *pPersonMove* and mean path length, the percentage of social paths found, and mean number of links per person at three different settings of inter-band marriage for mobility setting B, population density 0.001 persons/km^2. Results shown for *pIBM* = 0 (A); *pIBM* = 0.10, radius of search = mean annual range (B); and *pIBM* = 0.10, radius of search = 2x mean annual range (C).

**A. Probability of inter-band marriage = 0,
Radius of inter-band marriage = NA**



**B. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 18 (1x mean annual range)**



**C. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 36 (2x mean annual range)**

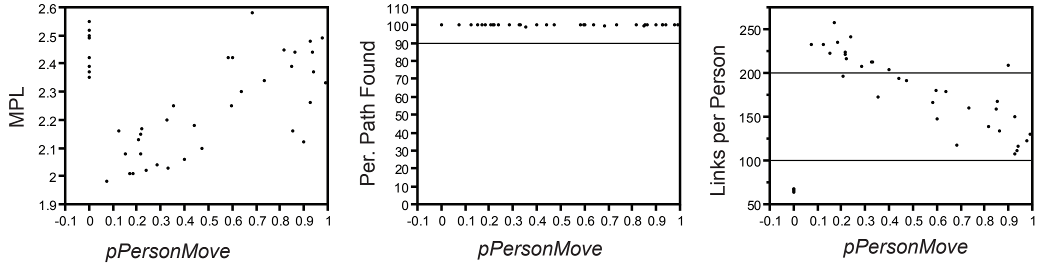


Figure 5.6. Relationship between value of *pPersonMove* and mean path length, the percentage of social paths found, and mean number of links per person at three different settings of inter-band marriage for mobility setting B, population density 0.002 persons/km^2. Results shown for *pIBM* = 0 (A); *pIBM* = 0.10, radius of search = mean annual range (B); and *pIBM* = 0.10, radius of search = 2x mean annual range (C).

the runs at this population density produced networks with relatively high mean numbers of links per person, however, especially at values of *pPersonMove* between 0.10 and 0.40.

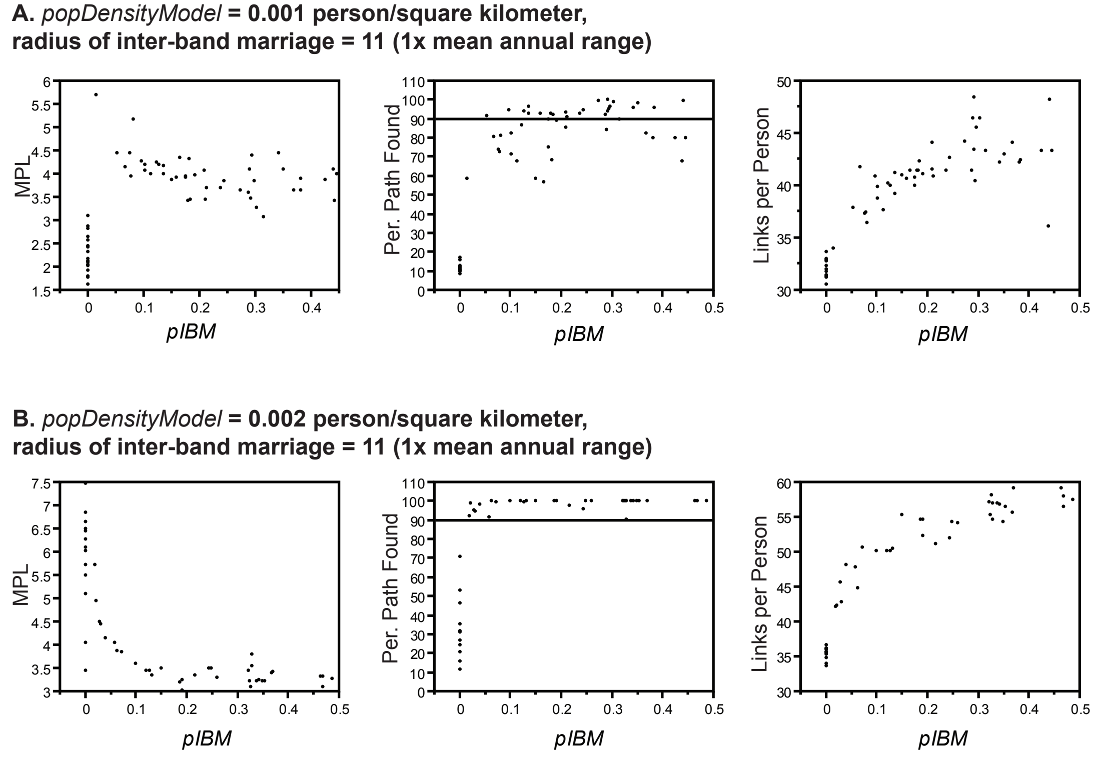
Mobility Setting D

At mobility setting D, residential groups move with the same frequency but, on average, about 60 percent of the distance per move of groups at mobility setting B (i.e., groups move once every other step on average but can move a distance of only 1 cell). This results in band territories that are about one third the area of those in mobility setting B, present on the landscape at about three times the density. The number of persons per aggregation site is correspondingly less than in mobility setting B at the same population densities. At a population density of 0.001 persons/km^2, the mean number of persons per aggregation site is 34 (i.e., lower than the maximum residential group size used during model runs). At a population density of 0.002 persons/km^2, the mean number of persons per aggregation site is 74.

The overall patterns associated with mobility setting D are similar to those seen in the data from mobility setting B but differ in some important respects. The value of *pIBM* is nonlinearly related to mean path length and the percentage of paths found at both population density settings (Figure 5.7). Values of *pIBM* over zero only *reliably* produce inter-connected systems at the higher setting of population density (0.002 persons/km^2), however. At a population density of 0.001 persons/km^2, mean path length is lower rather than higher when *pIBM* = 0. The runs with mean path lengths below 3 at *popDensityModel* 0.001 are associated with low degrees of inter-connectedness (less than 15 percent), suggesting that these low values of mean path length are primarily indicating that social paths can be found only between individuals who are not more than a few steps removed from one another. As in mobility setting B, none of the runs where *pPersonMove* = 0 produces a mean number of links per person over 100.

No combination of settings reliably produces viable networks in mobility setting D when the value of *popDensityModel* is 0.001 (Figure 5.8). While interconnected networks are reliably formed when *pIBM* = 0.10, runs with mean numbers of links per person between 100 and 200 are not reliably produced at any value of *pPersonMove*.

At a population density of 0.002 persons/km^2, viable networks are reliably



A. *popDensityModel* **= 0.001 person/square kilometer, radius of inter-band marriage = 11 (1x mean annual range)**

B. *popDensityModel* **= 0.002 person/square kilometer, radius of inter-band marriage = 11 (1x mean annual range)**

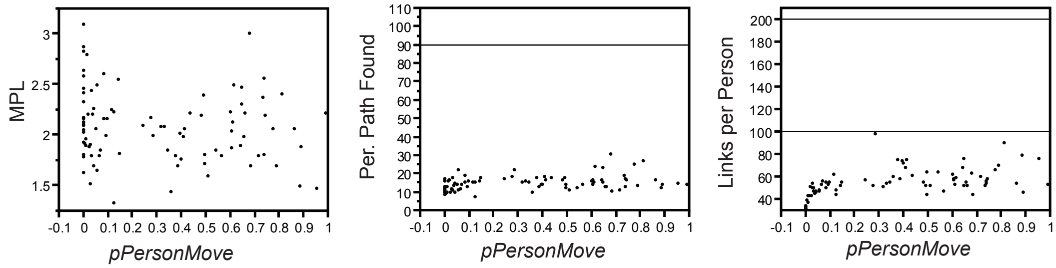
Figure 5.7. Relationship between probability of males seeking marriage with potential bride from a different band (*pIBM*) and mean path length, the percentage of social paths found, and mean number of links per person at population densities of 0.001 persons/km^2 and 0.002 persons/km^2 in mobility setting D.

formed at low values of *pPersonMove* when *pIBM* = 0.10 and the radius for inter-band marriage is 1x the mean annual range (Figure 5.9B). When the radius for inter-band marriage is doubled, most runs where *pPersonMove* > 0 produced a viable network.

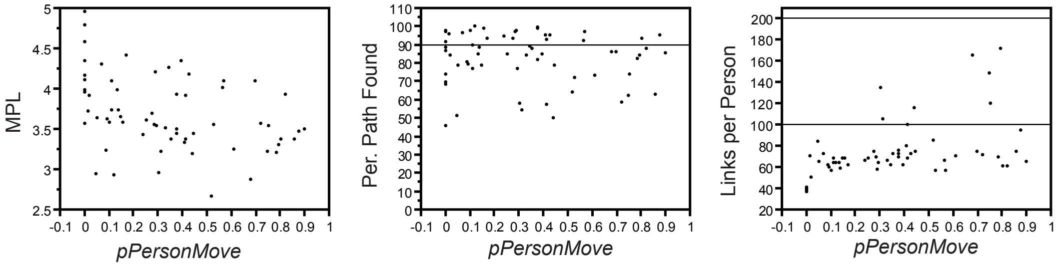
Mobility Setting E

In mobility setting E, residential groups move the same distance per move as groups at mobility setting D, but at half the frequency (i.e., groups move once every four steps on average with moves limited to a distance of 1 cell). Mobility setting E produces mean annual group ranges half as large as those of D, band

A. Probability of inter-band marriage = 0,
Radius of inter-band marriage = NA



B. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 11 (1x mean annual range)



C. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 22 (2x mean annual range)

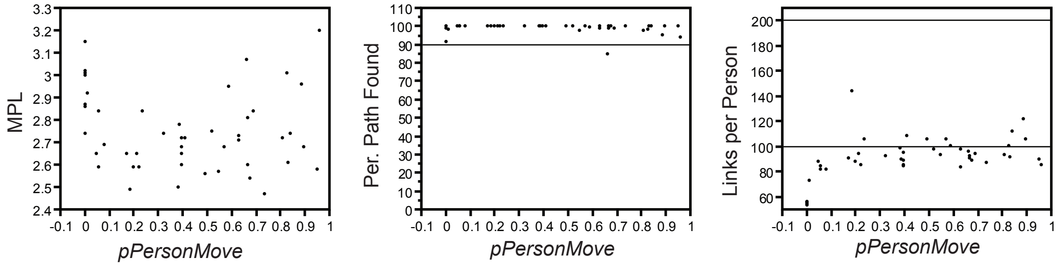
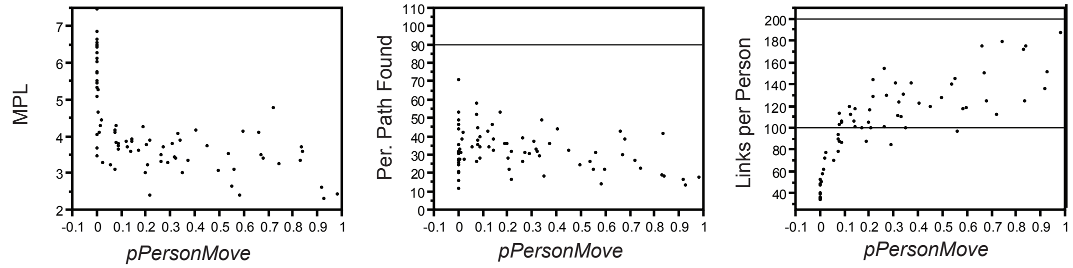
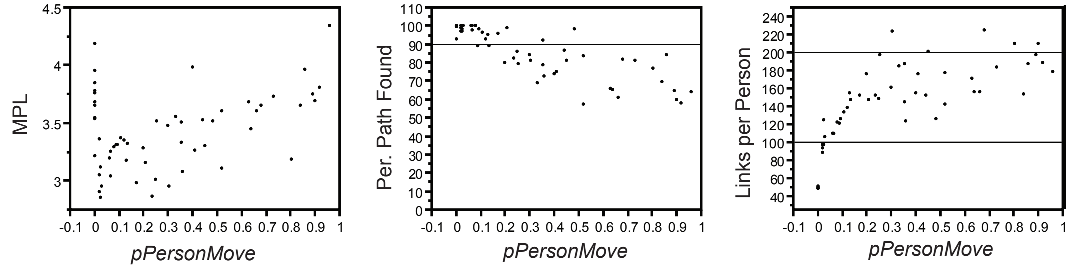


Figure 5.8. Relationship between value of *pPersonMove* and mean path length, the percentage of social paths found, and mean number of links per person at three different settings of inter-band marriage for mobility setting D, population density 0.001 persons/km^2. Results shown for *pIBM* = 0 (A); *pIBM* = 0.10, radius of search = mean annual range (B); and *pIBM* = 0.10, radius of search = 2x mean annual range (C).

A. Probability of inter-band marriage = 0,
Radius of inter-band marriage = NA



B. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 11 (1x mean annual range)



C. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 22 (2x mean annual range)

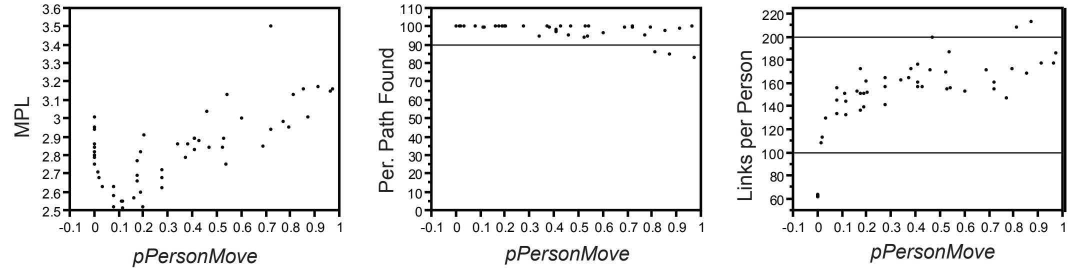
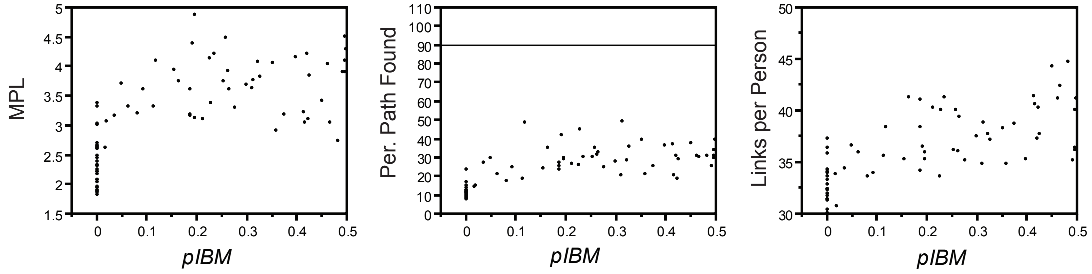


Figure 5.9. Relationship between value of *pPersonMove* and mean path length, the percentage of social paths found, and mean number of links per person at three different settings of inter-band marriage for mobility setting D, population density 0.002 persons/km^2. Results shown for *pIBM* = 0 (A); *pIBM* = 0.10, radius of search = mean annual range (B); and *pIBM* = 0.10, radius of search = 2x mean annual range (C).

territories one quarter of the area, and about four times as many aggregation sites on the landscape. Only at a population density of 0.004 persons/km^2 does the mean number of persons per aggregation site approach the maximum group size allowed by the model.

Holding the value of *pPersonMove* constant at 0, increasing *pIBM* has the expected effect of increasing the inter-connectedness of the network (Figure 5.10). At population densities 0.001 and 0.002 persons/km^2, however, no value of *pIBM* between 0 and 0.5 is sufficient to reliably produce inter-connected networks in mobility setting E. The relationship between the value of *pIBM* and mean path length in these low population density runs is similar to that seen for mobility setting D when *popDensityModel* = 0.001: increasing *pIBM* from 0 tends to increase mean path length. Again, the runs with relatively low mean

A. *popDensityModel* **= 0.001 person/square kilometer, radius of inter-band marriage = 5 (1x mean annual range)**



B. *popDensityModel* **= 0.002 person/square kilometer, radius of inter-band marriage = 5 (1x mean annual range)**

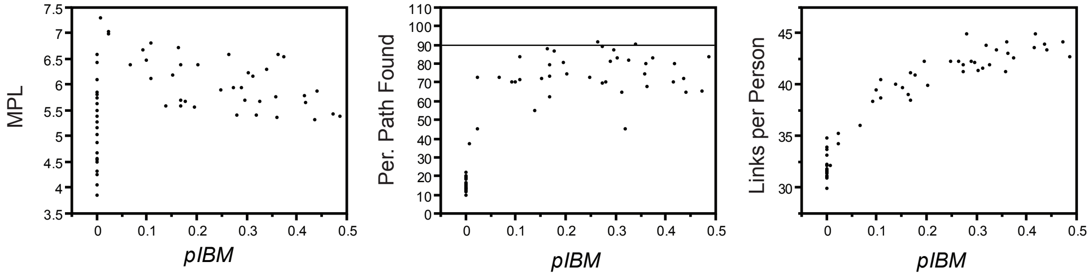


Figure 5.10. Relationship between probability of males seeking marriage with potential bride from a different band (*pIBM*) and mean path length, the percentage of social paths found, and mean number of links per person at population densities of 0.001 persons/km^2 and 0.002 persons/km^2 in mobility setting E.

path lengths are associated with low degrees of inter-connectedness, suggesting that these low values of mean path length are primarily indicating that social paths can be found only between individuals who are not more than a few steps removed from one another. As in mobility settings B and D, none of the runs where *pPersonMove* = 0 produces a mean number of links per person over 100.

No combination of settings reliably produces viable networks in mobility setting E when the value of *popDensityModel* is 0.001 or 0.002 (Figures 5.11 and 5.12). At a population density of 0.003 persons/km^2, viable networks are reliably produced at low values of *pPersonMove* (0.01-0.20) when *pIBM* = 0.10 and the inter-band marriage radius is 2x the annual group range (Figure 5.13C).

Mobility Setting F

Patterns of relationship in mobility setting F are similar to those associated with mobility setting D. These two mobility settings result in roughly comparable amounts of group-level mobility, as groups in mobility setting F move with half the frequency but 1.67x the distance of groups in mobility setting D (i.e., groups move once every four steps on average and can make moves of 1 or 2 cells).

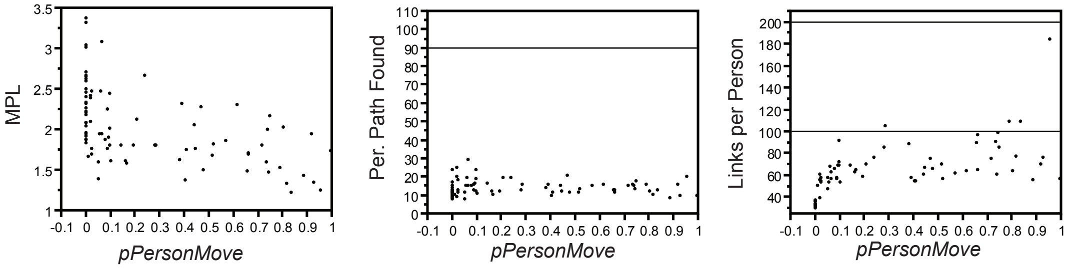
When *pPersonMove* is held at 0, values of *pIBM* > 0 reliably produce inter-connected systems at a population density of 0.002 persons/km^2 (Figure 5.14). The required mean number of social links per person is not reliably produced at any combination of settings at a population density of 0.001 persons/km^2 (Figure 5.15). When a value of *pIBM* > 0 is coupled with values of *pPersonMove* > 0, viable networks are produced at both settings of inter-band marriage radius at a population density of 0.002 persons/km^2 (Figure 5.16).

Mobility Setting G

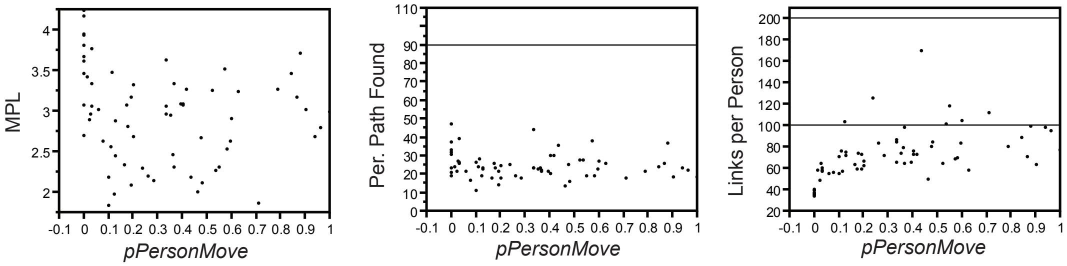
In mobility setting G, foraging groups make relatively fewer but longer residential moves compared to groups in mobility settings B, D, E, and F. In terms of mean annual group range, mean annual group distance moved, and the approximate area of band sizes, mobility settings F and G are comparable (see Table 5.1). Groups in mobility setting G move with about 40 percent of the frequency of groups in mobility setting F, but can move up to about 2.5x the distance in a single move.

Values of *pIBM* > 0 reliably produce inter-connected systems at population

A. Probability of inter-band marriage = 0,
Radius of inter-band marriage = NA



B. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 5 (1x mean annual range)



C. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 10 (2x mean annual range)

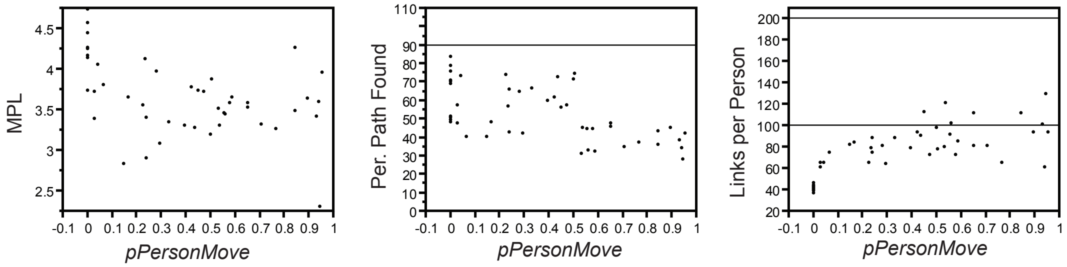
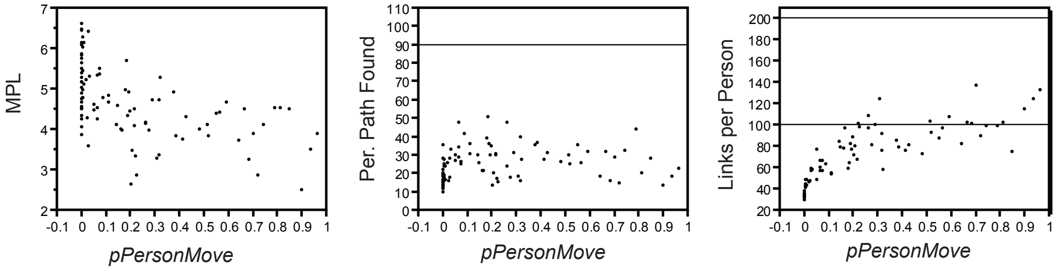
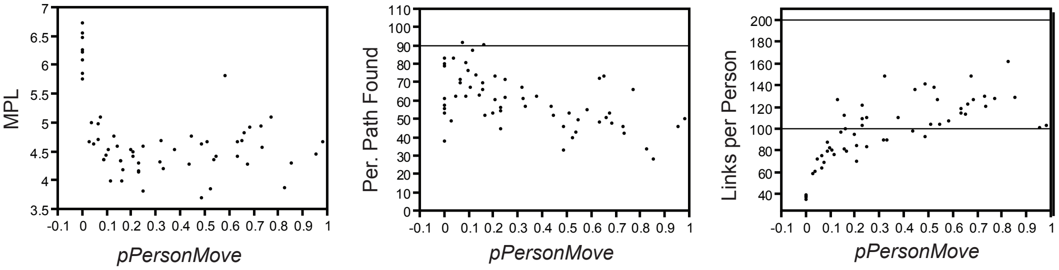


Figure 5.11. Relationship between value of *pPersonMove* and mean path length, the percentage of social paths found, and mean number of links per person at three different settings of inter-band marriage for mobility setting E, population density 0.001 persons/km^2. Results shown for *pIBM* = 0 (A); *pIBM* = 0.10, radius of search = mean annual range (B); and *pIBM* = 0.10, radius of search = 2x mean annual range (C).

A. Probability of inter-band marriage = 0,
Radius of inter-band marriage = NA



B. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 5 (1x mean annual range)



C. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 10 (2x mean annual range)

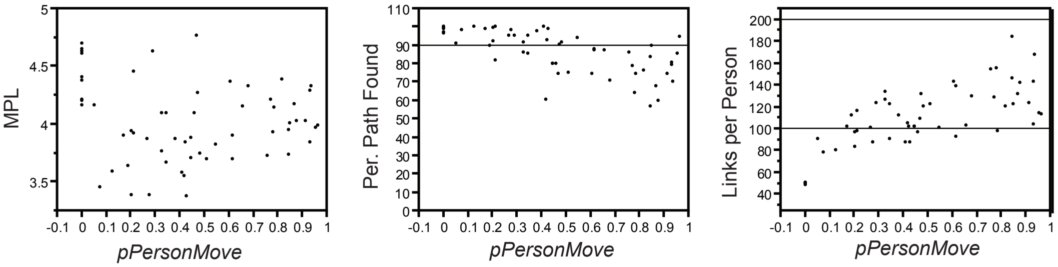
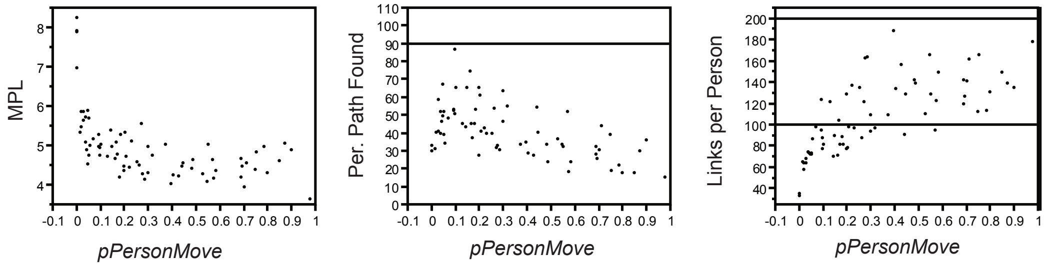
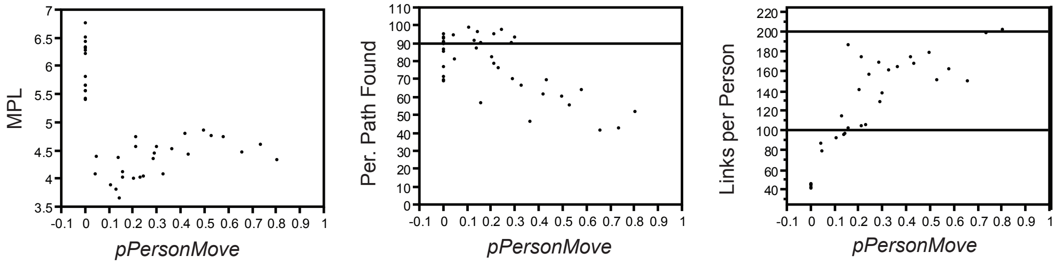


Figure 5.12. Relationship between value of *pPersonMove* and mean path length, the percentage of social paths found, and mean number of links per person at three different settings of inter-band marriage for mobility setting E, population density 0.002 persons/km^2. Results shown for *pIBM* = 0 (A); *pIBM* = 0.10, radius of search = mean annual range (B); and *pIBM* = 0.10, radius of search = 2x mean annual range (C).

A. Probability of inter-band marriage = 0,
Radius of inter-band marriage = NA



B. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 5 (1x mean annual range)



C. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 10 (2x mean annual range)

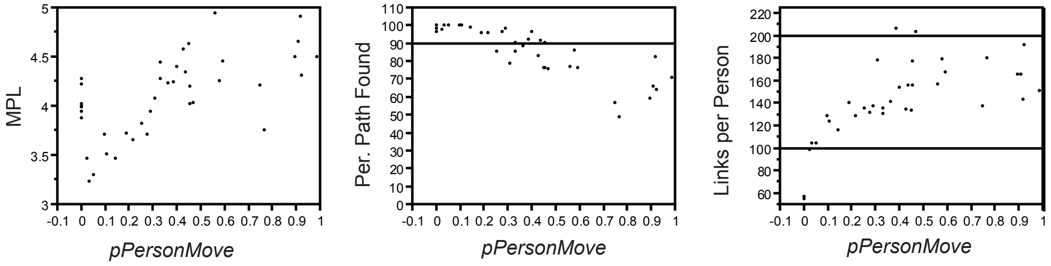
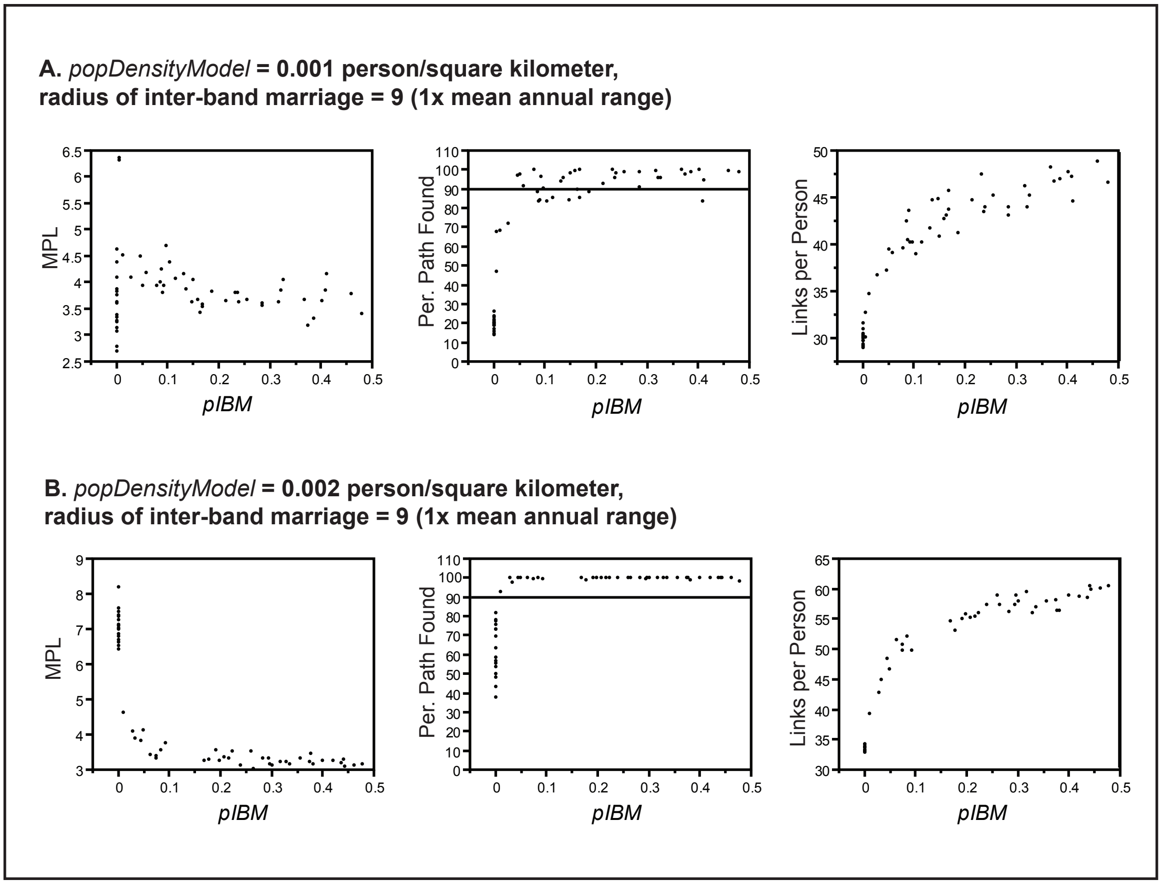


Figure 5.13. Relationship between value of *pPersonMove* and mean path length, the percentage of social paths found, and mean number of links per person at three different settings of inter-band marriage for mobility setting E, population density 0.003 persons/km^2. Results shown for *pIBM* = 0 (A); *pIBM* = 0.10, radius of search = mean annual range (B); and *pIBM* = 0.10, radius of search = 2x mean annual range (C).



A. *popDensityModel* **= 0.001 person/square kilometer, radius of inter-band marriage = 9 (1x mean annual range)**

B. *popDensityModel* **= 0.002 person/square kilometer, radius of inter-band marriage = 9 (1x mean annual range)**

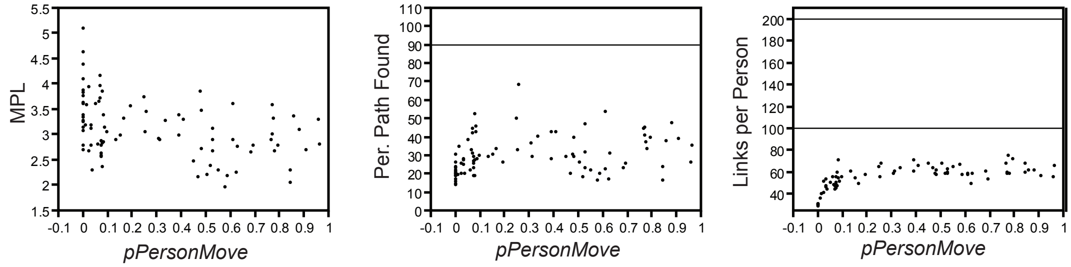
Figure 5.14. Relationship between probability of males seeking marriage with potential bride from a different band (*pIBM*) and mean path length, the percentage of social paths found, and mean number of links per person at population densities of 0.001 persons/km^2 and 0.002 persons/km^2 in mobility setting F.

densities of 0.001 and 0.002 persons/km^2 (Figure 5.17). As in other mobility settings, however, inter-band marriage does not produce the required mean number of social links per person in the absence of personal mobility.

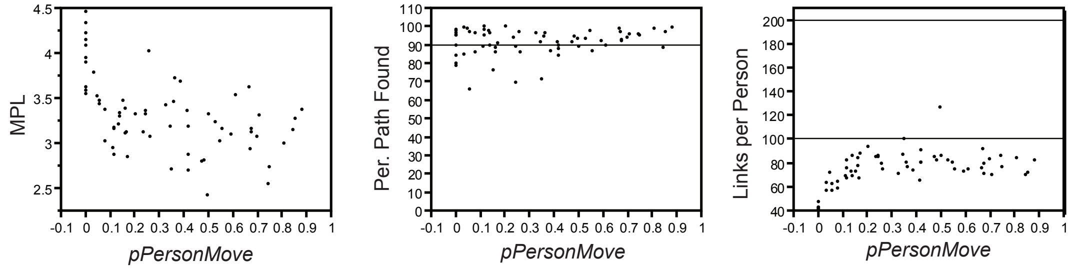
At a population density of 0.001 persons/km^2, viable networks are reliably created when the radius of inter-band marriage is 2x the mean annual range and values of *pPersonMove* are moderate (0.20-0.70) (Figure 5.18). When the population density is 0.002 persons/km^2, viable networks are reliably created in the absence of inter-band marriage that is guided by *pIBM* (Figure 5.19). When *pIBM* = 0.10, some systems are produced with mean numbers of social links per person above the threshold for what is considered realistic (i.e., > 200), especially when the radius for inter-band marriage is 2x the mean annual range.

These data suggest that person- and group-level interactions in mobility

A. Probability of inter-band marriage = 0,
Radius of inter-band marriage = NA



B. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 9 (1x mean annual range)



C. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 18 (2x mean annual range)

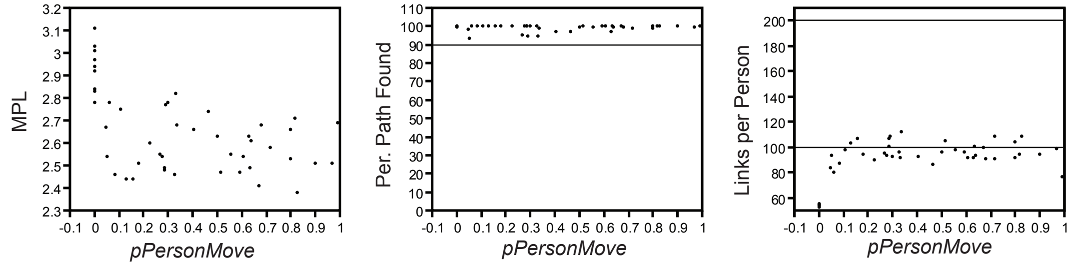
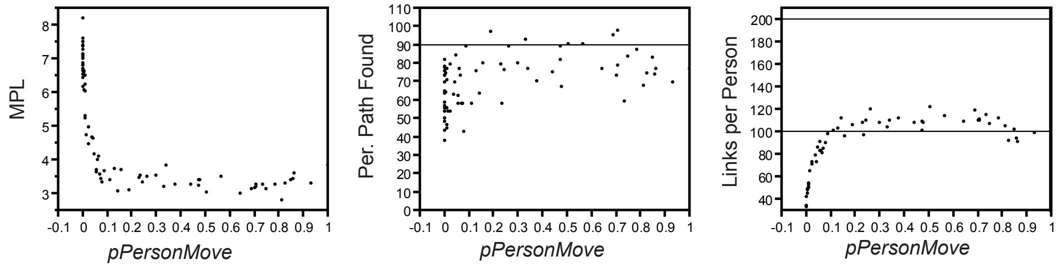
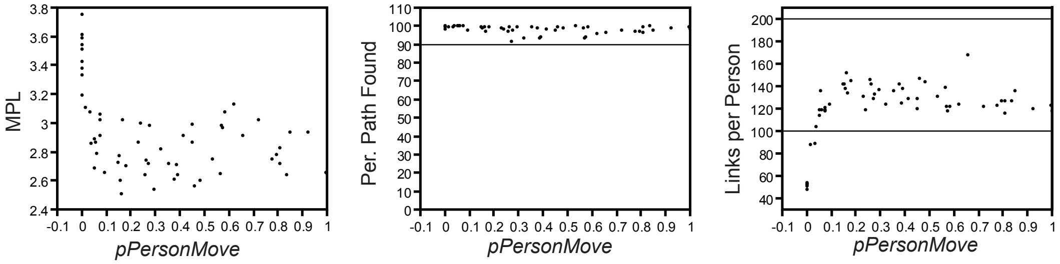


Figure 5.15. Relationship between value of *pPersonMove* and mean path length, the percentage of social paths found, and mean number of links per person at three different settings of inter-band marriage for mobility setting F, population density 0.001 persons/km^2. Results shown for *pIBM* = 0 (A); *pIBM* = 0.10, radius of search = mean annual range (B); and *pIBM* = 0.10, radius of search = 2x mean annual range (C).

A. Probability of inter-band marriage = 0,
Radius of inter-band marriage = NA



B. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 9 (1x mean annual range)



C. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 18 (2x mean annual range)

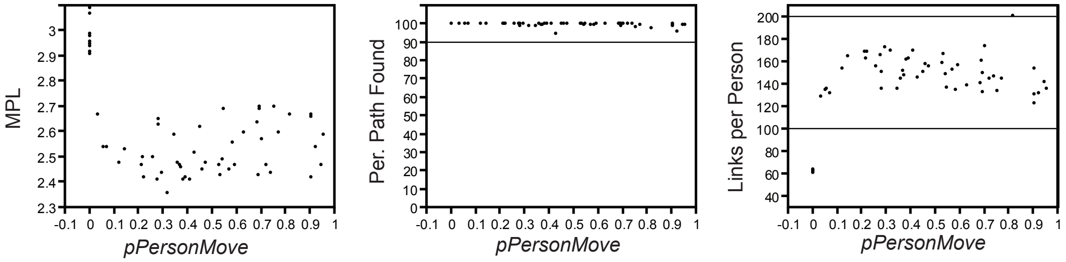
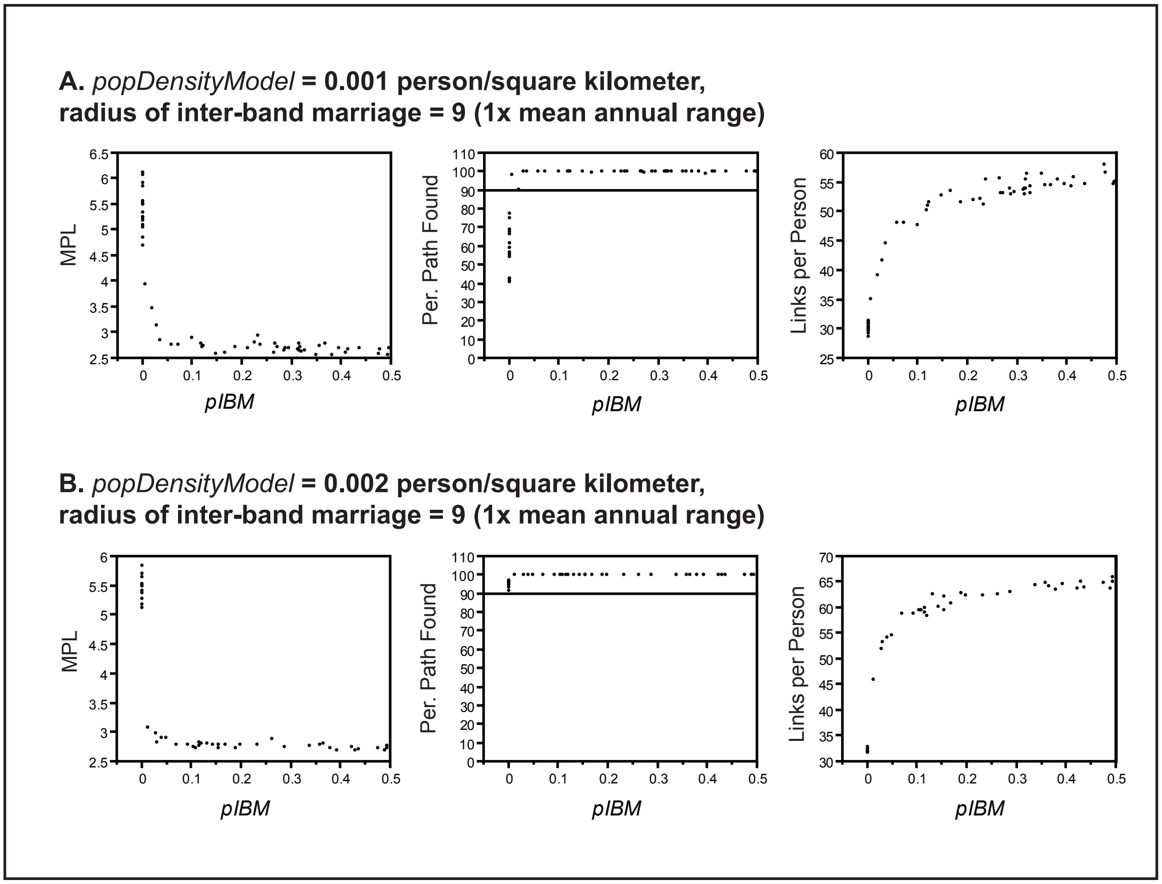


Figure 5.16. Relationship between value of *pPersonMove* and mean path length, the percentage of social paths found, and mean number of links per person at three different settings of inter-band marriage for mobility setting F, population density 0.002 persons/km^2. Results shown for *pIBM* = 0 (A); *pIBM* = 0.10, radius of search = mean annual range (B); and *pIBM* = 0.10, radius of search = 2x mean annual range (C).



A. *popDensityModel* **= 0.001 person/square kilometer, radius of inter-band marriage = 9 (1x mean annual range)**

B. *popDensityModel* **= 0.002 person/square kilometer, radius of inter-band marriage = 9 (1x mean annual range)**

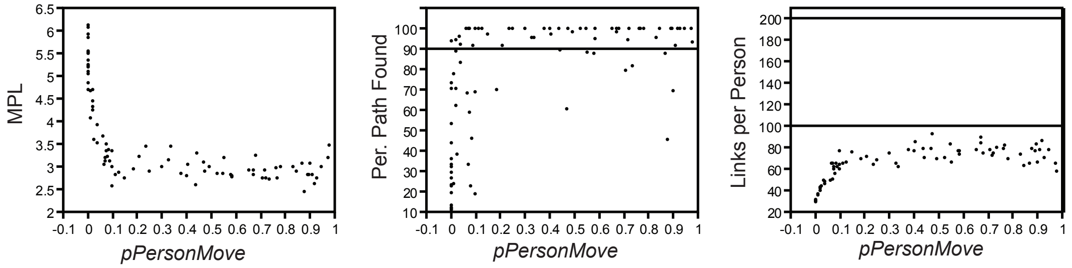
Figure 5.17. Relationship between probability of males seeking marriage with potential bride from a different band (*pIBM*) and mean path length, the percentage of social paths found, and mean number of links per person at population densities of 0.001 persons/km^2 and 0.002 persons/km^2 in mobility setting G.

setting G, as in B, facilitate the creation of viable networks at low population densities. Viable networks can be created at a population density of 0.001 persons/km^2 by combining low values of *pIBM* and moderate person-level mobility. Viable networks can be created at a population density of 0.002 persons/km^2 even in the absence of rules for inter-band marriage.

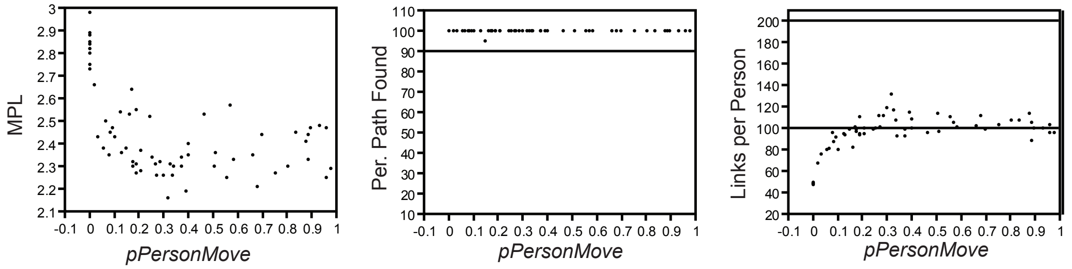
Mobility Setting J

Mobility setting J represents the lowest degree of group residential mobility that was systematically investigated. At this setting, groups make only about 2-3 short (1 cell, or 10 km) moves away from their aggregation site each year. At low population densities, the small band ranges produced by these settings entail

**A. Probability of inter-band marriage = 0,
Radius of inter-band marriage = NA**



**B. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 9 (1x mean annual range)**



**C. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 18 (2x mean annual range)**

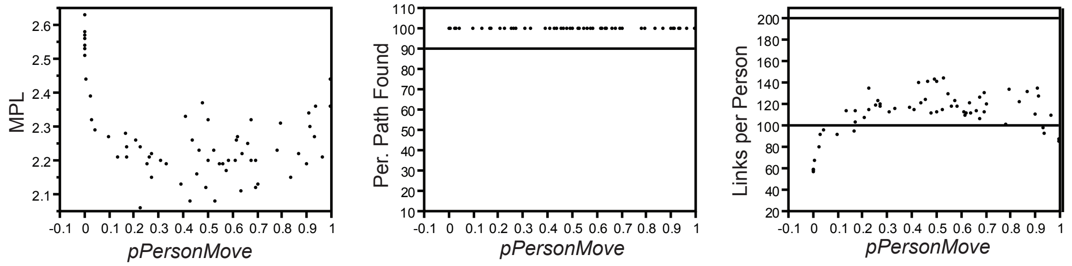
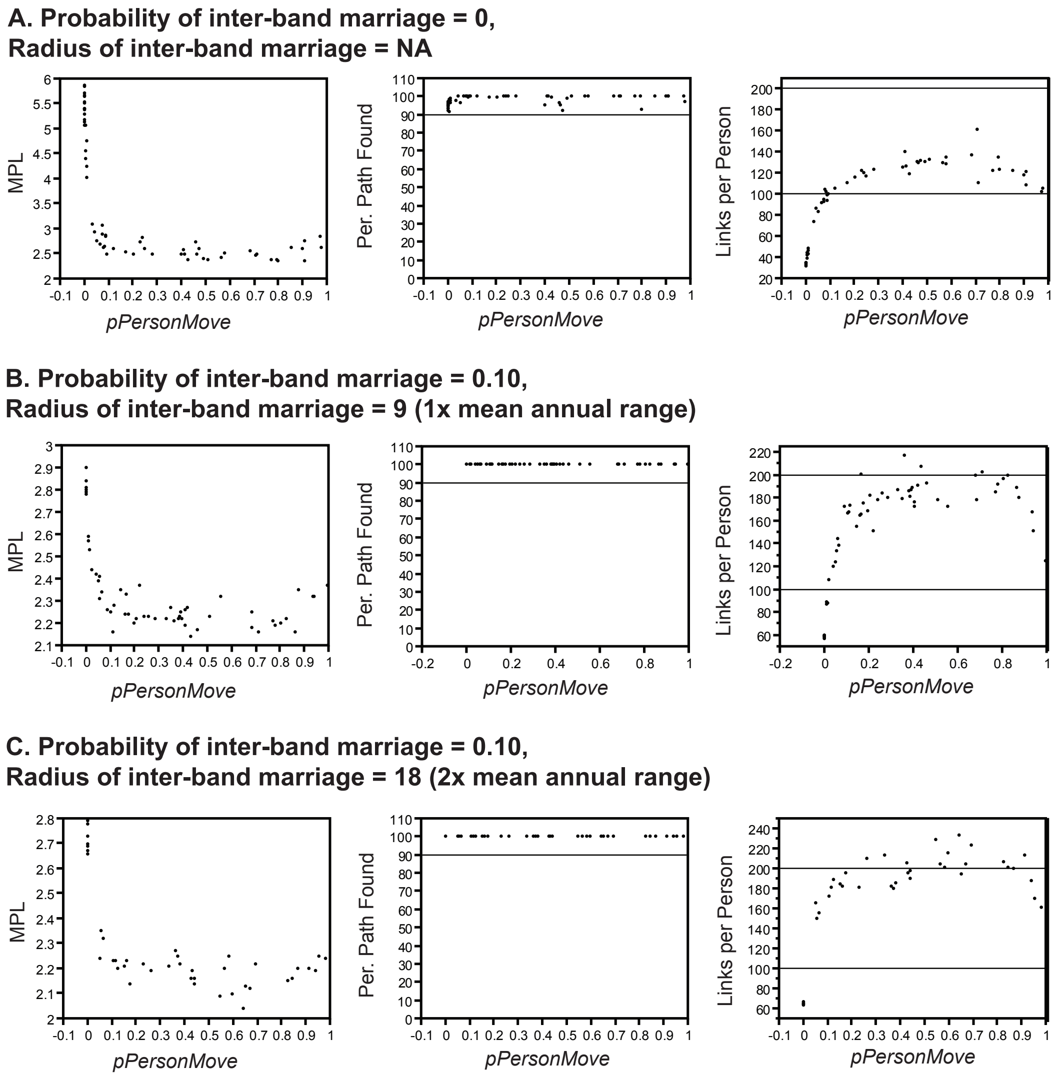


Figure 5.18. Relationship between value of *pPersonMove* and mean path length, the percentage of social paths found, and mean number of links per person at three different settings of inter-band marriage for mobility setting G, population density 0.001 persons/km^2. Results shown for *pIBM* = 0 (A); *pIBM* = 0.10, radius of search = mean annual range (B); and *pIBM* = 0.10, radius of search = 2x mean annual range (C).


A. Probability of inter-band marriage = 0,
Radius of inter-band marriage = NA

B. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 9 (1x mean annual range)

C. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 18 (2x mean annual range)

Figure 5.19. Relationship between value of *pPersonMove* and mean path length, the percentage of social paths found, and mean number of links per person at three different settings of inter-band marriage for mobility setting G, population density 0.002 persons/km^2. Results shown for *pIBM* = 0 (A); *pIBM* = 0.10, radius of search = mean annual range (B); and *pIBM* = 0.10, radius of search = 2x mean annual range (C).

large numbers of aggregation sites and, consequently, unrealistically small mean numbers of persons per aggregation site (see Table 5.1).

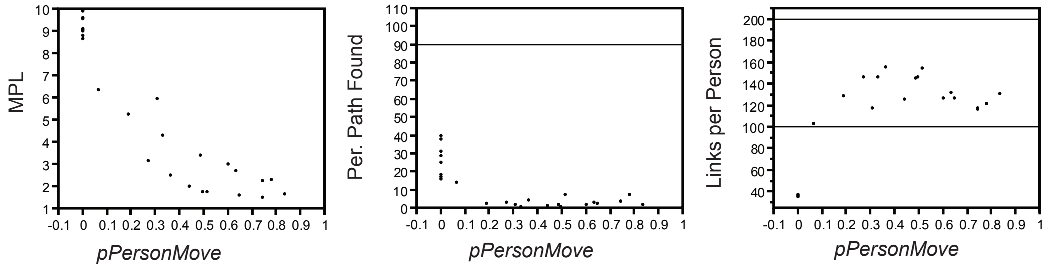
At the highest population density investigated (*popDensityModel* = 0.005 persons/km^2), mobility setting J did not reliably produce viable networks (Figure 5.20). While values of *pPersonMove* > 0 did produce networks with realistic mean numbers of links per person, inter-connected networks were only produced when there was no component of personal mobility. The systems formed at population densities between 0.001 and 0.005 persons/km^2 in mobility setting J do not appear to have been characterized by a distribution of persons and groups across the landscape that resembled those of actual human hunter-gatherer systems. Low mobility systems may produce viable networks under conditions of higher population density or different interaction rules. Expanding the radius used to identify potential brides for inter-band marriage may produce inter-connected systems.

Viable Social Networks in the Model

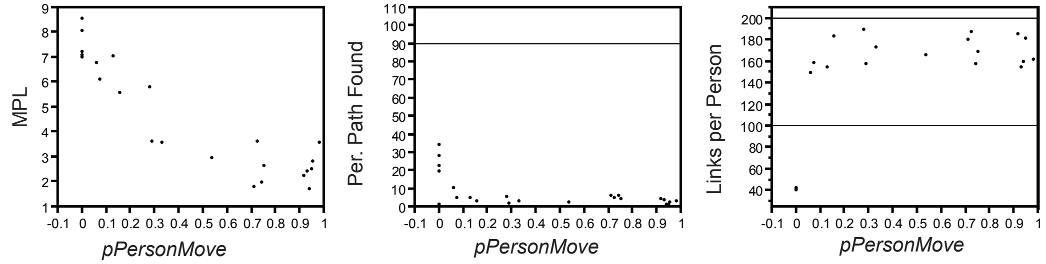
Population density, group residential mobility, personal mobility, and inter-band marriage play significant roles in producing viable social networks in the ForagerNet2 model. The combinations of settings which produced viable networks are summarized in Tables 5.3 and 5.4. Of the 3,440 experimental runs included in the discussion above, 641 produced social networks that met both criteria for viability: inter-connectedness and a realistic mean number of social links per person. This subset of experimental runs can be explored to further understand what conditions create a viable system-level social network and what the characteristics of those networks are.

The data discussed above suggest that, in most cases, the relationship between the probability of inter-band marriage (*pIBM*) and the degree of inter-connectedness of a system (measured by the percentage of social paths found) is strongly non-linear: a small value of *pIBM* produces the inter-band links necessary to tie a system together. The degree of personal mobility (controlled by *pPersonMove*), conversely, has a strong effect on the mean number of social links per person: persons acquire many of their social links through movement between groups. While the amount of inter-band marriage is positively related to the mean number of social links per person, in no case does inter-band marriage

A. Probability of inter-band marriage = 0,
Radius of inter-band marriage = NA



B. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 2 (1x mean annual range)



C. Probability of inter-band marriage = 0.10,
Radius of inter-band marriage = 4 (2x mean annual range)

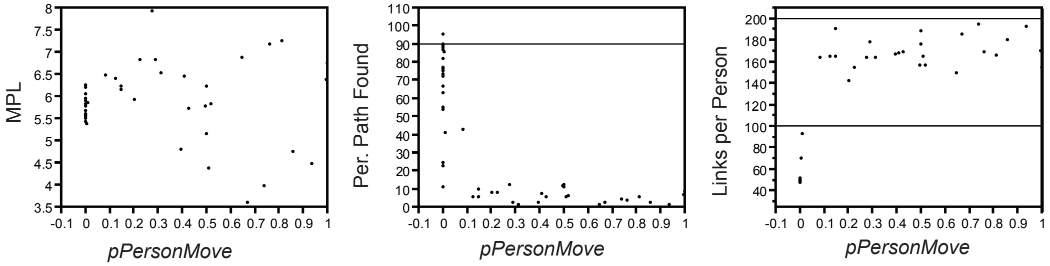


Figure 5.20. Relationship between value of *pPersonMove* and mean path length, the percentage of social paths found, and mean number of links per person at three different settings of inter-band marriage for mobility setting J, population density 0.005 persons/km^2. Results shown for *pIBM* = 0 (A); *pIBM* = 0.10, radius of search = mean annual range (B); and *pIBM* = 0.10, radius of search = 2x mean annual range (C).

Table 5.3. Summary of Combinations of Settings Producing Viable Model Social Networks at Values of *popDensityModel* of 0.001 and 0.002 Persons/km^2.

Group mobility setting	***popDensityModel* = 0.001**			***popDensityModel* = 0.002**		
	pIBM			***pIBM***		
	0	**0.10**		**0**	**0.10**	
		search radius = 1x MAGR	**search radius = 2x MAGR**		**search radius = 1x MAGR**	**search radius = 2x MAGR**
B (0.50,2)	Y(S)	Y(R) (*pPM* > 0.05)	Y(R) (*pPM* > 0.05)	Y(S)	Y(S)	Y(R) (*pPM* = 0.4-1)
D (0.50, 1)	N	Y(S)	Y(S)	N	Y(S)	Y(R) (*pPM* > 0.1)
E (0.25, 1)	N	N	N	N	Y(S)	Y(S)
F (0.25, 2)	N	Y(S)	Y(S)	Y(S)	Y(R) (*pPM* > 0.05)	Y(R) (*pPM* > 0.05)
G (0.10, 6)	Y(S)	Y(S)	Y(R) (*pPM* 0.2-0.7)	Y(R) (*pPM* > 0.1)	Y(R) (*pPM* = 0.05-0.15)	Y(R) (*pPM* 0.01-0.15)
J (0.10, 1)	N	N	N	N	N	N

Y(S) = "sporadic." Some runs produced interconnected networks (> 90% path found) with mean numbers of links per person between 100-200, but other runs with similar settings did not.
Y(R) = "reliable." Given settings reliably produced inter-connected networks (percentage of paths found > 90%) with mean numbers of links per person between 100-200.
N = no combination of settings produced networks that met both criteria for viability.

Table 5.4. Summary of Combinations of Settings Producing Viable Model Social Networks at Values of *popDensityModel* of 0.003 and 0.005 Persons/km^2.

Group mobility setting	***popDensityModel* = 0.003**			***popDensityModel* = 0.005**		
	pIBM			***pIBM***		
	0	**0.10**		**0**	**0.10**	
		search radius = 1x MAGR	**search radius = 2x MAGR**		**search radius = 1x MAGR**	**search radius = 2x MAGR**
B (0.50, 2)	-	-	-	-	-	-
D (0.50, 1)	-	-	-	-	-	-
E (0.25, 1)	N	Y(S)	Y(R) (*pPM* 0.01-0.2)	-	-	-
F (0.25, 2)	-	-	-	-	-	-
G (0.10, 6)	-	-	-	-	-	-
J (0.10, 1)	N	N	N	N	N	N

Y(S) = "sporadic." Some runs produced interconnected networks (> 90% path found) with mean numbers of links per person between 100-200, but other runs with similar settings did not.
Y(R) = "reliable." Given settings reliably produced inter-connected networks (percentage of paths found > 90%) with mean numbers of links per person between 100-200.
N = no combination of settings produced networks that met both criteria for viability.

alone produce social networks with realistic mean numbers of links per person.

Four basic metrics describing network characteristics were discussed in Chapter 2: network size, network density, mean number of links per person (i.e., mean node degree), and mean path length. Network size describes the total number of two-way links comprising a network. Network density is the proportion of links that exist relative to the number that are possible within a population of a given size. Mean path length is the average number of links required to connect one person to another. The mean number of links per person is a measure of the average size of the personal networks within the larger, system-level network. This last metric will not be discussed extensively because its value was used as a criterion for identifying which experimental runs produced viable networks.

Population Density and Population Size

Relationships between population density, mean network size, mean network density, and mean path length among the viable experimental runs are shown in Figure 5.21. Population density was calculated by dividing the mean number of persons during the data collection period (T1) by the estimated area occupied (the sum of all band ranges). Relationships between the network variables and population size are also shown in Figure 5.21.

Network size increases proportionally as a function of both population density and population size (Figure 5.21A). In both cases, $R^2 = 0.86$. Population size and population density are highly correlated in the experimental runs discussed here because the size of the world remains constant. (While the estimated sizes of the occupied areas vary somewhat according to group mobility settings, this does not affect the basic relationship between population size and population density in the model that is established by the value of the parameter *popDensityModel.*) Network size is roughly one half of the population size x 150 (the approximate mean number of links per person). If each person in a population of 2000 has 150 social links, for example, there are 150,000 two-way social links connecting individuals in the population.

The relationships between population and network density are curvilinear: network density decreases as a function of population density and population size (Figure 5.21B). This is understandable based on the disproportionate relationship between increases in population size and increases in the number of potential social links (see Bossard 1945; Kephart 1950). If the mean number

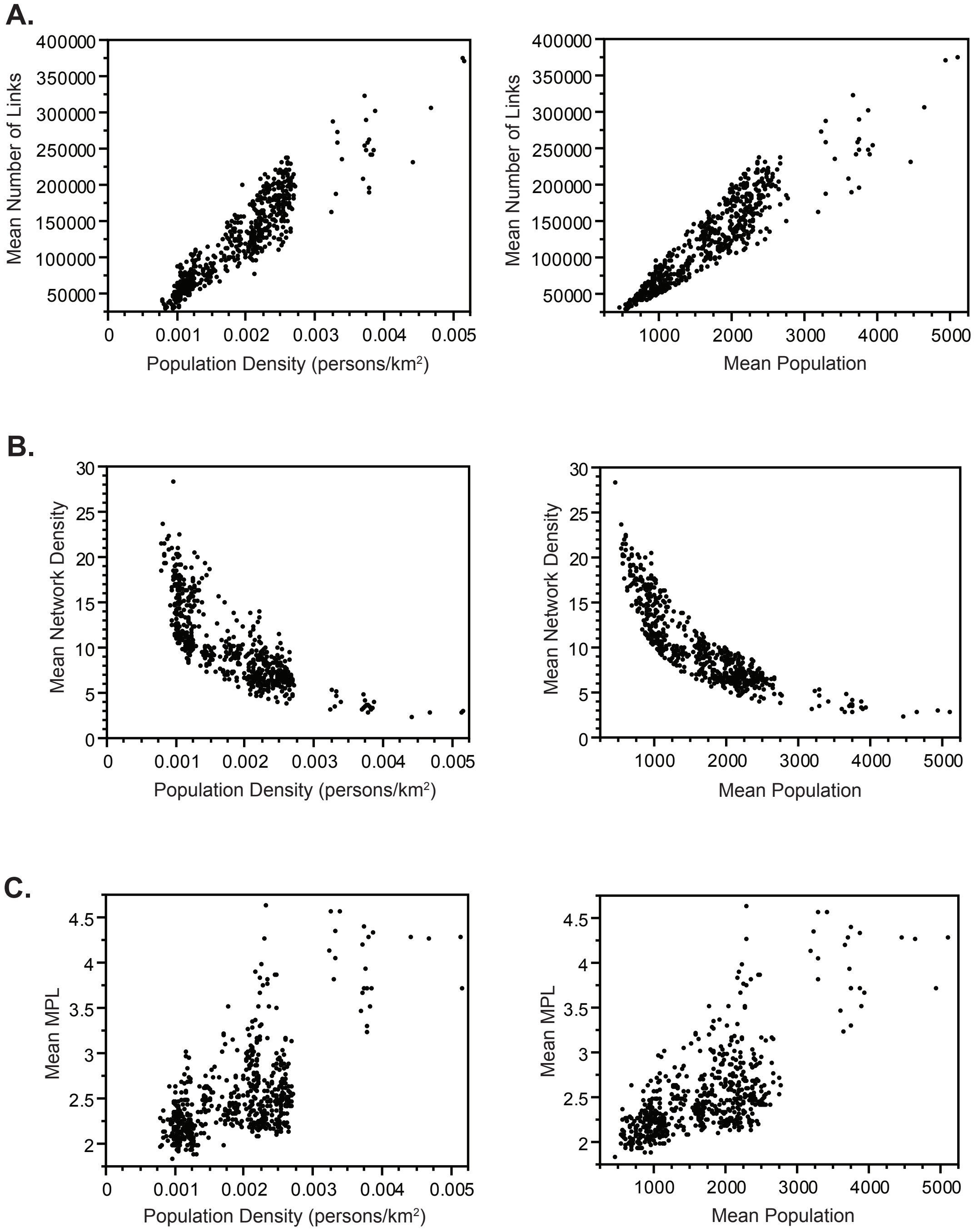


Figure 5.21. Relationships between calculated mean population density and mean network size, mean network density, and mean path length among runs producing viable networks.

of links per person remains relatively constant (as it does here, as this analysis is limited to experimental runs with 100-200 mean links per person), network density would be expected to drop disproportionately as population size increases. The relationship between population size and network density plots as a straight line when both the X and Y axes are logarithmic (Figure 5.22).

Population size and density are positively related to mean path length: mean path length tends to be higher in systems with higher populations (Figure 5.21C). Even in the "viable" runs with the highest population sizes, however, social networks were still characterized by mean path lengths below 5.

Mobility and Aggregation

The clustering of residential groups in close spatial proximity at annual aggregations provides opportunities for group fusion, marriage, and the transfer of persons between groups via mechanisms of personal mobility. Because the size of the world was held constant in the experimental runs discussed here, the number of aggregation sites decreases as a function of increased group annual mobility. At similar population densities, systems with a lower number of aggregation sites will have a higher mean number of persons per aggregation

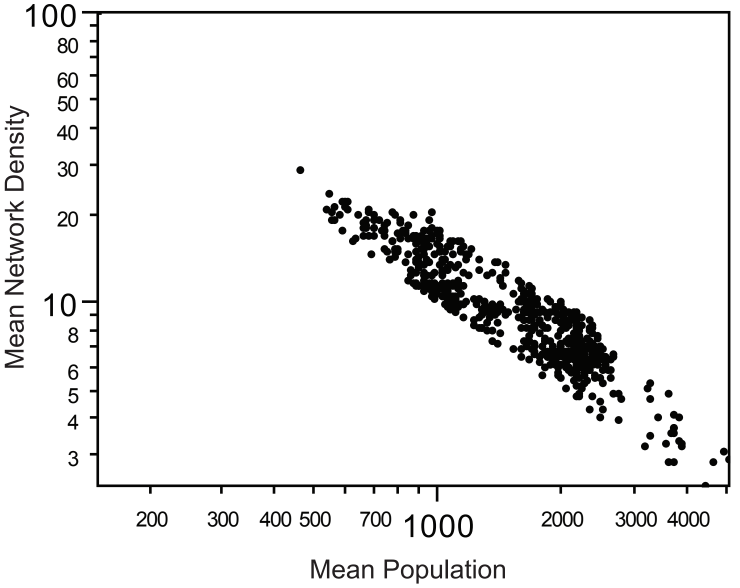


Figure 5.22. Relationship between mean population and mean network density displayed on a log-log plot.

site (i.e., a higher “band” population).

Relationships between the mean number of persons per aggregation site and the network variables are shown in Figure 5.23A. Within each mobility setting, there is a positive relationship between network size and the mean number of persons per aggregation site. As discussed above, this is a function of a relatively constant mean number of links per person: group mobility parameters being equal, systems with higher population densities will be associated with larger networks and higher mean numbers of persons per aggregation site.

Within each mobility setting, network density is negatively associated with the mean number of persons per aggregation site (Figure 5.23B). This is due to the negative relationship between network size and network density discussed above. Assuming the mean number of links per person is constant, larger networks will be characterized by lower network densities.

The plot of the mean number of persons per aggregation site vs. mean path length (Figure 5.23C) shows the contrast between the low mean path lengths associated with systems with relatively high mobility and large aggregations (i.e., mobility setting B) and the high mean path lengths associated with systems with relatively low mobility and small aggregations (i.e., mobility setting E). These differences are also visible in Figure 5.24. The social networks produced at low population densities by mobility setting B are characterized by relatively low mean path lengths and relatively high network densities. The reverse is true of the networks produced at high population densities by mobility setting E.

Inter-Band Marriage

In the majority of cases, the emergence of viable social network in the model required that the probability of a male seeking marriage with a female of a different band (*pIBM*) be greater than 0. Small amounts of inter-band marriage greatly increased the inter-connectedness of the model networks. Marriages between individuals previously residing in different bands foster inter-connectedness by creating direct links of kinship that extend between bands and a marriage link that can serve as a pathway for finding indirect social paths between unlinked individuals residing in different bands.

Figures 5.25 through 5.29 plot the mean geographic distance spanned by

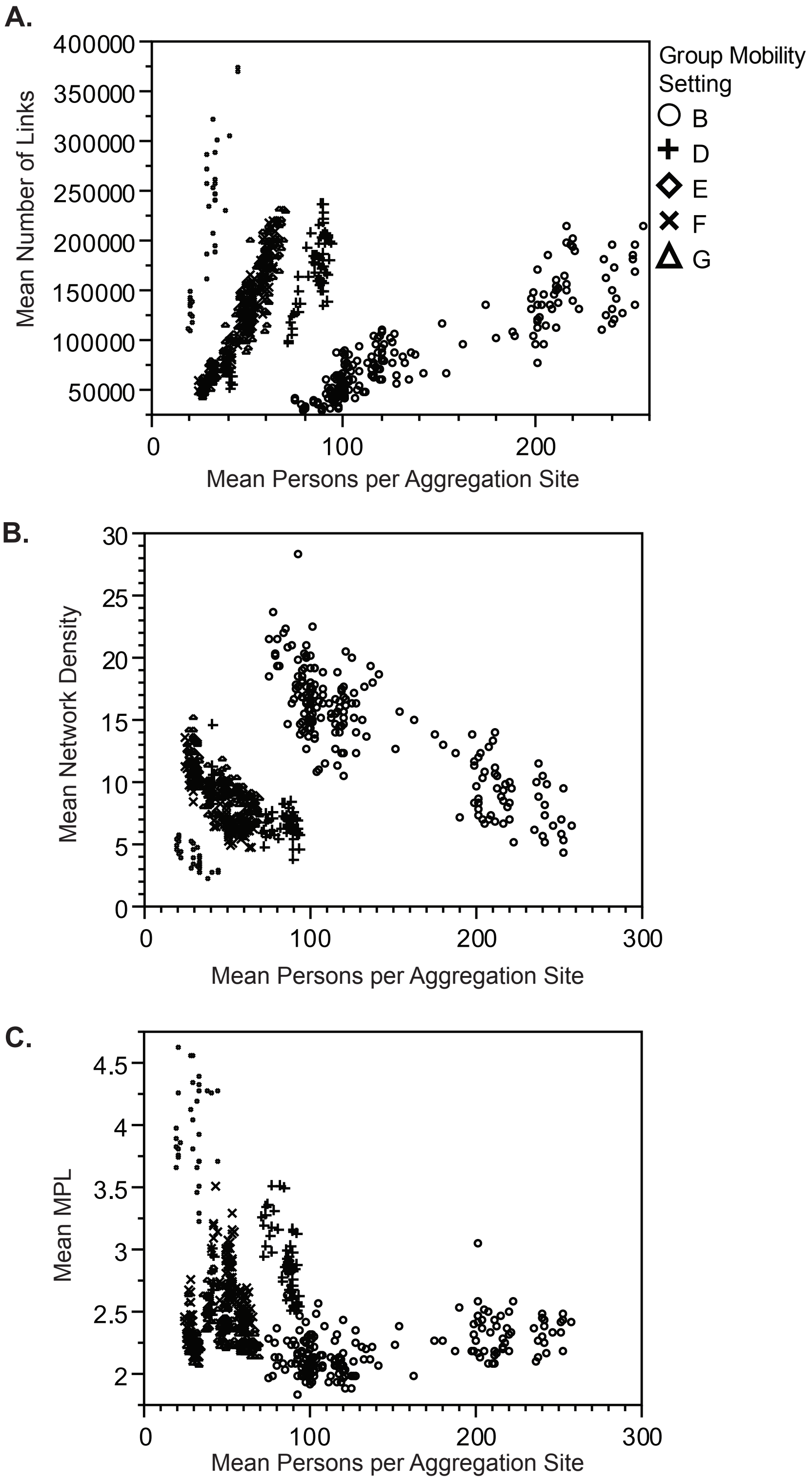


Figure 5.23. Relationships between calculated mean persons per aggregation site and mean network size, mean network density, and mean path length among runs producing viable networks.

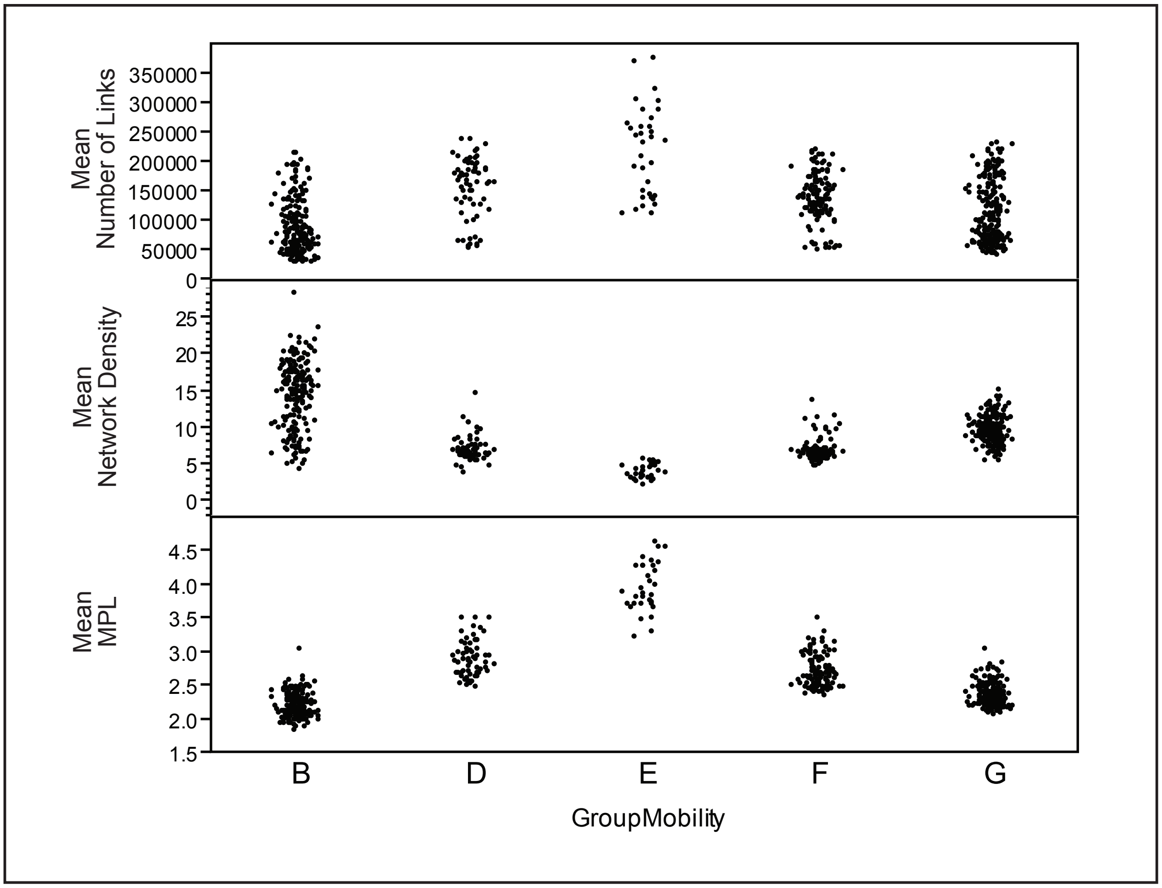


Figure 5.24. Plots of mean network size, mean network density, and mean path length by group mobility setting.

direct social links vs. the mean path length for experimental runs producing viable social networks. These charts are organized by mobility setting and population density to show the effects of increasing the radius employed when males search for potential brides from other bands. In all these runs*, pIBM* was either 0 or 0.10. When *pIBM* was 0.10, the search radius was either 1x or 2x the mean annual range.

At all mobility settings and population densities investigated, it is apparent that higher search radii (marked by “plus” symbols in the figures) tend to result in networks with higher geographical mean link distances and/or lower mean path lengths. This tendency is especially apparent in the data from mobility settings D, F, and G. In mobility setting D at a population density of 0.002 persons/km^2, there is almost no overlap between the runs with different search radii settings (see Figure 5.26). When viable networks can be produced without forcing inter-band marriage, those networks are typically characterized by higher

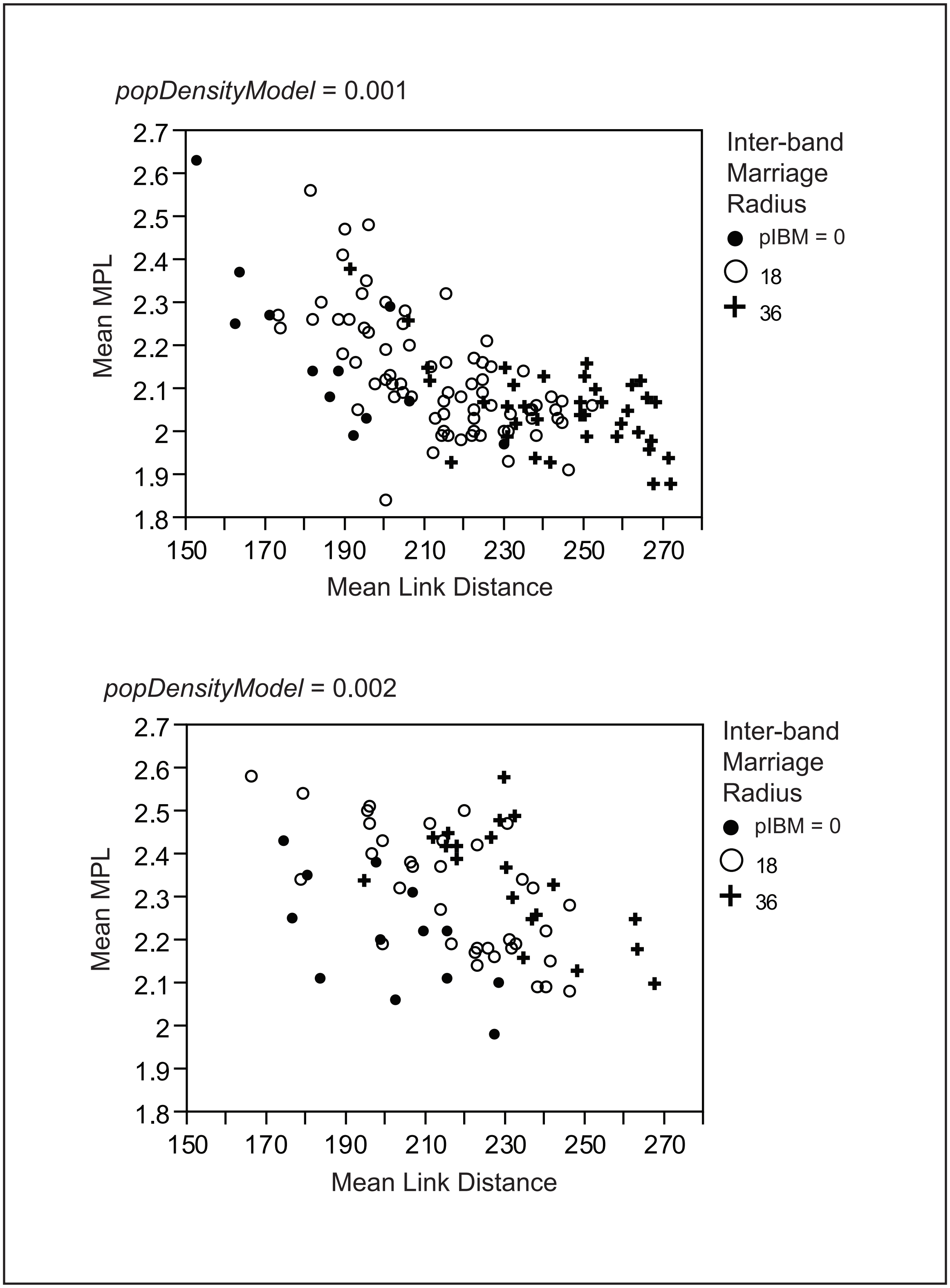


Figure 5.25. Relationships between mean link distance and mean path length among viable networks in mobility setting B. Value of *popDensityModel* = 0.001 (top) and 0.002 (bottom). Datapoints are coded by the radius used to search for potential brides for inter-band marriage.

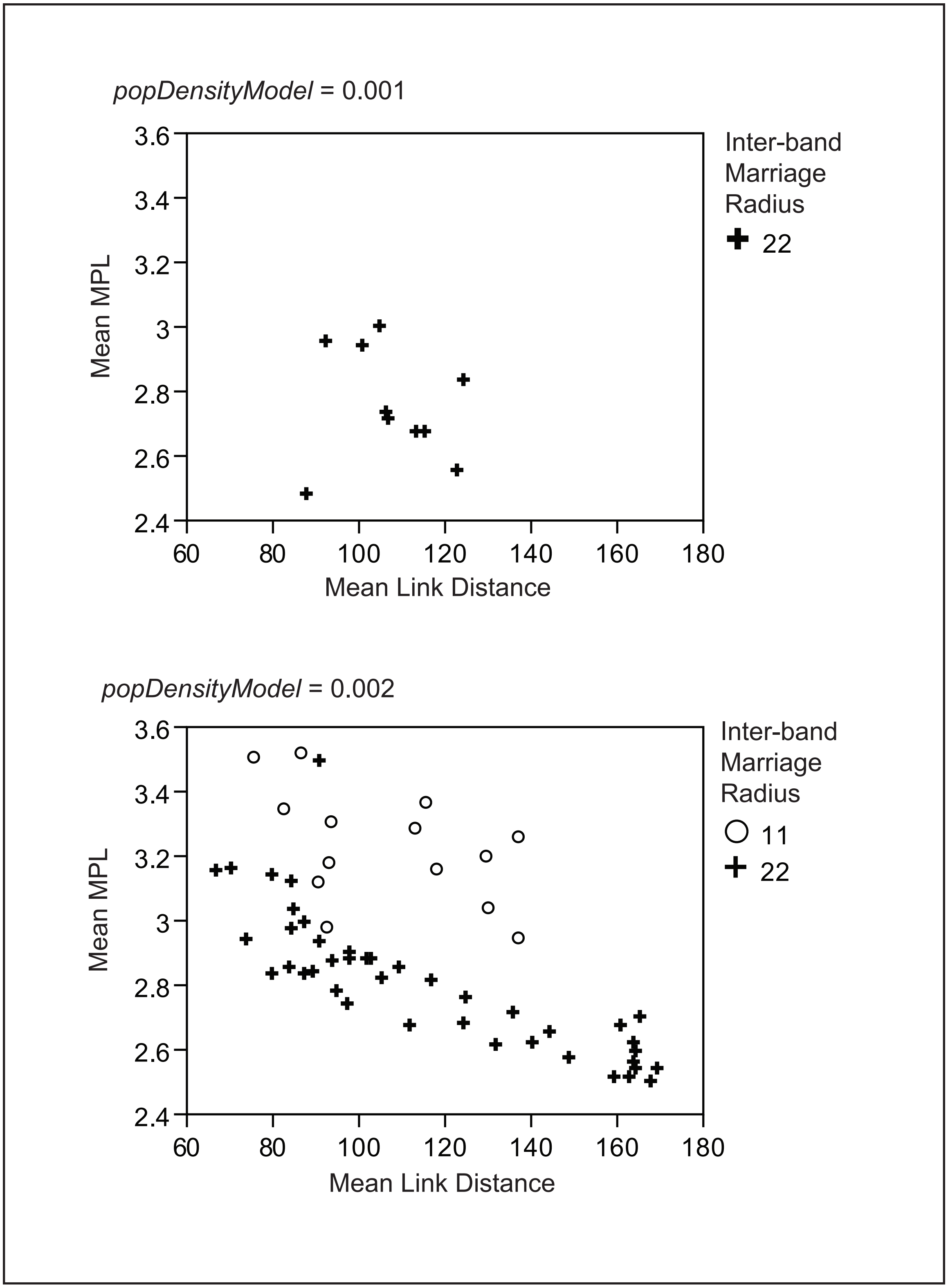


Figure 5.26. Relationships between mean link distance and mean path length among viable networks in mobility setting D. Value of *popDensityModel* = 0.001 (top) and 0.002 (bottom). Datapoints are coded by the radius used to search for potential brides for inter-band marriage.

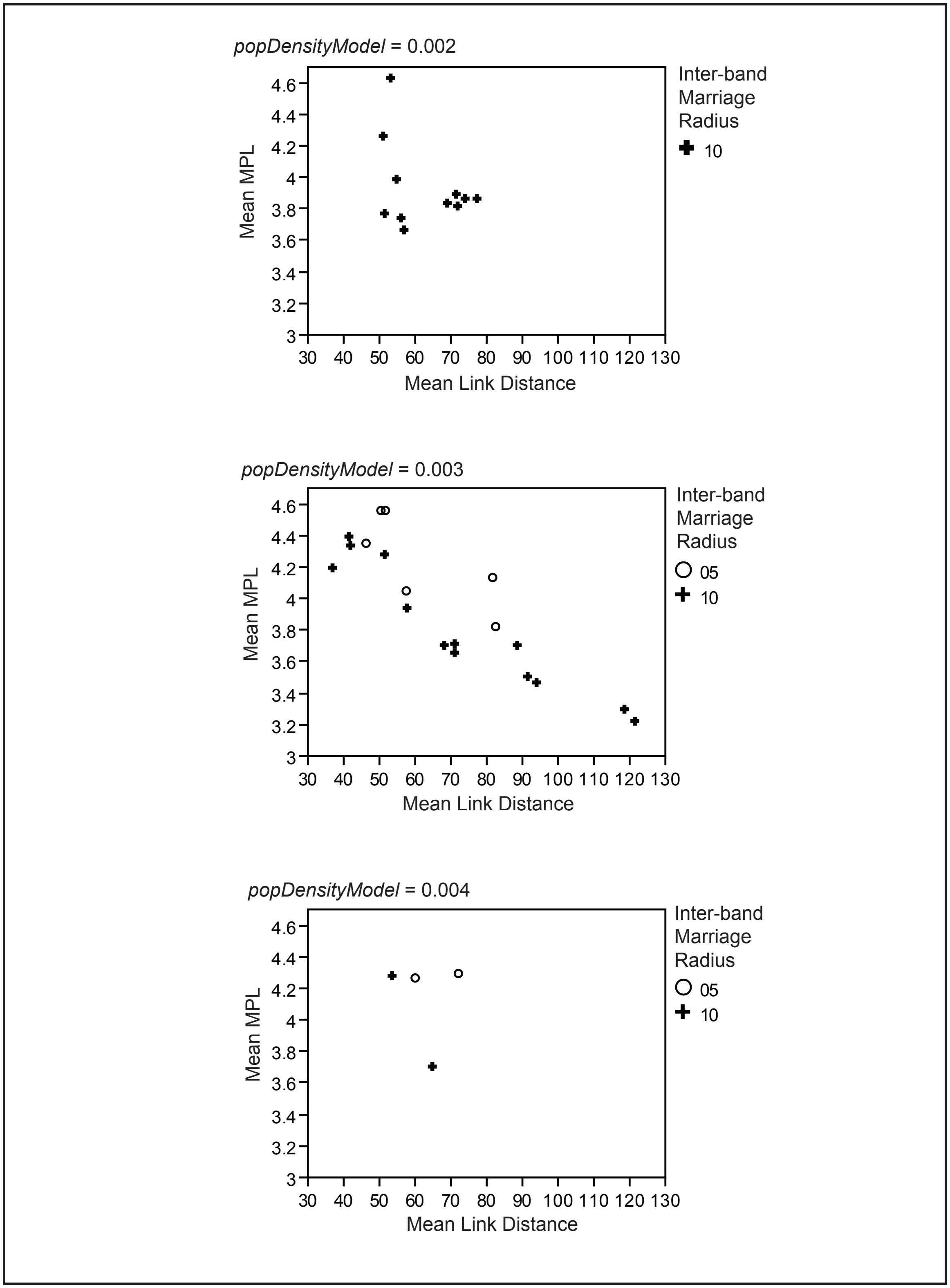


Figure 5.27. Relationships between mean link distance and mean path length among viable networks in mobility setting E. Value of *popDensityModel* = 0.002 (top), 0.003 (center), and 0.004 (bottom). Datapoints are coded by the radius used to search for potential brides for inter-band marriage.

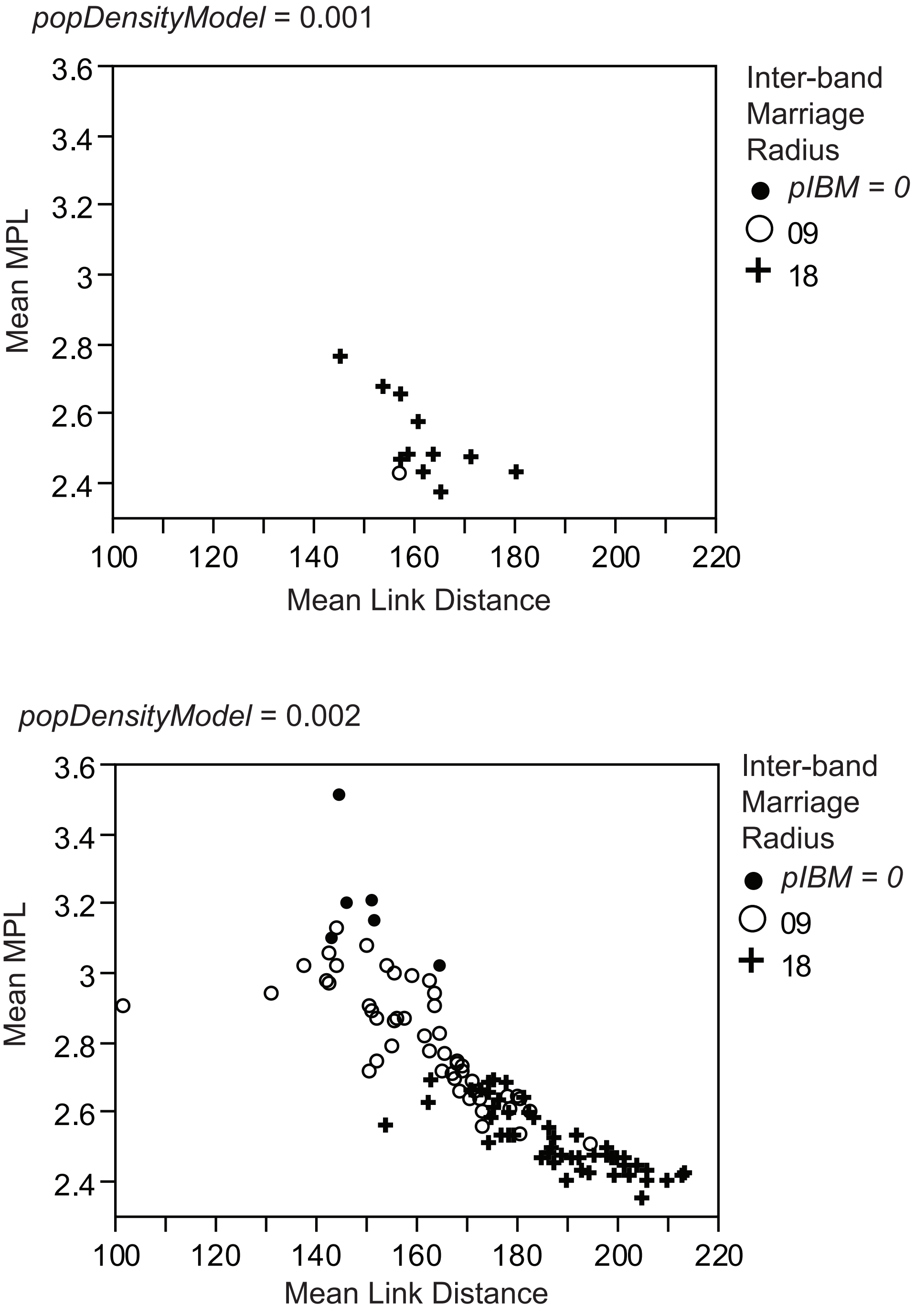
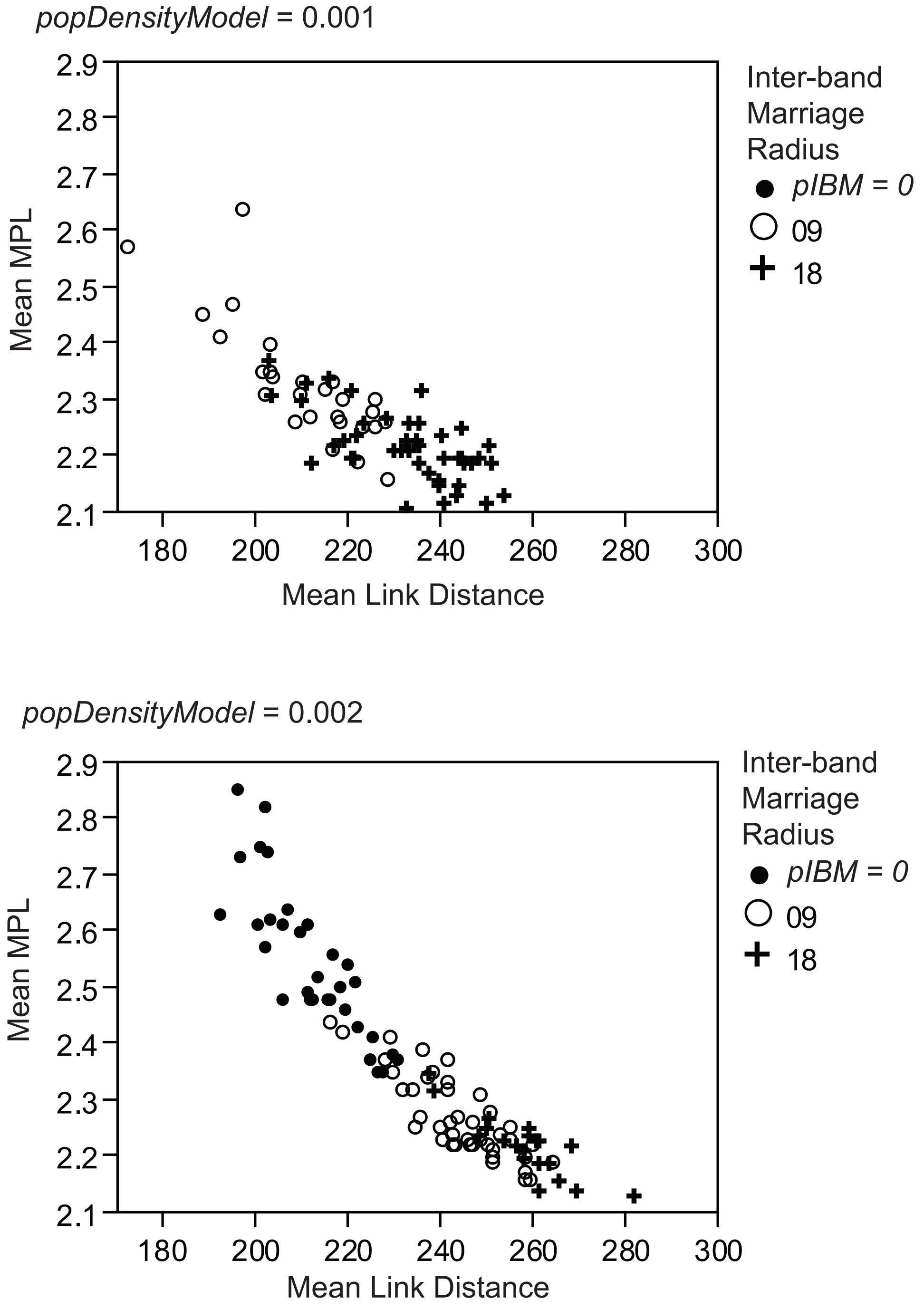


Figure 5.28. Relationships between mean link distance and mean path length among viable networks in mobility setting F. Value of *popDensityModel* = 0.001 (top) and 0.002 (bottom). Datapoints are coded by the radius used to search for potential brides for inter-band marriage.


popDensityModel = 0.001

popDensityModel = 0.002

Figure 5.29. Relationships between mean link distance and mean path length among viable networks in mobility setting G. Value of *popDensityModel* = 0.001 (top) and 0.002 (bottom). Datapoints are coded by the radius used to search for potential brides for inter-band marriage.

mean path lengths and shorter mean link distances (e.g., see mobility setting G, *populationDensityModel* = 0.002).

These data suggest that, even when the amount of inter-band marriage is relatively low (i.e., 10 percent or less), the spatial component of how inter-band marriage is carried out has potentially significant effects on the characteristics of social networks. Small amounts of inter-band marriage increase connectivity. Other things being equal, marriages between more spatially distant partners will tend to decrease the mean path length of a network and increase the mean geographic distance spanned by social links.

Network Characteristics and the Spread of Information

The three network characteristics considered here are related to one another in the sample of experimental runs that produced viable social networks (Figure 5.30). The characteristics of these networks are affected by the population size and density, mobility settings, and marriage rules in the model. At one end of the spectrum, runs characterized by high mobility and low population density produced networks that were relatively small, dense, and characterized by low mean path lengths. At the other extreme, runs characterized by low mobility and high population density produced networks that were large, sparse, and characterized by high mean path lengths.

As discussed in Chapter 4, the model includes a mechanism for generating data about the speed of information flow through the population of the model during a run. At the beginning of T1, a random person is chosen from the population to receive a "signal." The signal is subsequently spread through face-to-face interaction. The model tracks and reports the number of steps it takes for the signal to reach 50 percent, 75 percent, and 95 percent of the population. Figure 5.31 plots network size, density, and mean path length against the number of steps taken for the signal to reach 75 percent of the population in a run.

Based on the plot in Figure 5.31A, it is not clear that network size has a direct, discernible effect on how rapidly the signal spreads through the population. The relationship between the rapidity of signal spread and population size is similar, which is what would be expected given the linear correlation between population size and network size in the experimental runs (see above).

The plot of network density vs. the rapidity of spread suggests that denser networks (i.e., those where a greater proportion of possible ties actually exist)

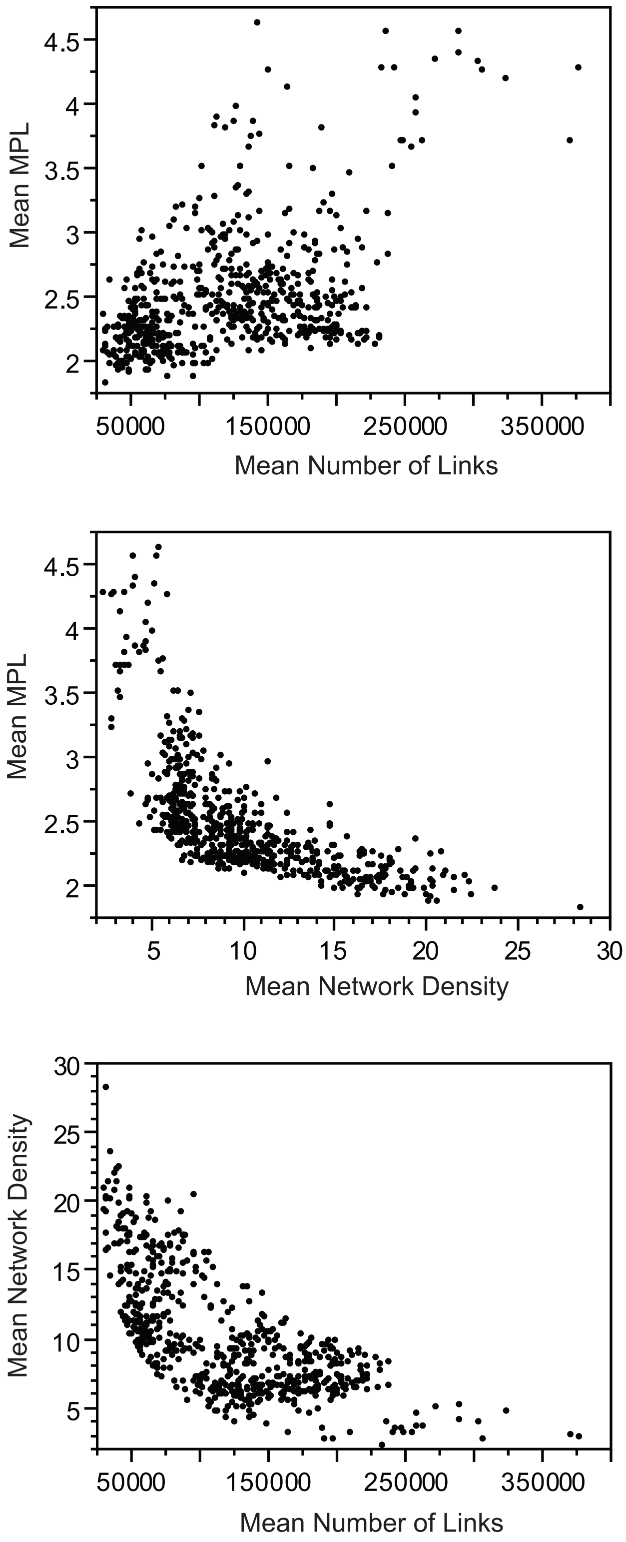


Figure 5.30. Inter-relationships between mean network size, mean network density, and mean path length among runs producing viable networks.

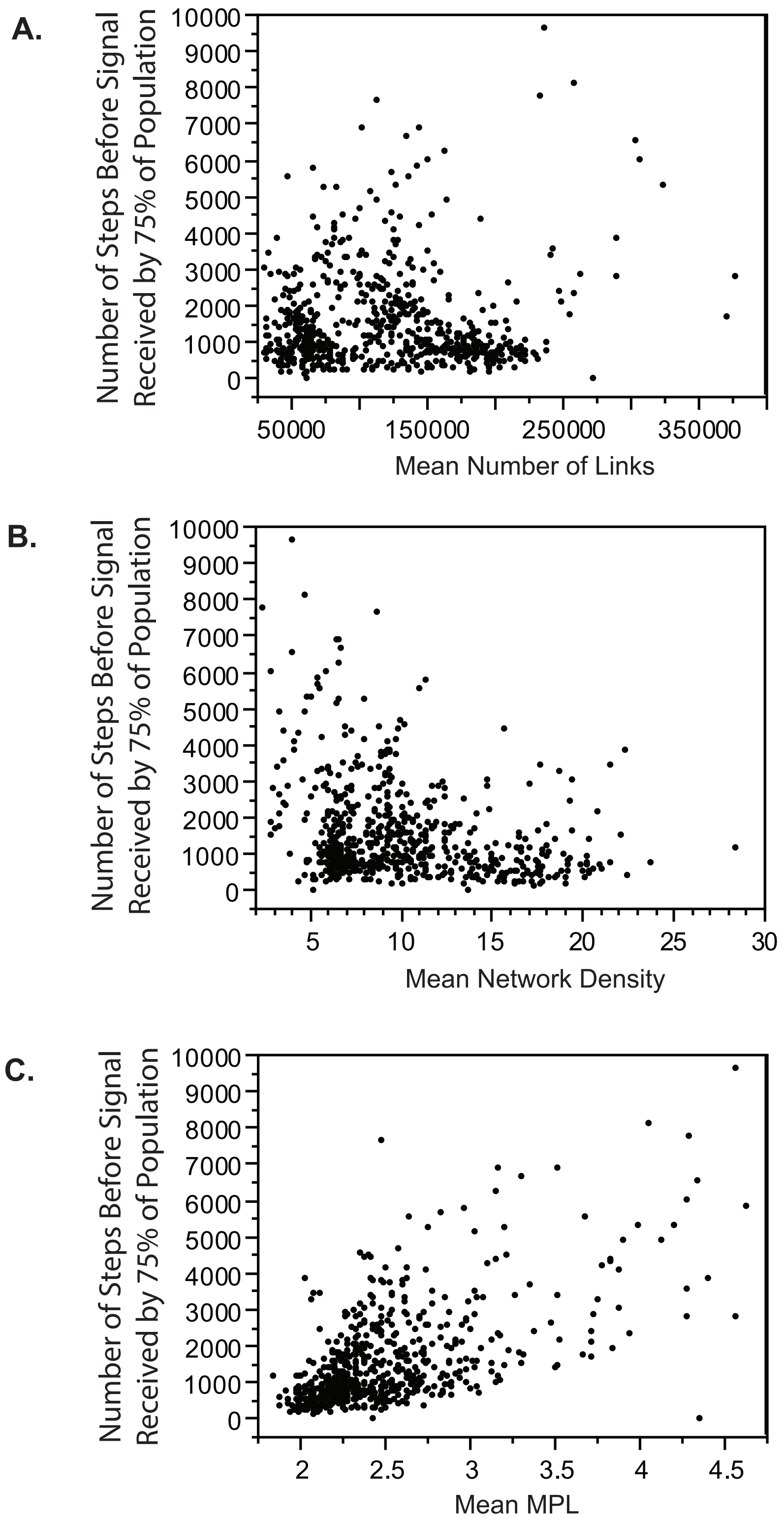


Figure 5.31. Relationships between the number of steps required for the signal to spread to 75 percent of the population and mean network size, mean network density, and mean path length among runs producing viable networks.

tend to facilitate more rapid spread of the signal (Figure 5.31B). Again, there is a relationship to population size in the model: network density tends to be higher in smaller populations because, assuming that the mean number of links per person stays constant, each individual has social ties to a greater proportion of the total population. The signal also must reach fewer people to reach 75 percent of the population. The distribution of outcomes at low network densities, however, makes it clear that information can flow rapidly even when the network is sparse and population size is high.

A loose, linear relationship between mean path length and the rapidity of spread is apparent in Figure 5.31C. This suggests that the mean path length of a network has a predictable effect on how rapidly information spreads through it. Figure 5.32 shows plots of mean path length vs. the rapidity of information spread for each of the mobility settings. Linear relationships are apparent in all mobility settings except B. The strongest correlations are produced in mobility settings F (r = 0.79) and G (r = 0.69). While the ranges of values of mean path length in the datasets from mobility settings F and G are not large (the difference between the highest and lowest MPL in mobility setting F, for example, is less than 1.2), the potential effects on the rapidity of the spread of information are not insubstantial. A difference of 5000 steps in the time it takes to spread a piece of information to 75 percent of the population in the model represents almost 100 years of “real world” time.

The relationship between mean path length and the ability of a model network to reliably spread information can be evaluated by comparing the distribution of mean path lengths of networks where the signal failed to reach 75 percent of the population during T1 (Figure 5.33A) to the distribution of those where the signal succeeded in reaching 75 percent of the population (Figure 5.33B). While both distributions have a right tail, the distribution of networks across which the signal spread to 75 percent of the population has both a lower mean and a smaller range.

Relative Benefits and Costs of Strategies for Creating Viable Networks

The relationship between mean path length and the rapidity of the spread of information suggests that there are real effects to reducing or minimizing the mean path length of a social network in the model. If an increased rapidity of information flow is assumed to be a positive effect, we can view reductions

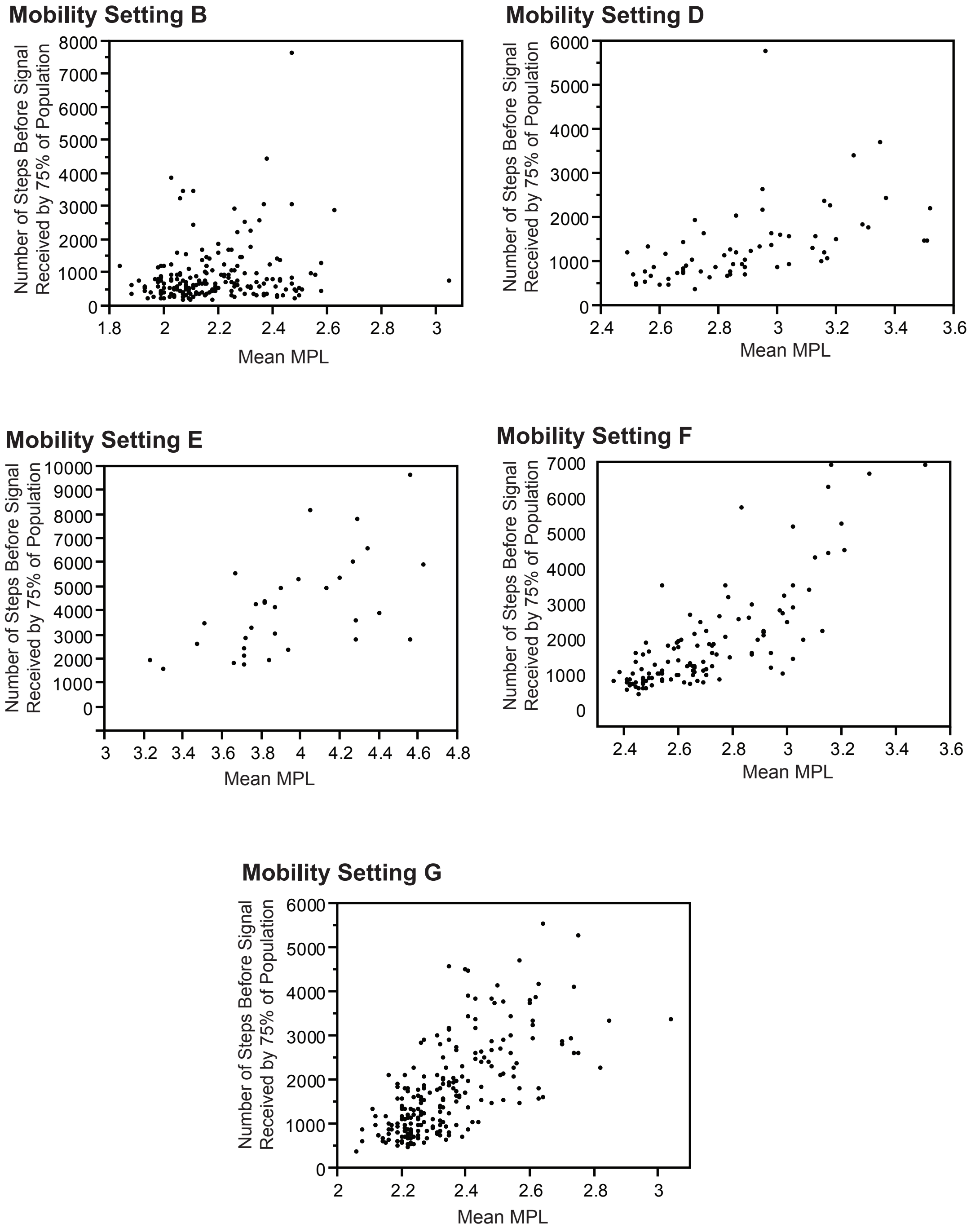


Figure 5.32. Plots of mean path length (MPL) vs. number of steps taken for signal to reach 75 percent of the population for viable runs in each mobility setting.

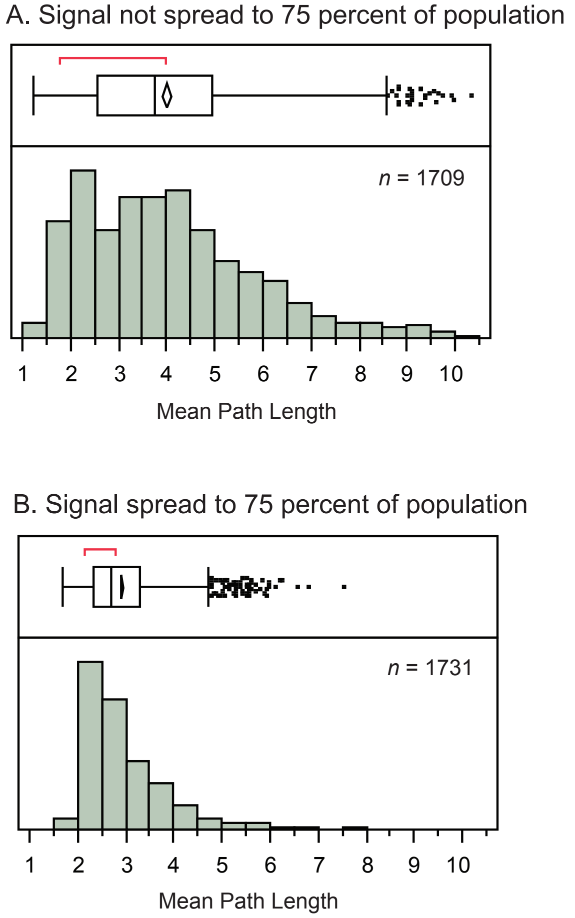


Figure 5.33. Histograms of mean path length for model experiment runs. Top histogram shows runs where signal did not reach 75 percent of the population; bottom histogram shows runs where signal did reach 75 percent of the population.

in mean path length as a “benefit” to a networked system. Lower mean path lengths allow information to spread more rapidly and with greater reliability.

Several parameters in the model have been shown to affect mean path length in a predictable fashion. The behaviors that these parameters represent can be assumed to have a “cost.” In the model, for example, establishing marriages that link bands tends to reduce mean path length by creating direct and indirect social paths that span relatively large geographic distances. We can assume that, other things being equal, it is more costly to maintain a social link over a longer distance than a shorter distance. Thus while the reductions in mean path length that are produced by inter-band marriage are beneficial to the system, they also entail a cost that can be measured in terms of the mean distance spanned by social links.

Other behaviors that contribute to the viability and characteristics of a network are associated with “costs.” Person-level mobility can be assumed to be a costly behavior. The results discussed above suggest that person-level mobility (i.e., the transfer of individuals and families from one co-residential foraging group to another) is a primary mechanism for creating personal social networks in the size range typical of human societies. These personal networks can be assumed to entail a “cost” in terms of their size: if the cost of maintaining each social link is approximately equal, a larger personal social network will be more costly to maintain.

Relationships between mean path length and mean link distance, the mean number of links per person, and person-level mobility among all the experimental runs are shown in Figure 5.34. These plots show results from thousands of runs (some of which produced viable networks and some of which did not) with various combinations of settings for population density, group mobility, personal mobility, and inter-band marriage. These amalgamated data show broad patterns in the relationships between mean path length (a network characteristic that is affected by multiple variables) and variables that represent aspects of “cost.” Systems with longer mean link distances are clearly associated with lower mean path lengths (Figure 5.34A). While the relationship between the mean number of links per person and mean path length is less clear given a dearth of data points of > 200 links per person, the available data do suggest a negative, nonlinear relationship between the two variables (Figure 5.34B). The notable feature of the plot in Figure 5.34C is the difference between the spread of data points when the value of *pPersonMove* = 0 versus the spread of data points at all other values. The amalgamated data suggest nonlinear, negative relationships between all three variables and mean path length.

A ratio of benefit to cost can be calculated for the runs that produced viable networks by using the amount of reduction in mean path length as a “benefit” and values of mean link distance, person-level mobility, and personal network size as “costs.” These calculations are performed separately for each mobility setting to control for the effects of differences in group-level mobility. The “benefit” within a single experimental run is calculated as:

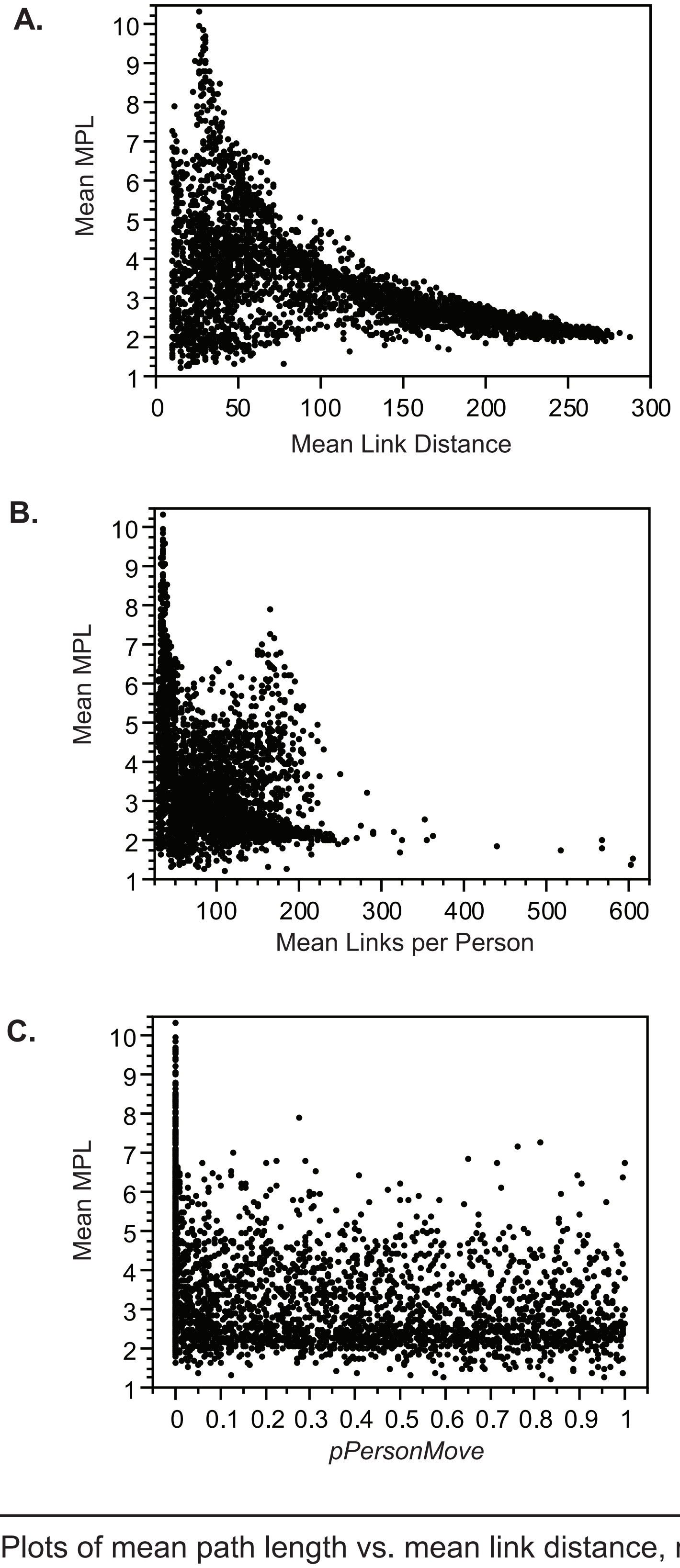


Figure 5.34. Plots of mean path length vs. mean link distance, mean number of links per person, and value of *pPersonMove* for all model experiment runs.

$$\frac{(\text{maximum MPL}) - (\text{MPL})}{(\text{range of MPL})}$$

where “maximum MPL” is the maximum mean path length recorded among all the runs with the same mobility setting, “MPL” is the mean path length of the system in the run, and “range of MPL” is the difference between the maximum and minimum values of mean path length recorded among all the runs with the same mobility setting. Thus the “benefit” is a value between 0 and 1 expressing the amount of reduction in mean path length in the run compared to the maximum possible.

The “costs” are also calculated as ratios between the values associated with a run and the maximum values recorded among all the runs with the same mobility setting. The “cost” of mean link distance is calculated as:

$$\frac{(\text{MLD})}{(\text{maximum MLD})}$$

where “MLD” is the mean link distance of the system in the run and “maximum MLD” is the maximum mean link distance recorded among all the runs with the same mobility setting. Thus the “cost” of mean link distance is a value between 0 and 1. The “costs” of mean links per person and the value of *pPersonMove* are calculated in the same way. The total cost of a run is calculated by adding these three components of cost and dividing by three. Each component contributes one third of the total cost, and the maximum cost is 1.

The ratio of benefit to cost is calculated by dividing “benefit” by “cost.” This gives a relative measure of the value of the benefit to a system (in terms of reduction in mean path length) of the higher costs associated with maintaining longer social links, larger personal networks, and higher degrees of personal mobility. The relationship between the value of *pPersonMove* and the benefit:cost ratio among the viable runs is shown in Figure 5.35A. In all mobility settings, the ratio of benefit to cost declines as the value of *pPersonMove* increases. This suggests that low values of *pPersonMove* are more efficient than high values at producing networks with sufficient inter-connectedness and mean numbers of links per person. Figure 5.35B shows these same data plotted by mobility setting with the value of *pPersonMove* on a logarithmic axis. In all cases, values of *pPersonMove* at or below 0.10 appear to offer the best trade-off between benefit and cost.

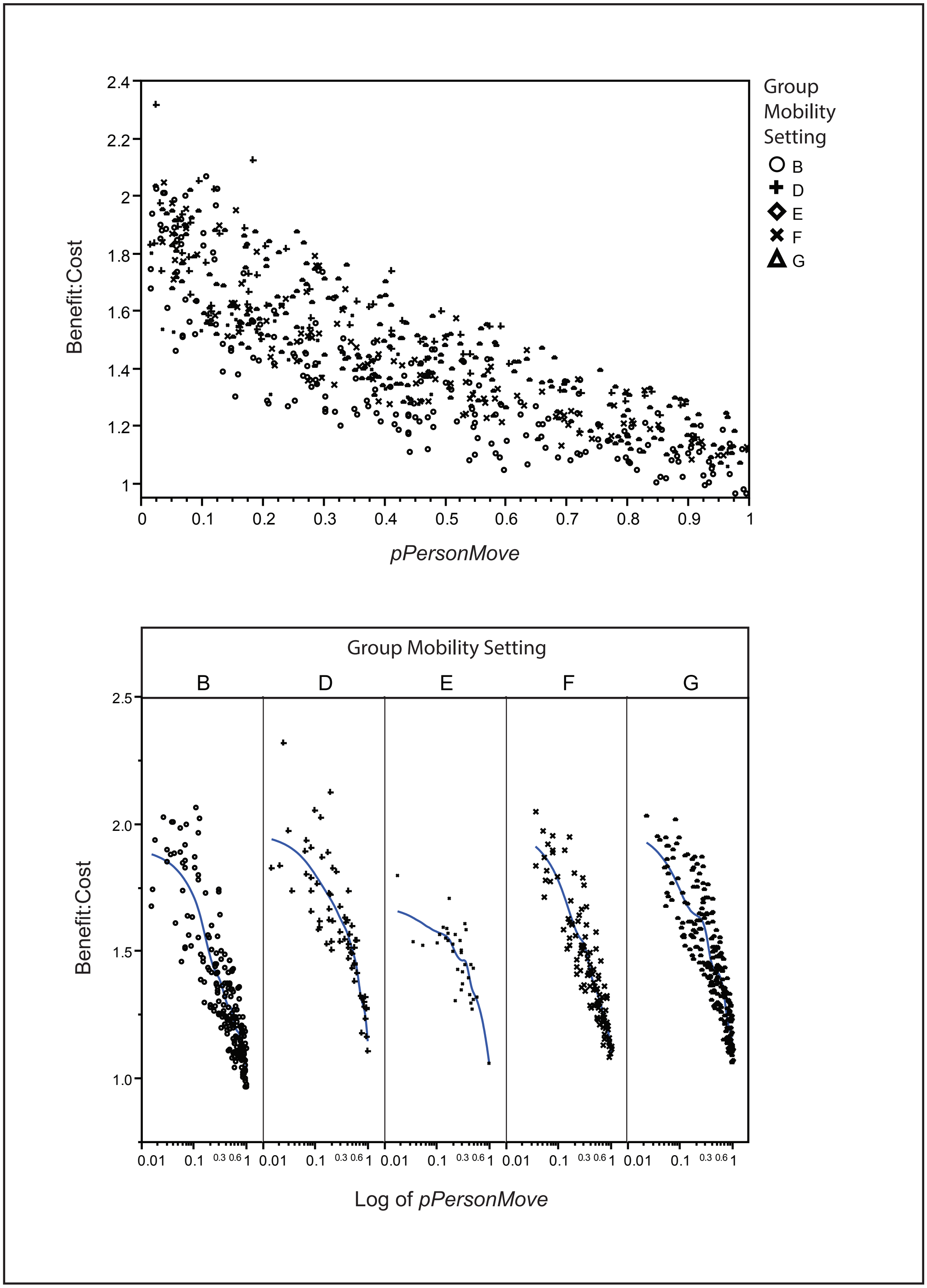


Figure 5.35. Plots of *pPersonMove* vs. the ratio of benefit:cost for runs producing viable social networks. Bottom plot shows ratio by group mobility setting with *pPersonMove* displayed on a log axis.

Conclusion

Taken together, the data explored here suggest a number of patterned relationships among the person- and group-level behaviors in the model systems and the characteristics of the social networks that emerge through those behaviors. Parameters affecting group mobility and aggregation have strong effects on the population densities required to create viable social networks through the mechanisms represented here.

At low population densities, viable networks can be reliably created in systems that combine high group residential mobility with relatively large periodic aggregations, a low to moderate degree of personal mobility, and some degree of inter-band marriage. These networks are relatively dense and have low mean path lengths.

Model systems with lower degrees of group mobility generally require higher population densities to produce viable social networks. In the model, this relationship is connected to the inverse relationship between the degree of group mobility and the number of aggregation sites on the landscape. In systems with both low population density and low mobility, each individual aggregation site has a lower population (both in terms of the number of groups and the number of individual persons). This means that there are fewer opportunities for interactions during yearly aggregations than in systems with the same mobility but higher population density. In low mobility systems, higher population densities are required to produce the conditions for a sufficient number of interactions to take place to create the numbers of social links required for a viable network. The larger populations of these systems create social networks that are less dense and characterized by higher mean path lengths than viable networks formed at lower population densities. The speed of information flow in these networks is correspondingly lower.

In general, a small amount of inter-band marriage in the model serves to produce inter-connected systems by creating direct and indirect links between bands. Inter-band marriage produces links that potentially span long geographic distances, increasing the mean link distance and lowering the mean path length of social networks. The degree of personal mobility has a strong effect on the mean number of social links per person because persons acquire many of their social links through movement between groups. Analysis suggests that a relatively low degree of person-level, inter-group movement is typically sufficient to produce systems with personal networks of realistic size. Systems with low levels of inter-band marriage and person-level movement appear to offer the best trade-off of benefit to cost in terms of producing inter-connected systems with low mean path lengths.

Chapter 6

THE ARCHAEOLOGY OF LATE PLEISTOCENE/EARLY HOLOCENE MIDCONTINENTAL NORTH AMERICA

The cultural transformations that occurred among late Pleistocene/early Holocene (ca. 11,050-9000 radiocarbon years before present [RCYBP]) hunter-gatherers formed the foundation for the next ten millennia of prehistory in eastern North America. In the midcontinent, significant changes in the formal lithic technologies and raw material transport patterns of hunter-gatherer groups occurred in the context of rapid and complex ecological changes as the environment shifted from a peri-glacial tundra/boreal parkland to one dominated by closed deciduous forest (Delcourt and Delcourt 1981; Shane 1994; Shane et al. 2001; Whitehead 1997). The widespread Early Paleoindian fluted point horizon (typified by Clovis and Clovis-like points that date to around 11,050-10,800 RCYBP) was replaced by regionalized point types during the Middle and Late Paleoindian periods (ca. 10,800-10,000 RCYBP). This stylistic regionalization was later eclipsed by more-or-less horizon-like successions of geographically-widespread point forms during the Early Archaic period (ca. 10,000-8000 RCYBP). This general sequence of "homogenous-regionalized-homogenous" has been attributed to changes in the scale and structure of social networks as well as the appearance of social boundaries during the Middle and Late Paleoindian periods (e.g., Anderson 1995; Anderson and Hanson 1988; Kidder and Sassaman 2009; Koldehoff and Loebel 2009; Koldehoff and Walthall 2009; Loebel 2005; Stothers 1996; Tankersley 1989; White 2006a).

This chapter presents an overview of the archaeological record of early foragers in the North American midcontinent, beginning with a brief discussion of the physical setting of the area. I discuss the major sources of lithic raw materials that are important to the analyses in subsequent chapters. I then provide a general outline of the chronology, environment, and culture history of the late Pleistocene/early Holocene archaeological record. This is followed by a description of the formal lithic hafted bifaces that act as chronological markers and are the main source of archaeological data used in this study. Finally, I summarize existing descriptions and interpretations of the patterns of change during this time period, focusing on scenarios that rely on changes in social networks and social interaction to explain processes of regionalization and homogenization of material culture.

Physical Setting

This section provides a basic overview of the physical setting of the North American midcontinent, which I define as including Illinois, Indiana, Kentucky, Ohio, southern Ontario, and the lower peninsula of Michigan. Within this area, I make reference to several major geographic sub-areas or "regions:" the Central Mississippi Valley, the Great Lakes, and the Ohio Valley. These general regions have more-or-less distinct physical characteristics, environmental histories, and archaeological trajectories that are relevant the archaeological case considered here.

Midcontinental North America is underlain by bedrock varying in age from Ordovician to Eocene (Figure 6.1). Most bedrock in this part of North America is sedimentary, formed from particles originally deposited in both terrestrial and marine environments (see Howe 1997). Deposits of limestone have the potential to contain bands or nodules of chert, the primary material used in this area for making chipped stone tools (see below).

Eastern North America was impacted by repeated Pleistocene glaciations. These glaciations significantly reshaped portions of the landscape, excavating the basins now occupied by the Great Lakes and burying previously exposed bedrock under unconsolidated rock and soil (i.e., glacial till). The Illinoian (ca. 220,000-110,000 years before present) and Wisconsinan (ca. 70,000-10,000 years before present) glaciations had the greatest impact on the physical characteristics of the midcontinent, covering most of the midcontinent north of the Ohio River by ice during their greatest extent (Figure 6.2). The glacial maximum of the Wisconsin interval occurred around 21,000 years ago (Melhorn 1997). A this point, ice covered all of Michigan and Ontario as well as significant portions of Illinois, Indiana, and Ohio.

The glacial margin had retreated from most of the midcontinent by about

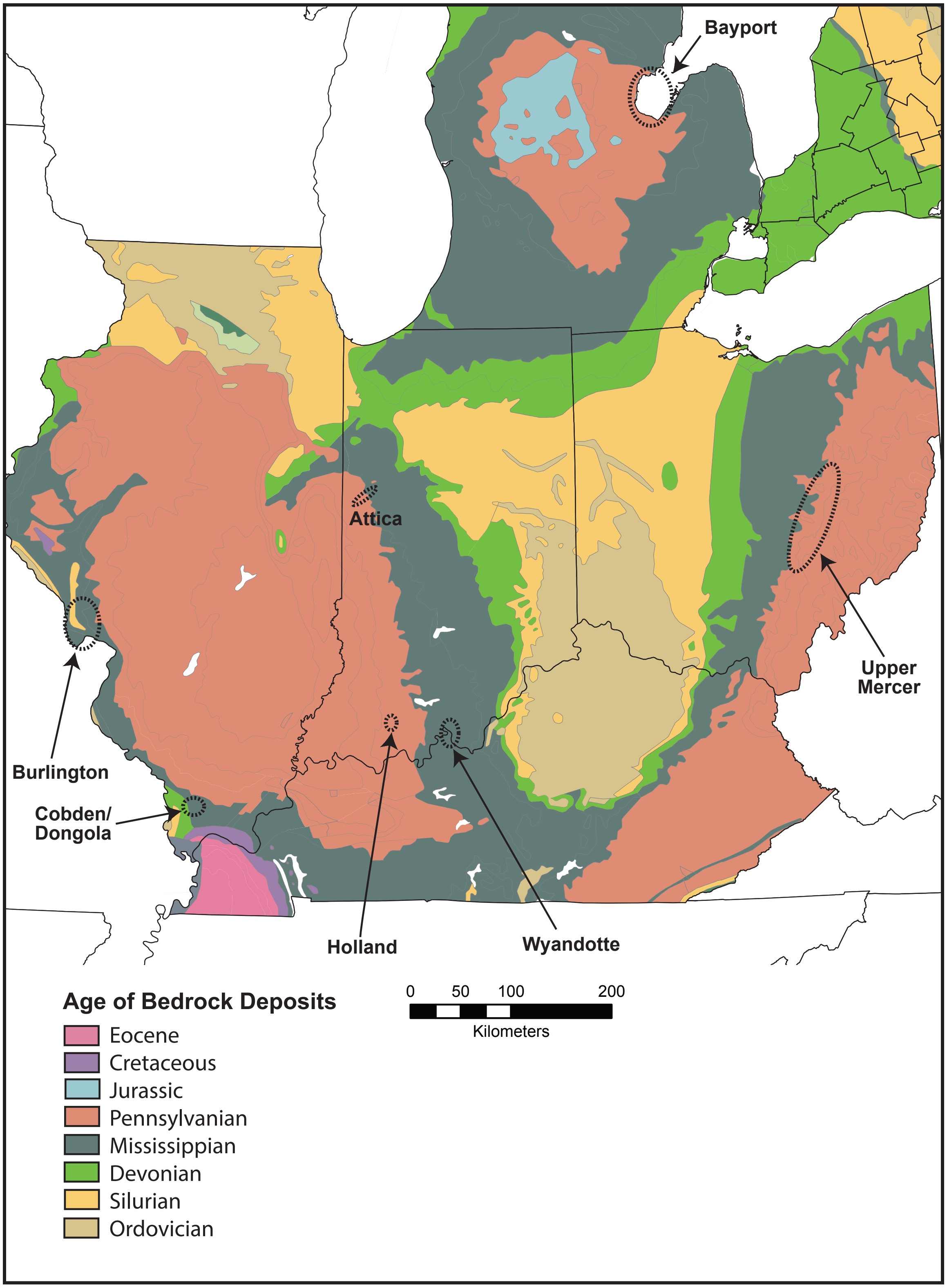


Figure 6.1. Map showing the distribution of bedrock of different geological ages in the midcontinent and correspondence to locations of chert source areas discussed in the text. Distribution of bedrock deposits adapted from GIS data published by the U.S. Geological Survey (GIS data based on Reed et al. [2005]).

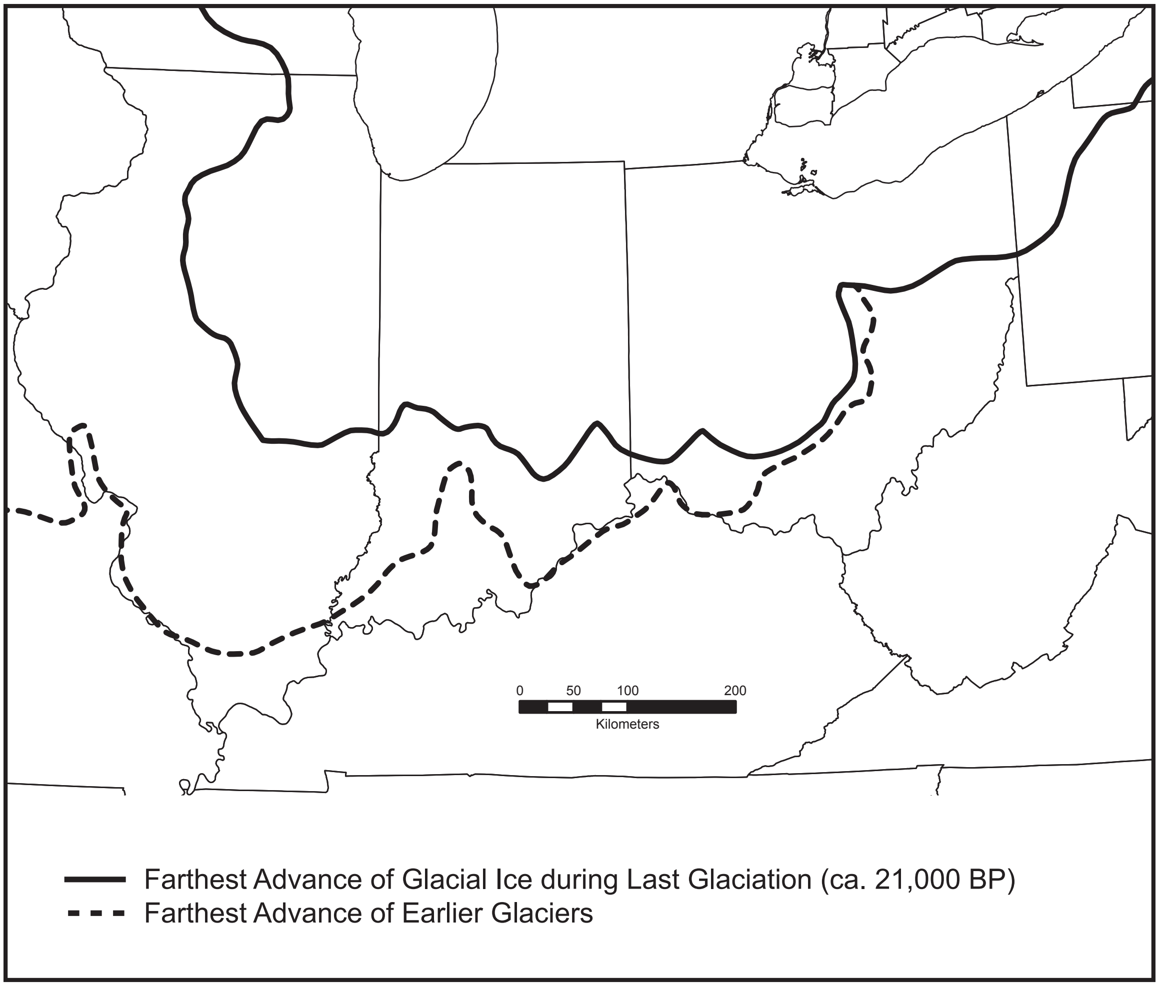


Figure 6.2. Map showing the farthest extent of glacial ice during the Wisconsinan glaciation and earlier glaciations. Lines marking glacial advances based on GIS data published by the U.S. Geological Survey.

13,000 RCYBP (see Larson and Schaetzl 2001; Melhorn 1997), well prior to the appearance of the Clovis points that mark the first unambiguous indications of human occupation in this area. Receding ice continued to affect climate and the environment as glacial lakes fluctuated in configuration (Larson and Schaetzl 2001).

Pleistocene glaciations are responsible for much of the physiography of the midcontinent. Much of the area under consideration here is included in the glaciated portions of the Central Lowland province defined by Fenneman (1928). The Eastern Lake and Till Plains sections of this province (Figure 6.3) are areas of relatively low relief containing features from recent glaciation: moraines, lacustrine plains, till plains, and small bogs and lakes that formed in depressions

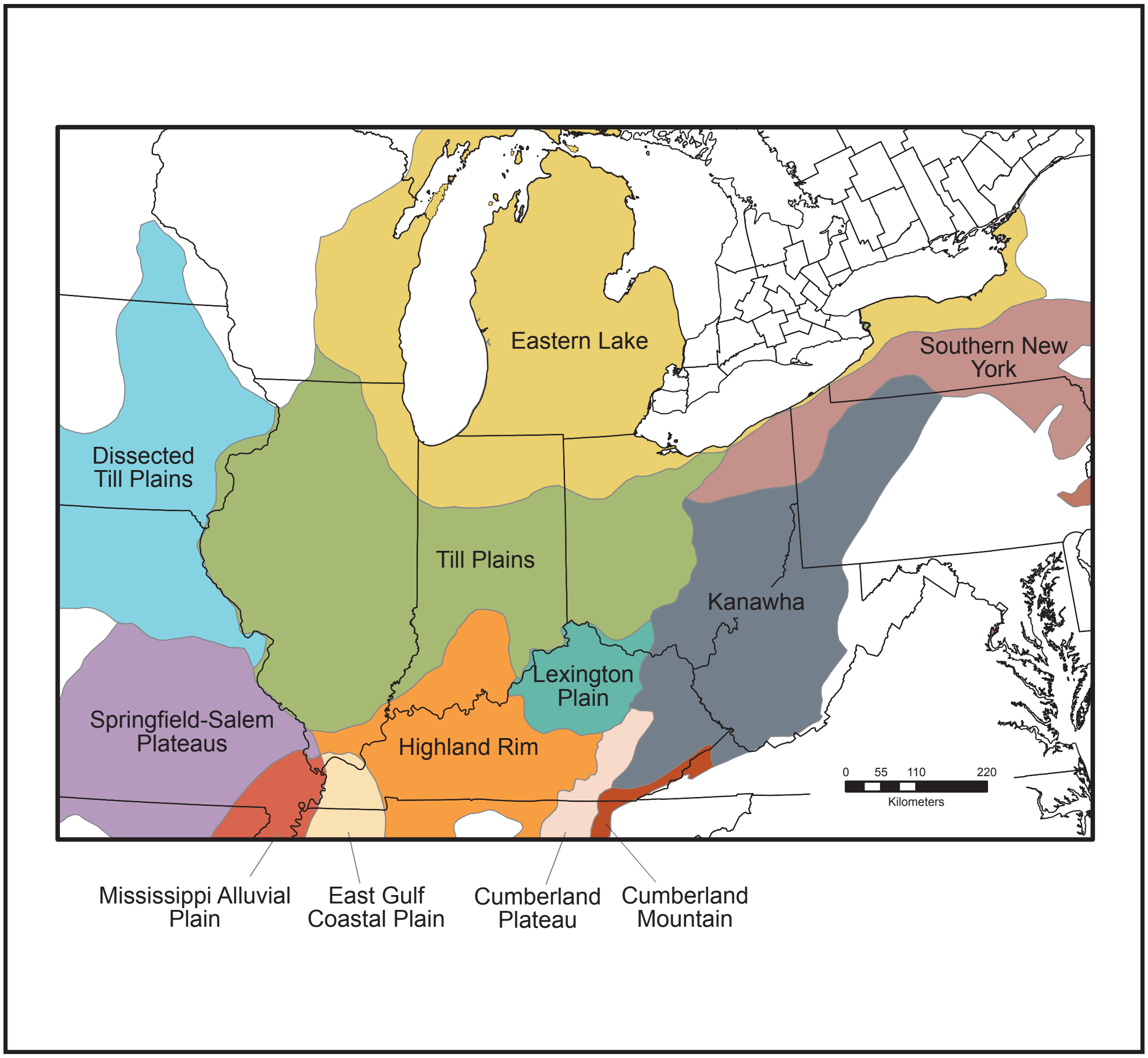


Figure 6.3. Map showing the physiographic sections of midcontinental North America. Adapted from GIS data published by the U.S. Geological Survey (GIS data based on Fenneman [1946]).

left by melting blocks of ice (Casebere 1997; Fenneman 1928; Melhorn 1997).

Potions of the midcontinent south of the maximum extent of Pleistocene glaciation feature greater relief and more numerous surface exposures of bedrock. Dissected uplands are present in the Highland Rim and Lexington Plain sections of Kentucky, southern Illinois, and southern Indiana as well as in the Appalachian Plateau of southeastern Ohio (see Figure 6.3). The common presence of bedrock at or near the ground surface in these areas is associated with a greater availability of better quality cherts in the unglaciated portions of the midcontinent (see Tankersley 1989).

Streams, rivers, and lakes in the midcontinent form three major watersheds as delineated by the U.S. Geological Survey: the Great Lakes, Ohio, and Upper Mississippi regions (Figure 6.4). These watersheds converge in northern Indiana. The boundary between the Till Plains and the Eastern Lake sections identified by Fenneman (1928) roughly corresponds to the boundary between the Great Lakes and Ohio watersheds (compare Figures 6.3 and 6.4).

Lithic Resources

Chert, a cryptocrystalline or microcrystalline form of quartz, was by far the material most commonly used for the manufacture of chipped stone tools by early foragers in the midcontinent. Chert forms as nodules or beds in limestone deposits. Cherts of different geological origins vary widely in color, texture, and the quantity and types of inclusions. This variability often makes it possible

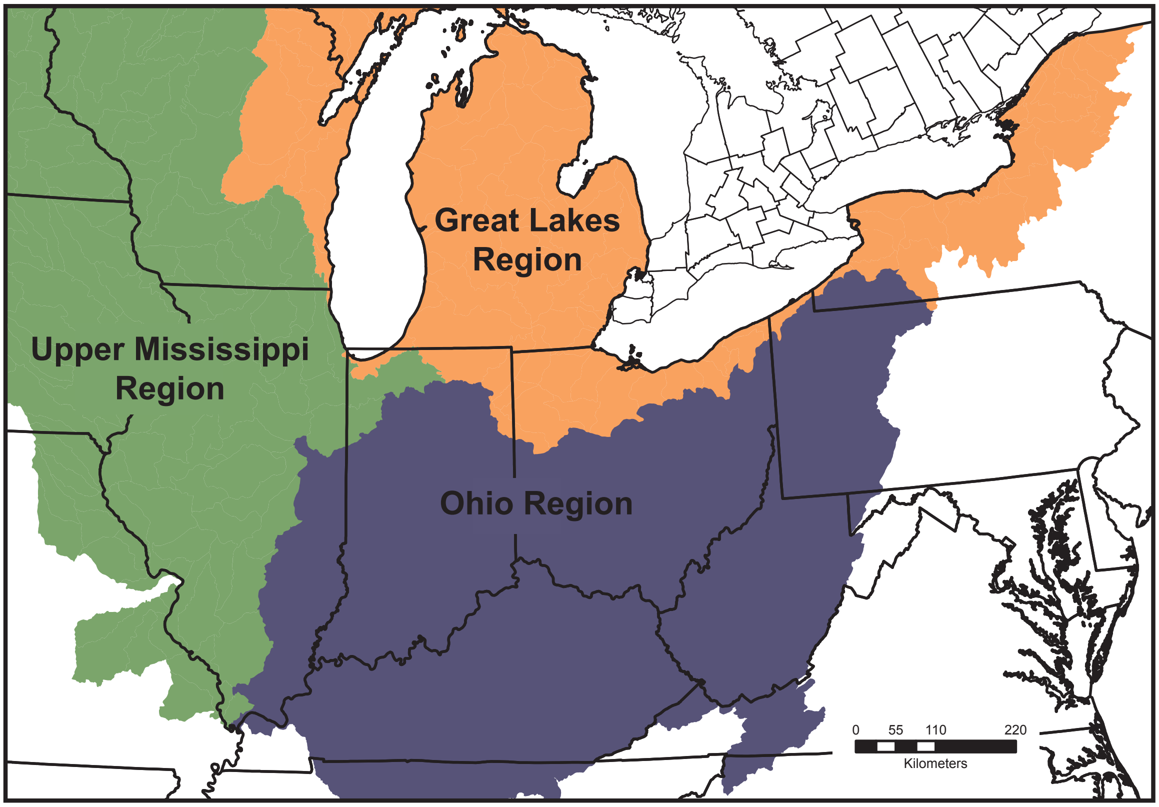


Figure 6.4. Map showing extent of Great Lakes, Ohio, and Upper Mississippi watersheds in the North American midcontinent. Adapted from GIS data published by the U.S. Geological Survey.

to macroscopically discriminate between cherts that originated from different deposits and/or different geographic areas.

Numerous sources of chert were utilized by early foragers in the midcontinent (e.g., see Cantin 1994; Converse 1994; DeRegnaucourt and Georgiady 1988; Munson and Munson 1984; Tankersley 1989; Vehik 1985). Many of these raw materials were procured from bedrock sources of known geographic location. In addition to these bedrock sources, till cherts would have been available in glaciated portions of the midcontinent (Tankersley 1989). Cherts in secondary contexts may have also been available in the gravel deposits of streams flowing through these formerly glaciated areas or through areas with bedrock outcrops of chert. This section will focus on describing the bedrock chert sources that are important to the analysis that follows: Attica, Bayport, Burlington, Cobden/Dongola, Holland, Upper Mercer, and Wyandotte. General source locations of these cherts are shown in Figure 6.1.

Attica

Attica chert (*aka* Indiana Green) is a bedded, Mississippian chert described by Cantin (1994) as a medium to medium-coarse, slightly fossiliferous, homogeneous chert containing occasional mineral vugs and sponge spicules. Coloring is blue-green to purple with streaks, bands, and mottles. Luster is usually dull to very slightly glossy with virtual opacity to slightly translucent on extremely thin edges. Outcrops of Attica chert are exposed by the Wabash River and its tributaries in Fountain and Warren counties, Indiana (Cantin 1994). Attica chert nodules in secondary context occur in stream deposits and glacial till deposits downstream from the source area (Cantin 1994).

Bayport

Bayport chert is a nodular, grey chert with abundant white inclusions, ranging in texture and luster from “chalky and earthy up to porcelaneous or waxy” DeRegnaucourt and Georgiady (1988:185). Bayport is of Missippian age, outcropping in the Saginaw Bay area of eastern Michigan, specifically in Huron, Arenac, and Tuscola counties (DeRegnaucourt and Georgiady 1988; Fitting et al. 1966). Most sources of Bayport chert were under water until about 10,400 RCYBP (Simons et al. 1984).

Burlington

Burlington chert is highly variable, ranging in texture from coarse to waxy or vitreous and occurring in colors described as white, tan, brown, cream, yellow, orange, red, pink, and black (DeRegnaucourt and Georgiady 1988:172). Prehistoric artifacts were most commonly made on white to light gray Burlington (e.g., see DeRegnaucourt and Georgiady 1988:Plate 34; Loebel 2005:131; Rick 1978:22).

Burlington chert is Mississippian in age, outcropping along both sides of the Mississippi River in portions of Illinois, Missouri, and Iowa (DeRegnaucourt and Georgiady 1988:172; Tankersley 1989; Ray 1985) as well as in portions of the Illinois River valley (Rick 1978). The variability of Burlington chert and its widespread outcrops makes it very difficult to determine the exact source areas used to manufacture particular artifacts (Loebel 2005:131).

Cobden/Dongola

Cobden/Dongola chert (aka Illinois Hornstone) is a gray, nodular, Mississippian chert that outcrops mainly in southern Illinois. The main source areas of Cobden/Dongola chert are in Union County, Illinois (DeRegnaucourt and Georgiady 1988:166). There is considerable macroscopic overlap between Wyandotte chert and Cobden/Dongola chert from southern Illinois (cf. DeRegnaucourt and Georgiady 1988:166). Both of these are fine-grained, blue-gray, nodular cherts that often have concentric bands.

Holland

Holland chert is a bedded Pennsylvanian chert that outcrops in Dubois and Spencer counties, Indiana (Cantin 1994). It varies in color and can be variegated, streaked, or dappled (Catin 1994). The “Ferdinand” or “Holland Dark-Phase” variety of Holland chert is macroscopically very similar to Upper Mercer chert from eastern Ohio (Cantin 1994; DeRegnaucourt and Georgiady 1988:100) as well as other black cherts from southern Indiana (see Munson and Munson 1984). Cantin (1994) notes that it may be possible to distinguish Upper Mercer chert from Holland Dark-Phase based on the higher density of fusilinids present in Upper Mercer chert. Tankersley (1989:107) notes that the geological circumstances under which Holland outcrops produces a greater degree of weathering and erosion in Holland cherts than in Upper Mercer cherts, resulting in Holland cherts being available in smaller masses than Upper Mercer cherts.

Upper Mercer

Upper Mercer chert (*aka* Coshocton chert) is a Pennsylvanian chert that outcrops over a large region of eastern Ohio. While most artifacts made from Upper Mercer are predominantly black with light mottles or streaks, this chert also occurs in grey/off-white forms (Converse 1994; DeRegnaucourt and Georgiady 1988:81).

The main source areas of Upper Mercer chert are in Muskingum, Coshocton, Licking, Perry, and Hocking counties, Ohio (DeRegnaucourt and Georgiady 1988:80). Upper Mercer chert was actively quarried during at least some periods of prehistory in Coschocton County (Converse 1994:174). Quarrying activities were focused on procuring unweathered chert available near the surface in bluff-top bedrock sources (see Lepper 1986; Mullet 2009; Tankersley 1989:107).

Wyandotte

Wyandotte chert (*aka* Harrison County chert, Indiana Hornstone) is a gray to blue-gray chert that occurs in both nodular and tabular forms. Generally, Wyandotte is regarded as a high-quality chert due to its characteristically fine texture, homogeneity, and rarity of internal flaws. Wyandotte chert was used extensively during the Paleoindian and Early Archaic periods (Seeman 1975).

Wyandotte chert originates in the Mississippian Ste. Genevieve limestone (Cantin 1994:61). While the “main” source areas of Wyandotte chert are located in Harrison County, Indiana, the Wyandotte outcrop extends into Crawford County, Indiana, and Meade, Breckinridge, and Hardin counties, Kentucky (Tankersley 1985, 1989). Seeman (1975) reports prehistoric quarrying activities associated with the procurement of unweathered nodules of Wyandotte.

There is considerable macroscopic overlap between Wyandotte chert and Cobden/Dongola chert from southern Illinois (cf. DeRegnaucourt and Georgiady 1988:166; Seeman 1975:59). Both of these occur as fine-grained, blue-gray, nodular cherts that often have concentric bands and a well-developed cortex.

While it may be possible to reliably discriminate Wyandotte chert from Cobden/Dongola using petrographic analysis (Tankersley 1985), the similarity of these cherts makes reliable macroscopic differentiation difficult.

Chronology, Environment, and Culture History

As defined here, the Paleoindian and Early Archaic periods in midcontinental North America extend from approximately 11,050 to 8000 radiocarbon years before present (RCYBP) (Figure 6.5). This period of time spans the end of the Late Pleistocene and the beginning of the Holocene, the dividing line between which is traditionally regarded as 10,000 RCYBP. Calibrated YBP dates shown in Figure 6.5 follow Reimer et al. (2009). The 3050 radiocarbon years of the Paleoindian and Early Archaic periods encompass approximately 4000 years of sidereal time, from about 12,930 to 8985 cal YBP. The large discrepancy between the span of radiocarbon years and the span of sidereal years is caused by "plateaus" of constant radiocarbon age around 10,000 RCYBP and 9,600 RCYBP (see Anderson 2005; Ellis et al. 1998; Fiedel 1999; Meltzer 2009; Shane et al. 2001). The 10,000 RCYBP plateau presents particular difficulties with regard to dating the complex environmental changes associated with the Pleistocene-Holocene transition.

A tripartite division of the Paleoindian period is used here. While division of the Paleoindian period into Early, Middle, and Late portions is fairly standard in eastern North America, the chronological spans of these segments of the Paleoindian period differ somewhat by region and researcher and have often been revised (e.g., see Anderson 1990, 2005; Ellis et al. 2011; White 2006a).

Pre-Clovis (>11,050 RCYBP)

A growing number of archaeologists are beginning to grapple with data that suggest the inadequacies of the Clovis-first model (see Bonnichsen and Lepper 2005; Bonnichsen et al. 2005; Bonnichsen and Turnmire 1999; Lepper and Bonnichsen 2004). The idea that human populations existed in eastern North America prior to the appearance of Clovis remains a controversial one (e.g., see Adovasio and Pedler 2005; Anderson 2005; Fiedel 2005; Goodyear 2005; Morrow et al. 2012).

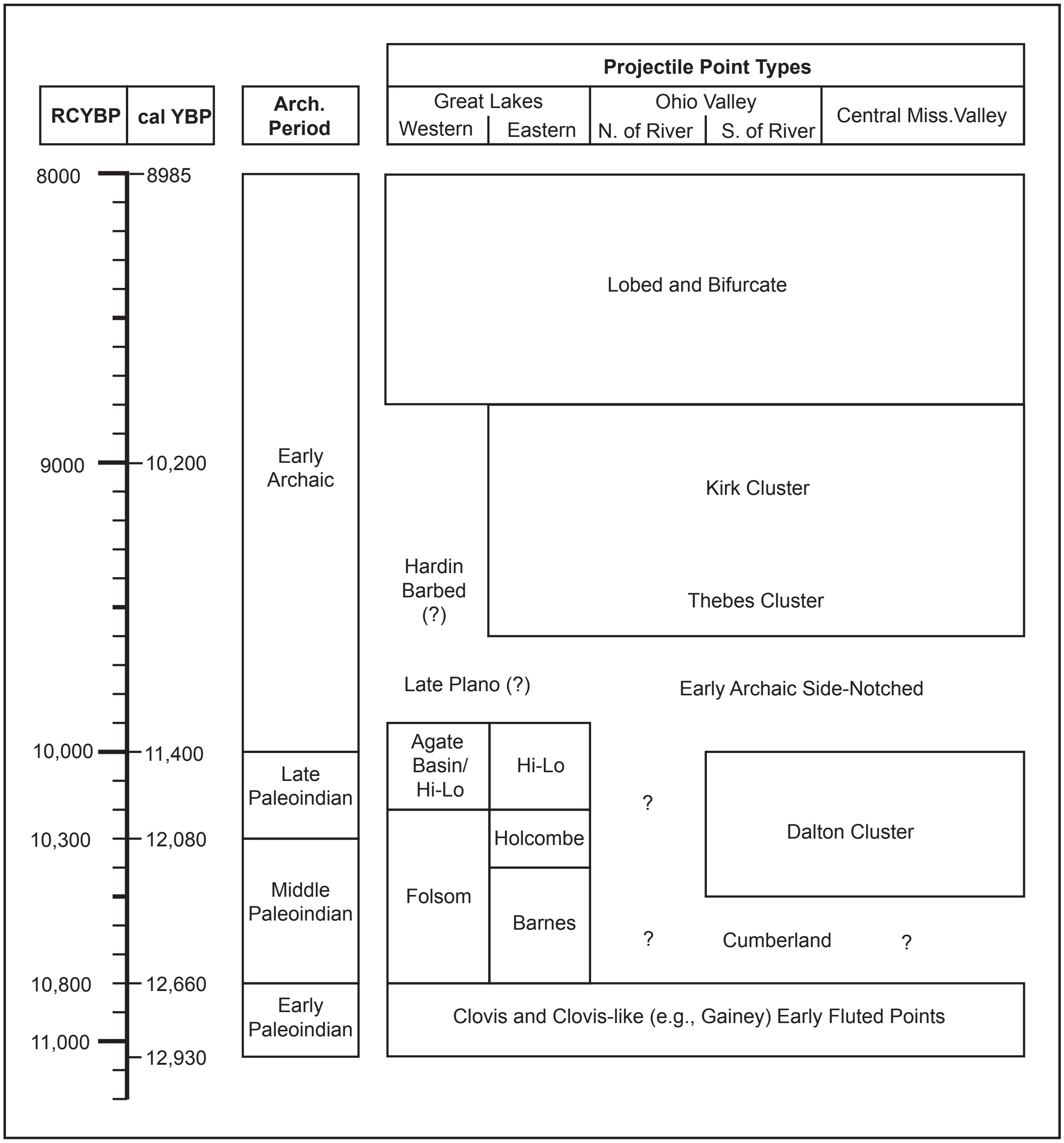


Figure 6.5. General associations between radiocarbon chronology, archaeological periods, and projectile point types in the Great Lakes, Ohio Valley, and Central Mississippi Valley regions. Cal YBP dates follow Reimer et al. (2009).

Perhaps the most widely accepted evidence for pre-Clovis occupations in eastern North America has thus far been obtained from the Meadowcroft Rockshelter in western Pennsylvania (Adovasio 1993; Adovasio et al. 1999) and the Cactus Hill site (McAvoy and McAvoy 1997) in Virginia. Other sites with possible pre-Clovis components have been identified in the southeast (see

Goodyear 2005). There is also some evidence of human interaction with large mammals in the midcontinent prior to the earliest dated occurrences of Clovis artifacts. Reports of human butchery include mastodons (e.g., Fisher et al. 1994), mammoths (Overstreet 2005), and ground sloth (Redmond et al. 2012). If the age of the Clovis complex suggested by Waters and Stafford (2007) is correct, these remains are evidence of pre-Clovis human activity involving the exploitation of megafauna.

Most purported pre-Clovis sites in eastern North America appear to postdate 16,000 RCYBP (i.e., after the last glacial maximum). Vegetation reconstructions from the period between 16,000 and 11,050 RCYBP suggest that the mixtures of species in many regions were unlike anything found today (see Overpeck et al. 1992). At 12,000 RCYBP, much of the North American midcontinent was covered by a spruce-dominated woodland with no modern analog (Overpeck et al. 1992).

Early Paleoindian Period (ca. 11,050-10,800 RCYBP)

Remains left by Early Paleoindian (i.e., “Clovis”) peoples mark the earliest unambiguous, well-documented human occupation of the North American midcontinent. A recent review of the radiocarbon evidence (Waters and Stafford 2007) places the Clovis occupation of North America to within the period 11,050-10,800 RCYBP. While not all archaeologists accept this narrow time range on a continental scale, most would probably agree that Clovis and Clovis-like manifestations in the midcontinent pre-date 10,500 RCYBP (e.g., see Anderson 1995; Ellis and Deller 2000; Ellis 2011). As defined here, the Early Paleoindian period encompasses the widespread appearance and use of initial Paleoindian fluted point technologies in eastern North America (see Fiedel 1999; Waters and Stafford 2007).

The Early Paleoindian period overlaps with the onset of the Younger Dryas chronozone (ca. 10,900-10,000 RCYBP), a widespread climatic episode that included a reversal of the warming trends of the Late Pleistocene (Shane and Anderson 1993; Shuman et al. 2002). The early portion of the Younger Dryas was associated with the replacement of deciduous tree species by spruce in many parts of the midcontinent (see Gonzales and Grimm 2009; Shane 1987; Shane and Anderson 1993; Whitehead 1997), indicating a return to cooler temperatures. Interpreting the pollen record from Indiana and Ohio, Shane

(1994:13-14) suggests changes in vegetation, temperature, and moisture would have been sufficiently abrupt to be perceived at human generational scales of time. The impact of the Younger Dryas appears to have been less pronounced in Michigan and Ontario, which experienced relatively gradual change from open spruce parkland to more closed boreal forest environments during this time (Ellis et al. 2011).

The boreal environments of Ohio and Indiana during the Early Paleoindian period supported a variety of large mammals: woodland muskox (*Bootherium*), elk-moose (*Cervalces*), giant beaver (*Castoroides*), caribou (*Rangifer*), and mastodon (*Mammut*) (McDonald 1994; Richards and Whitaker 1997; Shane 1994; see also Tankersley et al. 2009). Dated remains of at least one mammoth (*Mammuthus*) suggest tundra or open savanna/plains environments were present in some areas of Ohio during the Early Paleoindian period (see McDonald 1994:28-29). Open spruce parkland environments were likely present in the eastern Great Lakes (Ellis et al. 1998; Ellis et al. 2011).

The defining artifact of the Early Paleoindian period is the fluted projectile point. These points are generally large, parallel-sided forms with concave bases and flutes (longitudinal flakes removed from the basal edge) on both faces. In the midcontinent, specific Early Paleoindian point types include Clovis and Gainey forms (see below). Other distinctive Early Paleoindian artifacts found in the east are large, well-flaked unifacial tools (Deller and Ellis 1992b:132), blades and blade cores (Sanders 1988; Tankersley 1994; Yahnig 2004), and beveled bone and ivory artifacts (Hemmings et al. 2004; Redmond and Tankersley 2005; Tankersley 1994).

Early Paleoindian populations in eastern North America are typically thought to have been composed of small, mobile groups of foragers that exploited large annual ranges (Ellis 2011; Kelly and Todd 1988; Koldehoff and Loebel 2009; Seeman 1994). Claims for a high degree of residential mobility among Early Paleoindian peoples are based on the long-distance transport of lithic artifacts made from identifiable raw materials (see Ellis 2011; Loebel 2005; Seeman 1994; Stothers 1996; Tankersley 1989, 1994). Hypothesized scales of movement are large in comparison to most archaeologically-known and ethnographically-observed hunter-gatherer systems (e.g., see Amick 1996:419-420; Ellis 2011; Shott 1986:133-4, 141-2; Tankersley 1998). Exchange may have played a role in the movement of some artifacts (e.g., Deller 1989:219; Loebel 2005:142; Meltzer 1989; Speth et al. 2010; Tankersley 1990:289-292), and patterns of movement may have changed through time within this period. Artifacts other than fluted points may also offer important clues to patterns of social interaction: Loebel (2005:165) suggests that the transport of endscrapers of exotic raw materials may be related to the exogamous movement of females between bands.

The very-long distance transport of a few Early Paleoindian artifacts is argued by some researchers to be the result of movements of colonizing populations (e.g., Tankersley 1994; Loebel 2005). Clovis points made from Knife River Flint (outcropping in North Dakota) and Hixton Silicified Sandstone (outcropping in Wisconsin) have been identified in southern Indiana, southern Ohio, and central Illinois, for example, over 700 km from where they were presumably manufactured (Tankersley 1994). The transport of Wyandotte chert approximately 600 km from its source area in southern Indiana to the Paleo Crossing site in northeast Ohio has also been suggested to be the result of colonization movements (e.g., Brose 1994; Ellis 2011:393).

Direct data on Early Paleoindian subsistence are rare or absent in most of eastern North America. Animal species in the Early Paleoindian subsistence economy included now-extinct Pleistocene megafauna as well as an assortment of smaller game. Incidences of fluted points directly associated with mammoth and mastodon remains demonstrate that very large animals were part of the Early Paleoindian diet (e.g., see Graham et al. 1981; Haury et al. 1953; Haury et al. 1959; Haynes 1966; Surovell and Waguespack 2008; Tankersley 1989:7). The degree to which Early Paleoindian hunters in different parts of the continent were focused on megafauna as a central subsistence resource, however, is a matter of debate (see Canon and Meltzer 2004; Meltzer 2009; Meltzer and Smith 1986; Surovell and Waguespack 2008; Waguespack and Surovell 2003; Speth et al. 2010), as is the role that Early Paleoindian hunters played in the extinction of various taxa of megafauna (see Gillespie 2008; Grund et al. 2012; Haynes 2010; Meltzer 2009).

Caribou may have been an important food animal during the Early Paleoindian period in the Great Lakes and Northeast (see Jackson 1988, 1997; Koldehoff and Loebel 2009; Loebel 2005; Simons et al. 1984). Small amounts of caribou bone have been recovered from several Early Paleoindian sites in Ontario (Jackson 1997; Storck and Speiss 1994). A semi-circle of lithic debris clusters at the Nobles Pond site in northern Ohio has been interpreted as an aggregated encampment (Seeman 1994), possibly related to communal caribou hunting in the same fashion as later Middle Paleoindian sites (see below).

Middle Paleoindian Period (ca. 10,800-10,300 RCYBP)

As defined here, the Middle Paleoindian period extends from approximately 10,800 to 10,300 RCYBP. During this time Clovis and Clovis-like point forms are replaced by point styles with more limited geographic distributions. In eastern North America there is a trend towards smaller fluted points, often with constricted (rather than parallel-sided) hafts (see Carty and Speiss 1992; Justice 1987; Lewis 1954). In the Southeast, such "constricted haft" points are usually placed within the Cumberland cluster (Justice 1987). In the eastern Great Lakes, similar points are called Barnes. The earliest forms associated with the Dalton cluster in the southeast and Mississippi Valley date to the Middle Paleoindian period (see below). Folsom points occur in low numbers in Illinois and northwestern Indiana (Munson 1990) and in Wisconsin (Ellis et al. 2011). These point forms date to the period 10,800-10,300 RCYBP on the Plains (see Fiedel 1999; Haynes et al. 1984)

The environment continued to change during the Middle Paleoindian period. Following a spruce maximum, the progression of the Younger Dryas was associated with a general shift to pine forests in many parts of the midcontinent (Bernabo and Webb 1977; Shane 1994; Shane and Anderson 1993; Whitehead 1997; Whitehead et al. 1982), though there was considerable variability in the timing and nature of changes in forest composition (e.g., see Gonzales and Grimm 2009; Wilkins et al. 1991). Shifts from spruce to pine in Michigan and Ontario may have occurred in the context of more open parkland environments rather than closed forests (see Ellis et al. 2011; Ellis et al. 1998; Storck 1997:274).

Many of the megafaunal species that were present during the Late Pleistocene became extinct between about 11,000 and 10,000 RCYBP (Faith and Surovell 2009; Gillespie 2008; C. V. Haynes 1984; G. Haynes 2002, 2010). Dated mastodon remains from Michigan (Fisher 1984) and northern Indiana (Woodman and Athfield 2009) indicate that this species survived through the Middle Paleoindian period in at least some portions of the eastern Great Lakes. This is consistent with the later occurrence of spruce habitats in these areas (see Ellis et al. 2011; Teale and Miller 2012; Whitehead 1973; Whitehead et al. 1982).

Fauna that persisted or appeared in the midcontinent following the extinction of the megafauna included a number of extant ungulates: caribou, moose, elk, and deer (see Jackson 1988; Richards and Whitaker 1997). These species would have been present in suitable habitats, the distribution of which was unlike that of today.

The relatively open parkland/woodland environments in the eastern Great Lakes would have provided suitable habitat for caribou, the latest documented remains of which date to about 10,300 RCYBP in southern Ontario (see Jackson 1988:35). Most models of Middle Paleoindian subsistence and economy in the eastern Great Lakes are based on the premise that migratory caribou was indeed the primary game species during this period: several Middle Paleoindian sites in the Great Lakes and Northeast have produced clusters of artifact concentrations that have been interpreted as locations where multiple families aggregated, perhaps for the purposes of (among other things) communal intercept hunting of migratory caribou (e.g., see Deller and Ellis 1992a, 1992b; Ellis and Deller 2000:251; Fitting et al. 1966; Jackson 1997; Storck 1997). A Cumberland point was associated with caribou bone at the Dutchess Quarry Cave site in New York (Funk et al. 1969).

While use of non-local lithic raw materials continued among Great Lakes Middle Paleoindian peoples, very distant chert sources appear to be utilized to a lesser degree, if at all. This general shift in chert procurement probably signals a reduction in the scale of group mobility relative to the Early Paleoindian period (see Ellis 2011). It could also possibly correspond to a change in some other mechanism of stone tool transport, such as exchange.

South of the Great Lakes (i.e., central Indiana, Ohio, and Illinois), more closed spruce/pine woodlands may have supported elk, moose, bison, and a variety of other species of mammals common to boreal forests. Distinctive projectile point types dating to the Middle Paleoindian period appear to be present in these areas in lower densities than in other regions. While some Cumberland points have been documented north of the Ohio River (e.g., Prufer and Baby 1963; White 2006b, 2006c), the distribution of these points is clearly centered in Tennessee and Alabama, where they have been documented in high densities (see Anderson et al. 2009; Justice 1987). The distribution of early forms of Dalton points (i.e., Quad, Beaver Lake) is similar (Anderson et al. 2009; Justice 1987). Again, examples of these types have been documented in the Ohio Valley only in relatively low numbers (e.g., Prufer and Baby 1963; Tomak 1994). The lack of a clear intermediate form between Early Fluted Points and

Dalton in Missouri has led to the suggestion that Dalton developed directly from early fluted point technologies there at ca. 10,800 RCYBP (O'Brien and Lyman 1999; O'Brien and Wood 1998). Radiocarbon dates suggest the appearance of Dalton in this area at ca. 10,500 RCYBP, however (see Goodyear 1982; Koldehoff and Loebel 2009). The dearth of points of known Middle Paleoindian age in the area east of the Mississippi River Valley, north of the Ohio River Valley, and south of the Great Lakes suggests the possibility that portions of the midcontinent may have been largely unpopulated during this time period. This possibility is considered further in the analyses that follow.

The incursion of Folsom groups into Wisconsin, northern Illinois, and northwestern Indiana may be linked to presence of prairie habitat and the expansion of bison into those areas prior to 10,500 RCYBP (see Munson 1990). Raw material transport patterns associated with Folsom points in the western Great Lakes suggest a high degree of mobility among Folsom peoples (Ellis et al. 2011).

Late Paleoindian Period (ca. 10,300-10,000 RCYBP)

The Late Paleoindian period extends from 10,300 to 10,000 RCYBP. These 300 years of radiocarbon time encompass about 700 sidereal years, making the Late Paleoindian and Middle Paleoindian periods roughly comparable in length. This period was marked by a profusion of regionally distinctive projectile point styles. Small, gracile, unfluted Holcombe points are present in southern Ontario, Michigan and northern Indiana and probably date to around 10,200 RCYBP (Ellis et al. 2011). Hi-Lo points are distributed in a similar area and probably post-date Holcombe. Dalton cluster points are present in the Mississippi and Ohio Valleys. Point types that are typical of the Plains, such as Agate Basin, also occur in limited numbers across the midcontinent.

The Late Paleoindian period is associated with the beginning of the transformation to modern environments in southern portions of the midcontinent. The general retreat of boreal forests accelerated during the period 10,000-8000 RCYBP (Whitehead et al. 1982). Pollen records from Illinois, Indiana, Kentucky, and Ohio suggest that coniferous tree species are virtually absent from those areas after 10,000 RCYBP, replaced mainly by deciduous species such as oak and hickory (Bernabo and Webb 1977; Gonzales and Grimm 2009; Shane 1994; Shane et al. 2001; Whitehead 1973; Wilkins et al. 1991). Spruce was replaced by pine in the Great Lakes, and there was a significant eastward expansion of prairie in Wisconsin and northern Illinois (Bernabo and Webb 1977).

While both types lack associated radiocarbon dates in the Great Lakes, Holcombe points are generally thought to pre-date Hi-Lo points in this area (see below). Holcombe sites in the Great Lakes are generally thought to be the product of a caribou-hunting economy similar to that suggested for Early Paleoindian (Gainey) and Middle Paleoindian (Barnes/Parkhill) peoples in that region (Fitting et al. 1966). Concentrations of lithic debris at the Holcombe site were interpreted as the remains of the campsites of individual families that had aggregated to hunt caribou (Fitting et al. 1966:81; see also Cleland 1965).

Dalton components in the Central Mississippi Valley generally date to the period 10,500-10,000 RCYBP (Ellis et al. 1998; Goodyear 1982; Koldehoff and Loebel 2009). Faunal assemblages associated with Dalton sites include modern deciduous forest species such as whitetail deer, cottontail rabbits, and squirrels (Styles and McMillan 2009). Koldehoff and Walthall (2009:138) see a relationship between the development and expansion of Dalton in the Central Mississippi Valley and the expansion of deciduous forest in the region. Dalton components in this area are associated with formal cemeteries and the production of artifacts for exchange (Koldehoff and Walthall 2009; Morse 1997; Walthall 1999; Walthall and Koldehoff 1998). Along with decreased mobility relative to Early Paleoindian groups, these characteristics have been interpreted as evidence of increased formality in between-group interactions in a demographically “packed” or socially “bounded” landscape (Koldehoff and Loebel 2009; Koldehoff and Walthall 2009:141; Walthall and Koldehoff 1998).

The Hi-Lo cluster is often viewed as “Great Lakes Dalton” and is generally thought to have some chronological and historical relationship to the broader Dalton phenomenon (Ellis et al. 2009; Ellis and Deller 1982; Justice 1987; Koldehoff and Walthall 2009; White 2006a). The general similarity of Hi-Lo points to Dalton points and their presumed appearance in the Great Lakes subsequent to Holcombe suggests an age of around 10,200-9900 RCYBP (Deller and Ellis 1992a). While direct data on subsistence have not been recovered, the presence of boreal and mixed conifer-northern hardwood environments in the Great Lakes at this time (Delcourt and Delcourt 1981; Shane 1994) suggests that Hi-Lo subsistence and settlement would have been geared towards animal species such as caribou, moose, and/or elk. Hi-Lo points are often beveled and reworked in a fashion similar to Dalton points and later Early Archaic points, suggesting use as multi-purpose tools (Ellis 2004a; Ellis and Deller 1982). There are few, if any, known Hi-Lo sites that suggest large group sizes, extended stays, or investment in substantial structures or other facilities. Indications of cemeteries and formalized exchange such as those associated with Dalton are also thus far absent.

Agate Basin points are a Plano point form which dates to about 10,500-9700 RCYBP in the west (Bonnichsen et al. 1987; Frison 1982; Stanford 1999; Wyckoff 1989) occur across the midcontinent (Justice 1987). The distribution of these forms may be related to the eastward expansion of prairie between 10,000 and 8000 RCYBP (see Bernabo and Webb 1977; Styles and McMillan 2009). Hi-Lo and Plano points appear to have somewhat exclusive distributions in Ontario, suggesting the two point forms may be contemporary (Ellis 2004a:69). Wilson and Burns (1999:232) suggest that the Plano tradition was present in southern Ontario before 9500 RCYBP.

Early Archaic Period (10,000-8000 RCYBP)

At the onset of the Holocene, the stylistic regions that had developed during the Late and Middle Paleoindian period disappeared, replaced by a succession of Early Archaic point types with relatively wide geographic distributions. This occurred as the early Holocene climate continued to warm and floral communities in the midcontinent transitioned from forests dominated by pines to those composed of a mixture of deciduous species more similar to what we see today (Ellis et al. 1998; Shane 1994; Whitehead 1997:105). Although the functional, spatial, and temporal relationships between many Early Archaic hafted biface varieties remain poorly understood, a general time-sequential change from side-notched to corner-notched to bifurfcate points is suggested by stratified sites in the southeast and supported by radiocarbon data (Anderson and Hanson 1988; Broyles 1971; Chapman 1977:51; Collins 1979; Jefferies 1988; Tuck 1974).

The earliest identifiable Early Archaic technologies in some portions of the midcontinent are large side-notched points. These point forms have been dated to around 10,000 RCYBP in southern Indiana (Stafford and Cantin 2009). Understanding the distribution of early side-notched point forms in the midcontinent is complicated by the difficulty of confidently differentiating these forms from later side-notched points that date to the Middle/Late Archaic.

Thebes points (dating to around 9500-9000 RCYBP - see below) are the earliest Early Archaic point type that is recognizable across the midcontinent. Generally, Thebes points are relatively large, thick, well-made points with deep notches and heavily ground haft margins. There is considerable variability within the Thebes cluster as defined by Justice (1987). Distinct varieties of Thebes cluster points (e.g., Thebes, St. Charles, Lost Lake, and Calf Creek) are generally distinguished based on haft morphology, notch morphology, and flaking techniques used in manufacture and resharpening (see DeRegnaucourt 1992; Justice 1987; Luchterhand 1970; Winters 1963).

The widespread appearance of Kirk Corner Notched points during the period 9500-8800 RCYBP is often referred to as the "Kirk Horizon" because of the perceived homogeneity of this family of points (e.g., Ellis et al. 1998:162; Tuck 1974). Relationships between Kirk and the earlier point types are somewhat unclear. Even in areas with stratified sequences, the "ancestor-descendent" relationships between various Early Archaic point technologies are not clear. Tuck (1974:77), for example, identifies Big Sandy as the ancestor of Kirk (see also Stothers et al. 2001), while other researchers have speculated on links between Thebes and Kirk (e.g., Kimball 1996:158), and Dalton and Kirk (Cantin 2000:100). While Kirk is clearly a pan-eastern phenomenon, regional chronologies and technological relationships are not easy to reconcile. Corner-notched Kirk forms are followed by lobed and bifurcate forms such as MacCorkle and LeCroy points.

Early Archaic societies are usually thought to have been organized into small, highly mobile bands that practiced a forest foraging economy. It is apparent that Thebes and Kirk points were lost/discarded across the midcontinent in a wide variety of topographic settings, suggesting these groups were making regular use of almost all parts of the landscape in all parts of the Midwest (e.g., Cantin 2000; Munson 1986; Stafford 1994). Stafford used an analysis of the locations of Early, Middle, and Late Archaic hafted bifaces to suggest that the Early Archaic mobility strategy was "dominated by a pattern involving fine-grained patch-to-patch movement through multiple basins by procuring resources on an encounter basis as associated with foragers"(1994:232). Based on raw material data, Ellis et al. (1998:162) speculate that Kirk groups in the Great Lakes "exploited larger areas and maintained wider social networks than comparable Early Archaic groups in the Southeast." Exchange of materials between groups has been suggested (Ellis et al. 1990:80). Increases in population by the Early Archaic period are inferred from increases in numbers of sites and lost/discarded hafted bifaces dating to the Early Archaic period relative to the Paleoindian period.

Faunal remains from Early Archaic deposits in the Cloudsplitter rockshelter in Kentucky suggest a diet incorporating a variety of fauna, including deer, elk, beaver, bird, and turtle (Cowan et. al. 1981). Munson (1986) notes that, although a wide range of subsistence resources was exploited during the Early Archaic, there is little evidence of specialization.

Several possible domestic structures dating to the Early Archaic period have been identified in eastern North America. The earliest of these is what appears to be a small (ca. 4.9 m^2), ovoid, open-sided, post shelter associated with the Thebes component at the Twin Ditch site in Illinois (Morrow 1996:347-348). Abel (1994) attributed a small (ca. 7.8 m^2), circular, basin/post feature at the Weilnau site in Ohio to the Early Archaic period based on the presence of bifurcate and Stanley cluster projectile points in the fill. Ledbetter et al. (2004) described the remains of a possible tent structure defined by debris concentrations and a few possible anchor stones at the Vulcan site in Georgia. Perino (1970:119) described two “house sites or living areas” defined by dark soil or midden at the Stilwell II site. The site was attributed to the Early Archaic period based on the presence of Kirk and bifurcate projectile point forms.

The Early Archaic record includes a number of mortuary sites (both cremations and primary inhumations in formal cemetery areas) in Illinois, Indiana, Kentucky, and Tennessee (see Walthall 1999). Some of these mortuary components are associated with Kirk Corner Notched points. Thebes and Kirk mortuary components may have been present at the Bullseye site in Illinois (Hassen and Farnsworth 1987; Walthall 1999).

Walthall (1998, 1999) sees marked similarities between the behaviors indicated by these few early Holocene mortuary sites and the behaviors of later Archaic and Woodland peoples in eastern North America, noting that mortuary behaviors are just one of a suite of behavioral characteristics attributable to Early Archaic peoples that show a clear break with those of Pleistocene hunter-gatherers. By the Early Archaic period, the Pleistocene/Holocene transition had clearly “turned a corner” in terms of climate, environment, and the cultural adaptations of the residents of eastern North America.

Paleoindian and Early Archaic Hafted Biface Types

Formal lithic hafted bifaces constitute one of the primary sources of information about early hunter-gatherers in the midcontinent. Much of the variability that is evident in Paleoindian and Early Archaic hafted bifaces is related to their role as functional implements that were manufactured to perform a certain task or set of tasks. In addition to serving as the tips of projectile weapons, these tools often functioned as knives, saws, and/or scrapers. Some aspects of variability in these tools are essentially stylistic, however, and as such may hold chronological and/or social information. Identification of the raw materials from which hafted bifaces are made can potentially help us understand mobility, territoriality, and exchange. Thus different aspects of variability in these artifacts can be used to make interpretations about a variety of social, cultural, and economic dimensions of hunter-gatherer systems.

Functional, stylistic, and raw material variability in Paleoindian and Early Archaic hafted bifaces in the archaeological dataset used in this dissertation are considered in Chapter 7. The purpose of this chapter is to provide basic information on the typological categories that are used to classify these tools. Examples of the types discussed are shown in Figure 6.6.

Early Fluted Points

Clovis and Clovis-like hafted bifaces are subsumed into a single “early fluted point” (EFP) category for the purposes of this dissertation. Most of these point forms are thought to pre-date 10,500 RCYBP (see Anderson et al. 1996:9; Brose 1994; Ellis 2011; Ellis et al. 1998; Ellis et al. 2011; Goodyear 2006:102; Seeman 1994; Simons et al. 1984; Shott 1986; 1990; 1993).

Generally, Clovis points are relatively large, bifacially fluted forms with nearly parallel sides. Flattened cross-sections lacking medial ridges were produced by transverse percussion thinning (Morrow and Morrow 2002). Points similar to “classic” Clovis are generally thought to be the earliest fluted point technologies in the east, perhaps marking a pan-regional culture from which later eastern fluted point styles developed (see Anderson et al. 1996; Tankersley 1989; West 1983; Meltzer 1984). The uniquely eastern forms are generally distinguished from Clovis by a small number of morphological and/or technological criteria, usually including the presence of deeper basal concavities

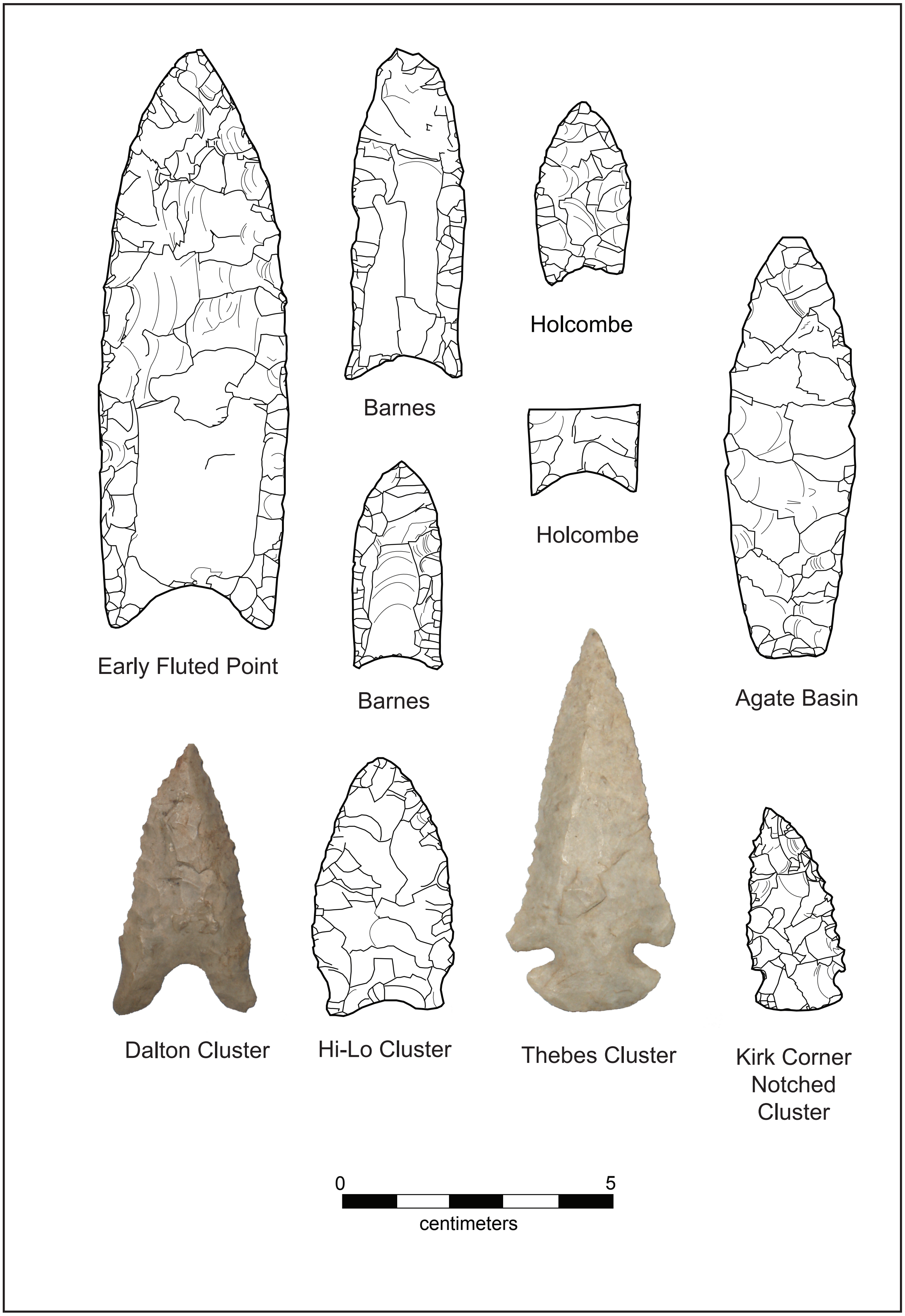


Figure 6.6. Examples of projectile point types discussed in the text.

and evidence of the employment of some fluting technique other than direct percussion (e.g., see Anderson et al. 1996:9; Haynes 1983; Justice 1987; Morrow and Morrow 2002; Tankersley 2004).

Named EFP varieties in the midcontinent include Gainey in the midwest and Great Lakes. Most researchers probably view Gainey as an Early Paleoindian fluted point variety that was developed from and post-dates Clovis. This view is based largely on the analogous size and morphology of Clovis and Gainey points and similarities between apparently post-Clovis fluting techniques employed in the manufacture of Folsom and Gainey hafted bifaces (see Morrow and Morrow 2002). Gainey hafted bifaces are thought to predate 10,500 RCYBP based primarily on their morphology, the geoarchaeological settings of Gainey sites in the Great Lakes, and a few radiocarbon determinations (see Brose 1994; Deller and Ellis 1992a; Ellis et al. 1998; Ellis et al. 2011; Jackson 1998; Seeman 1994; Simons 1997; Simons et al. 1984; Shott 1986; 1990; 1993). If Gainey is somewhat analogous to “true” Clovis, it may predate 11,000 RCYBP (cf. Shott 1986:120). Ellis et al. (2011:535-536) suggest a fairly narrow time frame for Gainey, perhaps from about 10,900-10,800 RCYBP.

Cumberland and Barnes

Across much of eastern North America, the period from about 10,800-10,400 RCYBP witnessed a technological shift to narrower, fluted points with constricted hafts (see Carty and Speiss 1992; Justice 1987; Lewis 1954). Justice (1987:25) includes these materials within a generalized Cumberland cluster (cf. Roosa 1965; Roosa and Deller 1982:4). Deller and Ellis (1992a:131) state, however, that Barnes points can be differentiated from Cumberland points based on several metric and morphological criteria. In the New England-Maritimes region, small, flared ear/waisted points that appear analogous to Barnes are called Michaud-Neponset (see Bradley et al. 2008; Curran 1999).

Barnes hafted bifaces are the dominant forms associated with the Parkhill complex. The Parkhill complex was first defined by Roosa (1977a, 1977b) based on work at the Barnes and Parkhill sites in Ontario (Deller 1980; Roosa 1963, 1965; Wright and Roosa 1966). Barnes/Parkhill complex assemblages have been the focus of several recent studies (Deller and Ellis 1992a, 1992b; Ellis and Deller 2000; Roosa and Deller 1982; Shott 1993; Storck 1983, 1997). Barnes points are narrow with concave basal edges and flaring basal “ears” or "fishtails." Basal widths tend to be less than 20mm, while basal concavities are in the 3-5mm range (Deller and Ellis 1992a). Flutes occur on one or both faces, and were struck from a prepared nipple (Roosa 1963; Wright and Roosa 1966). The base was often finished subsequent to fluting by the removal of one or more short, broad flakes over the origin of the flute scar (Deller and Ellis 1992a, 1992b; Roosa 1965). Morrow (1995) refers to this "Barnes finishing technique" as composite fluting.

Arguments about the chronological placement of the Parkhill complex in Ontario have been summarized by Ellis and Deller (2000) and Shott (1986). The idea that these constricted haft points found in the Great Lakes post-date, and are an evolution from, Gainey points is well-established. Constricted haft points are also thought to post-date early, Clovis-like fluted points in the southeast (Anderson et al. 1996). In general, Barnes points are thought to date to the central portion of the 11th millennium RCYBP, perhaps to around 10,600-10,400 RCYBP (Deller and Ellis 1992a, 1992b:19; Ellis et al. 2011:536; Roosa 1977a; Roosa and Deller 1982; Shott 1986, 1990, 1993), roughly contemporary with Folsom in the west (see Haynes et al. 1984; Taylor et al. 1996). This judgment is based on geochronology (see Ellis and Deller 2000), a number of morphological and technological similarities between Folsom and Barnes hafted bifaces (Roosa 1963, 1965; Storck 1983), and the essentially non-overlapping geographical distributions of the two point types (Justice 1987).

The Cumberland type was originally defined by Lewis (1954). Like Barnes points, Cumberland points have a constricted haft with flared or "fishtail" ears. Fluting is typically bifacial and often extends the length of the point (Justice 1987; Lewis 1954). Boldurian and McKeel (2011) and White (2006c) discuss aspects of Cumberland fluting technology. Radiocarbon dates associated with Cumberland are limited to a suite of pre-Clovis-age dates from the Dutchess Quarry Cave site that most archaeologists consider far too early (see Boldurian and McKeel 2011; Funk et al. 1969; Gramly and Stratton 2005).

Holcombe and Crowfield

The Holcombe type was constructed based on an assemblage of hafted bifaces and basal fragments from the Holcombe Beach site in Michigan (Fitting et al. 1966; Wahla and DeVisscher 1969) and other nearby sites (DeVisscher and Wahla 1966). Some metric data are provided by Fitting et al. (1966) and Deller and Ellis (1992a).

Holcombe points are gracile with slightly concave basal edges and non-flaring pointed and/or rounded ears. The blade is characteristically widest in the distal portion of the point, and the basal edges contract markedly towards the base, resulting in relatively high face angles. Wahla and DeVisscher (1969) report that basal concavities are generally not deeper than 4.5 mm. Unifacial fluting is reportedly common (Fitting 1966; Justice 1987; Wahla and DeVisscher 1969). Finished Holcombe points sometimes have large unflaked surfaces, suggesting they were produced from flake blanks (Roosa and Deller 1982). Point forms of this general type occur across the central and western Great Lakes (Justice 1987), as well as in the northeast (Bradley et al. 2008; Deller and Ellis 1992a; Ritchie 1953).

Holcombe points are thought to date to approximately 10,400-10,000 RCYBP in the Great Lakes (Ellis et al. 2011; Deller and Ellis 1992a; Shott 1990). Comparable points in the New England-Maritimes region have been associated with radiocarbon dates around 10,200 RCYBP (Bradley et al. 2008:150).

The hafted bifaces from the Crowfield site are similar in many respects to Holcombe points (Deller and Ellis 1984; cf. Justice 1987:24). The Crowfield points are thin, fluted points with shallow basal concavities (0.5-4.0 mm) and basal widths less than 20 mm (Deller and Ellis 1984). The lateral edges of some of the points pictured by Deller and Ellis (1984) expand markedly from the base. Based on the larger size of some of the Crowfield hafted bifaces and the presence of bifacial fluting, Deller and Ellis (1984:45, 1992a:126) suggested that Crowfield was the antecedent of Holcombe. Although there do appear to be some morphological and technological (i.e., fluting) differences between the assemblages from the two sites, there is a good deal of overlap between the Crowfield assemblage (Deller and Ellis 1984) and the assemblage from the Holcombe site (Fitting 1966). There are no radiocarbon dates associated with these points.

Dalton Cluster

Dalton points are eared, lanceolate points with concave basal edges and incurvate lateral haft margins (Justice 1987). Heavy grinding is typical of the haft region. Alternative beveling of the blade is a common resharpening attribute. These forms date to the period ca. 10,500-10,000 RCYBP (see Ellis et al. 1998;

Goodyear 1982; Justice 1987; Koldehoff and Walthall 2009; Sherwood et al. 2004), and are often thought to represent a "transitional" technology between the lanceolate points of the Paleoindian period and the notched points of the Early Archaic.

While the core distribution of "classic" Dalton is in the central Mississippi Valley and Ozarks (Justice 1987; Koldehoff and Walthall 2009), a broader Dalton cluster is variously defined to include several named lanceolate and shallowly notched forms (e.g., Beaver Lake, Quad, Greenbrier/Breckenridge, San Patrice, and Hardaway Side Notched) that share a number of morphological and technological attributes (see Justice 1987; Koldehoff and Loebel 2009; Koldehoff and Walthall 2009; Goodyear 1982; Ray et al. 2009; Tuck 1974). A "Northern Mississippi Valley" variety of Dalton has also been described (see Koldehoff and Walthall 2009; Nolan and Fishel 2009). Koldehoff and Walthall (2009) include Hi-Lo within a Dalton horizon that extends across the midcontinent into the Great Lakes (see below).

The historical and chronological relationships among these various named types are not well understood (Koldehoff and Walthall 2009; Nolan and Fishel 2009). While some of these forms appear to date to the Paleoindian/ Early Archaic transition and comprise elements of a broad, synchronous Dalton "horizon" across much of the east, there is also some time depth within the Dalton cluster as defined by Justice (1987). Quad and Beaver Lake, particularly, may predate "classic" Dalton (see Justice 1987:36; Nolan and Fishel 2009:416).

Within Indiana, the distribution of the Dalton cluster as defined by Justice (1987) is largely limited to the southern part of the state. A small number of Dalton cluster points have been reported from central and northern Indiana. Dalton points with site-level provenience have been reported by Mohow (1987, 1989) in northeastern Indiana. Stothers (1996:193, 196) reports a Dalton point from the middle/lower Maumee River Valley. Several Dalton points observed in private collections purportedly from northern Indiana have been documented by White (2005:158, 2007:73). Moore (2008:88) reports a Dalton point from Carroll County.

Hi-Lo Cluster

Hi-Lo points are unfluted forms with concave bases, short hafts, and incurvate lateral haft margins (Fitting 1963; Justice 1987). Both lanceolate and waisted/weakly notched forms were included in Justice's (1987) Hi-Lo cluster. Basal edges are usually thinned (or sometimes "fluted"), and heavy grinding on haft edges is typical (Fitting 1963; Justice 1987). Alternative beveling is common. There is substantial variability within the Hi-Lo cluster (see Ellis 2004a; 2004b; Ellis and Deller 1982; Ellis et al. 2009; Fitting 1963; Stothers 1996) that may be the result of temporal, spatial, and/or technological differences in projectile point style and function.

Points of this general form are concentrated in the Great Lakes region in a spatial distribution that is largely non-overlapping with that of Dalton (Justice 1987). The Hi-Lo cluster is often viewed as "Great Lakes Dalton" and is generally thought to have some chronological and historical relationship to the broader Dalton phenomenon (Ellis and Deller 1982; Justice 1987; Koldehoff and Walthall 2009). As of this writing, there are no radiocarbon dates associated with Hi-Lo points. Their general similarity to Dalton points and their presumed appearance in the Great Lakes subsequent to Holcombe suggests an age of around 10,200-9900 RCYBP.

A great deal of variability is present among points that are typed as Hi-Lo. Variability in Hi-Lo points from Ontario was explored by Ellis and Deller (1982), who suggested that much of the variability in blade shape of Hi-Lo is due to resharpening. Ellis (2004a) described several variations of Hi-Lo, as have others (Fitting 1963; Payne 1982). Some variability in the haft region may be due to repair of broken ears (Ellis and Deller 1982:10). Many of the Hi-Lo cluster points from northeastern Indiana have an unflaked, flattened, or burin facet on the basal edge of one ear (see White 2006a). The repeated occurrence of this feature suggests it was a common or intentional outcome of the manufacturing process, or the result of a typical breakage/stress pattern. Many of the northern Indiana points conform closely to the descriptions of Hi-Lo points from Michigan and Ontario provided by Fitting (1963) and Ellis and Deller (1982). Others have more pronounced constrictions, some approaching side notching.

Hi-Lo points are common in northern Indiana relative to other Paleoindian forms but rare to absent in central and southern Indiana. The distribution of Hi-Lo extends west to eastern Wisconsin (Ellis et al. 2011; Justice 1987). The type appears to be limited to the southern portion of Ontario (Ellis 2004a). Hi-Lo points do not occur in the New England-Maritimes region (Bradley et al. 2008).

Agate Basin/Eastern Lanceolate

Agate Basin points are slender, unfluted, lanceolate forms with straight to convex basal edges and divergent lateral margins (Bradley 1982; Justice 1987). Although the distribution of Agate Basin is centered in the Plains, identical or morphologically similar forms have been reported throughout the Great Lakes region (see Bowen 1995; Fishel 1988; Jackson 1997; Justice 1987; White 2006a) and into the far northeast (Bradley et al. 2008).

Agate Basin points have been dated to the period 10,500-9700 RCYBP in the west (Bonnichsen et al. 1987; Frison 1982; Stanford 1999; Wyckoff 1989). The points postdate Folsom in stratified contexts (see Frison and Stanford 1982) and predate at least some forms of Dalton (Wyckoff 1989).

Thebes Cluster

Thebes cluster points are found across much of the eastern United States and are common across Indiana (Justice 1987) (see also Banks 1991; Bechtel 1988; Bowen 1990a, 1990b; Cantin 2000; Winters 1963). Generally, these are large, relatively thick, well-made points with deep notches and heavily ground haft margins. Varieties of points within the Thebes cluster (e.g., Thebes, St. Charles, Lost Lake, and Calf Creek) are generally distinguished based on haft morphology, notch morphology, and flaking techniques used in manufacture and resharpening (see DeRegnaucourt 1992; Justice 1987; Luchterhand 1970; Winters 1963).

The Thebes cluster appears to date to the period ca. 9500-9000 RCYBP based on radiocarbon dates from just a few sites (see Cantin 2000; Morrow 1996; Nolan and Fishel 2009; Stafford and Cantin 2009). This age range is consistent with stratigraphic associations that suggest that Thebes largely predates Kirk Corner Notched (see Bechtel 1988; Cantin 2000:7; Justice 1987; Kimball 1996:158; Luchterhand 1970:12; Winters 1963).

At least some of the type-level variability recognized in the Thebes cluster appears to have a spatial component, as not all varieties of Thebes occur everywhere within the range of the broader cluster (see Justice 1987). Indiana lies completely within the distributions of Thebes and St. Charles, which are common across the midcontinent (Justice 1987). Lost Lake and Calf Creek varieties of Thebes have not been well-documented in the central and northern regions of the state. The distributions of these types are centered in the southeast and central Mississippi Valley/Ozarks (see DeRegnaucourt 1992:57; Justice 1987:58). Morrow (1996) has suggested some functional differentiation between Thebes and St. Charles points based on a macroscopic examination of points from the Twin Ditch site.

Kirk Corner Notched Cluster

Points in the Kirk Corner Notched cluster are trianguloid with haft regions formed by corner-notching (see Cantin and Stafford 2009; Justice 1987). These points are generally thinner in cross-section than Thebes points and less commonly exhibit heavily ground basal edges and alternate bevelling of the blade. Named varieties such as Kirk Corner Notched, Stilwell, Palmer, Charleston, Decatur, and Pine Tree are generally distinguished based on criteria related to haft morphology, basal finishing techniques, and blade resharpening (see DeRegnaucourt 1992; Justice 1987; Nolan and Fishel 2009; Stafford and Cantin 2009). The wide geographic distribution of Kirk points led Tuck (1974) to name an Early Archaic “corner notched horizon” in eastern North America.

Radiocarbon dates indicate that the Kirk phenomenon is focused in the period ca. 9500-8800 RCYBP (see Cantin 2000; Chapman 1976; Nolan and Fishel 2009; Stafford and Cantin 2009), largely between Thebes and later lobed/bifurcate point forms. The Thebes-like characteristics of some (apparently early) Kirk forms from stratified sites in the southeast (see Kimball 1996) is consistent with some form of historical/developmental relationship between the two clusters.

As with Thebes points, not all varieties of Kirk are present within the range of the broader Kirk cluster. Indiana falls completely within the range of Decatur and both large and small (Palmer) varieties of Kirk Corner Notched, while the distributions of Stilwell, Charleston, and Pine Tree in Indiana appear to be limited to the southern portions of the state (Justice 1987). The meaning of these differences in distribution is not clear. Sites with large excavated assemblages in the Great Lakes, Ohio Valley, and southeast (e.g., Broyles 1971; Chapman 1975; Coe 1964; Collins 1979; Daniel 1998; Ellis et al. 1991; Smith 1995) have the potential to help us understand variability within more narrow “windows” of time and space and complement a large-scale study.

Patterns and Explanations of Change

The Early Paleoindian through Early Archaic sequence in the midcontinent is characterized by significant changes in environment, formal lithic technologies, and raw material transport patterns. During the period 10,800-10,000 RCYBP, scales of raw material transport decreased and the widespread Early Paleoindian fluted point horizon was replaced by regionalized point types as the environment underwent a complex transition from Pleistocene to Holocene conditions. The stylistic regions that emerged during the Middle and Late Paleoindian periods were eclipsed by more-or-less horizon-like successions of geographically-widespread Early Archaic point forms after the onset of the Holocene at around 10,000 RCYBP. Thus the archaeological record of late Pleistocene/early Holocene hunter-gatherers in midcontinental North America includes two notable phenomena: (1) *regionalization* of material culture (the emergence of stylistic regions from relative homogeneity); and (2) *homogenization* of material culture (the emergence of relative homogeneity from stylistic regions).

These phenomena are important for what they might be able to tell us about the operation and characteristics of the social networks which structured interaction as the processes related to regionalization and homogenization unfolded. Numerous researchers have interpreted aspects of these phenomena evident in the early archaeological record of midcontinental North America in terms of the scale and structure of social networks, patterns of social interaction within and between groups, and the appearance of social boundaries The purpose of this section is to outline and clarify scenarios explaining regionalization and homogenization in service of the modeling and analysis efforts presented in Chapter 8. The scenarios discussed below are summarized in Table 6.1.

Early Paleoindian

Most researchers would probably agree that Early Paleoindian systems were characterized by high mobility and low population density. These systems would have been organized to allow the flow of information and mating partners between co-residential groups, probably utilizing periodic aggregations to allow the degree of interaction among groups required for demographic viability (Anderson 1995; Koldehoff and Loebel 2009; Loebel 2005). This consensus view

Table 6.1. Summary of Existing Scenarios Explaining Regionalization of Style during the Middle and Late Paleoindian Periods and Homogenization of Style during the Early Archaic Period.

Phenomenon	Explanation
Regionalization	Reductions in mobility resulting from post-colonization "settling in" lead to the establishment of habitual-use areas. Changes in patterns of social interaction are required to alleviate tensions that arise from increased contact between groups. As populations grow, mechanisms and patterns of social interaction become more formalized, leading to the establishment of archaeologically-recognizable stylistic regions (Anderson 1995).
	Holocene environments led to population growth, reduced mobility, and demographic "packing" of hunter-gatherer groups in the Central Mississippi Valley. These conditions encouraged territoriality, group identity, and negotiation of social alliances *within* this region. Stylistic differentiation between regions was the result of social boundaries characterized by a lack of interaction (Koldehoff and Walthall 2004, 2009; Koldehoff and Loebel 2009; Walthall and Koldehoff 1998).
Homogenization	Homogenization across the midcontinent is the result of population movements associated with a fully developed technology (see Stothers 1996; White 2006a).
	Stylistic homogeneity is the result of some change in network structure or patterns of social interaction that alters whatever processes or conditions were the original causes of regionalization. This change allows regionally differentiated styles to converge, removing the association between space and stylistic variability.

is based mostly on the hypothesized low population densities associated with this period and the theoretically-demonstrated need to maintain social/mating networks of sufficient size and scale for demographic viability and risk mitigation (e.g., Whallon 2006; Wobst 1974). Several researchers have suggested that the extent of "home ranges" or habitual-use areas of Early Paleoindian groups/bands may be discerned by patterns in the transport of artifacts made from specific raw materials (e.g., Koldehoff and Walthall 2004; Loebel 2005; Tankersley 1989).

Middle to Late Paleoindian Regionalization

The two archaeological hallmarks of the Middle to Late Paleoindian periods are (1) the replacement of the pan-regional early fluted point "tradition" by a number of stylistically diverse point types with more limited geographic distributions; and (2) reductions in the scale of raw material transport relative to the Early Paleoindian period, presumably signaling reductions in the scale of group mobility. Existing interpretations suggest two main scenarios to explain the emergence of stylistic regions during the Middle and Late Paleoindian periods. Though these scenarios are similar in some respects, they differ somewhat in terms of the specific role that population growth and demographic “packing” of the landscape played in changing patterns of group mobility and between-group interactions.

The first scenario (Anderson 1995) is a generalized explanation of the social and demographic context in which stylistic regions emerged in eastern North America. In this scenario, reductions in mobility seen during the Middle Paleoindian period are the result of a “settling in” process following colonization during the Early Paleoindian period. The scale of group mobility is reduced as “bounded” habitual-use areas are adopted. Anderson (1995:5) emphasized that decreased mobility was the *result* of the adoption of habitual-use areas (rather than the reverse) and that decreases in mobility occurred in the absence of pressures or constraints from population growth (but see also Anderson 2005:33). Patterns and mechanisms of social interaction between groups changed “in part to alleviate the tensions being generated by increased contacts between groups” (Anderson 1995:6), and continued to evolve and become more formalized as populations grew, promoting the emergence of regional or subregional traditions. This explanation for the emergence of stylistic regions specifies that reductions in mobility preceded significant population growth and demographic “packing” of hunter-gatherer groups on the landscape. As population levels grew, new mechanisms for interaction within and between regions would have developed. At no time, however, would interaction between regions cease. This is a generalized scenario for eastern North America.

The second scenario (Koldehoff and Walthall 2004, 2009; Koldehoff and Loebel 2009; Walthall and Koldehoff 1998) pertains specifically to Dalton groups. This scenario attributes the appearance of stylistic regions to changing patterns of social interaction linked to the demographic “packing” of Dalton bands in deciduous woodland environments, specifically in the Central Mississippi Valley. Koldehoff and Walthall (2004:63) argue that

> . . . this new woodland setting, with its more localized and predictable resources, fostered among Dalton groups reduced mobility and increased population densities, which in turn necessitated ritualized exchange as a means of alliance formation to help mediate potential interband conflicts and food shortfalls stemming from the new, less mobile lifestyle (Walthall and Koldehoff 1998).

In this scenario, the Holocene resource base “promoted reduced mobility, population growth, and bounded landscapes” (Koldehoff and Loebel 2009:285). By “bounded landscape,” they are referring to a populated landscape in which long-distance, “unbounded” mobility was no longer possible because of the presence of other groups (Ellis et al. 2011:539) (note the difference from Anderson’s (1995) use of “bounded”). They attribute the existence of cemeteries and evidence for ritualized exchange among Dalton populations in the Central Mississippi Valley to the emergence of some degree of territoriality, group-based identity, and formalized between-group relationships. Stylistic differences among various regionally-specific Dalton and Dalton-like projectile points found across eastern North America are attributed to the presence of social boundaries associated with a lack of interaction between these regions (Koldehoff and Loebel 2009:284).

Both scenarios relate changes in mobility to changes in the structure and nature of social interactions between groups. As pointed out by Anderson (1995:7) mobility strategies and between-group social interaction “were profoundly interrelated and evolved together over time.” While both scenarios see reductions in mobility and the concurrent change in intergroup relations as part of a “settling in” process, the Dalton scenario is more reliant on demographic “packing” and increases in population density to place constraints on mobility.

Both scenarios lack some clarity as to the causal relationships between changes in interaction patterns and the stylistic differentiation of regions. Anderson (1995) does not specify how changes in within- and between-band interactions produce the patterns of variability that we recognize archaeologically as stylistic regions. It is not clear if stylistic regions are thought to be the result of “active” signaling of group identities or the result of “passive” processes of differentiation related to isochrestic variation (see Chapter 3). The Dalton scenario links the emergence of regional point styles during Dalton times to the presence of social boundaries separating Central Mississippi Valley Dalton from other Dalton groups. While Koldehoff and Loebel (2009:284) specify that these boundaries are associated with a lack of interaction (based on the lack of evidence for inter-regional transport of raw materials and the absence of Sloan Dalton points outside the Central Mississippi Valley), they do not specify if stylistic differentiation is due to “active” or “passive” processes.

Early Archaic Homogenization

The archaeological phenomenon of interest during the Early Archaic period is the eclipse of regionalized Late Paleoindian projectile point styles by Early Archaic points with wide geographic distributions. Two main scenarios can be constructed to explain this homogenization: (1) a population replacement scenario; and (2) a stylistic convergence scenario. Neither of these scenarios has been well-developed.

In a population replacement scenario, the appearance of stylistic homogeneity is attributed to an influx of populations from the south. Population replacement has been proposed to explain the appearance of Kirk technologies over a wide area, specifically in northern portions of the midcontinent (see Cantin 2000:100; Cochran 1986:36; Stothers 1996:204; Tuck 1974:76; White 2006a). The south-to-north transport of raw materials and the lack of a clear technological ancestor in the north are cited as evidence that this technology spread from the south to the north through a population influx, typically conceived of as particular bands extending their territories northward as the environment changed (e.g., Stothers 1996:194, 204; Stothers et al. 2001:239).

In a stylistic convergence scenario, the homogeneity of initial, geographically-widespread Early Archaic projectile point styles (i.e., Thebes) is a result of interactions mediated by existing social networks. Changes in network structure or patterns of social interaction could trigger homogenization by altering whatever processes or conditions were the original causes of regionalization. In the case of the Early Archaic, if regionalization during the Late Paleoindian period was a result of “passive” stylistic differentiation, for example, changing the conditions that allowed differentiation to occur could allow stylistically distinct (but functionally similar) traditions to converge into a homogenous “horizon” through normal processes of learning and information transfer.

The structure of Early Archaic social networks is important in both of these scenarios. In their discussion of Early Archaic adaptations in the southeast, Anderson and Hanson (1988:280) list their expectations for the archaeological correlates of a postulated open-mating network in the Early Archaic:

> Given a presumed open-mating system with a fairly fluid social network, clinal variation in style zones would be expected; stylistic differences might be observable only at major macroband boundaries, or over several watersheds marking individual band territories.

In contrast, Tuck (1974:78) hypothesized that the Kirk horizon corresponded to a time of “settling in” that would have been associated with *decreased* communication and resulted in the emergence of regional variations in style that would be detectable archaeologically.

Summary

The archaeological record of late Pleistocene and early Holocene hunter-gatherers in midcontinental North America is largely limited to formal stone tools. Projectile points from the Paleoindian and Early Archaic periods vary substantially in their size, shape, and raw materials. The Middle and Late Paleoindian periods (ca. 10,800-10,000 RCYBP) are recognized as a time of stylistic regionalization between two periods of relative homogeneity. The appearance of stylistic regions appears to coincide with a reduction in the scale of raw material transport. These changes in lithic technologies occurred in the context of rapid and complex environmental changes as flora, fauna, and climates shifted from those associated with the late Pleistocene to those of the Holocene.

The appearance of stylistic regions during the Middle/Late Paleoindian periods has been attributed to changes in the scale and structure of social networks as well as the appearance of social boundaries. The existing scenarios outlined above identify a variety of demographic, economic, and social factors as important causal variables.

The brief discussion of the Paleoindian and Early Archaic archaeological record and the existing interpretations of that record provided in this chapter is mean to provide and introduction and context for the analyses of archaeological data presented in Chapter 7, the comparisons of archaeological and model data presented in Chapter 8, and the discussion and conclusions presented in Chapter 9.

Chapter 7

ARCHAEOLOGICAL DATASET

This chapter describes the archaeological dataset that will be compared with model data to evaluate network-based explanations for changes in the material culture of late Pleistocene and early Holocene hunter-gatherers in midcontinental North America. Data drawn from a sample of formal hafted bifaces are used to describe the patterns of artifact variability and raw material transport that characterize portions of the Early Paleoindian (ca. 11,050-10,800 RCYBP), Late Paleoindian (ca. 10,300-10,000 RCYBP), and Early Archaic (ca. 10,000-8000 RCYBP) periods in the midcontinent.

As discussed in the previous chapter, the Middle and Late Paleoindian periods are recognized as a time of regionalization between two periods of relative homogeneity. Network- and interaction-based explanations for the appearance and disappearance of these stylistic regions are one of the foci of this dissertation. The goal of this chapter is to describe the changes associated with regionalization in formal, quantitative terms that can be directly compared to model outputs. This will allow the archaeological assemblages that were produced by systems with unknown social network characteristics to be compared to model assemblages that were produced by systems with known social network characteristics (see Chapter 8).

I first describe the archaeological sample in terms of its size and geographic distribution. I then present two analyses: (1) a morphometric analysis that focuses on identifying stylistic and functional variability in the sample and understanding how those aspects of variability are patterned with regard to space; and (2) a raw material analysis that focuses on quantifying basic aspects of raw material transport among points manufactured from selected raw material sources. Conclusions from these two analyses are used to construct a quantitative description of the regionalization associated with the Late Paleoindian period.

Sample and Data Collection

The archaeological dataset is drawn from a sample of 2034 stone projectile points from Illinois, Indiana, Kentucky, Michigan, and Ohio, including EarlyPaleoindian fluted (*n* = 478), Hi-Lo (*n* = 200), Dalton (*n* = 170), Thebes (*n* = 489), and Kirk (*n* = 697) points (Table 7.1). While many or most of the tools included the sample were probably the points of projectile weapons, some of them were undoubtedly multifunctional tools and some may have never been intended to serve as the points of projectiles. The terms “hafted biface,” “projectile point,” and “point” are used interchangeably in this work to refer to these tools without implying assignment of particular function.

The sample includes points that were observed firsthand in institutional and private collections as well as points from previously published studies (e.g., Moore 1987; Payne 1982; Prufer 2010; Prufer and Baby 1963; Tankersley 1989). While there is considerable overlap in the samples constituting the morphometric and raw material datasets, these samples are not isomorphic. Raw data for each point used in the analysis are provided in Appendices B through F. The data in the appendices will allow the analyses presented here to be repeated.

Morphometric Sample

The morphometric sample is composed of points (*n* = 1771) that met three criteria: (1) the point could be confidently attributed to one of the point groups of interest (i.e., early fluted, Hi-Lo, Dalton cluster, Kirk cluster, or Thebes cluster); (2) the provenience of the point was known to at least the county level; and (3) the majority of the landmarks required for measurement were present.

Table 7.1. Numerical Summary of the Morphometric and Raw Material Samples in the Archaeological Dataset.

Hafted Biface Group	**Morphometric Sample (*n*)**	**Raw Material Sample (*n*)**	**Total (*n*)**
Early Fluted Points	357	289	478
Hi-Lo	192	32	200
Dalton	156	62	170
Thebes	438	234	489
Kirk	628	309	697
Total	*1771*	*926*	*2034*

Identification of point “types,” defined by more-or-less distinctive combinations of co-occurring attributes, was done using a polythetic approach, applying criteria discussed in the previous chapter.

The geographic distribution of each point group in the morphometric sample is shown by county in Figures 7.1 through 7.5**.** The UTM coordinates assigned to each point are those of the approximate center of the point’s county of origin. These coordinates were determined using geographic information system [GIS] software, utilizing North American Datum 1983 (NAD83) and working in Zone 16N. Points that could be attributed to the area occupied by two adjacent counties (e.g., Carroll/Tippecanoe, Indiana) were included: in these cases, the UTM coordinates of the point were taken to be on the line between the two counties. Summary information on the mean, minimum, and maximum UTM eastings and northings of each group in the sample are provided in Table 7.2. The mean UTM coordinates of each group are plotted in Figure 7.6. The Kirk and Thebes sample means fall in central Indiana. The EFP sample mean falls farther east, near the Indiana/Ohio line: this reflects the inclusion of a relatively large number of previously recorded points from Ohio and Kentucky (i.e., from Prufer 2010; Tankersley 1989). When combined, the Hi-Lo/Dalton sample mean falls in central Indiana. The maximum, minimum, and mean UTM coordinates of each point group in the sample provide a basis for evaluating to what degree the spatial distributions of the samples are comparable. Figure 7.6 shows that the spatial distribution of each sample is centered in central/southern Indiana, suggesting that the point group samples have similar central tendencies in terms of their spatial distributions.

With the exception of maximum thickness, all metric data were derived from plan view, scaled digital images using computer software. This strategy allowed for collection of data from photographs or drawings when original materials were not accessible for study. Each image was first oriented with the proximal-distal axis vertical using symmetry of the lateral haft margins as a guide. A series of replicable landmarks in the haft area was located and digitized on each image using Adobe Illustrator (Figure 7.7). Not all landmarks are applicable to all haft configurations (e.g., lanceolate points with no neck constriction do not have landmarks 3 and 4, while points with an excurvate basal edge do not have landmarks 1 and 2). When the location of a landmark was absent, indeterminate, or not applicable, it was omitted. The Cartesian coordinates (in mm) of each landmark present were determined using tpsDIG software (Rohlf 2008). A

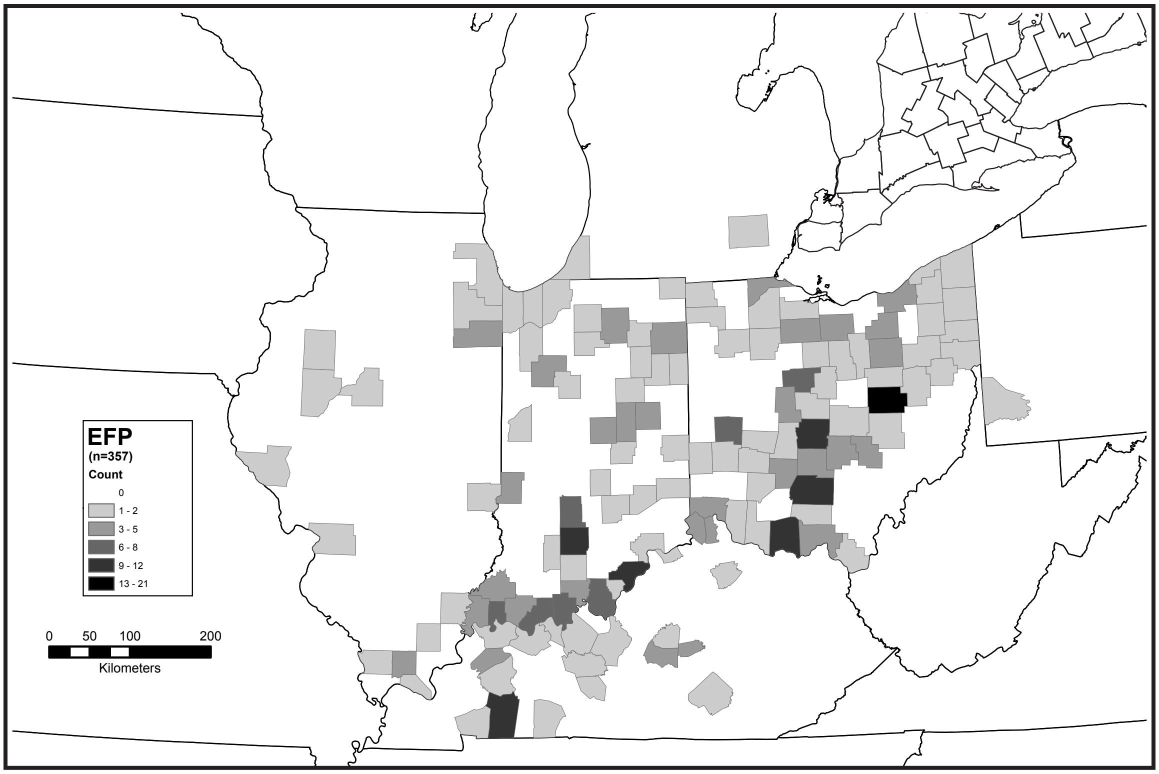


Figure 7.1. Spatial distribution and density (by county) of Early Fluted Point morphometric sample (*n* = 357).

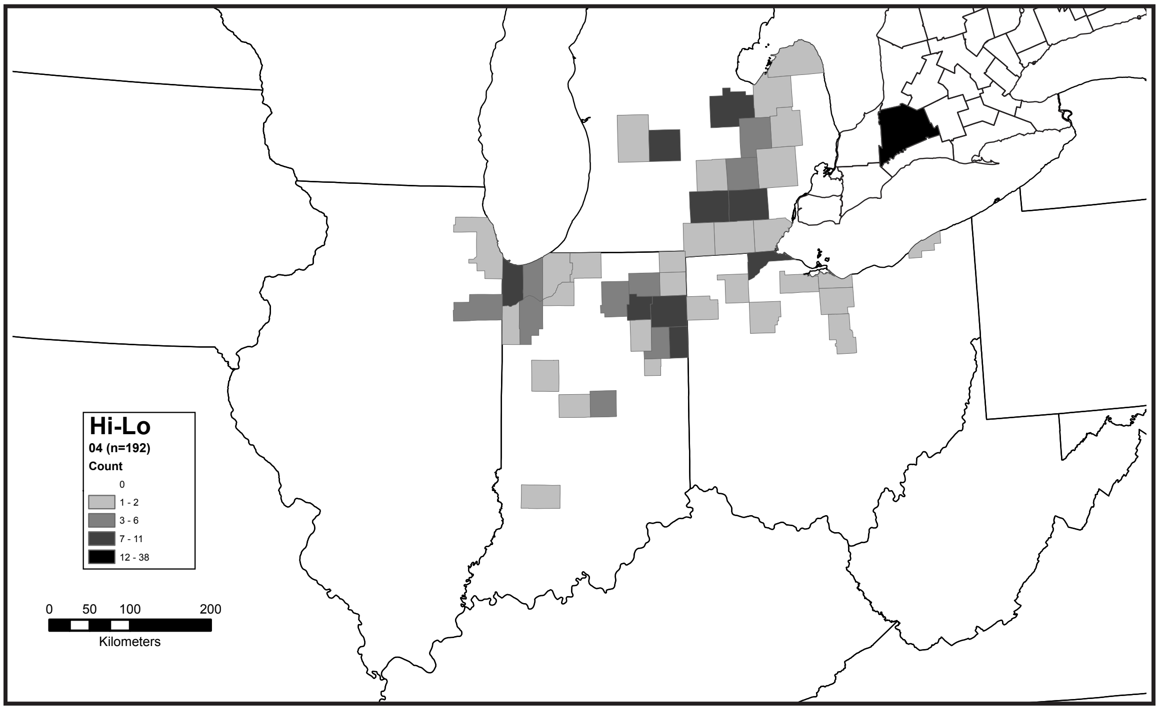


Figure 7.2. Spatial distribution and density (by county) of Hi-Lo morphometric sample (*n* = 192).

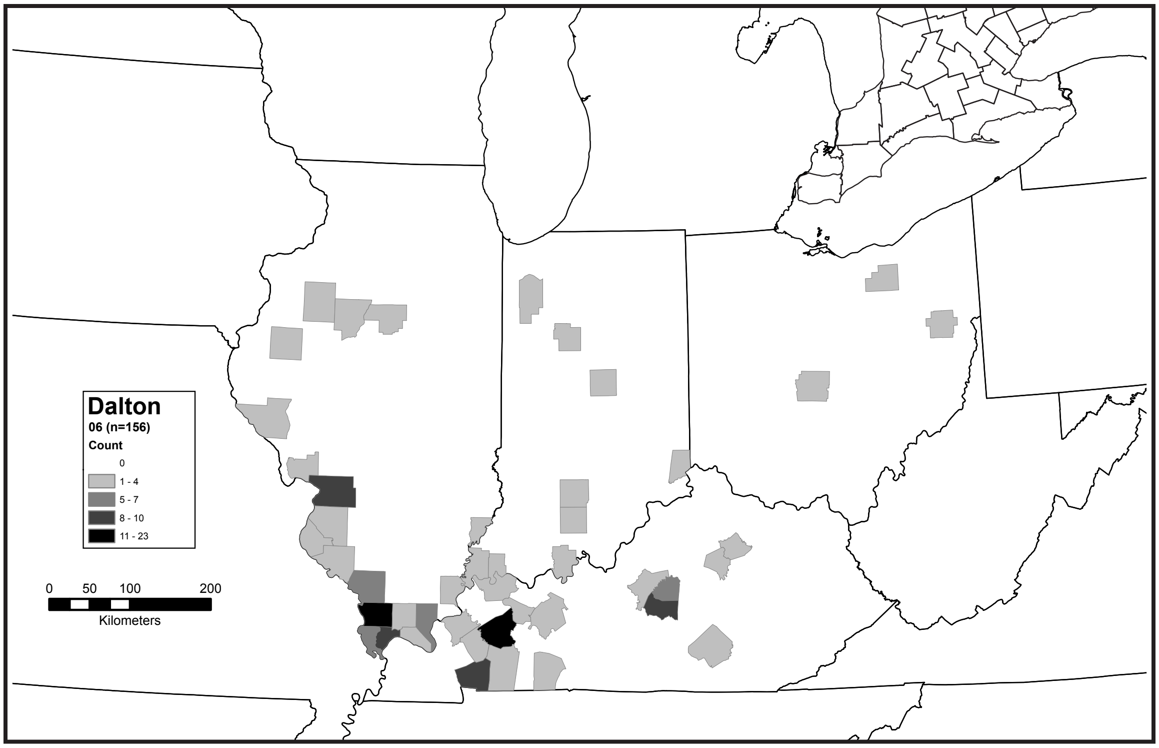


Figure 7.3. Spatial distribution and density (by county) of Dalton Cluster morphometric sample (*n* = 156).

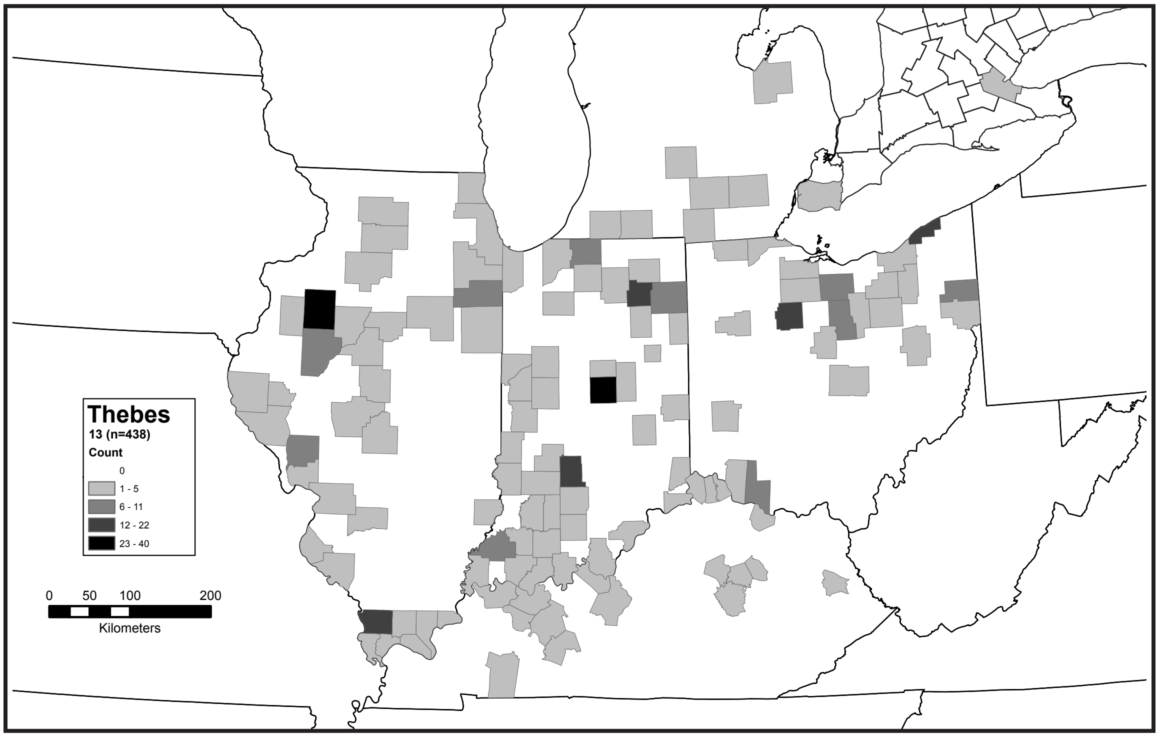


Figure 7.4. Spatial distribution and density (by county) of Thebes Cluster morphometric sample (*n* = 438).

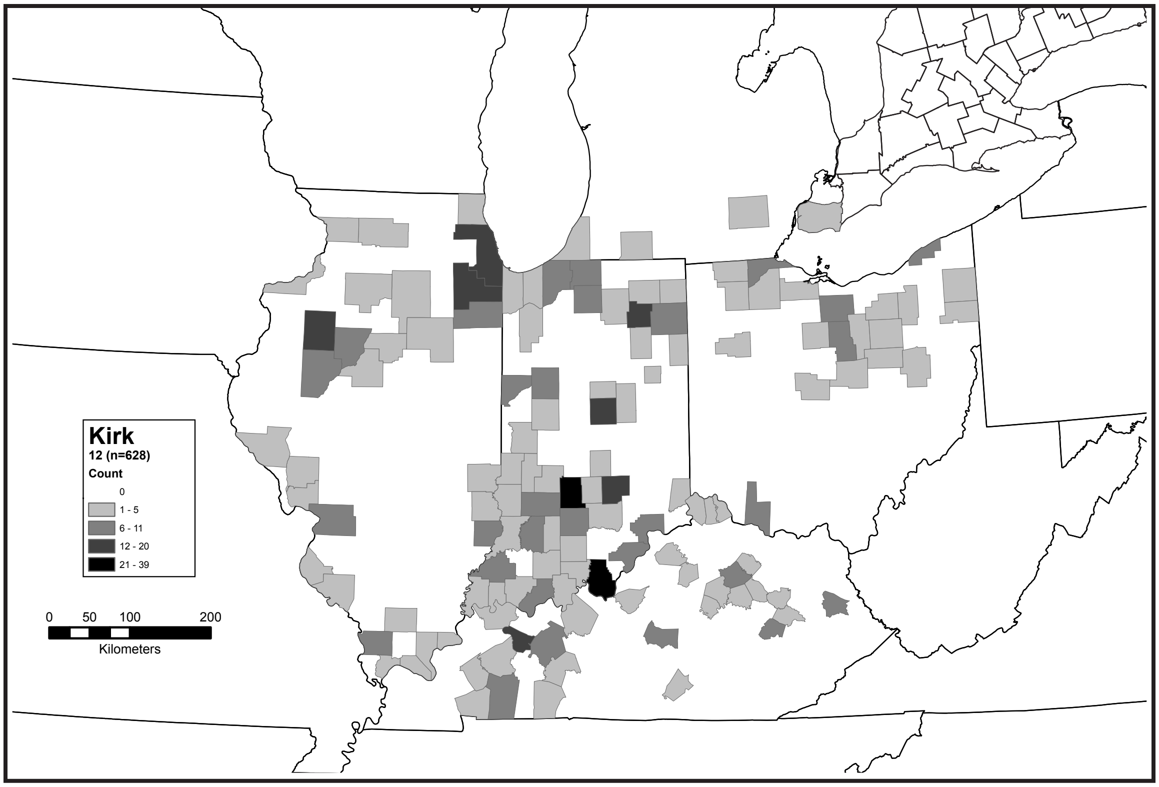


Figure 7.5. Spatial distribution and density (by county) of Kirk Cluster morphometric sample (*n* = 628).

Table 7.2. Summary Information on the Mean, Minimum, and Maximum UTM Eastings and Northings of each Point Group in the Morphometric Sample.

Hafted Biface Group	UTM Easting			UTM Northing		
	Mean	**Min.**	**Max.**	**Mean**	**Min.**	**Max**
Early Fluted Points	674016	164463	1071543	4372464	4073979	4683019
Hi-Lo	722378	425769	978736	4654399	4320951	4861343
Dalton	398771	164463	999643	4204038	4073979	4566038
Thebes	544712	142610	1071648	4441995	4083206	4818691
Kirk	550183	164463	1024994	4375587	4073979	4686697
Hi-Lo & Dalton	577313	164463	999643	4452513	4073979	4861343

spreadsheet was used to calculate eight linear variables from these coordinates, designated alphabetically (Table 7.3).

Maximum thickness was measured using calipers (or taken from published data). This measurement was taken at the point of maximum thickness perpendicular to the axial plane (typically distal to the haft region). This measurement was not taken if a point was broken or damaged in such a way as to make it unclear whether the thickest portion of the point had been removed.

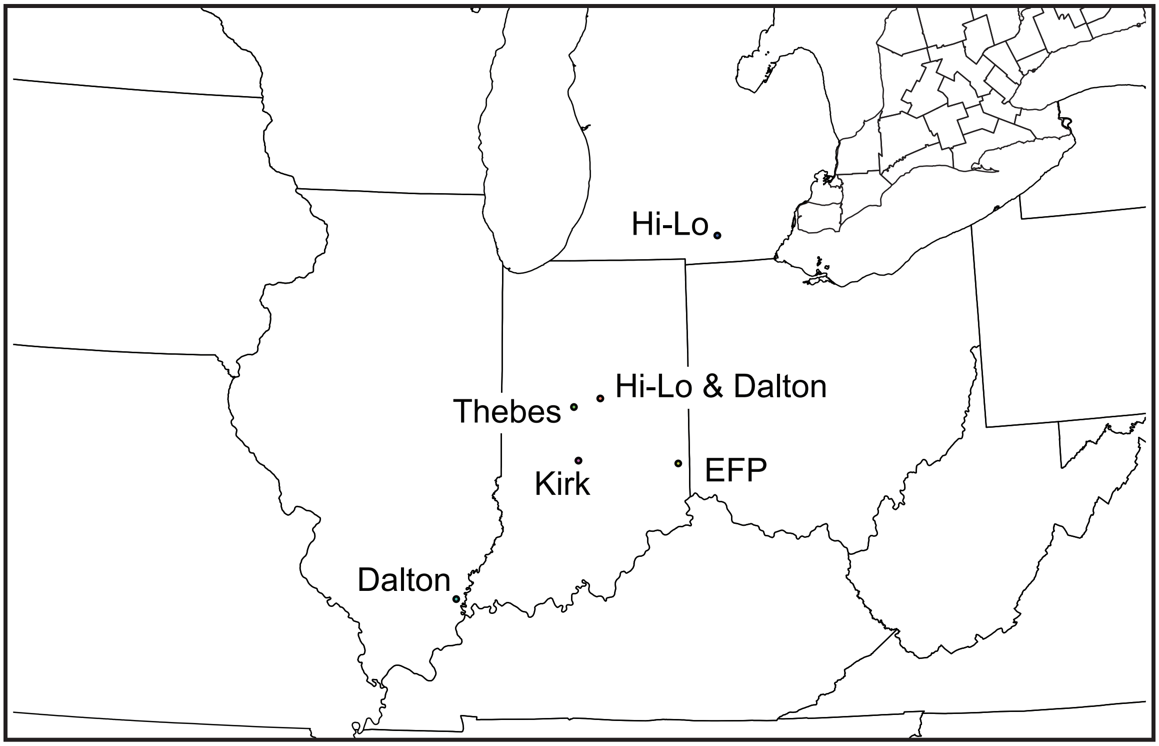


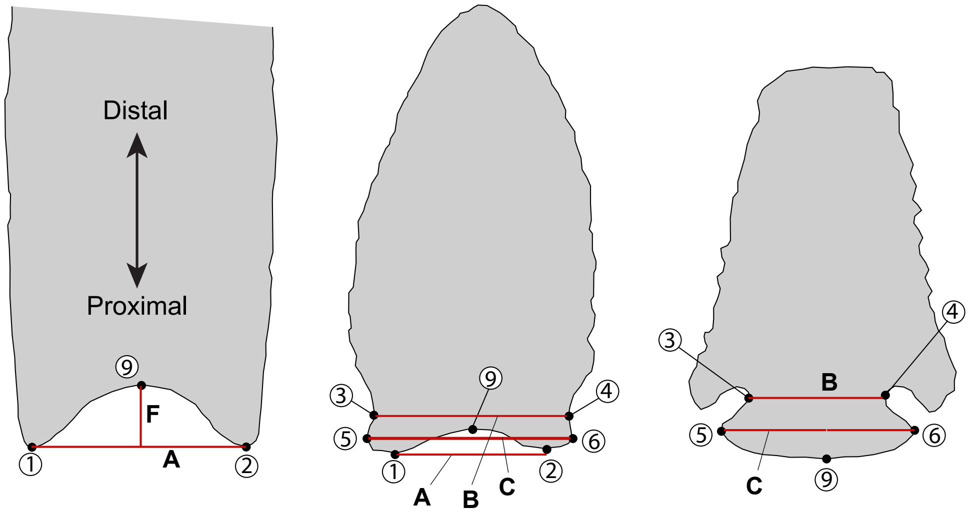
Figure 7.6. Geographic center locations (mean UTM eastings and northings) of point groups in morphometric sample.

Measurements were focused on the haft area because it is (logically) the least likely part of the point to undergo change in size or shape via intentional post-manufacture modification (e.g., resharpening). In some cases, however, it appeared that the haft region had been reworked subsequent to the original manufacture of the point (e.g., to repair damage). While these points are interesting for a number of reasons, they have been excluded from this analysis.

When present, the amount of haft constriction (variable E) is quantified as the difference between variable C (maximum basal width) and variable B (width at the narrowest part of the haft distal to the plane of variable C).

Raw Material Sample

The raw material sample is composed of points that met three criteria: (1) the point could be confidently attributed to one of the point groups of interest; (2) the provenience of the point was known to at least the county level; and (3) the raw material of the point could be identified as belonging to one of five major raw material groups (see below). Raw material identifications were



Landmarks 1 & 2: most proximal points of basal margin (do not exist on points with a continuous straight or convex basal margin)

Landmarks 3 & 4: points of minimum haft width distal to basal edge (do not exist on points with continuous straight or convex lateral haft margins)

Landmarks 5 & 6: points of maximum width distal to basal margin but proximal to Landmarks 3 and 4 (do not exist on points with continuous straight or convex lateral haft margins)

Landmark 9: point of maximum deviation from horizontal along basal edge

Metric Variables Defined by Horizontal Differences

A	1-2	width at proximal haft
B	3-4	width at point of maximum haft constriction
C	5-6	width at point of maximum haft width
E	(mean 5,6) - (mean 3,4)	mean haft constriction

Metric Variables Defined by Vertical Differences

F	9-(mean 1,2)	maximum offset of basal edge (depth of basal concavity)
G	9-(mean 3,4)	mean distance between maximum basal offset and point of maximum constriction
H	9-(mean 5,6)	mean distance between maximum basal offset and point of maximum haft width
I	(mean 3,4) - (mean 5,6)	mean offset of maximum consrtiction from maximum basal width

Figure 7.7. Definition of landmarks and metric variables used in morphometric analysis.

Table 7.3. Definition of Metric Variables Calculated from Landmark Coordinates.

Variable	Verbal Description	Calculation from Landmark Coordinates (see Figure 7.7)	Notes
A	Width at the most proximal points of the haft	(2X) – (1X)	Does not exist on points with continuous convex or straight basal edge
B	Width at point of maximum haft constriction	(4X) – (3X)	Does not exist on points with straight/convex lateral haft margins
C	Width of point of maximum haft width proximal to point of maximum haft constriction	(6X) – (5X)	Does not exist on points with continuous straight or convex lateral haft margins
E	Haft constriction	(mean of 5X and 6X) – (mean of 3X and 4X)	Does not exist on points with continuous straight or convex lateral haft margins
F	Maximum offset of basal edge from most proximal points of the haft (depth of basal concavity)	(9Y) – (mean of 1Y and 2Y)	Does not exist on points with a continuous straight or convex basal edge
G	Distance between maximum offset of basal edge and point of maximum haft constriction	(mean of 3Y and 4Y) - (9Y)	Does not exist on points with continuous straight or convex lateral haft margins
H	Distance between maximum offset of basal edge and point of maximum haft width	(mean of 5Y and 6Y) - (9Y)	Does not exist on points with continuous straight or convex lateral haft margins
I	Offset between point of maximum haft constriction and point of maximum haft width	(mean of 3Y and 4Y) – (mean of 5Y and 6Y)	Does not exist on points with continuous straight or convex lateral haft margins

based on macroscopically-discernible characteristics of color, texture, luster, and inclusions. Reliance on macroscopic criteria and simple experience for identification of raw materials, while potentially problematic, is intrinsic to the rapid, cost-effective collection of data from private collections (cf. Loebel 2005:133-134).

As in the morphometric sample, the UTM coordinates assigned to each point are those of the approximate center of the point's county of origin (determined using GIS software). Summary information on the mean, minimum, and maximum UTM eastings and northings of each point group in the raw material sample are provided in Table 7.4. The mean UTM coordinates of each

Table 7.4. Summary Information on the Mean, Minimum, and Maximum UTM Eastings and Northings of each Point Group in the Raw Material Sample.

Hafted Biface Group	**UTM Easting**			**UTM Northing**		
	Mean	**Min.**	**Max.**	**Mean**	**Min.**	**Max.**
Early Fluted Points	691747	142610	1071543	4365592	4076893	4683019
Hi-Lo	698960	425769	978736	4704052	4487504	4818691
Dalton	344092	164463	727818	4235010	4111857	4539000
Thebes	474376	142610	1024994	4426064	4117927	4818691
Kirk	534648	142610	1024994	4361909	4073979	4802261
Hi-Lo & Dalton	464898	164463	978736	4394684	4111857	4818691

group are plotted in Figure 7.8. The overall geographic distribution of the points in the raw material sample is similar to that of the morphometric sample.

Morphometric Analysis

Early projectile points from Midcontinental North America vary substantially in size and shape. The goals of this section are to: (1) partition some of the variability in these artifacts into "functional" and "stylistic" categories; and (2) quantify temporal changes in the spatial patterning of functional and stylistic variability.

I first outline basic expectations for functional constraints on variability in these tools by considering their role as elements of compound, propelled weapons systems. I argue that attributes closely linked to functional constraints should exhibit less variability than purely "stylistic" attributes. I present basic metric data for each of the point groups and use the coefficient of variation (CV) to assess how the mixture of variables related to "style" and "function" changes during the transition from lanceolate to notched point technologies. I identify variables that appear to remain either stylistic or functional in all point groups. I look at spatial patterning in these variables to characterize the Late Paleoindian regionalization in quantitative terms that can be compared to model data.

Functional Variability in Projectile Weapons

As discussed in Chapter 3, functional and stylistic variability are here defined as mutually exclusive categories. *Functional variability* is defined as formal

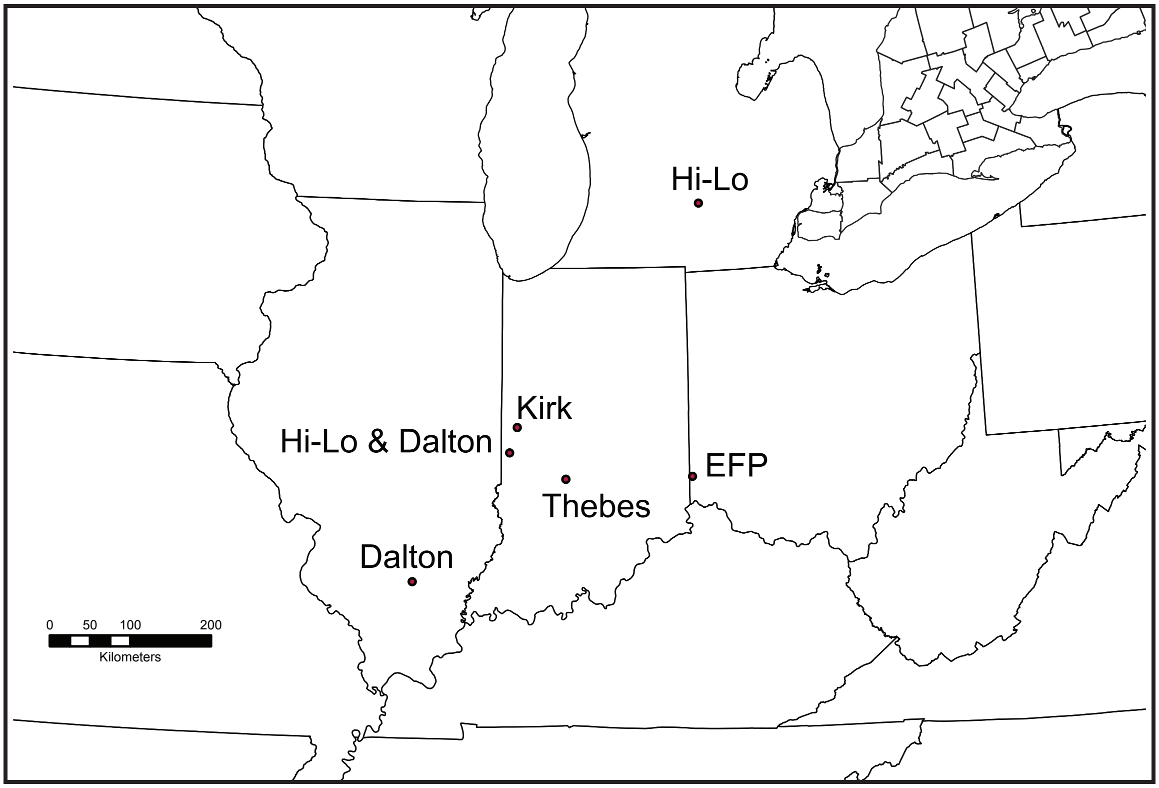


Figure 7.8. Geographic center locations (mean UTM eastings and northings) of point groups in raw material sample.

variability related to the operation of an artifact in the material realm: function is what an artifact does and is designed to do (Kamminga 1982; Sackett 1982). Following Sackett (1982), *stylistic variability* is defined as that portion of formal variability that is not functional in the material realm: function and style together can be assumed to exhaust the majority of formal variability that can be observed. Observational error is an additional source of variability that assumed to be trivially small.

Because functional variability affects the performance or utility of an artifact, it is conditioned by a selective environment in which the results of design choices are evaluated based on some criterion or criteria of performance (cf. Bleed 1986; Meltzer 1981:314; Schiffer and Skibo 1987, 1997; Shott 1996; White 2008). Design trade-offs may influence how a tool performs various aspects of its intended function: a more robust projectile point may be less prone to breakage on impact but less efficient at cutting/piercing and more difficult to securely haft, for example (e.g., see Bleed 1986; Guthrie 1983). When multiple variables are involved, the "best" solution to a design problem is usually not obvious. Trial-and-error experimentation can be employed to evaluate the relative performance of different combinations of attributes. A selective environment constrains variability because not all possible combinations of attributes will allow a tool to be used for its intended purpose.

Partitioning stylistic and functional variability generally involves isolating functional variability and then assuming that the remaining variability is non-functional (i.e, stylistic). Understanding the "functional field" in which tool performance is evaluated (e.g., see Cotterell and Kamminga 1990) allows us to learn something about the design constraints that selection imposes and, consequently, identify functionally-sensitive variables. Understanding what a screwdriver is designed to do, for example, is helpful in understanding which attributes of the screwdriver are relevant to how it performs its intended purpose (e.g., the size and shape of the bit) and which are less so (e.g., the color of the handle).

The role of hafted bifaces as components of compound, propelled projectile weapons offers one avenue for asking which aspects of metric variability might be related to function (e.g., see Christenson 1986; Cotterell and Kamminga 1990). Several studies have considered how variability in point size and/or shape relate to the function of these tools as projectile tips (e.g., Christenson 1986; Shott 1986, 1990, 1996; 1997; Thomas 1978). Other studies have examined the physics of the atlatl (e.g., Baugh 1998, 2002; Cotterell and Kamminga 1990; Hrdlicka 2004; Raymond 1986).

Multiple lines of evidence indicate the use of hafted bifaces, including Early Paleoindian fluted points, as tips for projectile weapons. First, use of these points as hunting weapons is demonstrated by cases where points are embedded in and/or associated with the remains of large game (e.g., Graham et al. 1981; Haury et al. 1953; Haury et al. 1959; Surovell and Waguespack 2008; Tankersley 1989:7). The presence of longitudinal resharpening and impact fractures on Clovis points and many other Paleoindian/Early Archaic point forms clearly argues for the use of these tools as piercing implements (e.g., Haynes 1980; Morrow 1996). Microwear studies also indicate their use as projectile points (Kay 1996; Smallwood 2006; Shoberg 2010).

The use of the atlatl as a means of propelling projectiles in North America probably dates to the earliest inhabitants of the continent. The mass of darts with Clovis-like points attached would fall well within the range for atlatl darts documented ethnographically (see Baugh 2002; Cattelain 1997; Palter 1977).

Microscopic fractures indicate the use of these points as tips for high speed projectiles propelled with an atlatl (Hutchings 1997) rather than as tips for hand-thrown spears. Frison (1989) experimentally demonstrated the effectiveness of Clovis-tipped darts for piercing the hide of African elephants. Finally, there is direct evidence of the existence of atlatl systems dating to the Paleoindian period (Bradley et al. 2010; Hemmings et al. 2004:89), and atlatls have been documented in Upper Paleolithic contexts in Europe and Asia (see Cattelain 1997).

The studies of Christenson (1986) and Shott (1990) highlight the fundamental trade-off between power and accuracy that is applicable to all projectile weapons. Assuming that the propulsive force is a constant, this trade-off is largely a function of projectile mass. Heavier projectiles can carry more force to a target at a given range but are less accurate because a trajectory with a greater arc must be employed to deliver them there. Atlatl-propelled darts are not exempt from this principle. Thus there is a strong incentive to produce darts that are heavy enough to penetrate the intended target but not so heavy that they needlessly squander accuracy and range: the “best” projectiles for any given purpose are those having the longest range and best accuracy possible while delivering sufficient power to the target.

This trade-off will tend to constrain the mass of projectiles designed to meet a specific set of power and accuracy requirements. The shaft contributes the majority of the mass to a stone-tipped atlatl dart (a 200 cm willow shaft with a diameter of 2 cm has a mass of ca. 260 g, for example, while the mass of fluted points is typically in the range of 10-30 g). The hafting width of a point (i.e., the neck width of notched points, the basal width of lanceolate points) tends to correlate with the diameter of the shaft or foreshaft to which the point is attached (see Christenson 1986; Shott 1990; 1997; Thomas 1978). This may be especially true in “maintainable” systems that are designed to have easily interchangeable parts (Bleed 1986). Because it is sensitive to changes in shaft diameter (and therefore functionally-constrained projectile mass), hafting width is a good candidate for a functional variable in projectile points.

Point thickness is also related to both ballistics and hafting. Thickness is related to cross-sectional area, which affects both penetration (thinner is better) and resistance to fracture on impact (thicker is better) (e.g., see Christenson 1986; Guthrie 1983). The thickness of a point is also likely to be constrained somewhat by the dimensions and configuration of the shaft to which it must be attached. As with hafting width, this may be especially true when points are designed to be interchangeable. The combined result of these functional limitations will be to constrain variability in thickness.

In summary, variability in hafting width and thickness are likely to be constrained by the size and configuration of the hafts (shafts or foreshafts) in which a point will be mounted. In projectile weapons, these hafts themselves are likely to be constrained in size by functional considerations and may be highly curated, requiring more effort to produce than the points themselves (Keeley 1982).

The articulation of functional and stylistic variability in utilitarian artifacts is potentially complex (Lemmonier 1992; Schiffer and Skibo 1997; Wiessner 1985). While other size/shape attributes of the haft regions of projectiles may have functional significance (perhaps related to the way a point is hafted), it seems unlikely that minor differences in the curvature of basal concavities, basal ears, and the lateral haft margins will have a significant effect on tool performance. Sackett (1985, 1986, 1990) argues that much of what we perceive as “style,” particularly in utilitarian stone tools, is actually attributable to *isochrestic* (“equivalent in use”) variation (see Chapter 3). Given that the basal region of a point is largely hidden from view when a point is hafted, stylistic variation in haft morphology is likely to be isochrestic rather than emblemic. The opposite may be true if unhafted projectile points are exchanged between social groups and serve to signal group affiliation.

Free from the direct, performace-related selection that constrains functional variability, stylistic attributes can vary within a range of functionally-equivalent choices. While the neck width of a projectile point may need to be within a fairly narrow range in order for the point to fit into an existing shaft, for example, the choice of the exact form and point of origin of the notches used to create the neck may be less constrained by functional considerations and more based on cultural tradition. Of course there will be limits on stylistic variability in functional artifacts: the range of possible notch shapes will be limited by the depth of the notches required (e.g., it is not possible to produce notches that appear curved if notch depth is very shallow), for example, as well as by the skill of the artisan (e.g., the thicker the biface the more difficult it is to execute long, narrow notches). The greater degree of independence of stylistic variability from functional constraints permits the production of greater amounts of variability through time than is possible when variation is directly constrained by selection.

Thus we expect that stylistic attributes will generally be more variable than functional attributes unless there are intentional cultural mechanisms operating to constrain variability (i.e., the “active” use of style to communicate group identity).

Functional and Stylistic Variability in the Sample

The purpose of this section is to describe patterns of metric variability in the sample and to use the expectations outlined above to identify some aspects of this variability that are functional and some that are stylistic. The technological changes that span the Paleoindian-Early Archaic transition complicate this task somewhat, as the morphological shift from lanceolate to notched projectile point forms entails a change in which variables are most relevant to functional aspects of hafting.

Basic descriptive statistics for the metric variables within each group in the sample are provided in Table 7.5. All measurements are in millimeters. Histograms showing the distribution of each variable in each group are shown in Figures 7.9 through 7.13.

The coefficient of variation (CV), calculated by dividing the standard deviation by the mean, is a simple statistic for expressing the amount of variability in an attribute relative to the value of the mean (Simpson and Roe 1939; Thomas 1986). This allows the relative amounts of variation to be compared among variables with different means. Coefficients of variation for each point group are provided in Table 7.6. Variables G (the distance of the basal edge from the point of maximum haft constriction) and H (the distance of the basal edge from the point of maximum basal width) are omitted from further analysis here because the values of these variables can be positive or negative depending on whether landmark 9 is proximal or distal to planes of maximum haft constriction and maximum haft width. Coefficients of variation cannot be meaningfully calculated on variables which can be negative.

Haft width is the width of the point at a location presumed to reflect the diameter of the shaft in which the point was hafted. Constricted hafts (i.e., hafts with incurvate lateral margins distal to the point of maximum haft width) characterize the Early Archaic notched (Thebes and Kirk) and Late Paleoindian (Hi-Lo and Dalton) point groups. In these groups, variable B is taken as haft width. Most Early Fluted Points in the sample are lanceolate forms with no haft constriction. Slight constriction of the haft (varying up to 4 mm) is present in

Table 7.5. Summary Descriptive Statistics for Metric Variables.

Variable		EFP	Hi-Lo	Dalton	Thebes	Kirk
A	*n*	357	192	139	228	391
	Mean	20.9	16.0	20.4	14.1	15.4
	Min	9.8	9.0	10.6	3.2	3.7
	Max	32.7	24.1	31.6	36.1	30.2
	Std Dev	3.19	3.33	3.50	6.00	4.71
B	*n*	118	171	133	438	628
	Mean	24.2	20.4	22.9	18.3	16.8
	Min	15.4	10.9	15.0	10.1	9.7
	Max	33.0	29.2	33.9	32.5	27.1
	Std Dev	2.95	3.29	3.81	3.30	3.04
C	*n*	126	171	135	437	619
	Mean	25.2	21.5	25.9	30.0	22.7
	Min	16.0	12.4	18.6	18.1	14.0
	Max	36.0	29.8	38.4	53.2	35.9
	Std Dev	3.25	3.25	4.02	6.26	3.75
E	*n*	118	171	118	437	619
	Mean	0.9	1.1	3.0	11.7	5.9
	Min	0.1	0.0	0.1	2.6	1.5
	Max	4.0	3.7	7.4	28.6	14.8
	Std Dev	0.71	0.74	1.77	4.27	1.99
F	*n*	356	192	138	225	390
	Mean	4.4	2.8	4.7	1.1	1.0
	Min	1.1	0.6	0.6	0.1	0.1
	Max	12.5	6.6	11.0	6.3	3.2
	Std Dev	1.68	1.15	2.09	0.90	0.62
G	*n*	117	171	130	433	612
	Mean	4.0	3.4	5.0	12.6	6.8
	Min	-2.5	-1.6	-3.4	6.0	1.2
	Max	19.0	8.7	12.1	22.1	12.5
	Std Dev	3.54	1.43	2.92	2.94	1.70
H	*n*	125	171	134	432	603
	Mean	-1.7	0.0	-2.3	5.6	1.9
	Min	-6.7	-3.3	-10.3	0.8	-1.3
	Max	4.5	3.2	4.4	18.3	6.2
	Std Dev	1.71	1.32	2.57	2.24	1.21
I	*n*	118	171	118	437	619
	Mean	5.5	3.4	7.2	7.0	5.0
	Min	1.0	1.1	1.9	3.0	2.0
	Max	19.8	7.9	15.5	14.9	11.1
	Std Dev	3.52	1.22	2.84	2.44	1.40
Max. Thick-ness	*n*	287	166	137	422	596
	Mean	7.4	8.0	7.0	9.0	6.6
	Min	4	4.2	3.9	5.7	4.5
	Max	11	11.2	9.1	13.9	10.1
	Std Dev	1.34	1.1	1.03	1.14	0.95

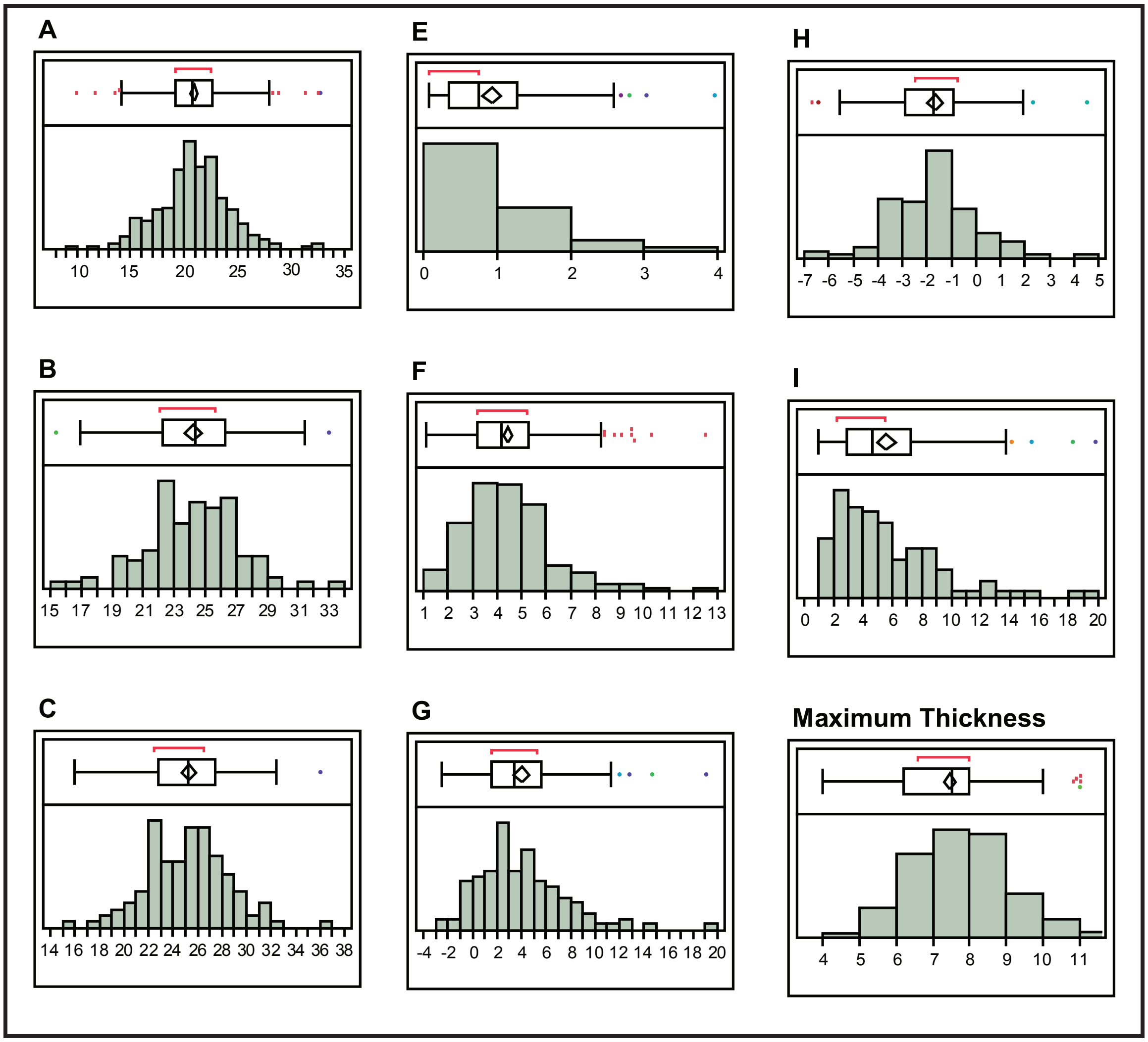


Figure 7.9. Histograms of metric variables, Early Fluted Point sample. All measurements in millimeters.

about a third of the sample. Variable A is taken as haft width in the EFP group when no constriction is present. When measurable constriction is present, variable B is taken as haft width.

Figure 7.14 shows the CV values in Table 7.6 plotted graphically by point group (Hi-Lo and Dalton combined). Two basics aspects of the data in Figure 7.14 are immediately notable. First, the variables exhibit dissimilar amounts of variation: values of the CV range between 12 and 82 percent. Second, the CV of some variables differs substantially among the different point groups while the CV of other variables remains relatively constant. The variables can be segregated into three groups: (1) variables with a CV that is relatively low (i.e., < 20 percent) in all point groups (B, C, haft width, and maximum thickness); (2)

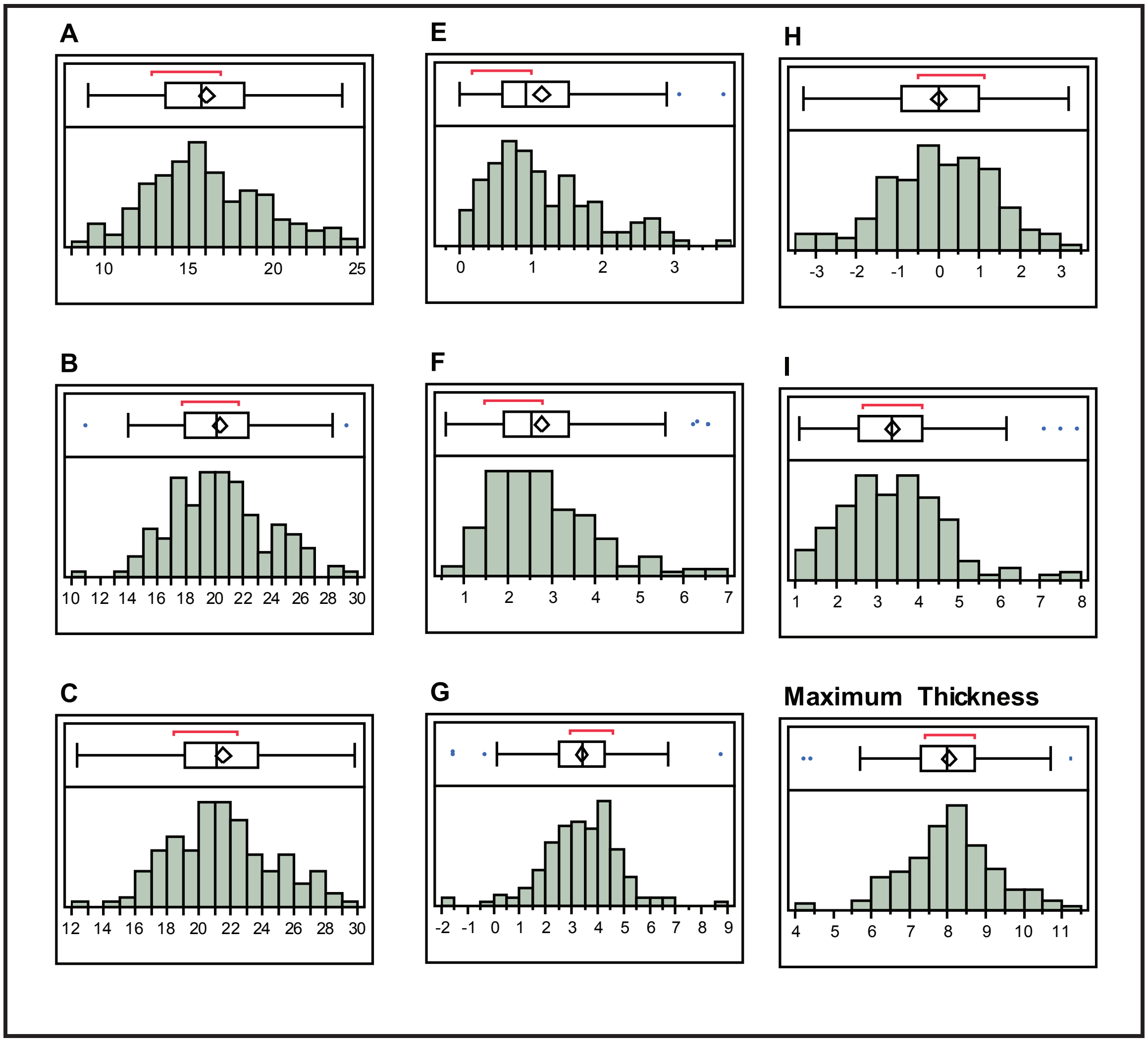


Figure 7.10. Histograms of metric variables, Hi-Lo sample. All measurements in millimeters.

variables with a CV that is relatively high (i.e., > 25 percent) in all point groups (E, F, and I); (3) a variable that is relatively high in some point groups but relatively low in others (A). These data can be interpreted in light of the discussion of functional and stylistic variability presented above and the shift from lanceolate to notched points that characterizes the Paleoindian to Early Archaic transition.

The variables that have a low CV in all point groups (B, C, haft width, and maximum thickness) describe basic aspects of the size of the point that are related to overlapping constraints associated with hafting and use. A low CV in each of these variables is consistent with the manufacture of points with relatively consistent haft sizes to facilitate hafting in relatively standardized shafts or foreshafts: shafts are designed to accommodate points of a certain size and

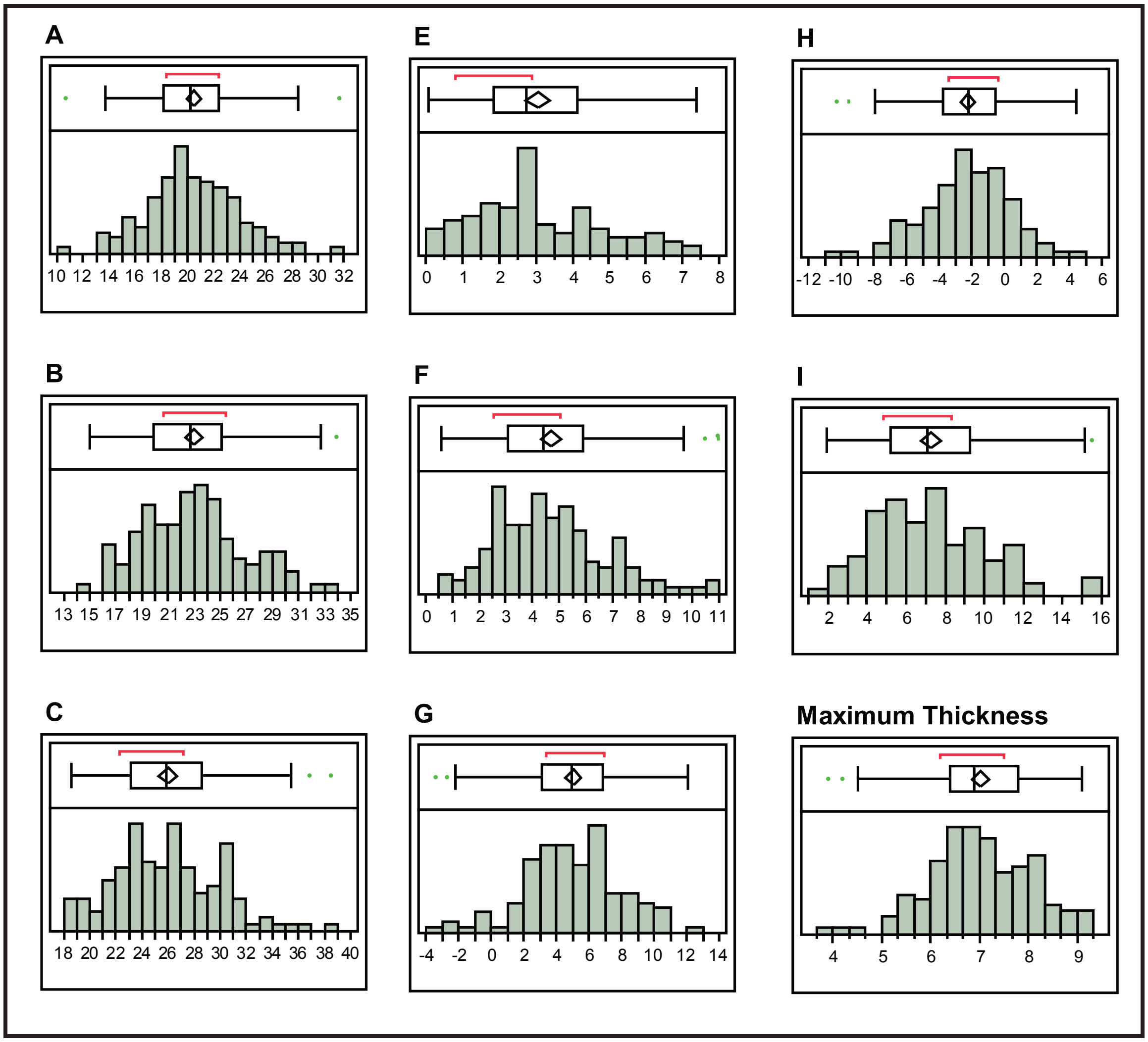


Figure 7.11. Histograms of metric variables, Dalton Cluster sample. All measurements in millimeters.

points are designed to fit in shafts of a certain size. Low variation in hafting width is also consistent with the proposed role of these points as tips for projectiles of relatively consistent shaft diameter and mass. Low variation in thickness is also consistent with use-related constraints as well as hafting constraints: points that are too thick to haft are not useable, while points that are too thin are more likely to break on impact and provide less material for repair and re-sharpening (i.e., they may have shorter use-lives). The low CV of these variables across all point groups is consistent with the expectation that they are under functional constraint that reduces the amount of variability that is present.

The CV of three variables (E, F, and I) is relatively high in all point groups. Variable E describes the amount of haft constriction (i.e., the reduction in width

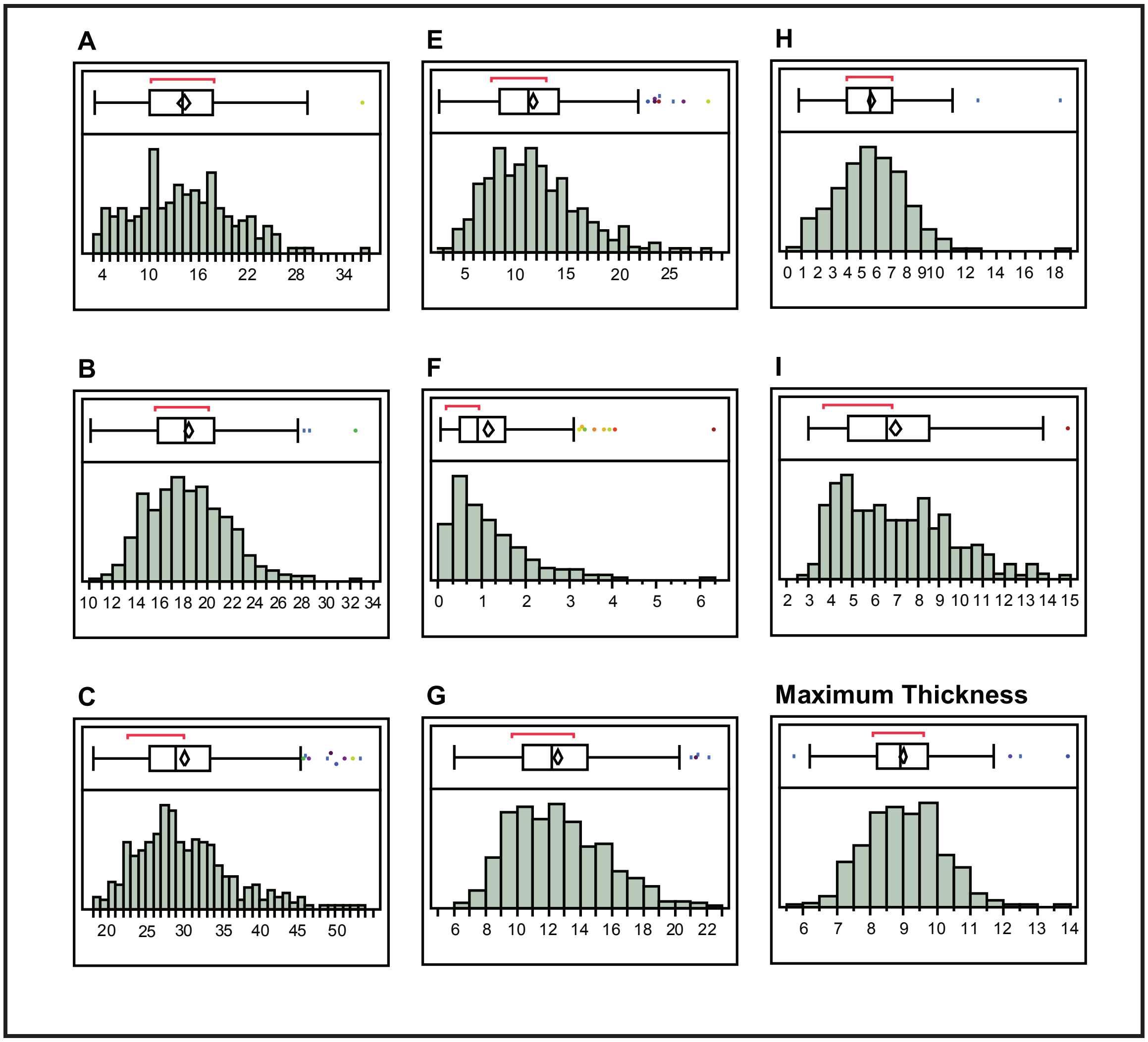


Figure 7.12. Histograms of metric variables, Thebes Cluster sample. All measurements in millimeters.

from the widest portion of the basal margin to the narrowest portion of the haft). While this variable is related to the configuration of the haft, note that it does not measure the width of the haft itself. The degree of haft constriction in the EFP, Hi-Lo, and Dalton samples, while slight in absolute terms (0-4 mm, 0-3.7 mm, and 0-7.4 mm, respectively), is highly variable. The CV of variable E in the notched point groups, while lower than that in the Paleoindian point groups, remains high relative to the variables that directly measure haft size. This pattern makes sense if we understand haft constriction as a way to produce a desired hafting width while preserving blade width. The high CV of variable E in the Paleoindian point groups can be attributed to the variable role that haft constriction can play in producing lanceolate points of a desired width:

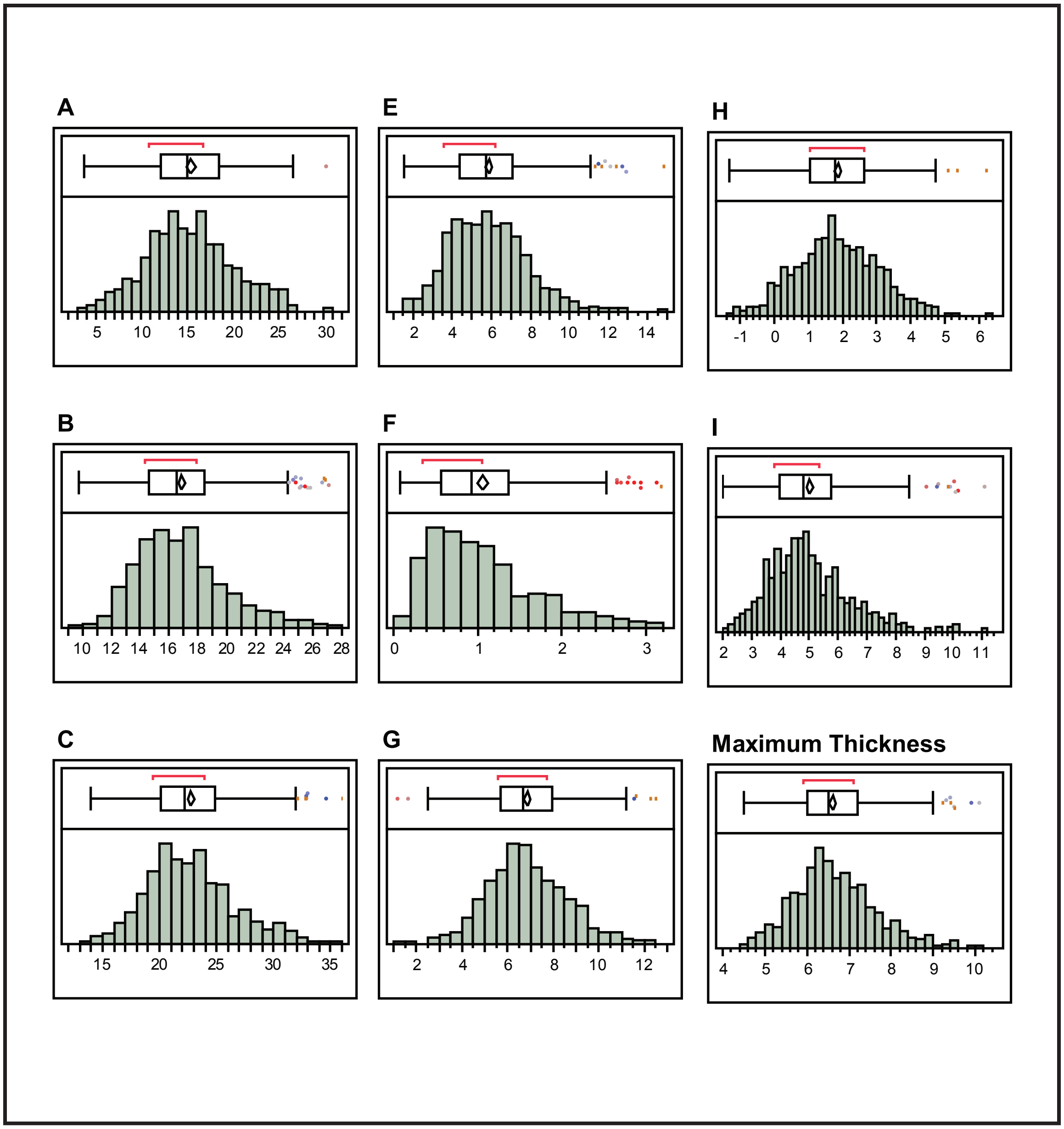


Figure 7.13. Histograms of metric variables, Kirk Cluster sample. All measurements in millimeters.

in lanceolate points, a hafting region of a desired width is produced wholly or mostly through reduction of the entire lateral haft margin. In notched points, by contrast, notches are executed to produce a hafting region of the desired width without necessarily reducing the width of the lateral haft area or the blade. While the resulting width of the haft may be constrained by the size/shape of the shaft in which the point is to be hafted, the amount of constriction (i.e., the depth of notches) required to produce a desired haft width will vary depending on the

Table 7.6. Coefficients for Variation for Non-Negative Metric Variables.

Point Group	**A**	**B**	**C**	**E**	**F**	**I**	**Max. Thick.**	**Haft Width**
EFP	15.3	12.2	12.9	77.5	38.3	63.7	18.0	16.3
Hi-Lo	20.8	16.1	15.1	64.3	41.6	36.2	14.8	16.1
Dalton	17.1	16.6	15.5	58.1	44.7	39.3	14.7	16.6
Hi-Lo/Dalton (combined)	22.6	17.4	18.0	81.8	52.4	56.3	16.2	17.4
Thebes	42.4	18.0	20.9	36.6	78.5	35.0	12.7	18.0
Kirk	30.7	18.1	16.5	34.0	59.6	28.0	14.4	18.1

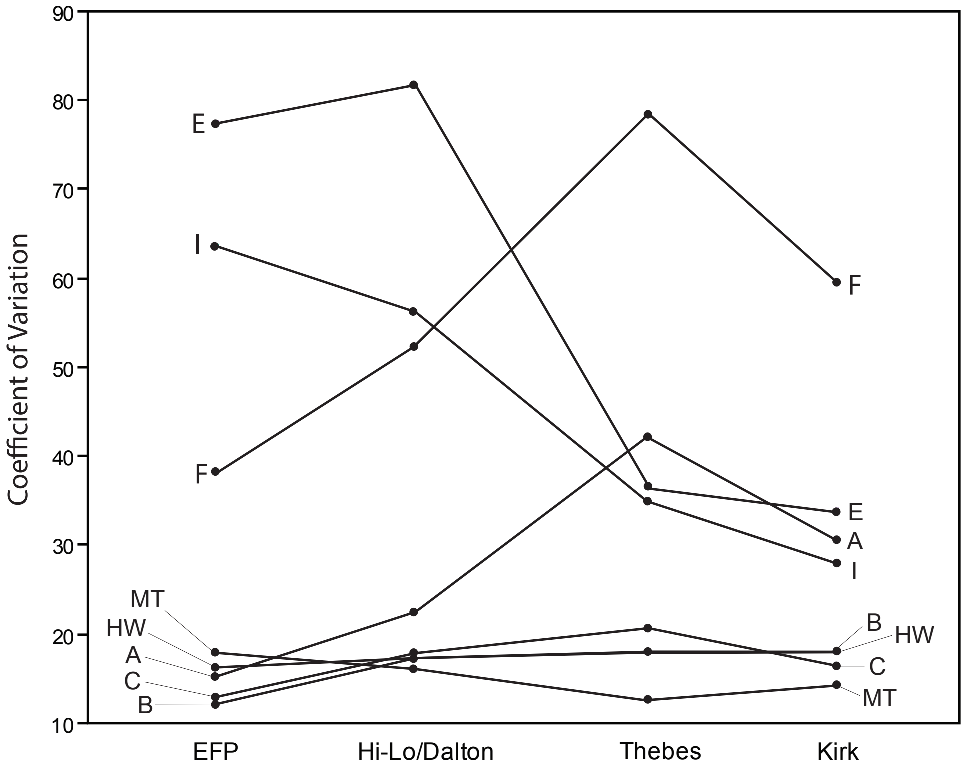


Figure 7.14. Coefficients of variation of metric variables plotted by point group.

size and shape of the preform. The decrease in the CV of variable E from the lanceolate to the notched point groups is consistent with the fundamental role of notches in defining haft size in the Early Archaic technologies.

Variable F describes the depth of the basal concavity. Several researchers have previously suggested that the depth of the basal concavity may reflect stylistic rather than functional variability, particularly in fluted points (see Ellis 2004c:246; Gramly 1982:70-71, Meltzer 1984:286-287). Among Thebes and Kirk cluster points the morphology of basal edges varies from concave to straight to convex: these differences sometimes figure into the definition of specific varieties (see Justice 1987). The relatively high degree of variability in basal edge morphology and the lack of a good argument for the functional significance of this attribute suggest that basal concavity depth (and shape?) is primarily stylistic in all the point groups.

Variable I describes the proximal-distal distance between the plane of maximum basal width (i.e., variable C) and the plane of maximum haft constriction (i.e., variable B). This variable exhibits a pattern of change in CV similar to that of variable E, for similar reasons. In the lanceolate point groups, the proximal-distal location of the greatest degree of constriction (when constriction was present) was apparently not under a great deal of constraint. The reduced CV of variable I in the notched point groups reflects a more limited range of options for the placement of notches relative to the plane of maximum basal width. The CV of variable I remains significantly higher than the CV of variables directly associated with haft size in the notched point groups, however.

Variable A (the distance between the two most proximal points on the basal margin, defined by the lateral limits of the basal concavity) is the only variable that appears to switch from a “low” to a “high” CV in the sequence of samples considered here. Variable A is closely related to hafting width in the lanceolate point groups. In the EFP group, variable A is taken to be hafting width unless the haft of the point is constricted. When haft constriction is present in the lanceolate point groups (i.e., in about a third of the EFP group and in most of the Hi-Lo and Dalton groups), its shallowness means that variables A and B are strongly correlated.

Variable A is much less relevant to hafting width in the notched point groups. Basal concavities among the notched points, especially Thebes cluster, are highly variable in configuration, ranging from shallow concavities spanning the basal edge to discrete notches/indentations executed in the central portion of a convex basal edge. The widths defined by the most proximal and distal portions of these basal concavities vary accordingly, and bear a looser relationship to haft width then among the lanceolate points (where concavities typically span the entire basal edge and the lateral haft edges are relatively straight).

In summary, consideration of the CV data is concordant with the expectation that, all other things being equal, attributes closely related to the width and thickness of the haft should be less variable than those that are not. Haft width and maximum thickness meet the expectations of functional variables both in terms of the physics of projectile weapons and the statistical characteristics of the current sample.

The relatively high CV values of variables E, F, and I in all point groups suggest that these attributes can be treated as stylistic variables. While variables E and I are related to haft constriction and do become less variable in the course of the transition from fluted lanceolate points to notched points, the values of CV for these variables remain well above those of variables that are directly related to haft size. Variable F (the depth of the basal concavity) is highly variable in all the point groups, suggesting the choice of the morphology of the basal edge may be a largely stylistic one. This is not to say that basal edge morphology has no effect on hafting, but to suggest that there is a relatively wide continuum of functionally-equivalent choices available for the final shape and configuration of the basal edge.

Histograms of haft width and maximum thickness in the four point groups (Figure 7.15), illustrate temporal changes in two aspects of haft size in the sample. A trend of reduction in haft width is apparent through time from the EFP sample (bottom) to the Early Archaic samples (top). Maximum thickness is approximately the same in the Early Paleoindian and Late Paleindian samples. Thebes and Kirk points differ significantly from one another in maximum thickness, with Thebes points being the thickest of all the point groups and Kirk points being the thinnest.

Spatial Patterning of Stylistic and Functional Variability

Based on the discussion above, variables E, F, and I are identified as primarily stylistic variables while haft width and maximum thickness are identified as functional variables. Understanding how these aspects of stylistic and functional

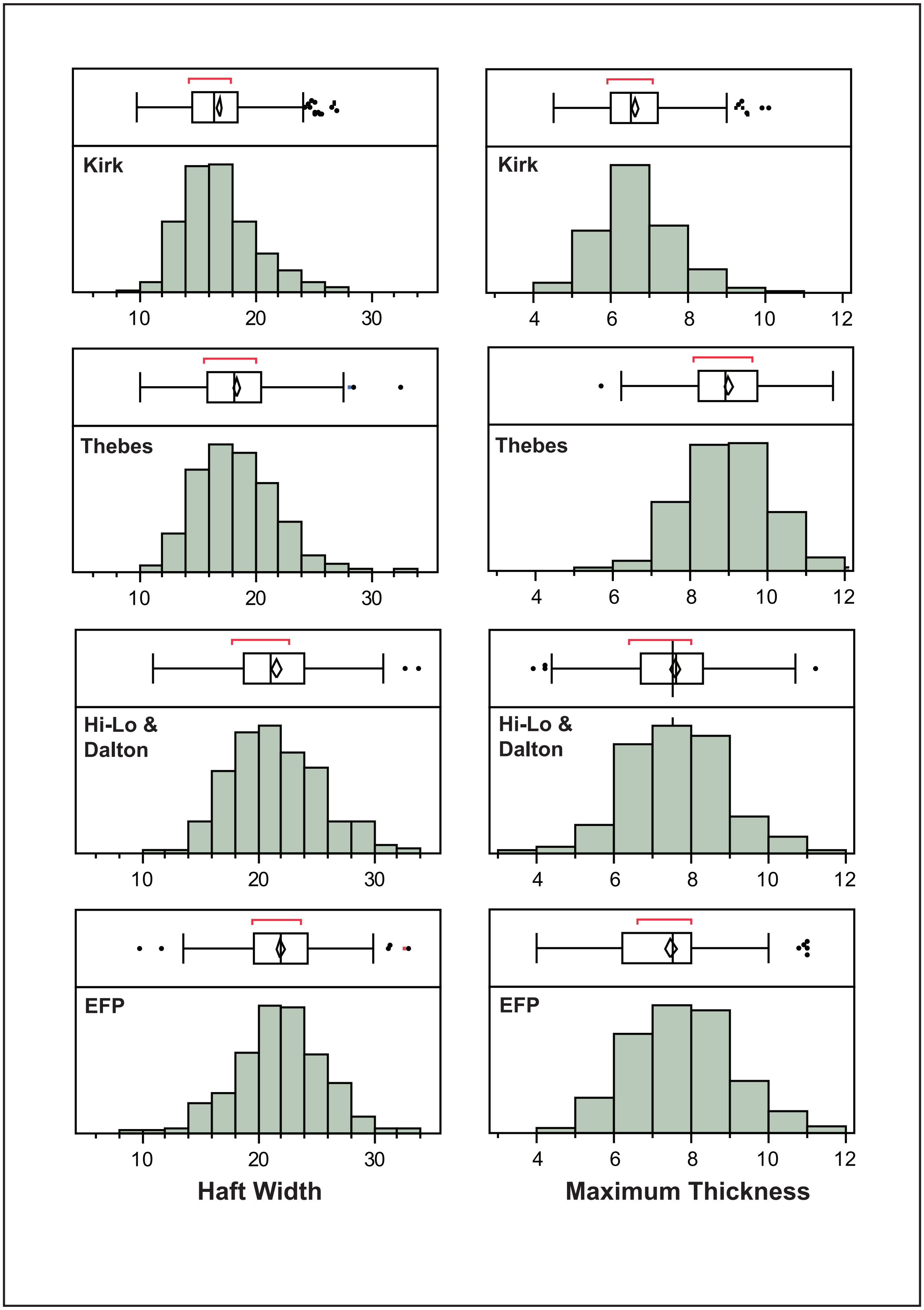


Figure 7.15. Histograms of haft width and maximum thickness in each point group. Note bottom-to-top temporal trend towards points with narrower hafts.

variability are patterned with regard to space will allow us to quantitatively describe the archaeological dataset in a way that can be compared to model data.

Principal components analysis (PCA) can be used to “flatten” the groups of stylistic (n = 3) and functional (n = 2) variables into single variables that can be plotted across space in a geographic information system (GIS). PCA is a mathematical procedure that reduces the dimensionality of datasets with multiple variables. It uses analysis of covariance to first extract the axis which captures the greatest amount of variance in the data. This is called the first principal component. It then finds the axis orthogonal to the first axis which captures the greatest amount of variance. This is called the second principal component. In this way, PCA can reduce a dataset containing more than two variables into a two-dimensional dataset. For this analysis, only the first principal component will be used (i.e., the data will be transformed into a one-dimensional dataset).

Scatterplots of variables E, F, and I for each point group are shown in Figure 7.16. Correlation coefficients are reported in Table 7.7. The highest correlations are between variables E and I, which both measure aspects of the placement and degree of haft constriction. The results of the PCA on variables E, F, and I are shown in Table 7.8. The first principal component explains about 55-65 percent of the variance in each point group. This new variable will be called “EFI.”

The results for haft width and maximum thickness (i.e., the functional variables) are shown in Table 7.9. The first principal component explains about 60-73 percent of the variance in each point group. This new variable will be called “HWMT.”

The spatial distribution and patterning of the new variables EFI and HWMT can be considered using GIS software. Figures 7.17 through 7.20 are graphic representations of the distribution of variable EFI in each point group. The raster images of EFI were created by interpolating from the point data using the Inverse Distance Weighted tool in ArcMap 9.2. The default settings were used (Power: 2; Search radius type: variable; Number of Points in search radius: 12). The rasters are all displayed using the same color ramp with 32 classes (equal interval). Figures 7.21 through 7.24 are graphic representations of the distribution of variable HWMT in each point group. Rasters of HWMT were created and are displayed as described above for EFI.

The Moran’s I statistic can be used to quantitatively describe the degree of spatial autocorrelation among the values of EFI and HWMT in each point

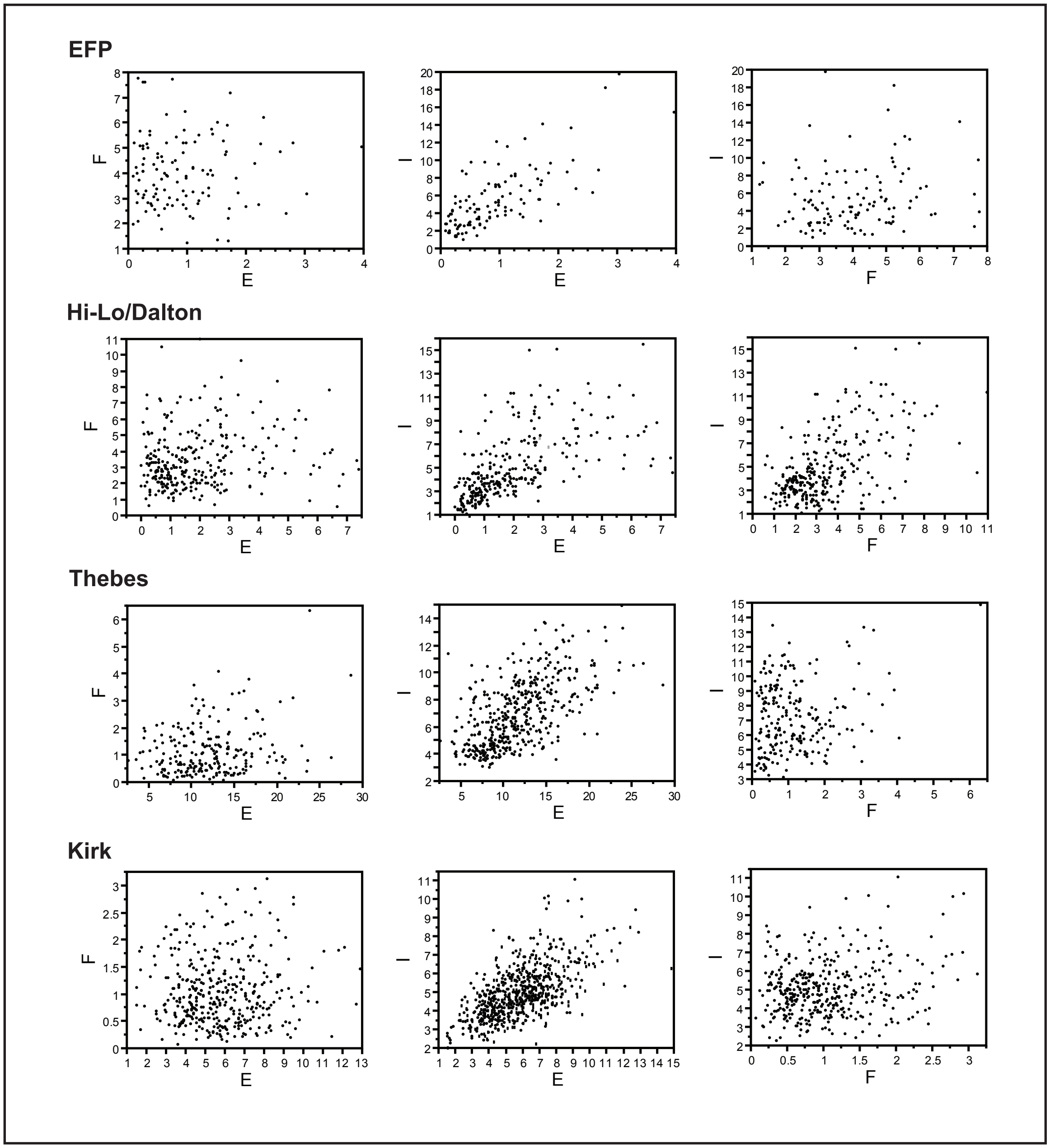


Figure 7.16. Scatterplots showing correlations among variables E, F, and I in each point group.

group. Spatial autocorrelation is the degree to which the value of a variable at a point in space is related to the values of the same variable in adjacent points in space (see Cliff and Ord 1973; Moran 1950). Moran's I is an index: values range from +1 (perfect correlation) to -1 (perfect dispersion). A value of 0 indicates a random arrangement in space (i.e., spatial proximity has no effect on the value of a variable). Values between 0 and 1 indicate some degree of spatial

Table 7.7. Correlation Coefficients among Variables E, F, and I in each Point Group. Correlation coefficients were estimated using the REML (restricted maximum likelihood) method in JMP 9.0.3.

Early Fluted Points		**Variable E**	**Variable F**
	Variable F	0.0087	-
	Variable I	0.7212	0.1849
Hi-Lo/Dalton		**Variable E**	**Variable F**
	Variable F	0.1732	-
	Variable I	0.6129	0.5722
Thebes		**Variable E**	**Variable F**
	Variable F	0.2229	-
	Variable I	0.6042	0.1983
Kirk		**Variable E**	**Variable F**
	Variable F	0.0320	-
	Variable I	0.6037	0.1924

Table 7.8. Results of Principal Components Analysis (PCA) on Variables E, F, and I. PCA was performed using JMP 9.0.3.

Point Group	**Principal Component 1**		**Principal Component 2**	
	Percent Variance	**Eigenvalue**	**Percent Variance**	**Eigenvalue**
Early Fluted	58.2	1.747	33.2	0.996
Hi-Lo & Dalton	64.3	1.929	27.6	0.827
Thebes	57.5	1.726	29.3	0.878
Kirk	54.8	1.644	32.7	0.982

Table 7.9. Results of Principal Components Analysis on Haft Width and Maximum Thickness.

Point Group	**Principal Component 1**		**Principal Component 2**	
	Percent Variance	**Eigenvalue**	**Percent Variance**	**Eigenvalue**
Early Fluted	68.6	1.371	31.4	0.629
Hi-Lo & Dalton	60.3	1.207	39.7	0.793
Thebes	64.5	1.290	35.5	0.711
Kirk	73.4	1.467	26.6	0.533

clustering, where similar values are located closer to each other in space than would be expected randomly. The standardized normal deviate (*z* score) is used to evaluate the statistical significance of a result. A *z* score greater than 1.96 or less than -1.96 is statistically significant at the $p = 0.05$ level.

Moran's I was calculated on variables EFI and HWMT in ArcMap 9.2

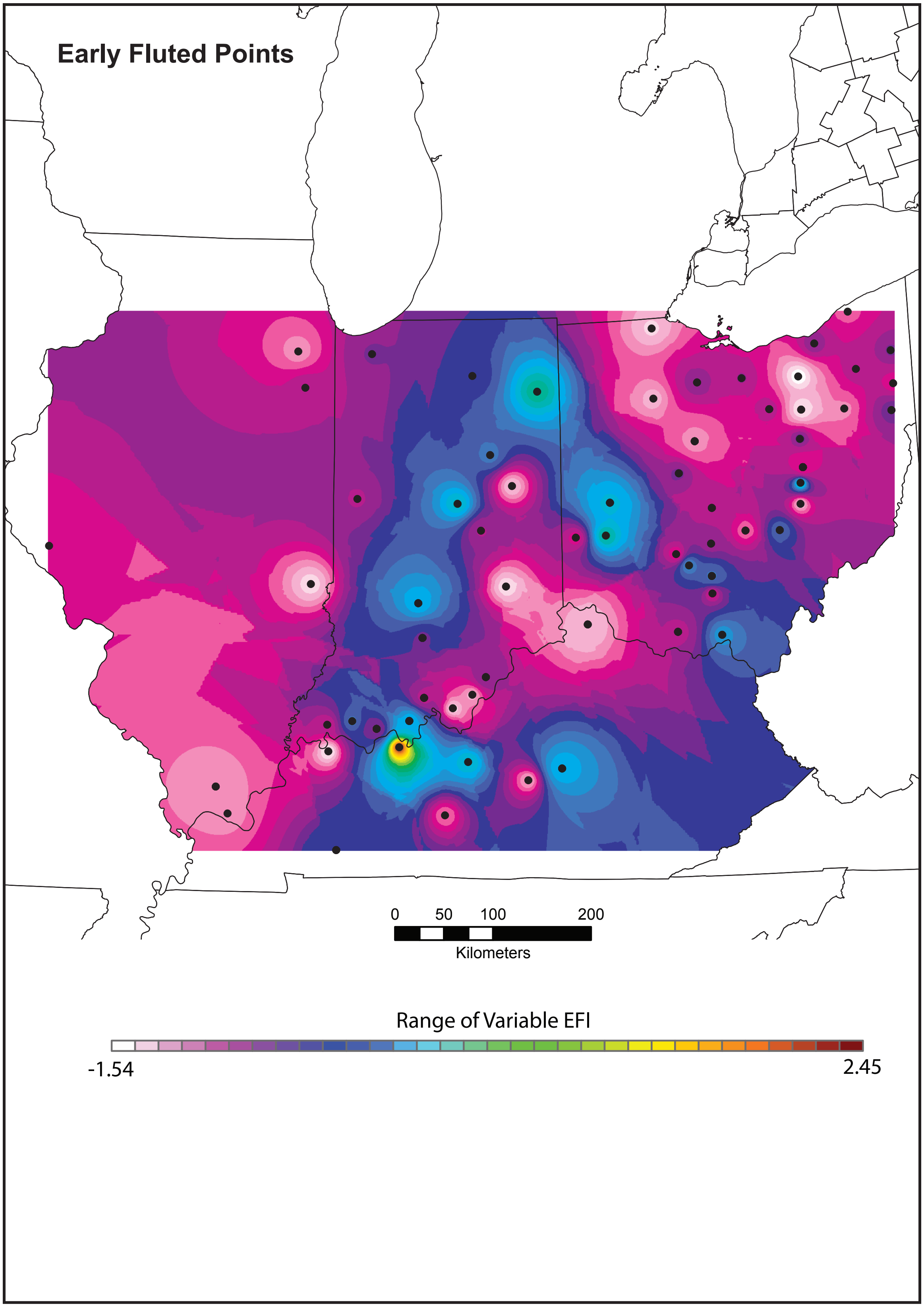


Figure 7.17. Raster image of spatial distribution of variable EFI, Early Fluted Point sample.

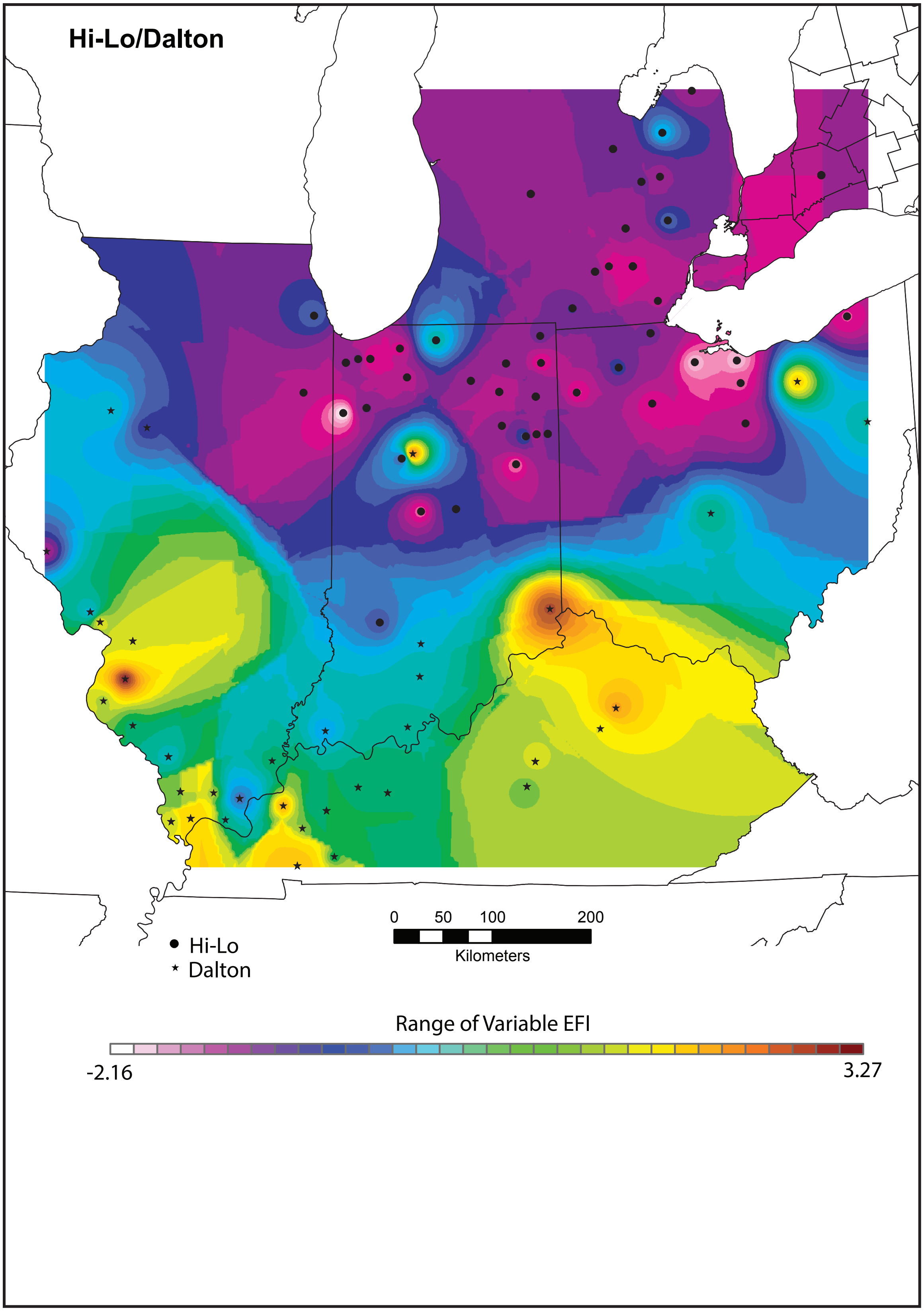


Figure 7.18. Raster image of spatial distribution of variable EFI, Hi-Lo/Dalton sample.

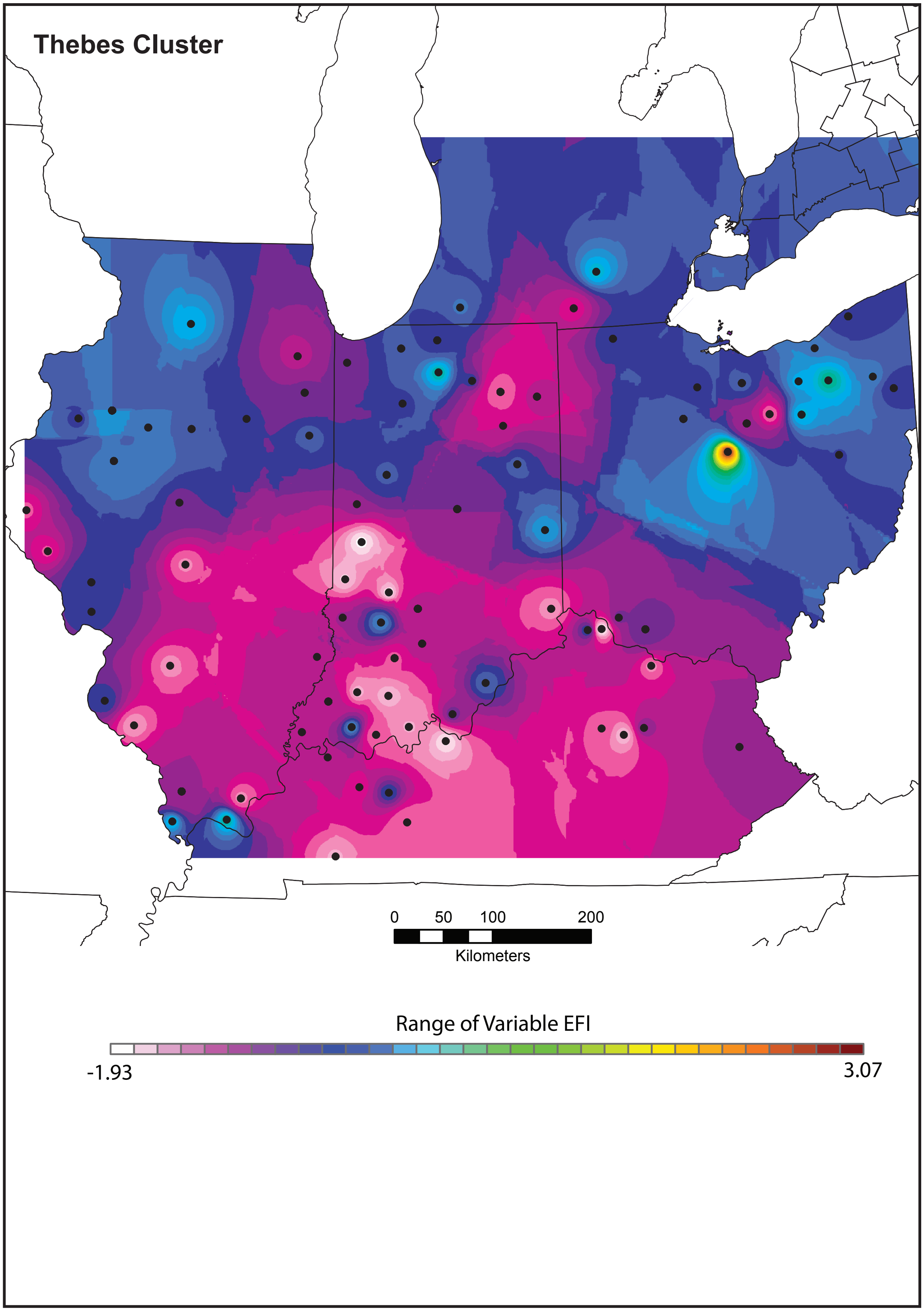


Figure 7.19. Raster image of spatial distribution of variable EFI, Thebes Cluster sample.

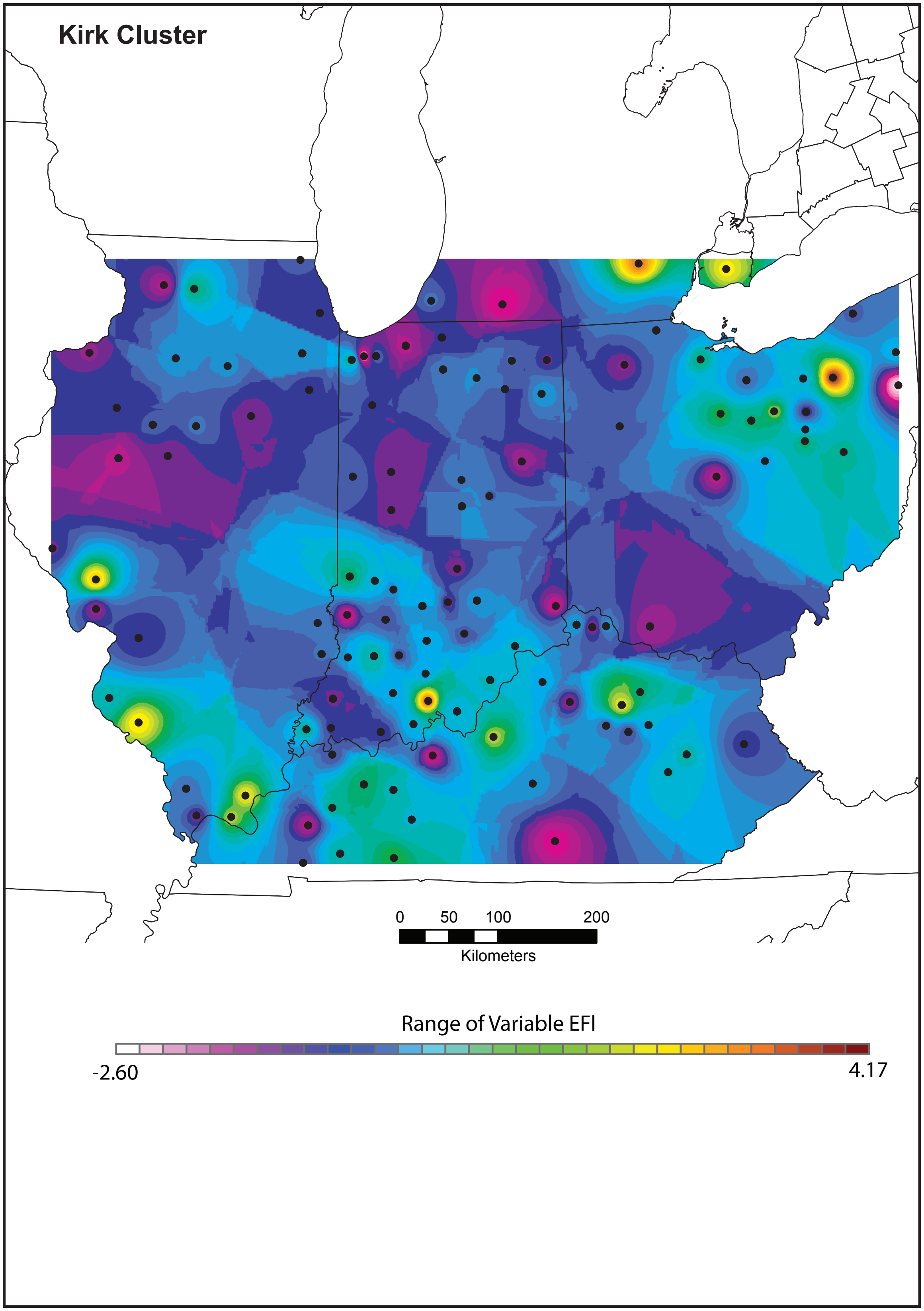


Figure 7.20. Raster image of spatial distribution of variable EFI, Kirk Cluster sample.

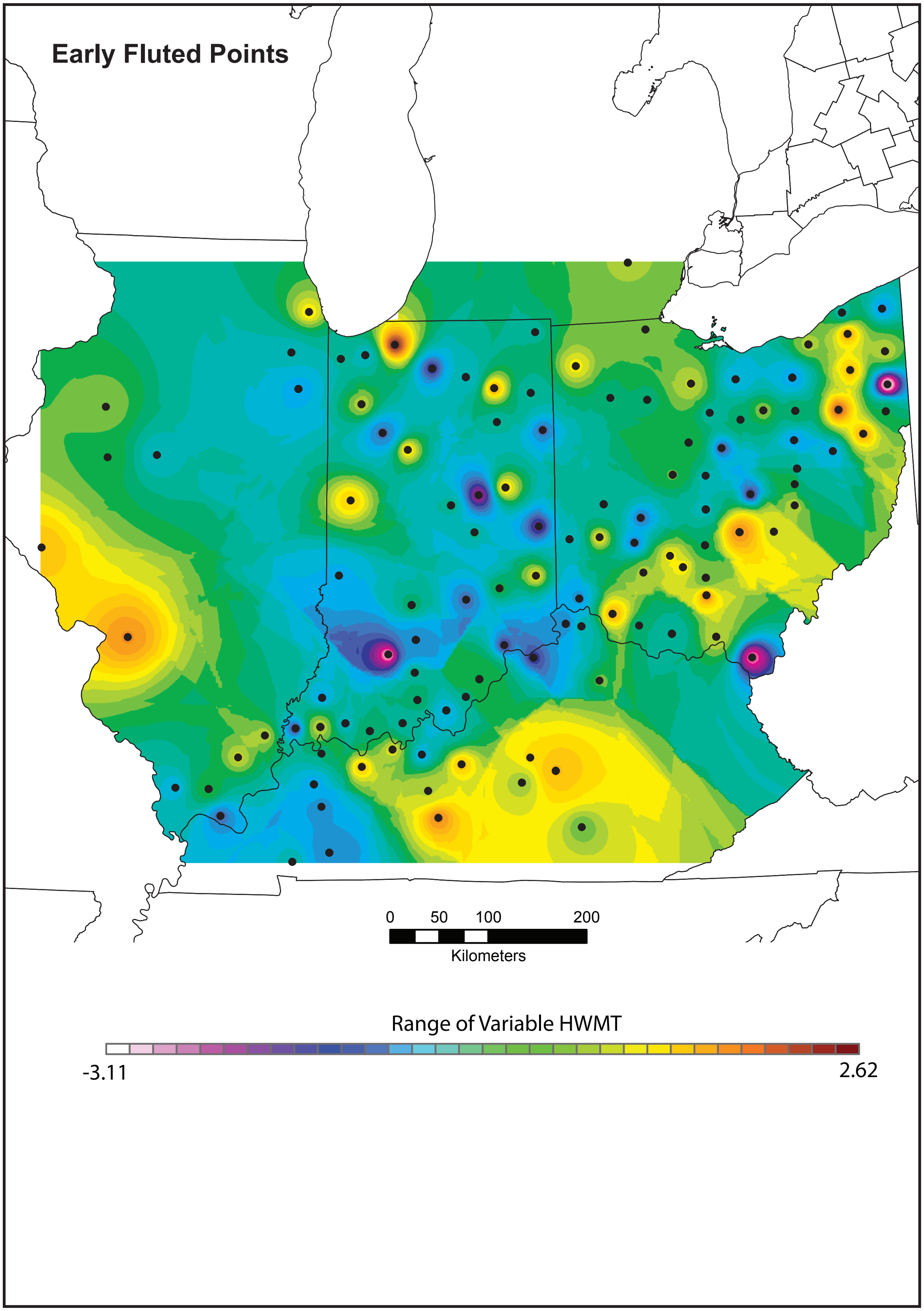


Figure 7.21. Raster image of spatial distribution of variable HWMT, Early Fluted Point sample.

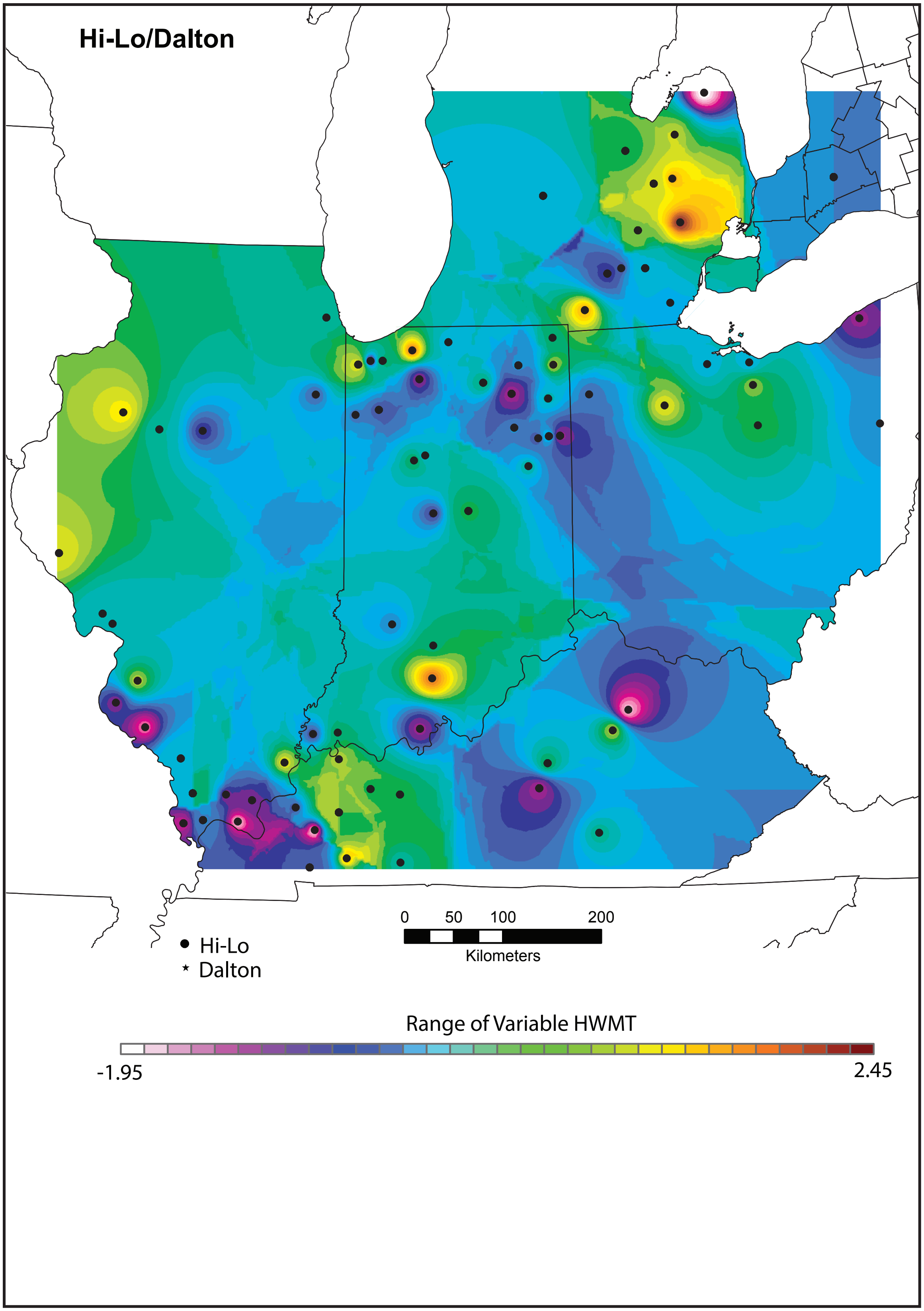


Figure 7.22. Raster image of spatial distribution of variable HWMT, Hi-Lo/Dalton sample.

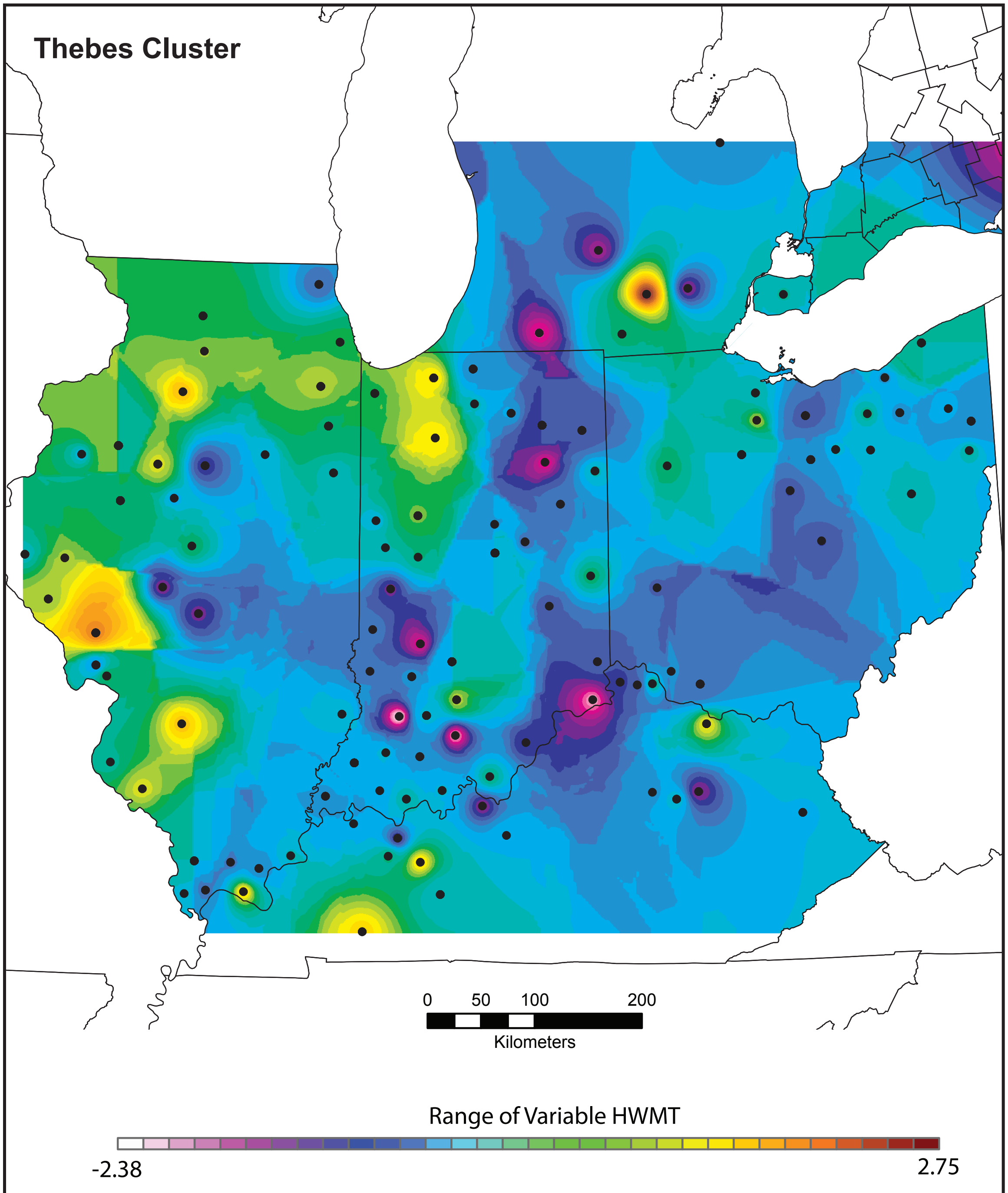


Figure 7.23. Raster image of spatial distribution of variable HWMT, Thebes Cluster sample.

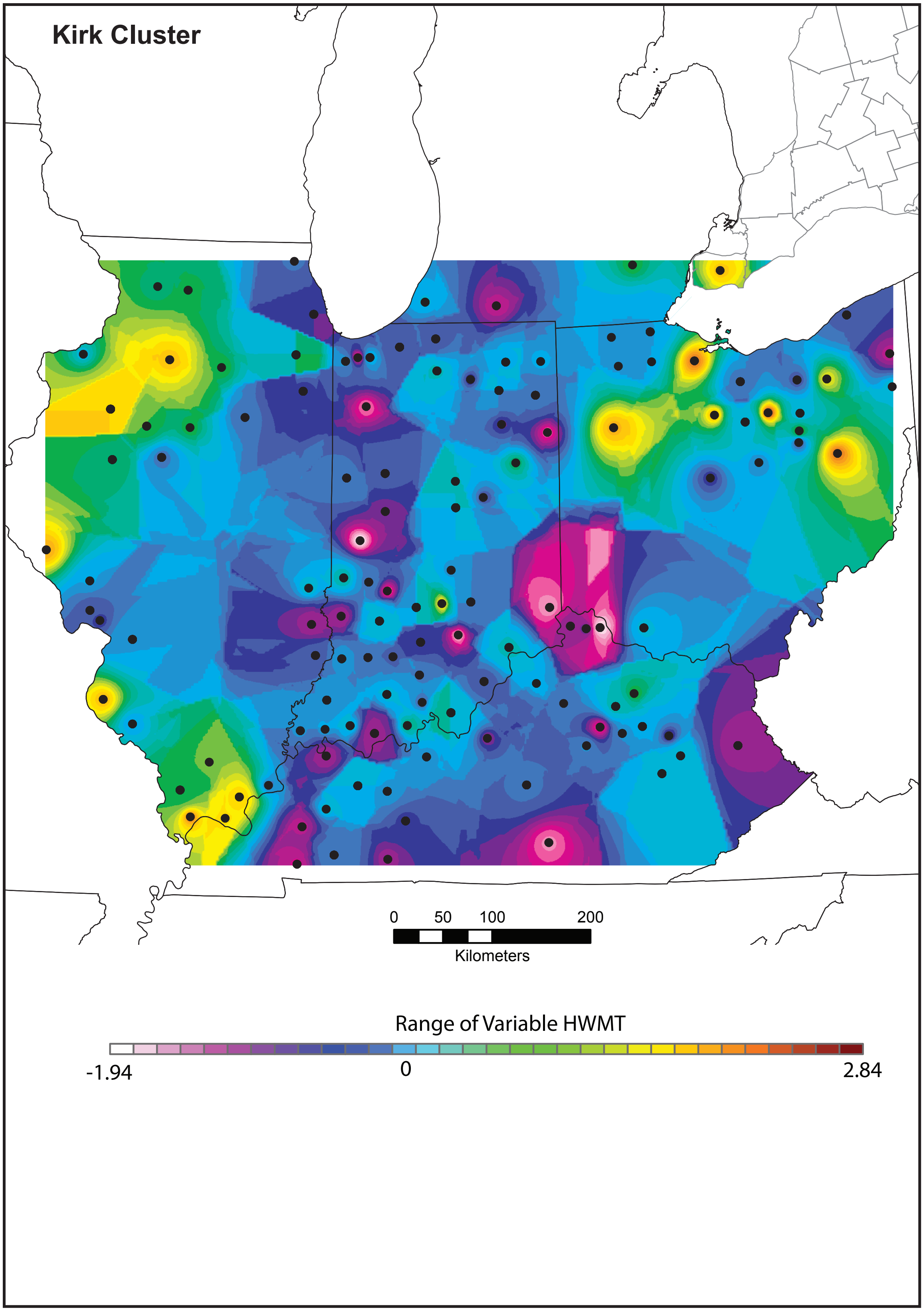


Figure 7.24. Raster image of spatial distribution of variable HWMT, Kirk Cluster sample.

using the default settings of the Spatial Autocorrelation tool (Conceptualization of Spatial Relationships: Inverse Distance; Distance Method: Euclidean Distance; Standardization: None). For each calculation in each point group, a datafile was produced that included only those points with the relevant variable. All values of the variable were made positive by adding 10 to the value of each variable. These two steps were undertaken to produce a file that included neither negative nor null values, as required for the calculations performed by the tool. The results are reported in Table 7.10.

It is immediately clear from both the raster images and the Moran's I results that there is a high degree of spatial organization to stylistic variability in the Late Paleoindian (i.e., Hi-Lo/Dalton) sample relative to the other point groups. The geographic separation of Hi-Lo and Dalton corresponds to a stylistic divide between the Mississippi/Ohio Valleys and the Great Lakes that is readily visible in Figure 7.18. The Moran's I result (0.326) readily defeats the null hypothesis of a random spatial distribution and is far greater than the result produced by any of the other point groups.

Statistically significant spatial organization of stylistic variability is also present in the Thebes and Kirk samples. In the Thebes sample, the raster image of EFI suggests that points from central and southern Illinois, southern Indiana, and Kentucky form a somewhat distinct stylistic zone. When variables E, F, and I are considered separately, statistically significant spatial patterning is associated with variable E (Moran's I = 0.014, *z* = 4.90, *n* = 437) and variable I (Moran's I = 0.014, *z* = 5.03, *n* = 437). Variable I measures the vertical distance between the point of maximum basal width and the point of maximum haft constriction. A raster image of variable I suggests, again, some differentiation between the northern and southern portions of the sample area: points with lower values of variable I tend to be from the Ohio Valley. The result for variable F is not

Table 7.10. Values of Moran's I Calculated on Spatial Distributions of Variables EFI and HWMT (statistically significant results are shown in bold italics; critical value of *z* for *p*=0.05 is 1.96).

Point Group	**Variable EFI**			**Variable HWMT**		
	n	**Moran's I**	***z***	***n***	**Moran's I**	***z***
Early Fluted Points	117	-0.000	0.69	285	0.001	1.02
Hi-Lo/Dalton	287	***0.326***	***49.26***	264	-0.010	-0.86
Thebes	224	***0.036***	***6.50***	422	***0.027***	***8.62***
Kirk	383	***0.017***	***5.54***	596	***0.007***	***4.32***

statistically significant (Moran's I = -0.009, *z* = -0.72, *n* = 224).

In the Kirk sample, as in the Thebes sample, variables E (Moran's I = 0.019, z = 10.06 , *n* = 619) and I (Moran's I =0.008 , z = 4.82, *n* = 619) return statistically significant results when they are considered separately. Also as in the Thebes sample, a raster image suggests that differentiation between points from the Ohio Valley and the Great Lakes underlies the spatial patterning. The result for variable F is not statistically significant (Moran's I = 0.003, *z* = 1.57, *n* = 383).

The EFP sample shows no indication of nonrandom patterning in variable EFI. Because EFI depends on the presence of haft constriction, however, a large part of the EFP sample is excluded from consideration when EFI is considered. When the Moran's I statistic is calculated using on variable F (depth of the basal concavity), a much larger portion of the EFP sample (*n* = 356 points) can be included. The Moran's I result is very similar to that of EFI, however (Moran's I = -0.000, *z* = 0.71).

The spatial distribution of the functional variable (HWMT) returned statistically significant results for both the Thebes and the Kirk samples (see Table 7.10), suggesting that values of this variable are not randomly distributed across space during the Early Archaic period. When haft width and maximum thickness are considered separately, the result is the same for both point groups: haft width returns a statistically significant result while maximum thickness does not (Table 7.11). This suggests some nonrandom spatial organization to haft width in both point groups. A raster of haft width in the Thebes sample (Figure 7.25) suggests that points with wider hafts tend to be disproportionately clustered in western and northern Illinois and northwestern Indiana. A raster of haft width in the Kirk sample (Figure 7.26) suggests that points with wider hafts tend to be located in western and northern Illinois as well as in northern Ohio.

Table 7.11. Values of Moran's I Calculated on Spatial Distributions of Haft Width and Maximum Thickness in the Thebes and Kirk Samples (statistically significant results are shown in bold italics; critical value of *z* for *p*=0.05 is 1.96).

Point Group	**Variable Haft Width**			**Variable Max. Thickness**		
	n	**Moran's I**	**z**	***n***	**Moran's I**	**z**
Thebes	422	***0.038***	***11.81***	422	0.001	1.23
Kirk	596	***0.013***	***6.58***	596	-0.001	0.41

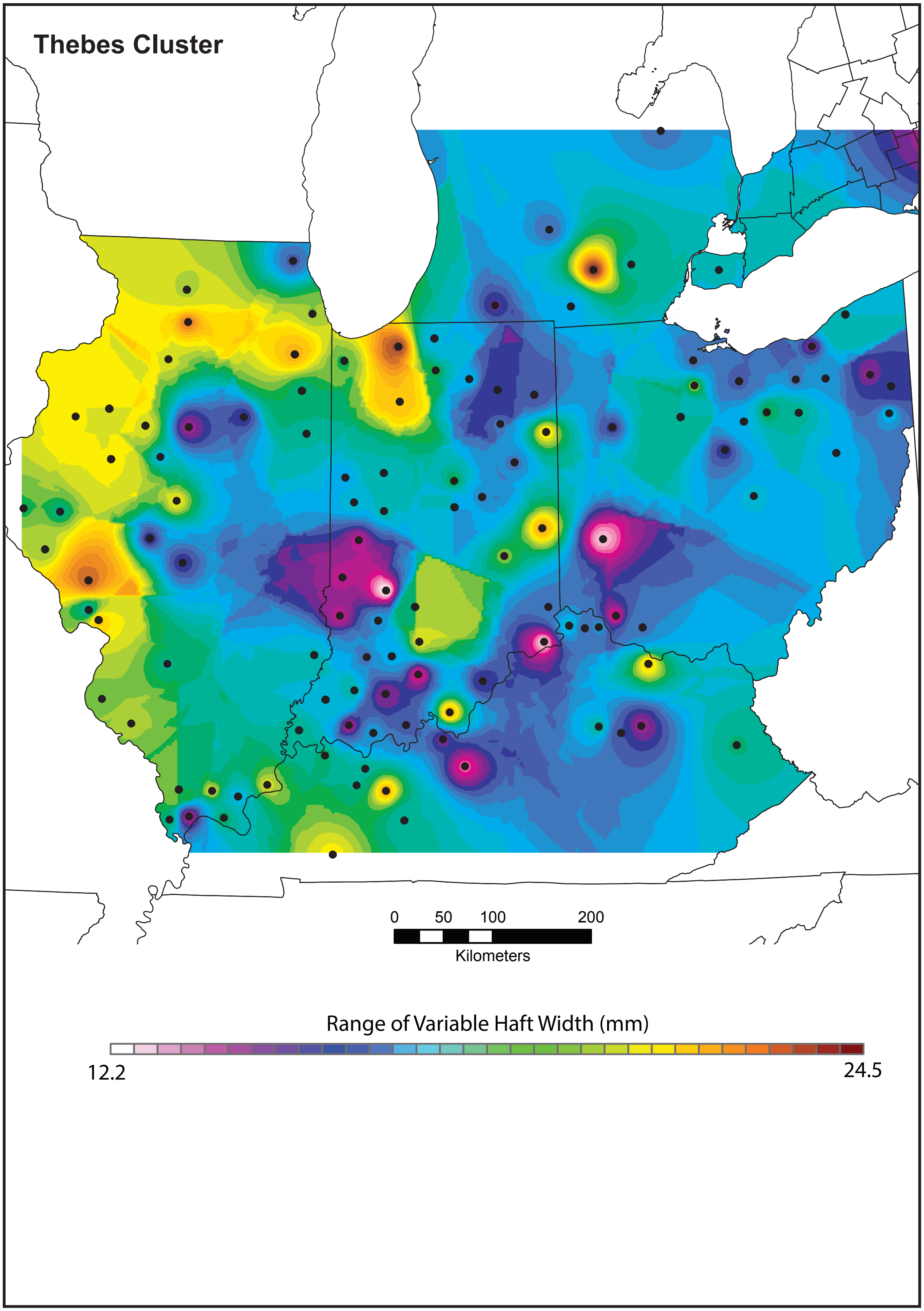


Figure 7.25. Raster image of spatial distribution of haft width, Thebes Cluster sample.

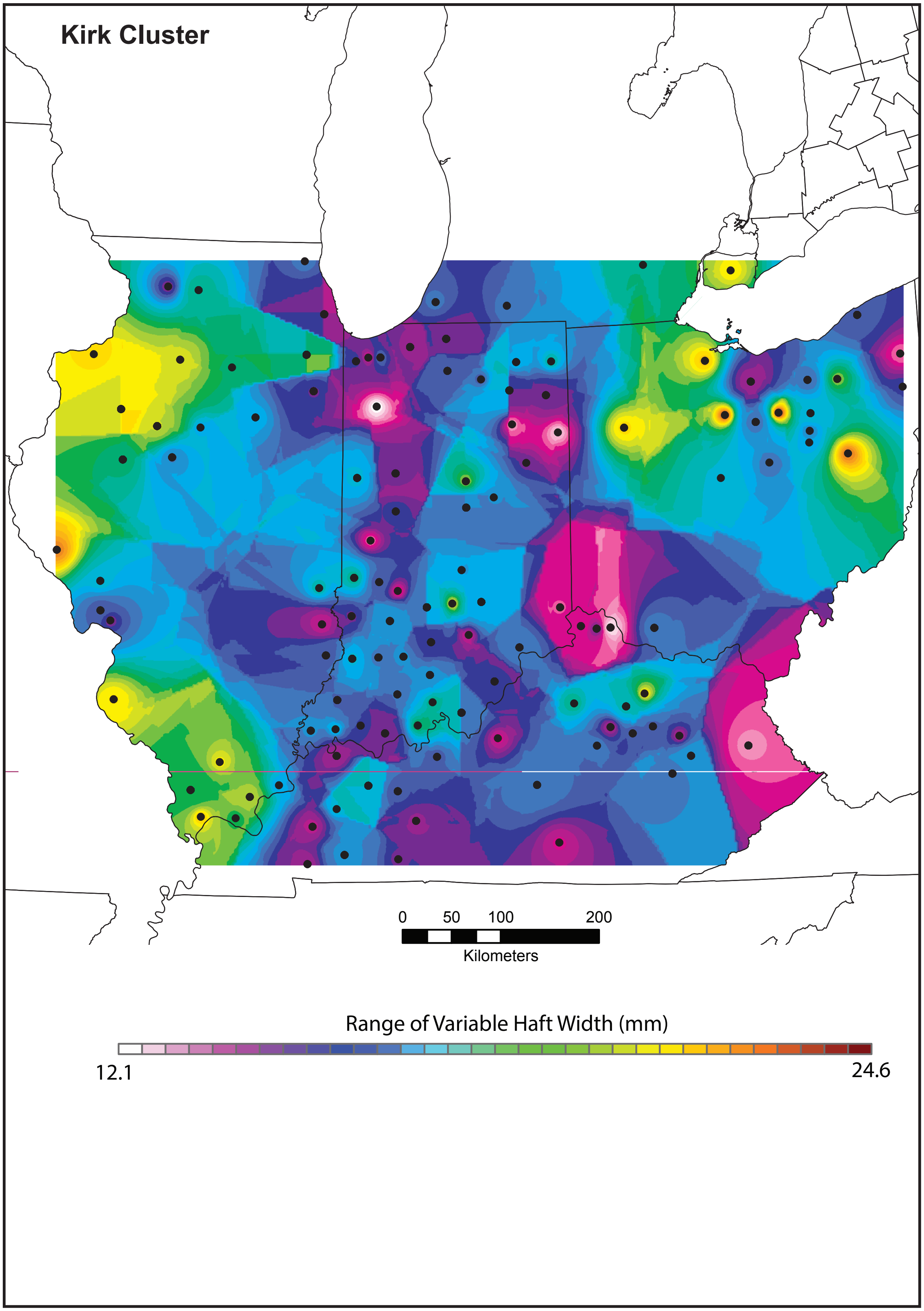


Figure 7.26. Raster image of spatial distribution of haft width, Kirk Cluster sample.

Raw Materials

This portion of the analysis is primarily concerned with quantifying changes in the patterns of transport of raw materials between the Early Paleoindian, Late Paleoindian, and Early Archaic periods. While numerous identifiable raw materials were utilized for the manufacture of stone tools by early foragers in the midcontinent (e.g., see Cantin 1994; Converse 1994; DeRegnaucourt and Georgiady 1998), this portion of the analysis relies on the identification of only a few major raw materials. These raw materials were described in Chapter 6.

Methods

Seven geographically separate raw material sources were combined into five raw material groups (Table 7.12). These raw material groups were constructed to mitigate some of the difficulties of reliably discriminating between major varieties of macroscopically similar cherts that were transported long distances during the Paleoindian and Early Archaic periods in two cases: (1) the blue-gray Wyandotte chert of southern Indiana and the blue-gray Cobden/Dongola chert of southern Illinois; and (2) the black Holland Dark-Phase chert of southern Indiana and the black Upper Mercer chert of eastern Ohio (see Chapter 7). The composition of the point groups in the raw material sample in terms of these raw material groups is shown in Table 7.13.

The use of raw material groups that are comprised of multiple "look-alike" raw materials that have distinct geographic source areas has both advantages and disadvantages. On the disadvantage side, analytical use of raw material

Table 7.12. Summary of Raw Material Groups Used in Analysis.

Raw Material Group	Geologic Age	Raw Material Source	Main Source Areas
1	Mississippian	Wyandotte	Harrison County, IN
		Cobden/Dongola	Union County, IL
2	Mississippian	Attica	Fountain/Warren counties, IN
3	Pennsylvanian	Upper Mercer	Coshocton/Muskingum/Licking/Perry/Hocking counties, OH
		Holland	Dubois/Spencer counties, IN
4	Mississippian	Burlington	Mississippi and Illinois rivers, central Illinois
5	Mississippian	Bayport	Huron and Arenac counties, MI

Table 7.13. Distribution of Points in the Raw Material Sample by Raw Material Group.

Point Group	**Raw Material Group**					**Total**
	1	**2**	**3**	**4**	**5**	
EFP	108	20	151	10	-	289
Hi-Lo/Dalton	30	9	2	31	22	94
Thebes	66	32	52	77	7	234
Kirk	153	47	64	39	6	309

groups that include multiple sources removes the ability to calculate a simple "source-to-discard" distance that can be used as a metric of raw material transport. On the advantage side, it allows the analysis to move forward utilizing points that could not be reliably attributed to a single, specific raw material source (e.g., either Cobden/Dongola or Wyandotte chert) but could be confidently assumed to have been manufactured at one or the other of the two sources. This eliminates the need to utilize expensive, time-consuming methods to discriminate between these look-alike cherts and avoids the pitfall of arbitrarily assigning points to one or the other raw material source based on proximity (i.e., simply assuming the point was manufactured at whichever source area is closer).

A series of calculations was performed to provide several quantitative measures of raw material transport within each point group. I will use the 234 points in the Thebes raw material sample as an example to describe these calculations. First, the mean UTM coordinates of the Thebes assemblage were calculated, including all points in all five raw material groups. The straight-line distance of each Thebes point from these mean coordinates was then calculated. These data were used to compute mean and maximum distances from the mean coordinates of the assemblage. These "assemblage distances" characterize the geographic spread of the Thebes sample as a whole, regardless of particular raw materials.

Then, each raw material group was considered separately within the Thebes sample. The mean UTM coordinates of all 66 Thebes points in Raw Material Group 1 (RMG 1), for example, were calculated and the straight-line distance between those coordinates and each Thebes point in RMG 1 was calculated. These data were used to compute mean and maximum distances from the mean coordinates of each raw material group. These "raw material distances" characterize the geographic spread of points within specific raw material groups.

It became apparent during analysis that the amalgamation of the Upper Mercer and Holland raw materials (i.e., Raw Material Group 3) presented a potential difficulty. Because these discrete raw material sources are so distant from one another (they are geographically separated by approximately 470 km), distances from individual artifacts in RMG 3 to the mean coordinates of all artifacts in RMG 3 produce large distances that are probably an unacceptably large distortion of patterns of transport. Results below are provided for datasets with and without RMG 3.

Results

The results of the distance calculations are given in Tables 7.14 and 7.15. The ratios in the right three columns of Table 7.14 are calculated by dividing the assemblage distance by the corresponding raw material distance. The maximum distance ratio, for example, is calculated by dividing the maximum distance from the whole assemblage by the maximum distance recorded within any of the raw material groups. Thus this ratio expresses the maximum distance within a raw material group as a percentage of the maximum distance possible given the spatial characteristics of the entire assemblage. Data are provided both for datasets where RMG 3 (Upper Mercer/Holland) is included and where it is excluded. Table 7.15 reports the ratio of the maximum to mean distances within raw material groups for each point group. Again, data are provided both for datasets where RMG 3 (Upper Mercer/Holland) is included and where it is excluded. Patterns are similar whether or not RMG 3 is included. Histograms of raw material distances (with RMG 3 included) are shown in Figure 7.27.

The data in Table 7.14 and Figure 7.27 indicate decreases in the scale of raw material transport during the Late Paleoindian period. While the mean and maximum assemblage distances of the Hi-Lo/Dalton sample are comparable to those of the other point groups, the mean and maximum raw material distances are significantly smaller. This results in relatively low ratios of maximum and mean distance.

Figures 7.28 through 7.31 plot the spatial distribution of points in each raw material group relative to the mean UTM coordinates of the raw material group. These figures immediately show the reduced scale of raw material transport that characterizes the Late Paleoindian sample relative to the other samples. While there is some spatial articulation between Dalton points of RM 1 and RM 4,

Table 7.14. Assemblage and Raw Material Distances Calculated within each Point Group. Assemblage distance values are calculated for the entire assemblage, regardless of raw materials. Raw material distance values are calculated on sets of points *within* raw material groups. In both cases, mean, maximum, and median distances are from the mean geographical center of the distribution, *not* the geographic location of the raw material source.

With Raw Material Group 3 Included										
Point Group	***n***	**Assemblage Distance (km)**			**Raw Material Distance (km)**			**Ratio of Assemblage Dist. to Raw Material Dist.**		
		Max.	**Mean**	**Median**	**Max.**	**Mean**	**Median**	**Max.**	**Mean**	**Median**
EFP	289	553.5	210.5	219.9	485.8	169.8	155.8	0.878	0.807	0.709
Hi-Lo & Dalton	94	618.8	309.6	279.1	297.3	99.6	82.4	0.480	0.322	0.295
Thebes	234	566.5	258.8	268.3	635.8	126.7	109.2	1.122	0.490	0.407
Kirk	309	539.7	216.9	213.5	526.4	164.0	139.7	0.975	0.756	0.654
With Raw Material Group 3 Excluded										
Point Group	***n***	**Assemblage Distance (km)**			**Raw Material Distance (km)**			**Ratio of Assemblage Dist. to Raw Material Dist.**		
		Max.	**Mean**	**Median**	**Max.**	**Mean**	**Median**	**Max.**	**Mean**	**Median**
EFP	138	488.3	182.2	157.4	485.8	169.8	150.2	0.995	0.932	0.954
Hi-Lo & Dalton	92	627.4	306.3	272	297	98.3	82.4	0.473	0.321	0.303
Thebes	182	628	225.3	207.4	635.8	111.4	90.6	1.012	0.494	0.437
Kirk	245	579.7	199	170.1	526.4	143.4	139.7	0.908	0.721	0.821

Table 7.15. Ratio of the Maximum Distance to the Mean Distance within Raw Material Groups.

With Raw Material Group 3 Included			
Point Group	**Distance within Raw Material Group (km)**		**Ratio of Max:Mean**
	Maximum	**Mean**	
EFP	485.8	169.8	2.86
Hi-Lo & Dalton	297.3	99.6	2.98
Thebes	635.8	126.7	5.02
Kirk	526.4	164.0	3.21
With Raw Material Group 3 Excluded			
Point Group	**Distance within Raw Material Group (km)**		**Ratio of Max:Mean**
	Maximum	**Mean**	
EFP	485.8	169.8	2.86
Hi-Lo & Dalton	297	98.3	3.02
Thebes	635.8	111.4	5.71
Kirk	526.4	143.4	3.67

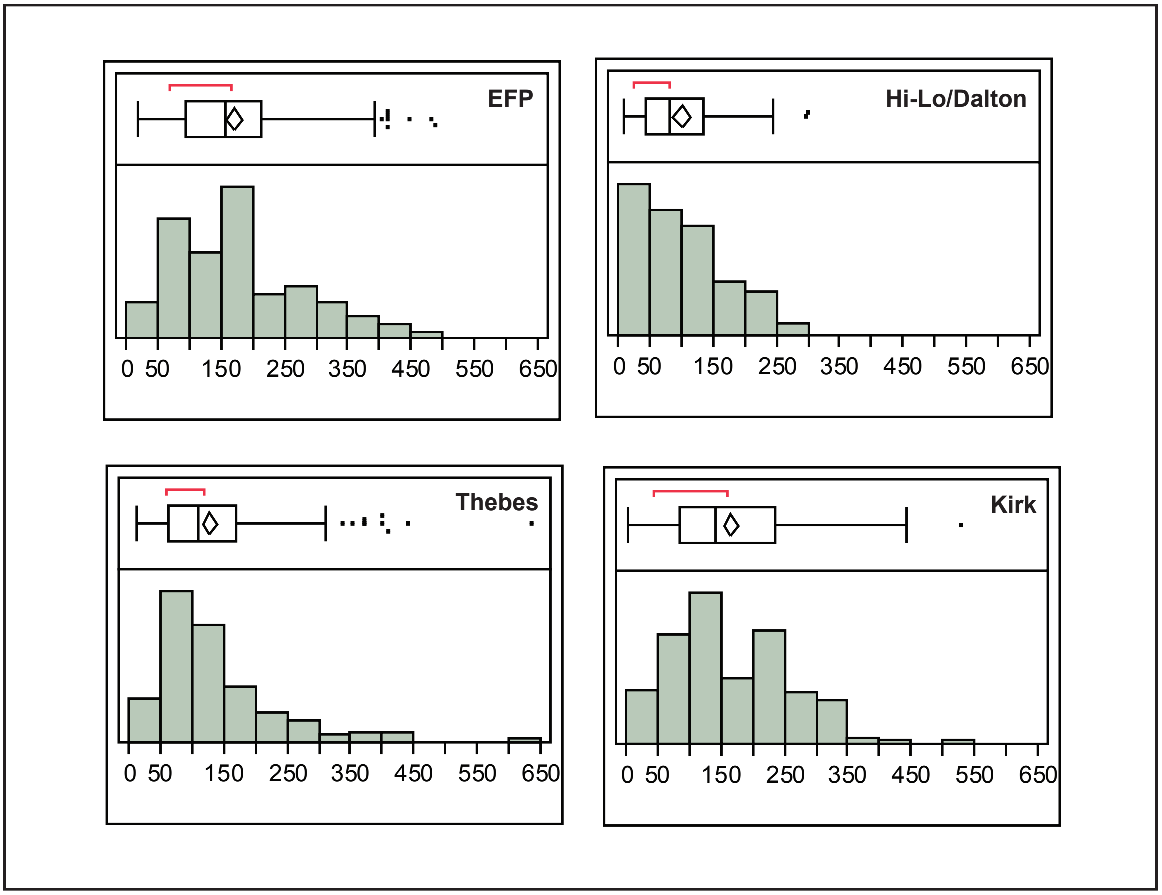


Figure 7.27. Histograms of distance between individual points of specific raw material groups and the geographic center of the distribution of all points within that raw material group (x axis = kilometers; Raw Material Group 3 included).

there is no spatial overlap in raw materials between the Mississippi/Ohio Valley and Great Lakes portions of the point sample. This contrasts with the Early Paleoindian and Early Archaic samples, all of which show some degree of spatial overlap between multiple zones of raw material transport.

Discussion and Conclusion

The results of the analyses presented above, summarized in Figure 7.32 and Table 7.16, are largely congruent with existing notions about changes in the spatial patterns of morphometric variability and raw material transport that characterize the early archaeological record of the midcontinent: the stylistic homogeneity of the Early Paleoindian period was followed by the marked stylistic

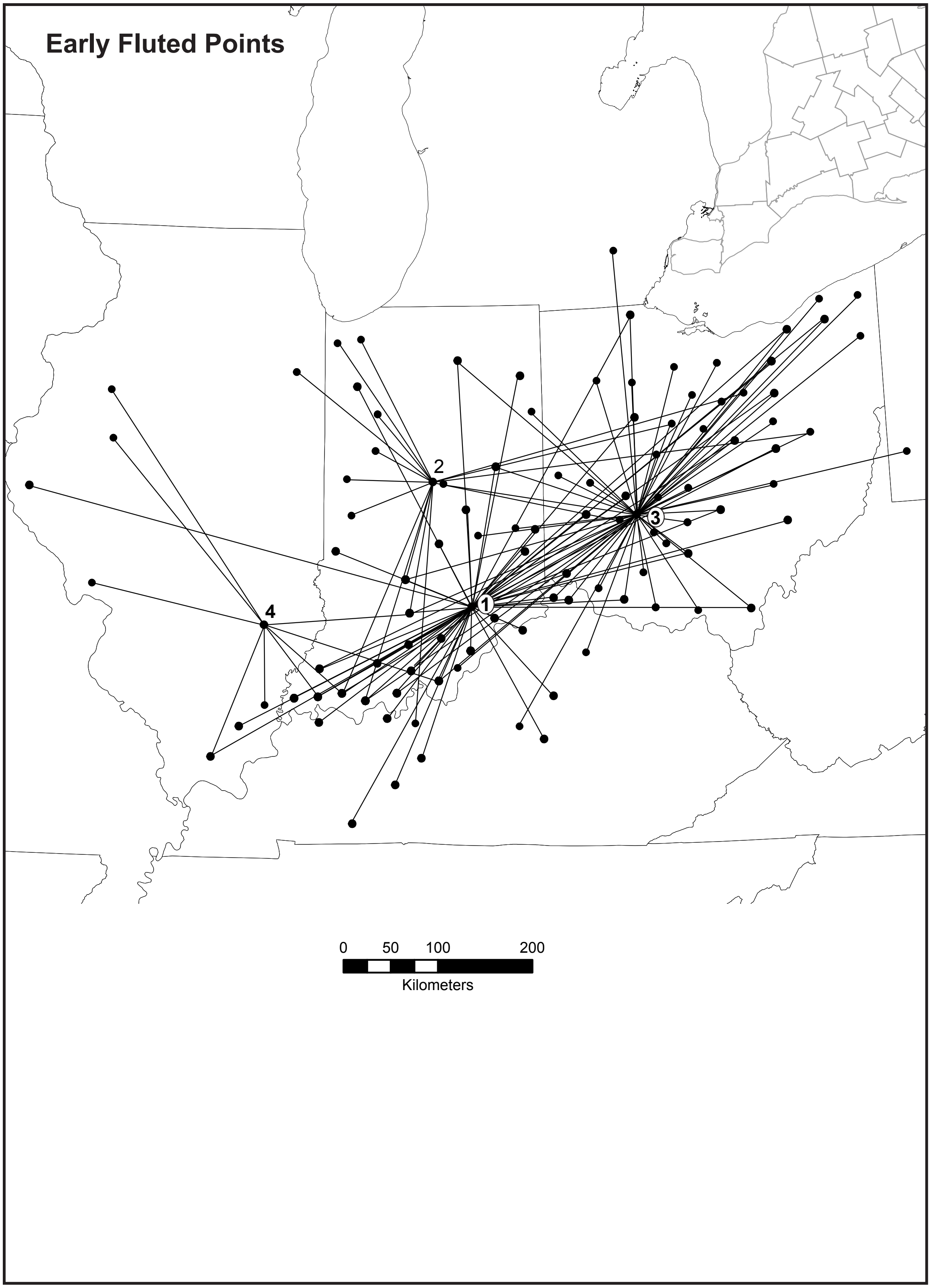


Figure 7.28. Graphic depiction of straight-line distances between locations of points and location of geographic center of distribution of points of same raw material group, Early Fluted Point sample.

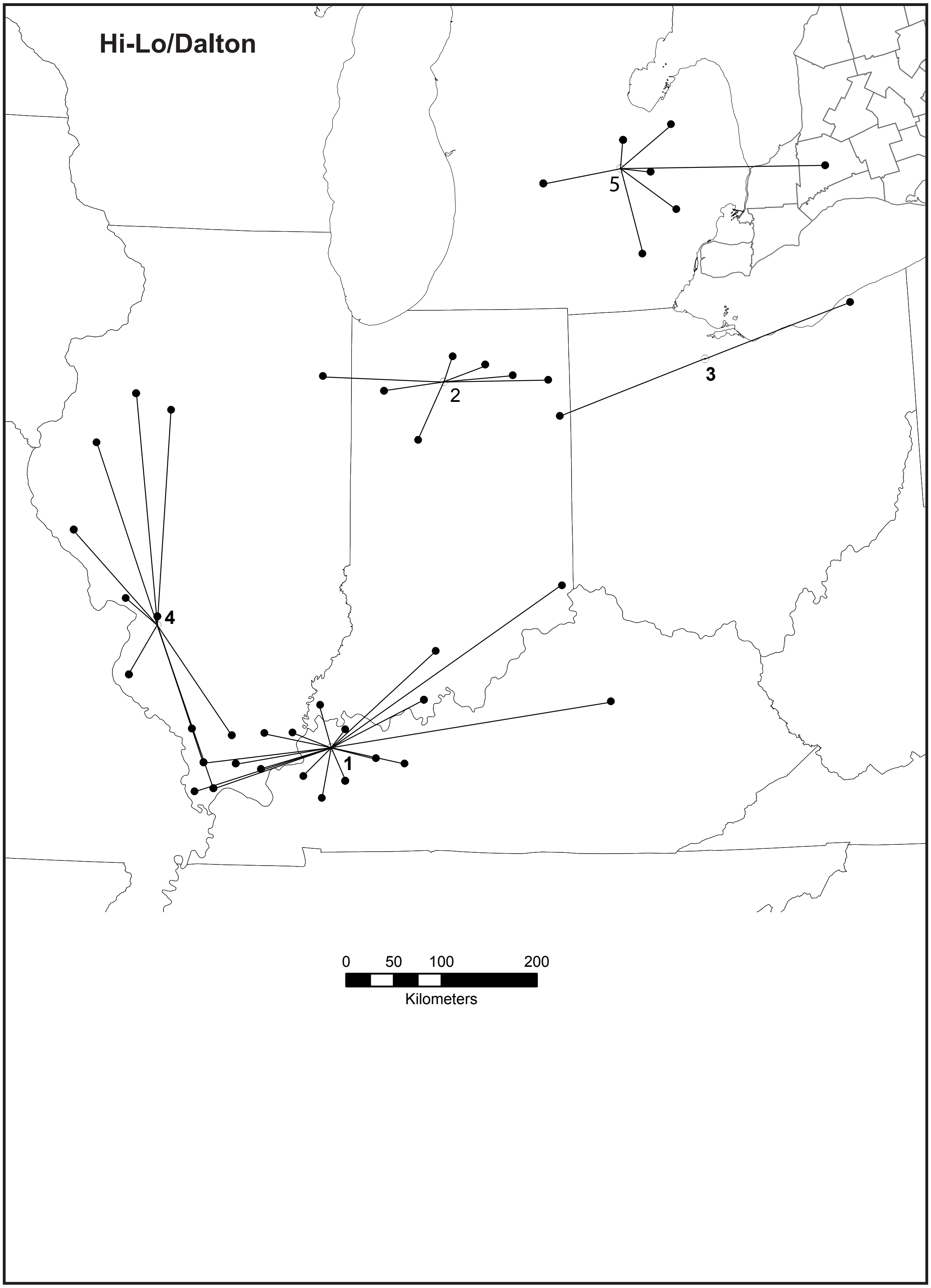


Figure 7.29. Graphic depiction of straight-line distances between locations of points and location of geographic center of distribution of points of same raw material group, Hi-Lo/Dalton sample.

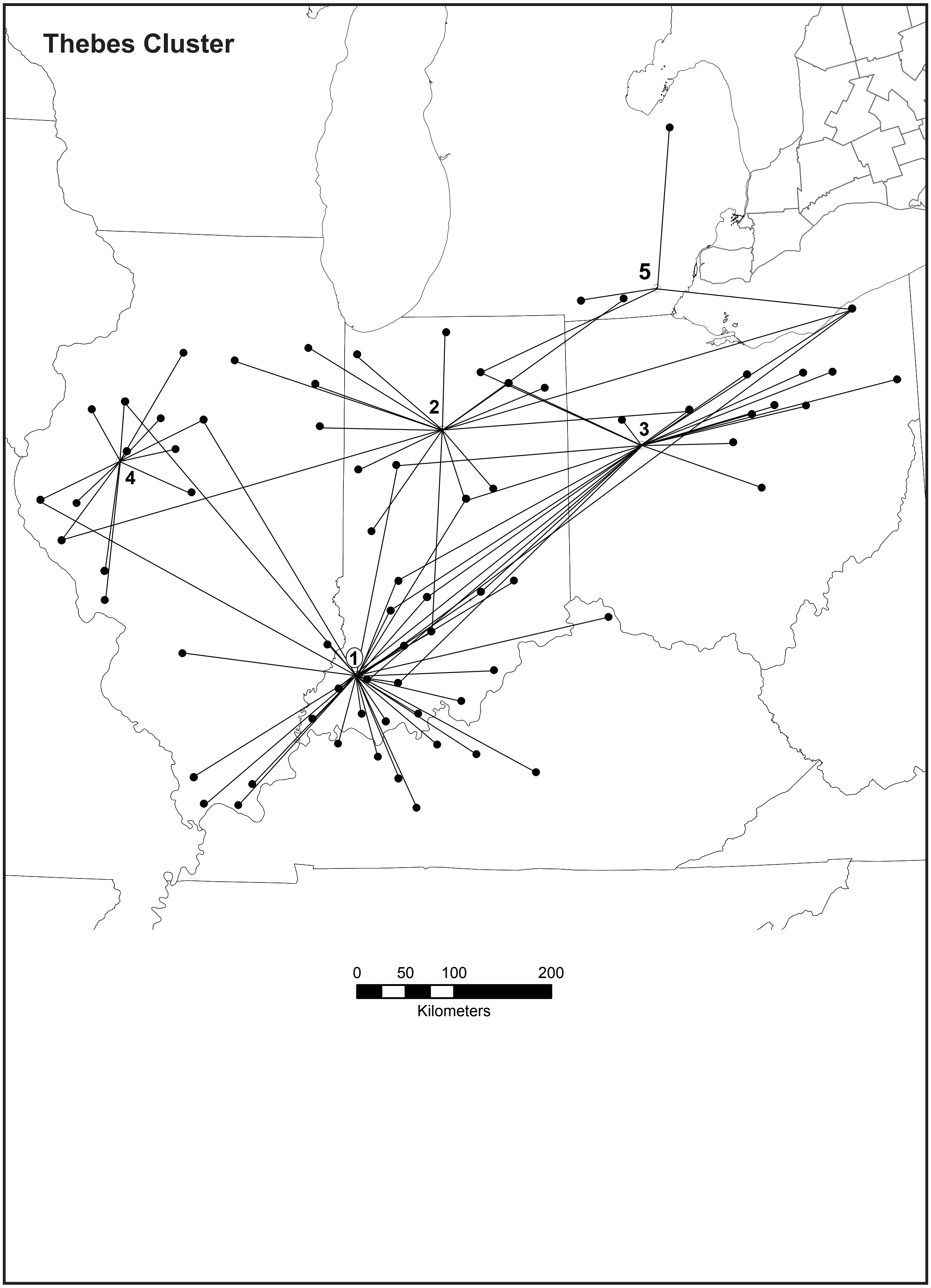


Figure 7.30. Graphic depiction of straight-line distances between locations of points and location of geographic center of distribution of points of same raw material group, Thebes Cluster sample.

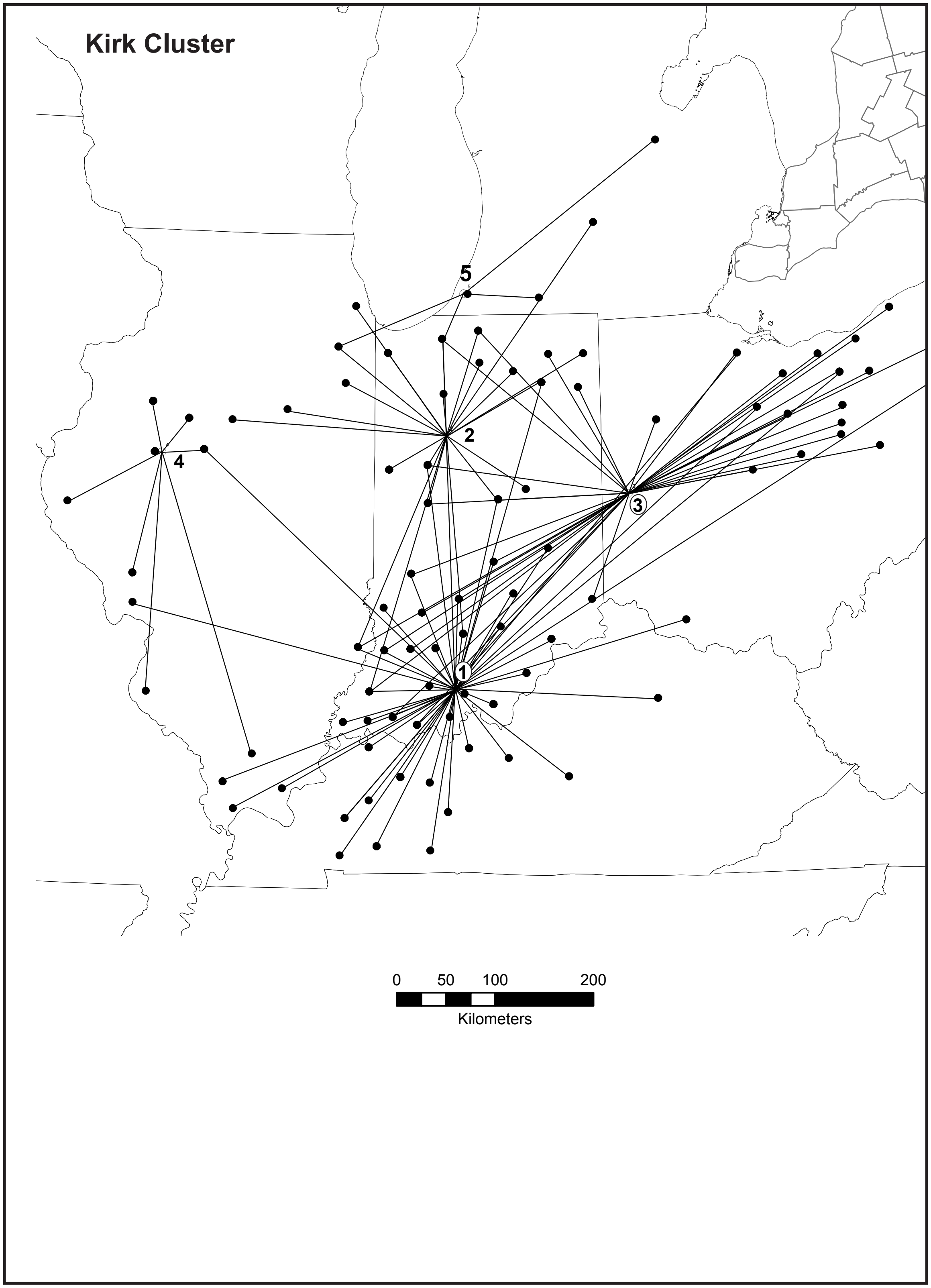


Figure 7.31. Graphic depiction of straight-line distances between locations of points and location of geographic center of distribution of points of same raw material group, Kirk Cluster sample.

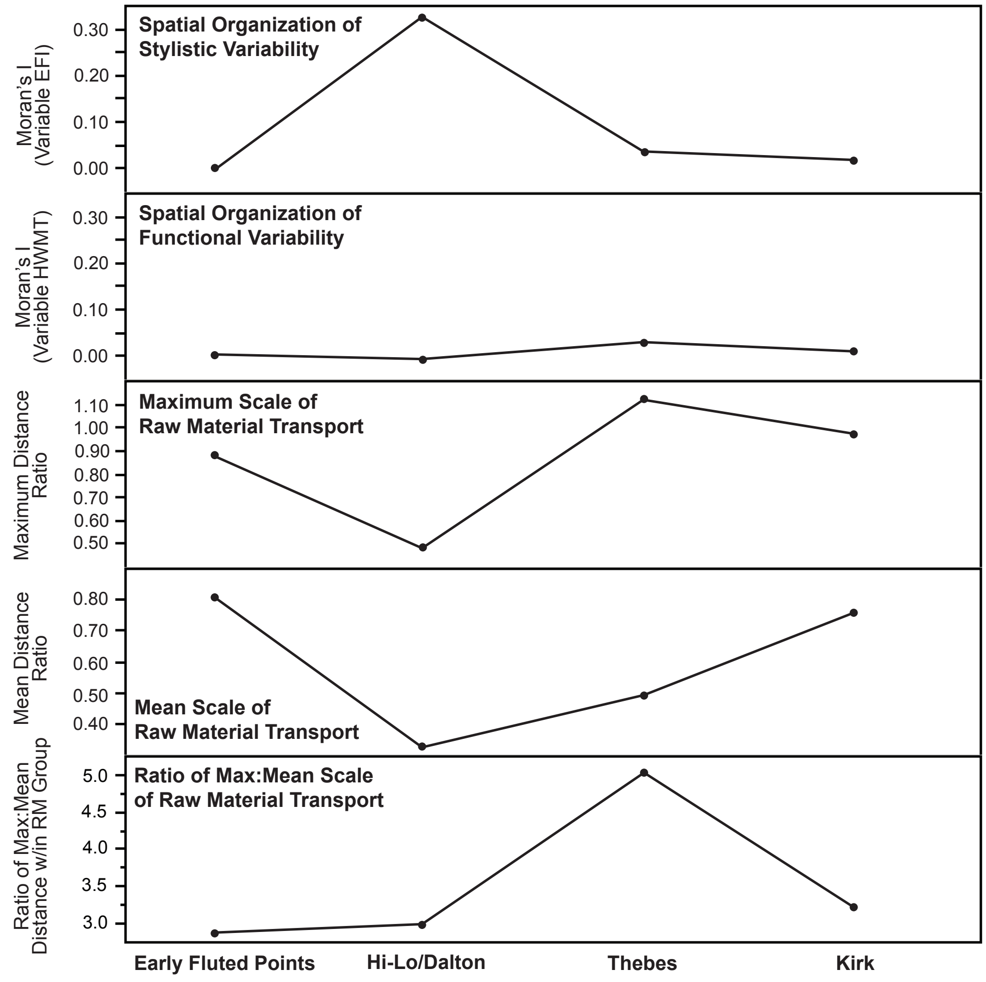


Figure 7.32. Summary of changes in patterns of morphometric variability and raw material transport (raw material measures calculated with Raw Material Group 3 included).

Table 7.16. Summary of Changes in Spatial Patterns of Morphometric Variability and Raw Material Transport.

Point Group	Style Moran's I	Function Moran's I	Max. Distance Ratio		Mean Distance Ratio		Ratio of Max:Mean within RM Group	
			With RMG 3	W/out RMG 3	With RMG 3	W/out RMG 3	With RMG 3	W/out RMG 3
EFP	0.000	0.001	0.878	0.995	0.807	0.932	2.86	2.86
Hi-Lo & Dalton	0.326	-0.010	0.480	0.473	0.322	0.321	2.98	3.02
Thebes	0.036	0.027	1.122	1.012	0.490	0.494	5.02	5.71
Kirk	0.017	0.007	0.975	0.908	0.756	0.721	3.21	3.67

regionalization of the Late Paleoindian period, which was later eclipsed by the relative stylistic homogeneity of the successive phases of the Early Archaic. The stylistic regionalization of the Late Paleoindian period was accompanied by a reduction in the scale of raw material transport relative to the Early Paleoindian period. The Early Archaic samples suggest greater mean and maximum raw material transport distances than the Late Paleoindian sample.

Most of the changes in pattern revealed by the analyses above (i.e., the coincident sequences of homogeneity-regionalization-homogeneity and high-low-high scales of raw material transport), were expected based on previous studies. What these analyses do that previous studies have not done, however, is quantitatively describe this sequence of changes at a level and scale that allow the archaeological data to be systematically compared to model data (see Chapter 8). These analyses add detail to our understanding of these general sequences of change that may be relevant to understanding of the archaeological record of early foragers in the midcontinent.

The Early Paleoindian sample is characterized by relatively high raw material transport distances and no indications that stylistic or functional variability are non-randomly distributed across space. This is concordant with two general ideas about the Early Paleoindian archaeological record in the east: (1) early fluted points are a “horizon” phenomenon that is marked by relatively little consistent regional variability; and (2) fluted points were moved large distances across the landscape by Early Paleoindian peoples and systems. As shown in Figure 7.28, there is significant spatial overlap in the areas across which raw materials were transported. Fluted points were routinely discarded or lost hundreds of kilometers from their raw material sources, and there is no apparent regionalization to raw material transport. (Note that the sample considered here does not include a significant number of fluted points of Attica chert that have been reported from western Illinois and American Bottom area because suitable data could not be obtained on these points [see Koldehoff and Loebel 2009; Koldehoff and Walthall 2004]).

The Late Paleoindian sample clearly shows the regionalization of style and reduced scale of raw material transport that has been noted in previous studies. The results of the spatial analysis of stylistic variability compare well to the largely non-overlapping spatial distributions of the Hi-Lo and Dalton clusters reported by Justice (1987:35-46). The reduced scale of raw material transport among Dalton groups relative to Clovis has been previously noted (Koldehoff and Loebel 2009;

Koldehoff and Walthall 2004, 2009), as has a reduced scale of raw material transport among Middle/Late Paleoindian groups in the Great Lakes (Ellis 2011).

The absence from the Late Paleoindian sample of significant numbers of points made from either Holland or Upper Mercer chert (i.e., Raw Material Group 3) is noteworthy, given the extensive use of these raw materials by both earlier (Clovis) and later (Thebes and Kirk) groups. The near total lack of use of these chert sources (only two Hi-Lo points were classified as RMG 3; see also Payne 1982; Stothers 1996:188) suggests that Hi-Lo and Dalton groups may not have made extensive, habitual use the geographic areas where these cherts outcrop. This suggestion articulates well with the spatial distributions of the Hi-Lo and Dalton samples shown in Figures 7.2 and 7.3: relatively few Dalton points were identified north of the Ohio River in southern Indiana and Ohio, and only a small number of Hi-Lo points were identified south of the northern regions of Indiana and Ohio.

The marked regionalization of style that characterizes the Late Paleoindian sample is evident in neither of the Early Archaic samples. While both the Thebes and Kirk samples suggest some statistically nonrandom spatial distribution of style, in neither case is the meaning of this spatial dimension of variability immediately obvious. Both the Thebes and the Kirk clusters subsume several named point “types” that do not have equivalent spatial distributions (see Justice 1987) and it is possible that the morphometric analysis is detecting some geographic aspects of this variability. The raster images of variable EFI (see Figures 7.19 and 7.20) suggest that some differentiation of the Ohio Valley portion of the study area may be significant.

The nonrandom spatial distribution of functional variability in both the Thebes and Kirk samples was not expected. In both cases, points with wider hafts tend to disproportionately clustered in western and northern Illinois (see Figures 7.23 and 7.24). It is possible that a tendency towards wider-hafted points in this area is a technological response to some kind of environmental difference, perhaps associated with exploitation of the tall grass prairie zone that extends across much of central and northern Illinois and into northwestern Indiana.

The Early Archaic samples suggest a significant increase in the scales of raw material transport relative to the Late Paleoindian period. Both the Thebes and Kirk samples contain points that have been transported more than 500 km from the mean of the raw material group (compared to a maximum of about 300 km in the Late Paleoindian sample). Mean raw material distances are also significantly greater. As shown in Figures 7.30 and 7.31, there is spatial overlap in the areas across which raw materials were transported.

There are some interesting differences between the Thebes and Kirk samples. The Thebes sample contains three points that were transported over 400 km from the mean coordinates of their raw material group: a point made from Attica chert found in Pike County, Illinois (Point ID 4199), a point made from Attica chert found in Lake County, Ohio (Point ID 5558), and a point made from Wyandotte chert found in Lake County, Ohio (Point ID 5559). This last point represents the greatest distance of raw material transport in this study. The mean raw material distance in the Thebes sample (126.7 km) is relatively low compared to the Early Paleoindian and Kirk samples. The combination of high maximum raw material distance and relatively low mean raw material distance results in a high ratio of maximum to mean: the maximum raw material distance of the Thebes sample is over five times the mean raw material distance.

The Kirk sample contains two points that appear to have been transported over 400 km from the mean coordinates of the raw material group. Both are made from Wyandotte chert, one found in Mahoning County, Ohio (Point ID 5529) and one found in Medina County, OH (Point ID 5307). The ratio of maximum to mean raw material distances in the Kirk sample is similar to that in other samples (i.e., around 3). Overall, the raw material transport "signature" of the Kirk sample, at least in terms of the metrics utilized here, is not unlike that of the Early Paleoindian sample. One potentially significant difference between the two samples is the shape of the tail of the distribution of raw material distance (see Figure 7.27). The tail of the Kirk distribution declines precipitously at distances over 350 km, while the tail of the Early Paleoindian distribution declines more regularly.

In summary, the spatial patterns of style and raw material transport in the Early Paleoindian, Late Paleoindian, and Early Archaic periods revealed by the current analyses are largely concordant with the results of previous studies. Stylistic regionalization during the Late Paleoindian period coincides with a significant drop in the scale of raw material transport. The regionalization of style evident during the Late Paleoindian period largely disappears during the Early Archaic period. This change is accompanied by increases in the scales of raw material transport comparable to those of the Early Paleoindian period. While some of the metrics are similar, however, some of the characteristics of raw material transport distances suggest that the behaviors producing these patterns of transport during the Early Paleoindian and Early Archaic period may have been different. Specifically, the high maximum distances and relatively low mean distances associated with the Thebes sample suggest that some different mechanism of transport (i.e., perhaps exchange rather than group or personal mobility?) may have been responsible for moving a few projectile points very long distances across the landscape.

The results of the analyses presented here serve to quantitatively characterize the archaeological data in ways that can be directly compared to model data (see Chapter 8). The measures used to quantify raw material transport and the spatial organization of stylistic and functional variability in the archaeological dataset can be replicated on datasets produced by the model.

Chapter 8

COMPARISON OF ARCHAEOLOGICAL AND MODEL DATA

The analysis of the archaeological data discussed in Chapter 7 provides a quantitative and qualitative description of changes in patterns of raw material transport and the spatial organization of stylistic variability in successive portions of the Early Paleoindian, Late Paleoindian, and Early Archaic periods (Figure 8.1). The Early Paleoindian period was characterized by relatively large scales of raw material transport and relatively small degree of spatial organization of stylistic variability. Stylistic regionalization during the Late Paleoindian period coincided with a significant drop in the scale of raw material transport. The stylistic regions that are evident in the Late Paleoindian data (i.e., Hi-Lo and Dalton) largely disappeared during the Early Archaic period. This change was accompanied by increases in the distances that raw materials were transported, roughly comparable to the scale seen in the Early Paleoindian period.

In most respects, the results of the analysis of the archaeological data presented in Chapter 7 are concordant with previous studies: recognition of a general sequence of changes in patterns of the spatial organization of stylistic variability (homogenous → regionalized → homogenous) and the relative scale of raw material transport (large → small → large) characterizing the archaeological record of late Pleistocene/early Holocene foragers in the midcontinent is not new (e.g., see Ellis 2011; Koldehoff and Walthall 2004; Koldehoff and Loebel 2009; Stothers 1996; Tankersley 1994; Tuck 1974). The focus of this dissertation is to develop a basis for understanding these archaeological patterns in terms of the network-mediated human behaviors that created them, specifically by using complex systems theory and computational modeling to evaluate alternative hypotheses for why the archaeological record appears as it does. Two phenomena are of primary concern: (1) the emergence of stylistic regions from a homogeneous state; and (2) the emergence of stylistic homogeneity from a regionalized state.

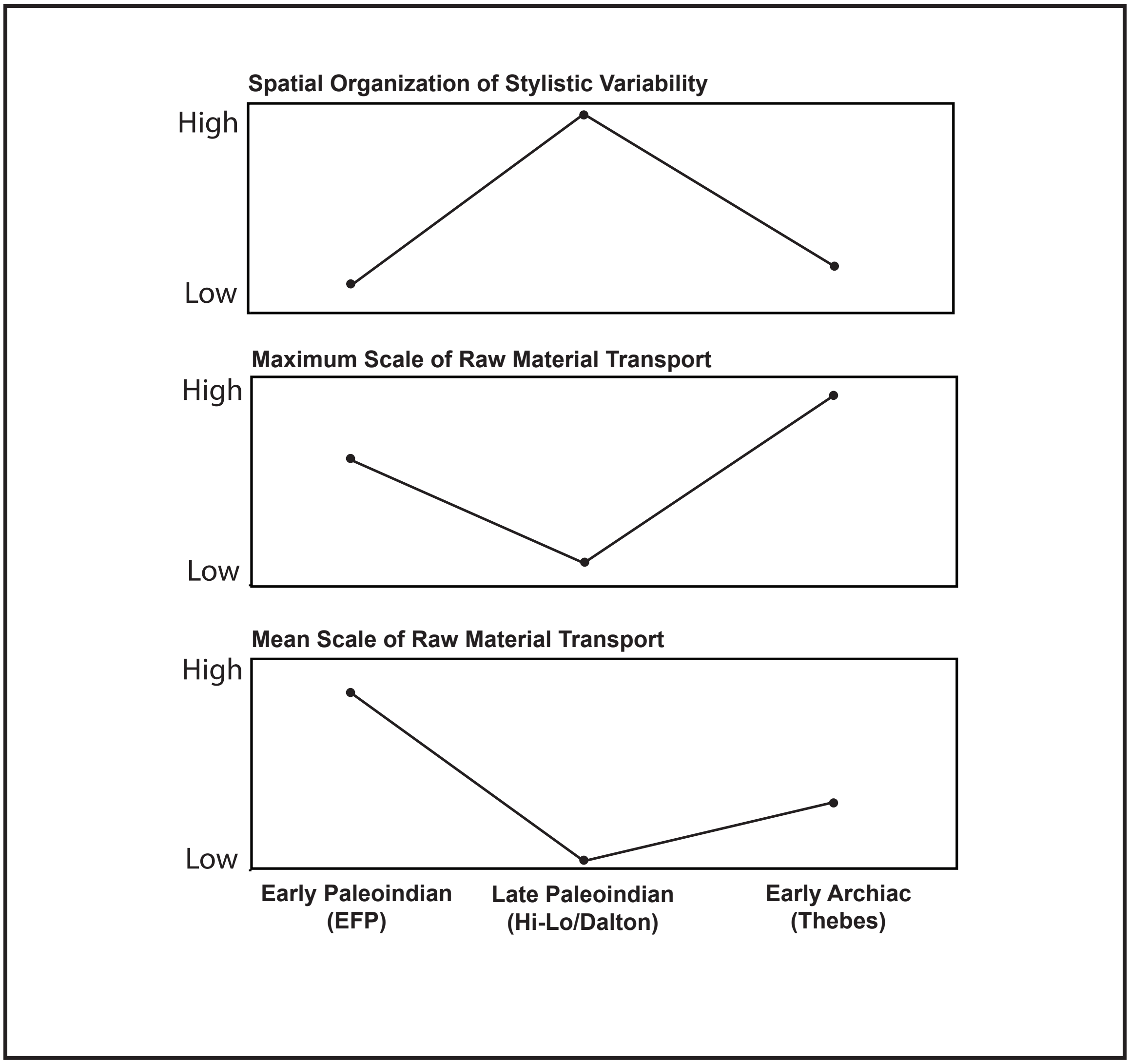


Figure 8.1. Summary of changes in patterns of morphometric variability and raw material transport in the archaeological dataset.

Existing explanations for these phenomena were discussed in Chapter 6. The purpose of this chapter is to use comparisons between archaeological data and data generated by the ForagerNet2 model to systematically evaluate network-based explanations for the patterns observed in the archaeological data. Constraints of time and computational resources limited the number and variety of experiments that could be conducted. The comparisons conducted here were focused on evaluating the plausibility of a sub-set of specific conditions and sequences of change in producing the patterns observed in the archaeological record.

I begin by discussing the methods used for comparing archaeological and model data. I then discuss relationships between patterns of raw material transport in the model and in the archaeological data, choosing two of the group mobility settings discussed in Chapter 5 to represent “high” and “low” mobility states suggested by the archaeological data. This is followed by a discussion of the representation of various kinds of social interaction and barriers to interaction in the model and an exploration of how patterns of social interaction are related to the spatial organization of stylistic variability in artifacts. I use general information generated from analyses of model data to develop several alternative explanatory scenarios for the changes seen in the archaeological record. Finally, I describe results from individual experiments designed to test the plausibilty of these scenarios.

Methods of Analysis and Comparison

Data from the ForagerNet2 model are produced by systems whose key network characteristics are known. Archaeological remains were produced by human systems whose key network characteristics are unknown. This chapter has two main objectives: (1) to use analysis of model data to develop general information about how patterns of social interaction and non-interaction in model systems are related to patterns of variability in material culture produced by those systems; and (2) to use comparisons between archaeological data and model data to make reasonable inferences about the conditions and processes that contributed to the characteristics of the archaeological dataset.

The first objective is relatively uncomplicated compared to the second objective as it involves analysis of information about systems where the parameters, network characteristics, and patterns of artifact variability are all “known.” Systematic experimentation can be used to investigate how different patterns of social interaction (controlled by model parameters) are related to patterns of artifact variability. Experimentation can be used to generate many cases of a phenomenon to provide multiple examples that aid in recognizing and understanding patterned relationships between phenomena.

The second objective is more complicated because it requires comparison between datasets from two different sources (archaeological and model). Successful comparison of data from the two sources requires similarity in key aspects of the datasets. Given the nature of the archaeological sample, it is clearly a simpler task to produce model datasets of a particular size and geographic scope to "match" the archaeological data rather than the other way around. For this reason, the ForagerNet2 model was constructed specifically to be a flexible platform that could be used to produce various kinds of data at various spatial and temporal scales. Model datasets must be comparable to the archaeological data in terms of several key characteristics: (1) spatial extent; (2) sample size; (3) scale of transport of raw materials; and (4) spatial organization of stylistic variability.

The first two characteristics are relevant to producing samples of a size and geographic extent comparable to the archaeological dataset. Both of the scale settings used to generate model data (Scale 3 represents 1,440,000 km^2 and Scale 4 represents 2,890,000 km^2 – see Chapter 4) represent a "world" that is significantly larger than that encompassed by the geographic area from which archaeological data were collected (approximately 732,000 km^2). This is because the archaeological data do not represent the remains of a self-contained, "closed" system of hunter-gatherers. Rather, the archaeological dataset is a sample of tools from a spatially-defined area superimposed on a larger area occupied by one or more social systems.

In the model, tools are discarded after a certain number of uses or "lost" based on a probability parameter (see Chapter 4). When tools are lost/discarded in the model, the model checks to see if they fall within a spatially-circumscribed area that is comparable to the area from which the archaeological sample is derived. This "archaeological data area" falls between UTM northings of 4073000 (south edge) and 4819000 (north edge) and UTM eastings of 142000 (west edge) and 1072000 (east edge) (Figure 8.2). Tools that are lost/discarded within the archaeological area are recorded in a text file (ArchToolData.txt), subject to a probability that specifies the proportion of lost/discarded tools that are recorded (see Chapter 4). From this file, samples of varying size and raw material composition can be generated for analysis. From a sample of 10,000 artifacts in the main file of data from a model run, for example, a sub-sample could be selected to match the raw material characteristics of the Early Paleoindian archaeological sample.

The length of experiments used to record data varied. For experimental runs representing the full sequence of archaeological time, the three archaeological time periods of interest (Early Paleoindian, Late Paleoindian, Early Archaic) are represented by three periods of model time designated,

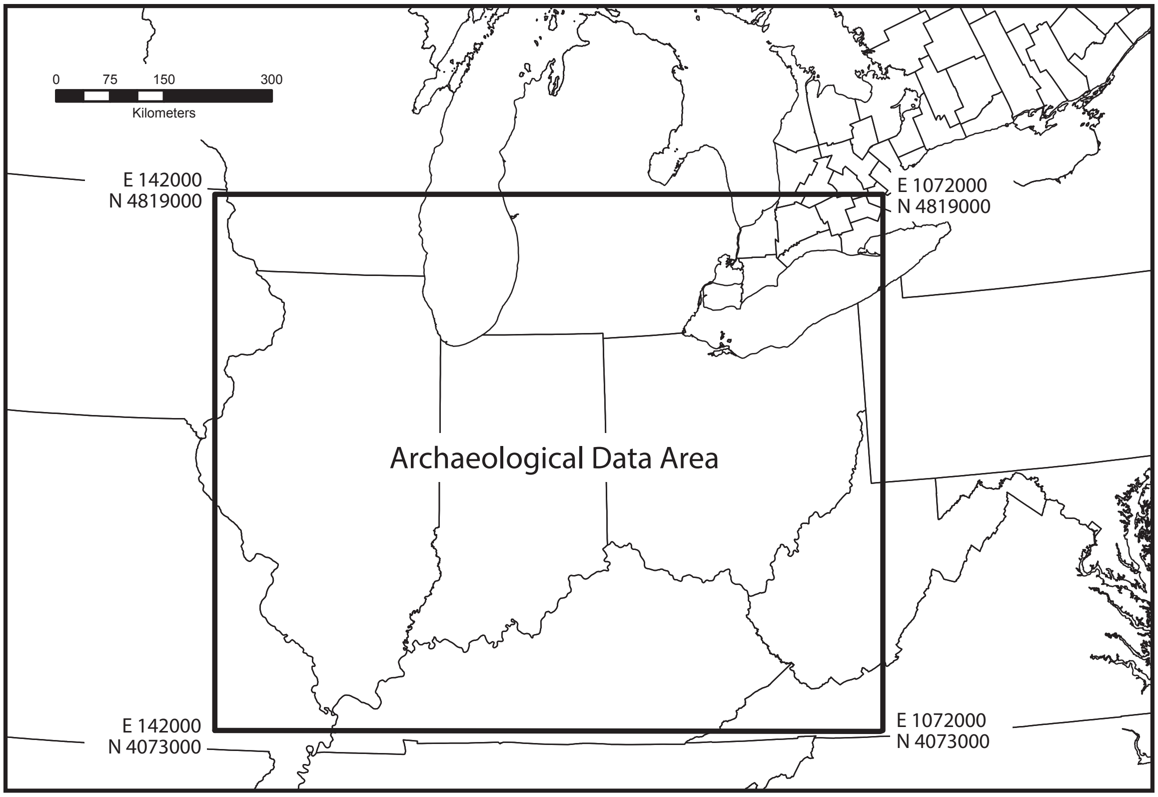


Figure 8.2. Extent of area in model used to match geographic limits of archaeological dataset.

respectively, T1, T2, and T3 (Figure 8.3). Each of these time periods comprises 15,600 steps of model time representing 300 years. Each time period is divided into two parts. Data are collected during the final 10,400 steps of each period, while the first 5200 steps allow the system to adjust to the start-up conditions (in the case of T1) or to changes in the values of parameters (in the case of T2 and T3). Summary data are reported at the end of each data recording period. The summary data file (SummaryData.txt) produced at the end of a run includes all the aggregate data recorded during T1, T2, and T3 as well as the values of key parameters during the data recording periods. Some experimental runs included only T1 (but not T2 and T3) or T1 and T2 (but not T3).

The use of three time periods each 300 "years" in length is not meant to imply that each of the archaeological periods of interest is 300 calendar years long. Time periods of this length are meant to provide enough time for social networks, patterns of raw material transport, and patterns of artifact variability to stabilize under a given set of conditions (i.e., in the first 100 years) and for the aggregate characteristics of system-level behaviors to be captured (i.e., in

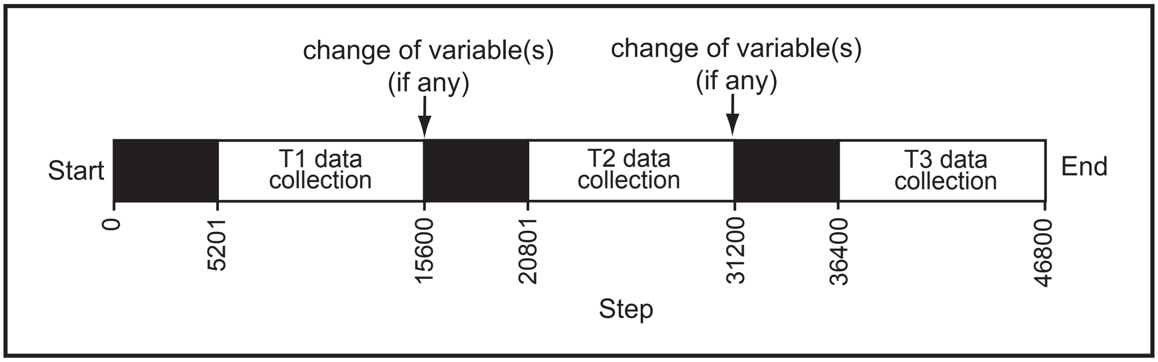


Figure 8.3. Structure of a basic model experiment using three time periods.

the last 200 years). Time periods of a constant length were chosen for these experiments in order to eliminate differences in length of time as a possible source of variability in the model data. It is possible, of course, that differences in the spans of time represented by the archaeological samples contribute to the patterns of variability in those samples. Given the generally low resolution of our chronological information about the Paleoindian and Early Archaic periods (see Chapter 6), however, it is not possible at present to confidently construct model time periods that precisely and accurately match spans of time represented by the archaeological samples. The comparison of model and archaeological data therefore depends on the idea that the conditions producing the patterns discernible in the archaeological data will produce similar patterns in the model data given a reasonable amount of time that does not exactly match that of the archaeological data.

The model includes provisions for constraining metric attributes of artifacts to a range between specified minimum and maximum values (see Chapter 4). For all but three of the metric variables, values are simply constrained within the range of the entire archaeological dataset (i.e., the combined sample of Early Fluted, Hi-Lo, Dalton, Thebes, and Kirk points) (Table 8.1). The values of three variables related to haft size and morphology (variable E, thickness, and haft width) are constrained to ranges that are specific to each time period (shown in bold italics in Table 8.1). Variable E measures the amount of haft constriction. Haft width is the width at the narrowest part of the haft, defined by variable A in lanceolate points without constricted haft margins and variable B in points with constricted haft margins (i.e., where variable E does not equal 0). Thickness is simply the thickness in the haft region. The values for T1 are from the Early Fluted Point sample. The values for T2 are from the combined Hi-Lo/Dalton

Table 8.1. Constraints on Minimum and Maximum Values of Metric Variables by Time Period (all values in millimeters).

Variable	**Time Period 1 (T1)**		**Time Period 2 (T2)**		**Time Period 3 (T3)**	
	Minimum	**Maximum**	**Minimum**	**Maximum**	**Minimum**	**Maximum**
A	3.2	36.1	3.2	36.1	3.2	36.1
B	9.7	33.0	9.7	33.0	9.7	33.0
C	12.4	53.2	12.4	53.2	12.4	53.2
E	***0.0***	***4.0***	***0.0***	***7.4***	***2.6***	***28.6***
F	-	12.5	-	12.5	-	12.5
G	- 4.0	12.4	- 4.0	12.4	- 4.0	12.4
H	-10.3	12.8	-10.3	12.8	-10.3	12.8
I	1.0	19.8	1.0	19.8	1.0	19.8
Thickness	***4.0***	***11.0***	***3.9***	***11.2***	***5.7***	***13.9***
Haft Width	***9.8***	***33.0***	***10.9***	***33.9***	***10.1***	***32.5***

sample. The values for T3 are from the Thebes cluster sample.

Placing period-specific constraints on these three variables allows the model to compel a change from lanceolate to notched point forms by specifying the range of haft constriction that is permitted. Selective pressures related to function are imposed in the model to mimic the functional constraints that presumably influenced haft size in the archaeological samples. As discussed in Chapter 4, the model compares the ratio of thickness : haft width in an artifact to a normal distribution based on the mean and standard deviation of the ratio of thickness to haft width from archaeological data. The means and standard deviations used to create the normal distribution for each model time period are given in Table 8.2. The model calculates the difference between the mean of the normal distribution and the ratio of thickness : haft width of the point in question. This difference is compared to the difference between the mean of the normal distribution and a random number drawn from the distribution. If the difference between the mean of the normal distribution and the ratio of thickeness :

Table 8.2. Mean and Standard Deviation of the Ratio of Thickness to Haft Width of Normal Distributions Used to Apply Functional Selection in Model Time Periods.

Ratio of Thickness to Haft Width	**Time Period 1 (T1)**	**Time Period 2 (T2)**	**Time Period 3 (T3)**
Mean	0.347	0.359	0.503
Standard Deviation	0.067	0.076	0.094

haft width of the point is greater than the difference between the mean of the normal distribution and the random number drawn from the distribution, the point is rejected (i.e., it is not manufactured and does not enter into the “world” of the model). This way of applying selection to the thickness : haft width ratio produces a distribution of this ratio in model artifact assemblages with an approximately normal distribution.

Points which fall within the period-specific minimum and maximum constraints on haft size and constriction and satisfy the probability-based functional “test” are free to vary in all other respects as long as the values of non-functional metric variables are within the ranges of the entire archaeological sample. In the model, then, “functional” variability is constrained by period-specific criteria while “stylistic” variability is constrained only by the outer limits of what the combined archaeological dataset indicates was possible. Thus tool assemblages produced by the model during specific periods will, by design, be similar to archaeological assemblages in some key aspects of haft variability related to function but have the potential to be dissimilar in terms of stylistic variability. It is the amount and spatial organization of stylistic variability, rather than specific aspects of size or shape, that will be the subject of comparisons between archaeological and model datasets.

Patterns of Mobility and Raw Material Transport

In the model, group- and person-level mobility behaviors are the only mechanisms that result in the transport of artifacts across the landscape. Artifacts are manufactured as needed to replenish tool inventories. When artifact manufacture occurs at or near one of the “named” lithic source areas represented in the model, artifacts are made from that specific raw material. Groups come into spatial proximity with “named” raw material sources fortuitously through the normal course of their movements: lithic procurement in the model is explicitly represented as “embedded” within the normal course of subsistence-related movements. Following manufacture, artifacts are deposited on the landscape through discard or loss. When an artifact made from a “named” raw material is deposited on the landscape, the model calculates and records the straight line distance from the artifact’s parcel of deposition to the parcel where the raw material source was located.

In real hunter-gatherer systems, mechanisms other than residential movements may contribute to transport of artifacts across the landscape. Exchange of finished artifacts or raw materials, or dis-embedded procurement of lithic materials could serve as mechanisms of artifact transport. These mechanisms of transport are not currently represented in the model and, consequently, no attempt was made to investigate their effects on patterns of raw material transport.

The purpose of this section is to explore the relationships between mobility behaviors and raw material transport distances in the model and determine which mobility settings produce patterns that are reasonable approximations for those discerned in the archaeological data. Analysis is focused on the mobility settings that were associated with viable social networks as discussed in Chapter 5: mobility settings B, D, E, F, and G. Characteristics of these mobility settings are summarized in Table 8.3. These settings are points along a range of group residential mobility behaviors.

Mobility and Source-to-Discard Distances in Model Experiments

The distance from an artifact's loss/discard location to the source where the artifact was manufactured is referred to as the source-to-discard distance. This distance was recorded for artifacts that were manufactured from "named" raw materials. Figure 8.4 plots the mean vs. the maximum and standard deviation of source-to-discard distance for a series of runs varying the mobility setting (the values associated with the data points in these plots are provided in

Table 8.3. Parameters and Resulting Characteristics of Mobility Settings.

Mobility setting	***pGroupMove, groupMoveRadiusCells***	**Mean annual group distance moved (km)**	**Mean annual group range (km)**	**Maximum possible 1 year group range (km)**
B	0.50, 2	434	183	440
D	0.50, 1	260	110	220
E	0.25, 1	130	55	220
F	0.25, 2	217	92	440
G	0.10, 6	219	96	1320

Mean annual group distance moved = (mean group move distance) * (mean *n* annual group moves)
Mean annual group range = (*pGroupMove*) * (mean group move distance)* 22
Approximate band range = (mean annual group range)^2 * pi

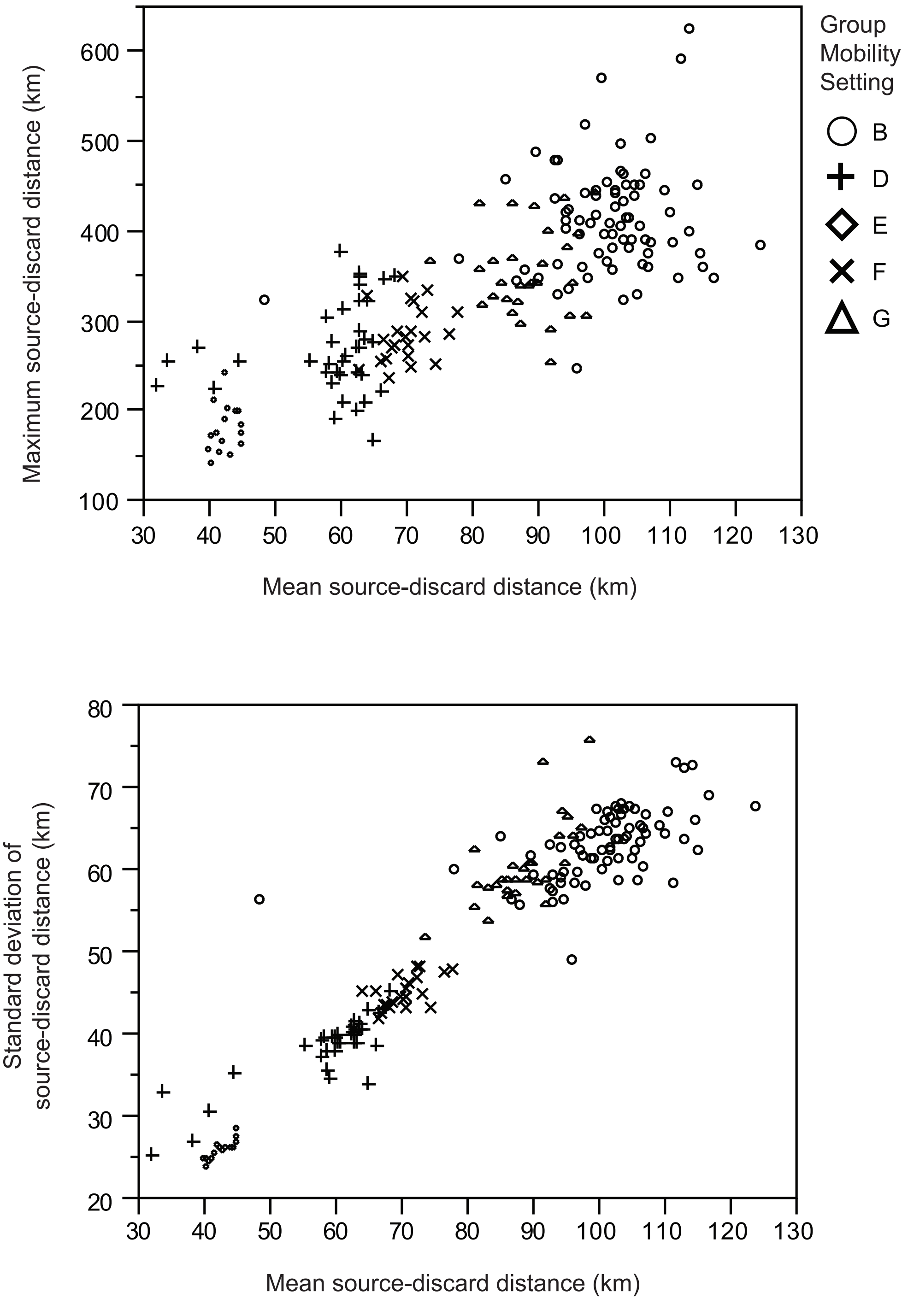


Figure 8.4. Plots of mean source-discard distance vs. maximum source-to-discard distance and the standard deviation of source-discard distance for experiments using different mobility settings.

Appendix G). There are clear positive relationships between these variables: larger mean source-to-discard distances tend to be associated with larger maximum source-to-discard distances and more variability in source-to-discard distance.

While overlap in the source-to-discard distances produced by different mobility settings is apparent both in Figure 8.4 and in histograms of mean and maximum source-to-discard distance by mobility setting (Figure 8.5), it is clear that different mobility settings tend to be associated with different scales of raw material transport. Generally, there is a positive relationship between the distance that groups move annually and the mean and maximum distances that artifacts are transported from their locations of manufacture (Figure 8.6). The source-to-discard distances generated in mobility setting D deviate from this general trend, appearing lower than one would expect based on results from mobility settings B, F, and G.

Despite the ranges of values that are produced by each mobility setting, there are statistically significant relationships between group mobility metrics (mean annual group range and mean annual distance moved) and the mean and maximum source-to-discard distances (Figure 8.7). Values of R^2 are higher when the mean (rather than the maximum) source-to-discard distance is considered. This suggests that the mean source-to-discard distance is a slightly better indicator of the scale of group mobility than the maximum source-to-discard distance, presumably because the mean is a general measure based on all the values in the distribution rather than a single value.

Figure 8.8 shows example histograms of source-to-discard distance within single experimental runs at mobility settings B, D, E, and G. The distributions are right-tailed, reflecting the tendency of the majority of artifacts to be lost or discarded in close proximity to their locations of manufacture relative to the few artifacts that are moved significantly longer distances. This is consistent with archaeologically discernible falloff curves that measure the frequency of artifacts as a function of distance from a source (e.g., see Cantin 2000; Tankersley 1989).

Differences in the scale of mobility are visually apparent when the data from these same example runs are shown as spatial plots (Figures 8.9 through 8.12). Comparison of the examples of mobility settings B and D clearly show the smaller scale of raw material transport in mobility setting D relative to mobility setting B. Note that the model has no provisions for orienting group movements with respect to sources of raw material: the spatial patterning in these examples

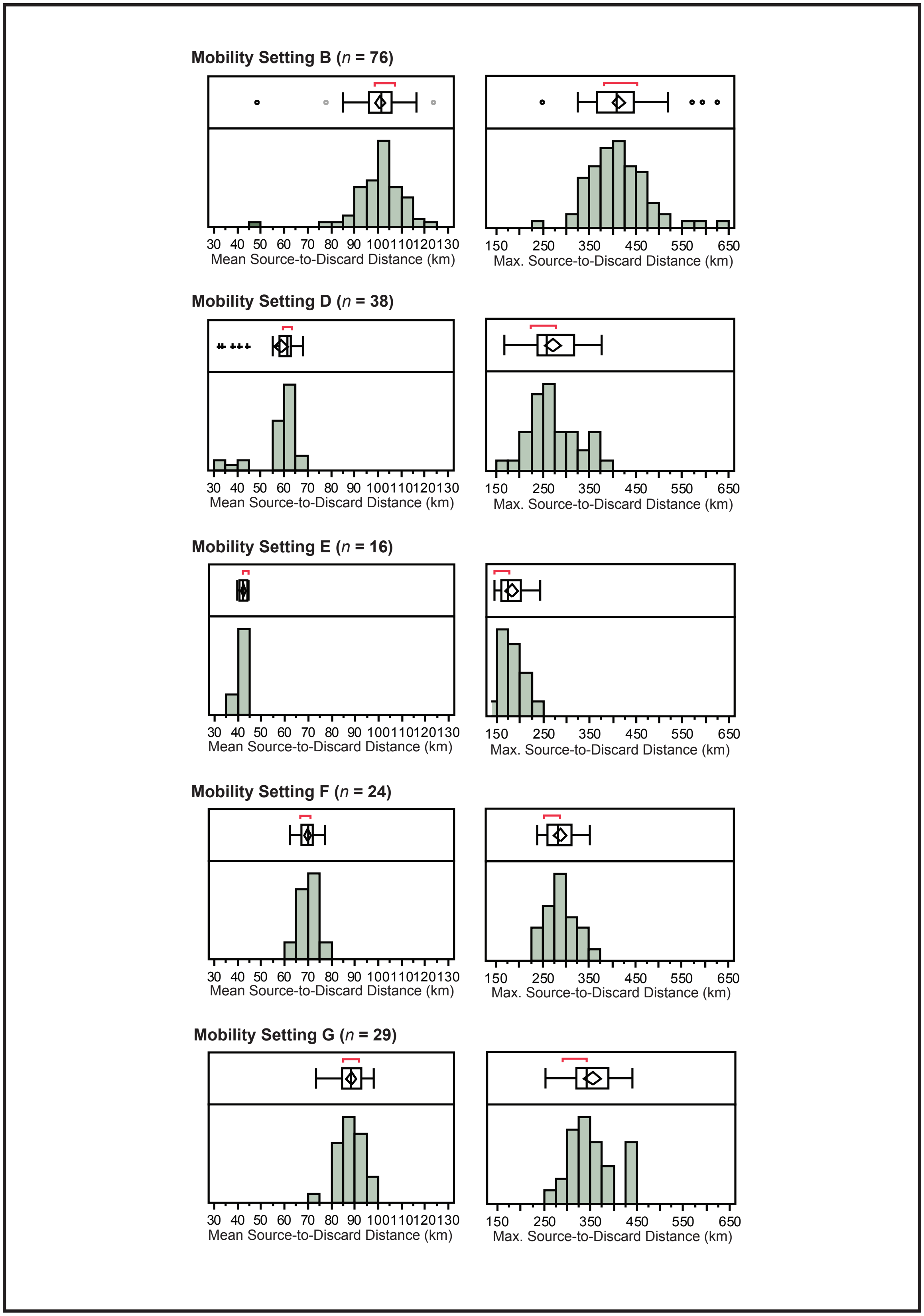


Figure 8.5. Histograms of mean and maximum source-to-discard distance for experiments using different mobility settings.

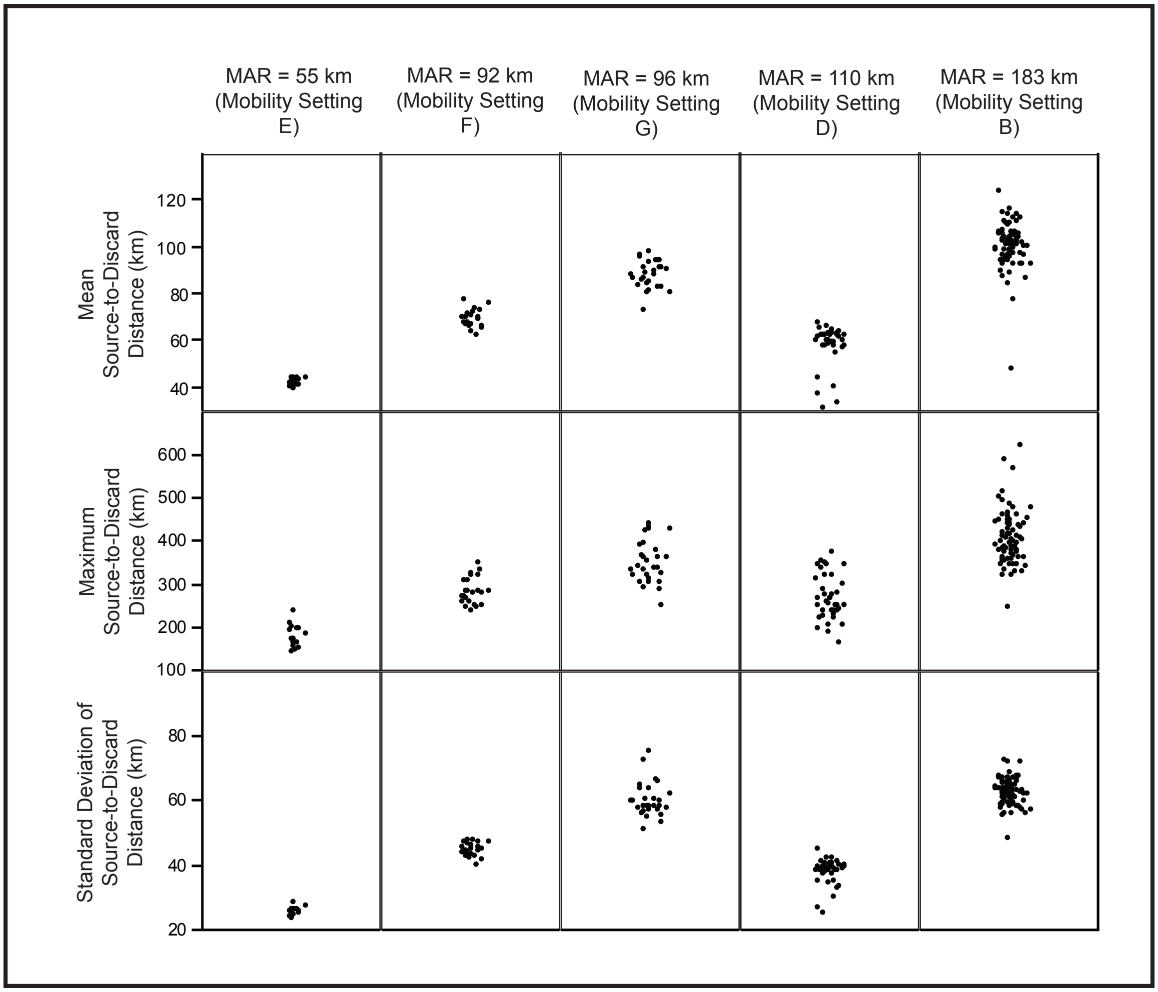


Figure 8.6. Relationship between mean annual range (MAR) and mean, maximum, and standard deviation of source-to-discard distance in model runs using different mobility settings.

is the result of groups coming into close proximity to raw material sources during their normal movements. Note also that only artifacts falling within a specified data collection area corresponding to the archaeological dataset are shown: this is why the distribution of artifacts made from Bayport does not include the Bayport source area.

In many of the experimental runs, maximum source-to-discard distances are greater than the mean annual group range. There are a number of possible explanations for this. The simplest is that, because group residential mobility is based on probability, a group may travel farther than the mean distance from its aggregation site in any given year. The maximum possible annual group range (i.e., the maximum distance from an aggregation site that a group could

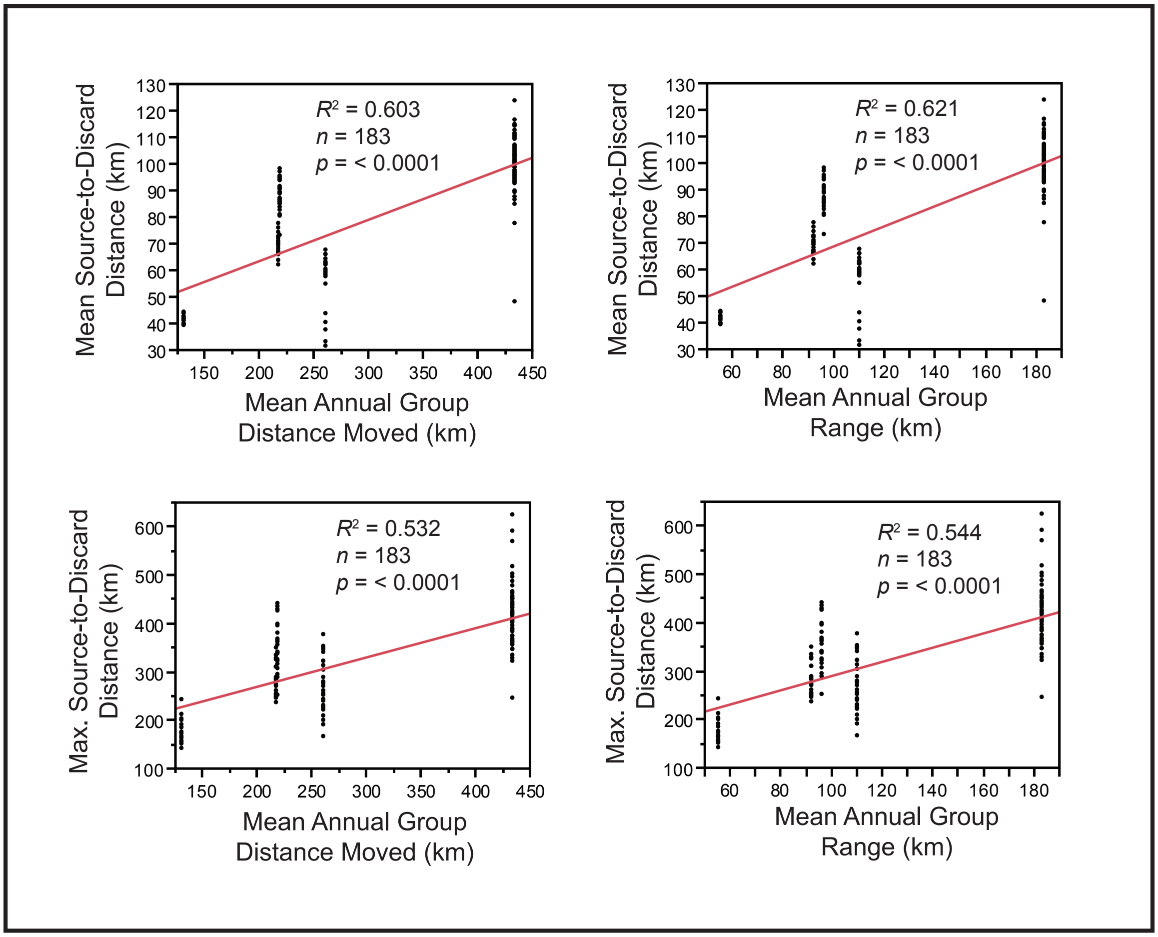
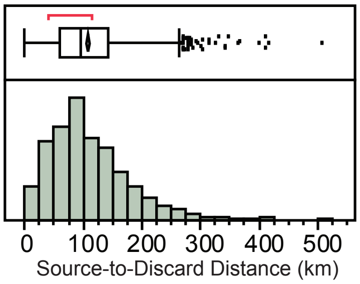


Figure 8.7. Relationships between group mobility parameters and mean and maximum source-to-discard distance in model experiment runs.

move before returning if the group moved the maximum number of cells possible at each step) is reported for each mobility setting in Table 8.3. The maximum source-to-discard distances associated with some mobility settings regularly exceed these maximums, suggesting that simple one-way annual travel from aggregation sites does not alone explain maximum transport distance.

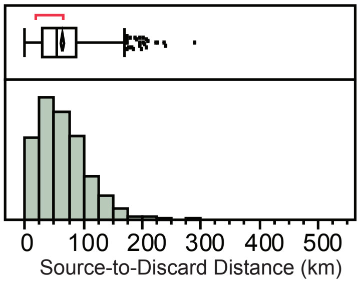
A second possible explanation is that the fusion of groups allows artifact source-to-discard distances to exceed the "typical" annual distance traversed by a single group travelling directly to/from an aggregation site. Group fusion most commonly occurs at yearly aggregations (i.e. within bands) or when groups from different bands come into contact during their travels away from the yearly aggregation sites. Fusion of groups with different spatial "ranges" could allow tools to be transported farther than permitted by yearly group mobility alone. There is currently no way to examine this explanation as data on the frequency

Mobility Setting B
013-22-03-50 run 19



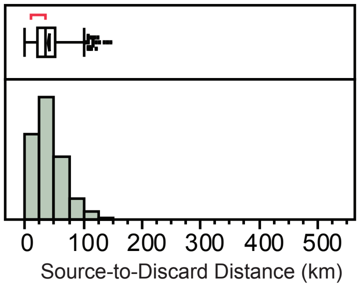
Mean = 107 km
Maximum = 505 km
Standard Deviation = 64.4 km
n = 1836

Mobility Setting D
014-07-15-24 run 4



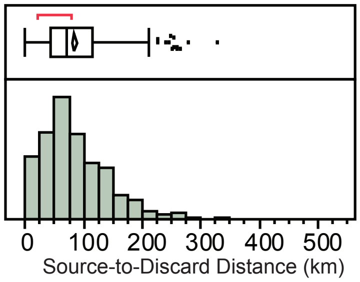
Mean = 63 km
Maximum = 289 km
Standard Deviation = 40.0 km
n = 2523

Mobility Setting E
010-10-58-10 run 2



Mean = 40 km
Maximum = 144 km
Standard Deviation = 23.9 km
n = 1180

Mobility Setting G
003-21-50-30 run 10



Mean = 83 km
Maximum = 326 km
Standard Deviation = 53.5 km
n = 677

Figure 8.8. Histograms of source-to-discard distance in example runs of mobility settings B, D, E, and G.

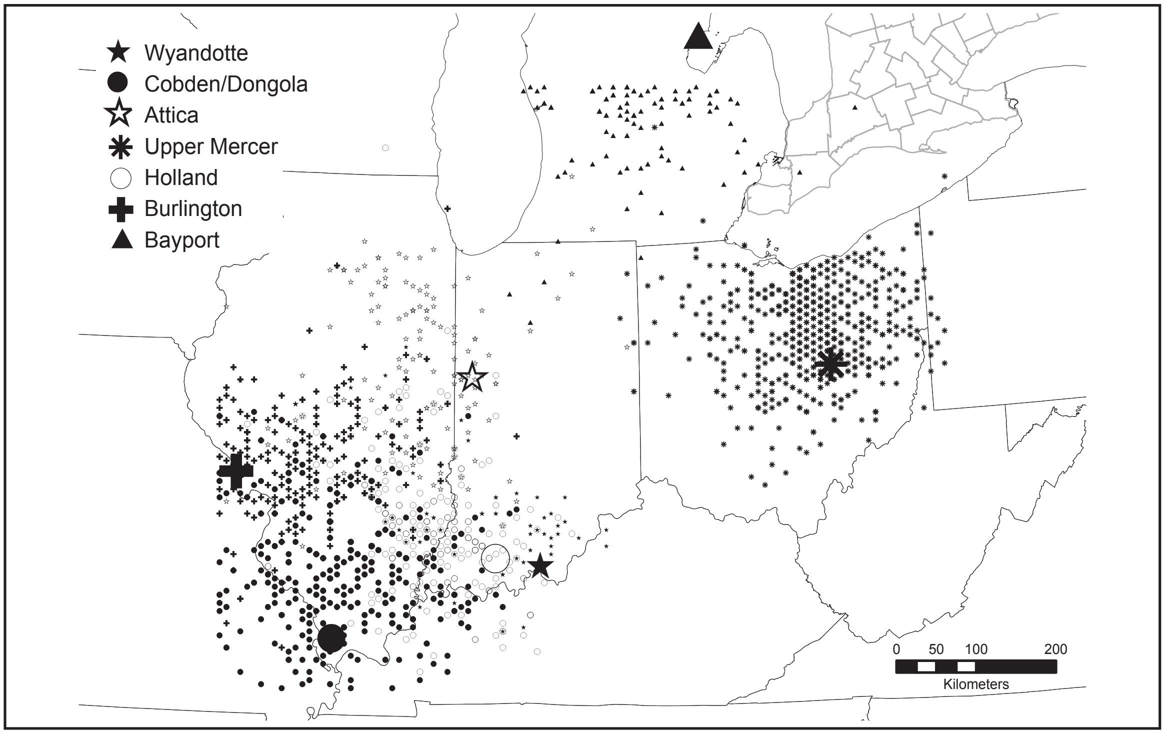


Figure 8.9. Plot of raw material distributions from example run of mobility setting B (Experiment 013-22-03-50 run 19, *n* = 1836 tools).

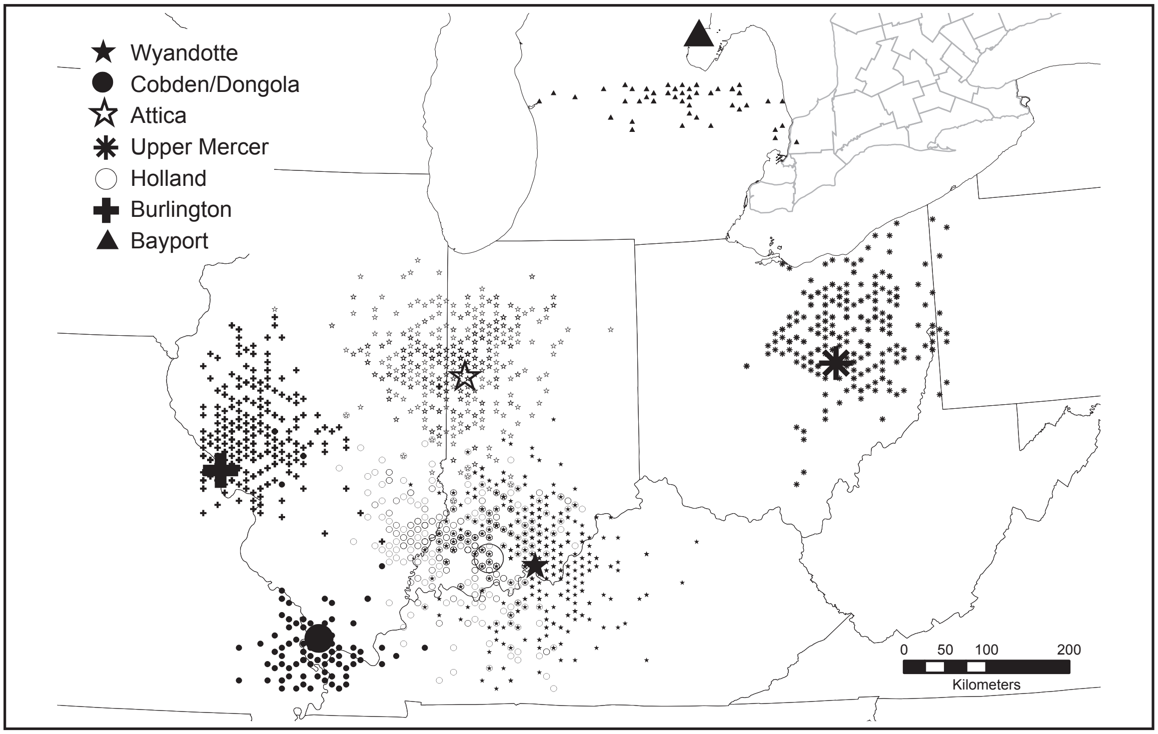


Figure 8.10. Plot of raw material distributions from example run of mobility setting D (Experiment 014-07-15-24 run 4, *n* = 2523 tools).

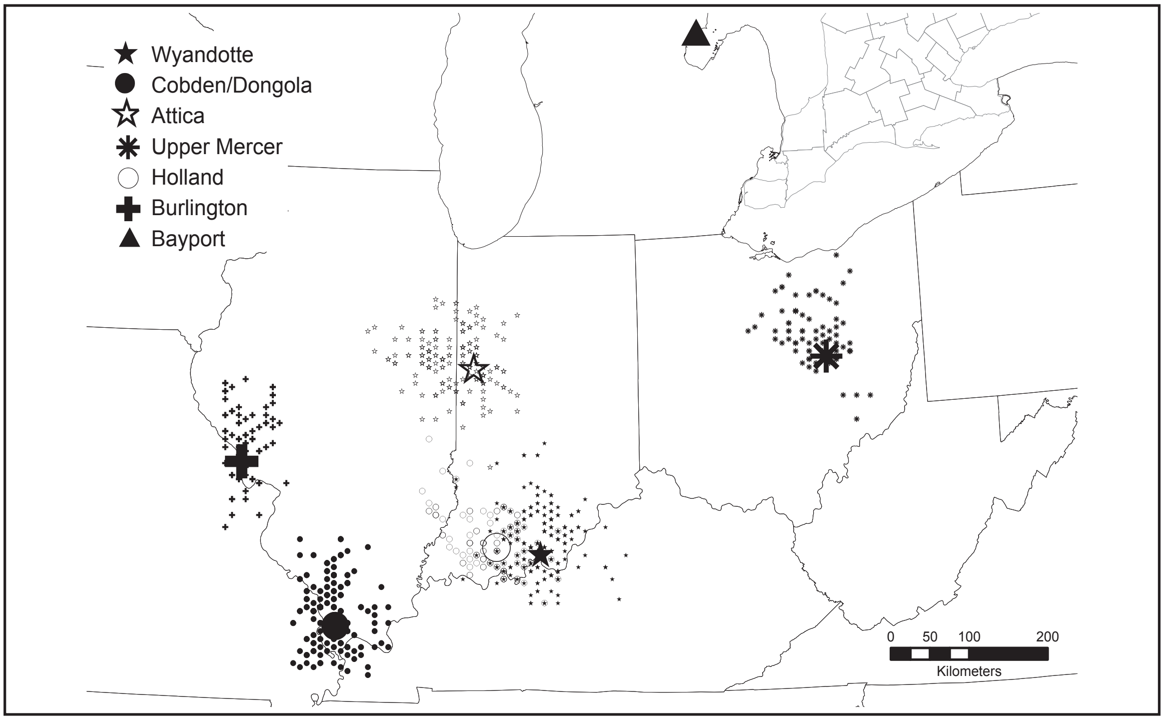


Figure 8.11. Plot of raw material distributions from example run of mobility setting E (Experiment 010-10-58-10 run 2, *n* = 1180 tools).

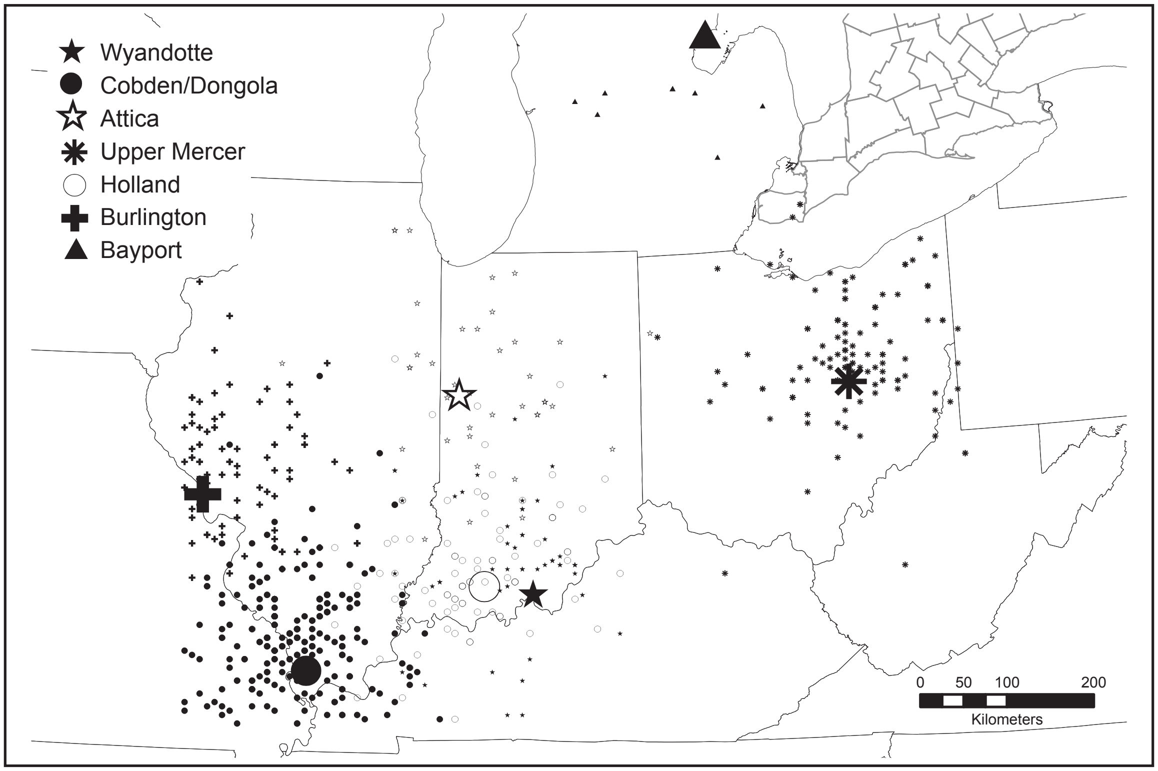


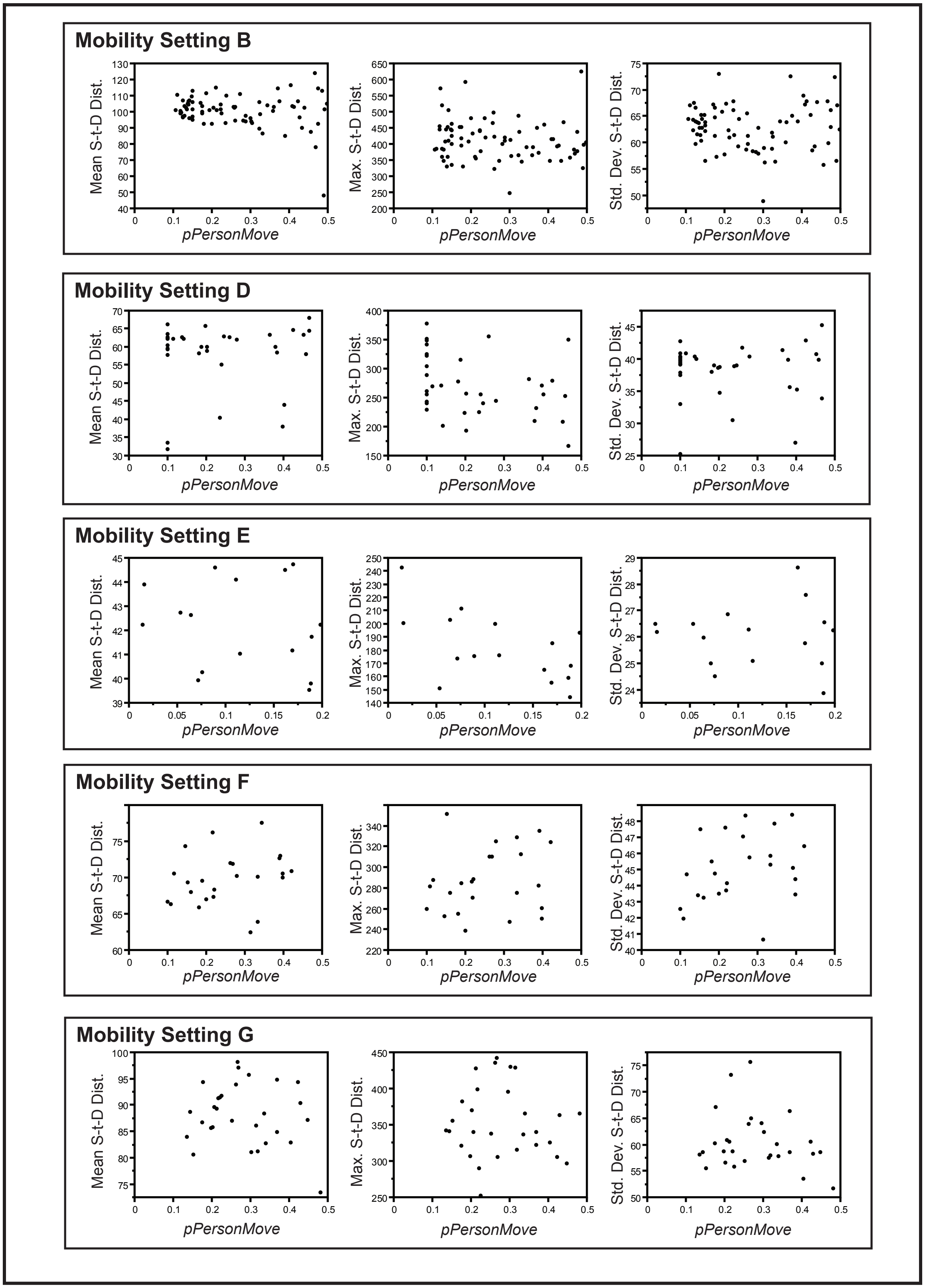
Figure 8.12. Plot of raw material distributions from example run of mobility setting G (Experiment 003-21-50-30 run 10, *n* = 677 tools).

or timing of group fission/fusion events were not collected for any of the experiments considered here.

A third possibility is that the between-group transfer of individuals allows artifact source-to-discard distances to exceed the distances of group travel. As with group fusion, the movement of persons between groups can occur when groups are in close spatial proximity to one another. The probability of persons moving between groups (controlled by the value of the parameter *pPersonMove*) varied in these experimental runs between 0.10 and 0.50. When the value of *pPersonMove* is plotted against the metrics of source-to-discard distance, there are no apparent relationships (Figure 8.13). This suggests that, if the probability of personal mobility does affect the distances that artifacts are transported, the relationship is not a simple one.

Another possible explanation for the large maximum source-to-discard distances associated with some runs is a low degree of spatial redundancy in the annual mobility patterns of individual groups. In the model, the direction of group movements is only controlled to the extent that groups are required to move away from their aggregation site during the first part of the year and towards their aggregation site during the second part of the year. Because groups cluster in the vicinity of the aggregation parcel during a yearly aggregation, the direction of travel away from the aggregation site tends to be the opposite of the direction of travel to the aggregation site (i.e., if a group heads south to get to the aggregation site, it will tend to “camp” on the north side of the aggregation site and later head north to depart). It is possible, however, that shifts in patterns of group travel could result in groups departing an aggregation site in some direction other than a direction opposite that which they arrived. In this case, transport of artifacts could exceed the maximum annual move distances. There is currently no way to examine this explanation as data on the direction/redundancy of yearly movements were not collected for any of the experiments considered here.

In summary, experimental data show that group mobility and artifact source-to-discard distance are clearly related in the model. One or more mechanisms other than group mobility serve to produce maximum source-to-discard distances that exceed those possible through simple, spatially redundant, annual group mobility. While it is not possible to precisely identify these mechanisms with the data at hand, changes in group membership through group fission/fusion (and possibly personal mobility) are likely candidates.


Mobility Setting B

Mobility Setting D

Mobility Setting E

Mobility Setting F

Mobility Setting G

Figure 8.13. Relationships between the value of *pPersonMove* and mean, maximum, and standard deviation of source-to-discard distance for model mobility settings (Y axis in km).

Determination of Mobility Parameters to Represent Archaeological Behaviors

Analysis of the archaeological dataset (Chapter 7) suggested a “high-low-high” pattern of change in the scale of raw material transport associated with the Early Paleoindian-Late Paleoindian-Early Archaic sequence. Metrics characterizing the scale of raw material transport during this sequence can be compared to the experimental data to determine which model mobility settings produce raw material transport patterns that are comparable to those suggested by the archaeological data.

Comparisons between archaeological and model data are complicated by several factors: (1) the inability to reliably discriminate between some “look-alike” cherts used to manufacture some of the artifacts in the archaeological dataset; (2) the relatively small and disparate sample sizes associated with portions of the archaeological dataset; and (3) potential elements of non-randomness in the archaeological samples. These complications will be discussed as comparisons are made.

The inability to reliably discriminate between some “look-alike” cherts in the archaeological dataset makes the calculation of simple source-to-discard distances impossible. Reliable discrimination is a problem in two cases: (1) Wyandotte and Cobden/Dongola cherts; and (2) Upper Mercer and Holland cherts. Analysis of the archaeological data in Chapter 7 included a procedure for amalgamating these look-alike raw materials into raw material groups, the spatial dispersion of which could be characterized based on the distances of individual artifacts from the mean coordinates of all artifacts in the group. Ratios were computed to express the mean and maximum distances within raw material groups as percentages of the distances possible given the spatial characteristics of the entire assemblage within a specific time period.

It became apparent early in the analysis of model data that the amalgamation of the Upper Mercer and Holland raw materials (i.e., Raw Material Group 3, or RMG 3) presented a difficulty. Because these discrete raw material sources are so distant from one another (they are geographically separated by approximately 470 km), distances from individual artifacts in RMG 3 to the mean coordinates of RMG 3 always included some very large distances regardless of parameters of group mobility. Thus RMG 3 was dropped from further raw material transport comparisons between archaeological and model data. The characteristics of the archaeological samples without RMG 3 are summarized in

Table 8.4.

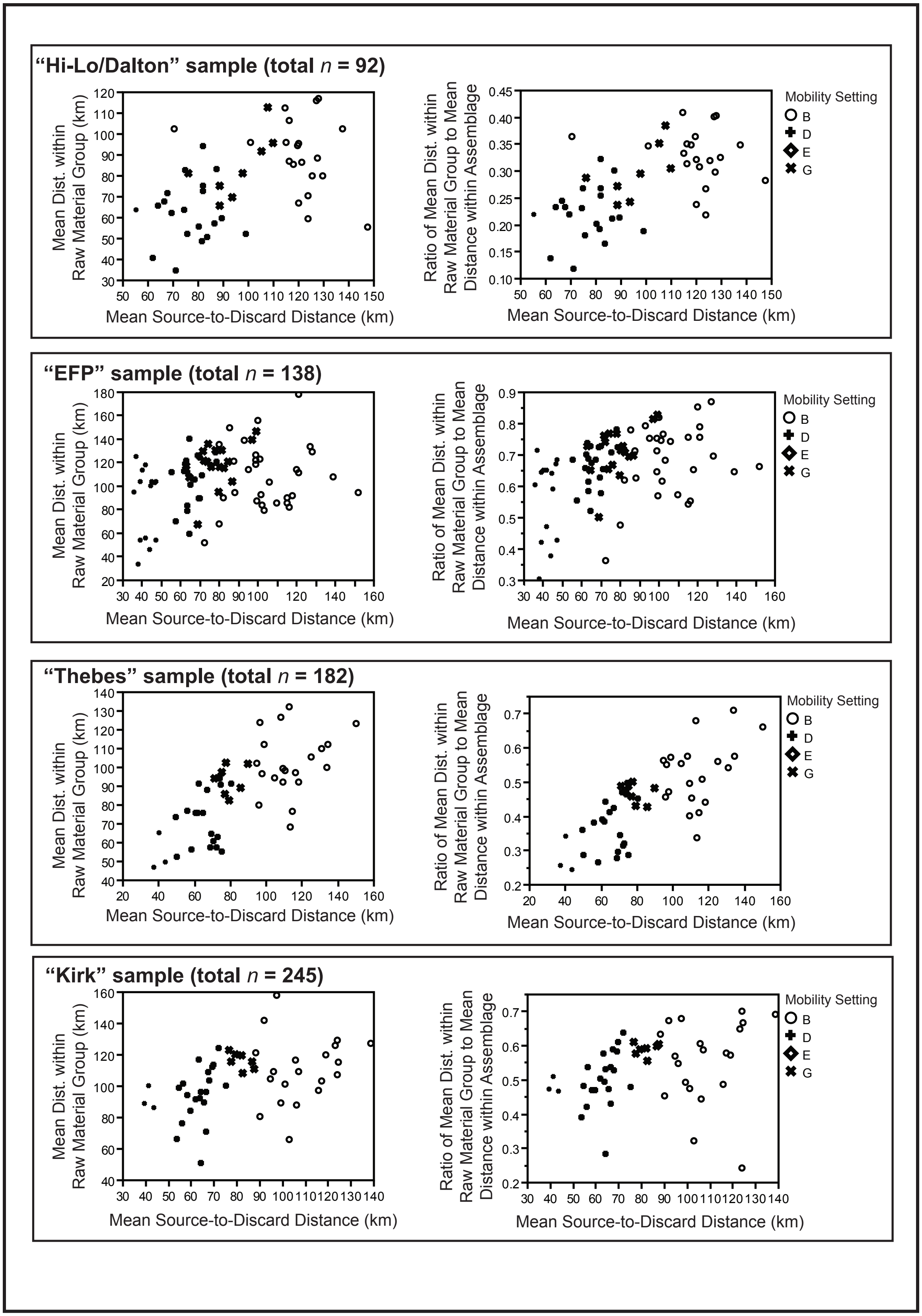
Model data were used to determine how raw material transport metrics developed for the archaeological samples (i.e., metrics based not on "actual" source-to-discard distances but on distances to the mean coordinates of artifacts within raw material groups) corresponded to actual source-to-discard distances in samples where both measures could be calculated. Based on the analysis above, the mean source-to-discard distance is a reasonable predictor of group mobility in the model. Figure 8.14 plots of the mean source-to-discard distance of model runs against both the mean distance within raw material groups (left column) and the ratio of the mean distance within raw material groups to the mean distance within the entire assemblage (right column). The distance calculations were performed on random samples of artifacts matching the archaeological samples in terms of total number and breakdown by raw material group.

It is apparent both that: (1) the distance metrics based on raw material groups do have a positive relationship with actual source-to-discard distances in the model; and (2) the calculations performed to produce these metrics introduce a substantial amount of "noise." Despite this, all of the plots in Figure 8.14 are statistically significant at the $p < 0.05$ level. The ratio of mean distance within raw material group to mean distance within the entire assemblage tends to be a better predictor of mean source-to-discard distance than the mean distance within raw material group alone.

The distance metrics from the archaeological samples are compared with the distance metrics from the model runs in Figure 8.15. The overlap in the distributions of model outcomes at various mobility settings is substantial: none of the archaeological data points correspond exclusively to a single mobility setting in the model. In some cases, the distance metrics from the

Table 8.4. Distribution of Hafted Bifaces in the Raw Material Sample by Raw Material Group (distances in kilometers).

Point Group	Raw Material Group				Total *n*	Assemblage Distance		Raw Material Distance		Ratio	
	1	2	4	5		Max.	Mean	Max.	Mean	Max.	Mean
EFP	108	20	10	-	138	488.3	182.2	485.8	169.8	0.995	0.932
Hi-Lo/Dalton	30	9	31	22	92	627.4	306.3	297	98.3	0.473	0.321
Thebes	66	32	77	7	182	628.0	225.3	635.8	111.4	1.012	0.494
Kirk	153	47	39	6	245	579.7	199.0	526.4	143.5	0.908	0.721



"Hi-Lo/Dalton" sample (total *n* = 92)

"EFP" sample (total *n* = 138)

"Thebes" sample (total *n* = 182)

"Kirk" sample (total *n* = 245)

Figure 8.14. Relationships between actual source-to-discard distances and raw material transport metrics in model experiment runs.

archaeological samples fall outside the range of those produced by any model settings. Table 8.5 presents a summary of the correspondence between the distance metrics of the archaeological samples and the ranges of values produced by experimental runs.

Mobility setting B, the highest mobility setting investigated here, provides the closest match to the Early Fluted Point sample. At this mobility setting, groups move every other step (every other week), on average, and may move up to 2 cells (20 km). This results in a mean annual group range of about 183 km and mean annual group movements totaling 434 km. Values of two of the four distance metrics of the EFP sample fall within the ranges produced by model runs with a third (maximum distance within raw material group) coming very close. The values associated with the EFP sample are on the high end of those produced by mobility setting B. The actual source-to-discard distances produced in mobility setting B (see above) are *generally* comparable to those suggested for midcontinental Early Paleoindian assemblages in other studies (see Ellis 2011:390; Ellis et al. 2011; Koldehoff and Loebel 2009:282; Loebel 2005:151; Mullet 2009; Tankersley 1989:157-165). Taken together, the data suggest that mobility setting B provides a reasonable representation of Early Paleoindian mobility.

The distance metrics associated with the Hi-Lo/Dalton sample fall within the range of those produced by several mobility settings in the model. The archaeological data clearly show a decrease in the scale of raw material transport during the Late Paleoindian period: mean and maximum distances within raw material groups are about 60 percent of those associated with the Early Fluted Point sample. This is concordant with the data assembled by Ellis (2011:Figure 5), which suggest post-Clovis maximum source-to-discard distances about half those associated with Clovis and Clovis-like assemblages (see also Koldehoff and Loebel 2009:284; Walthall and Koldehoff 2004). These data suggest that mobility setting D is a reasonable representation of Late Paleoindian mobility. A shift from mobility setting B (Early Paleoindian) to D (Late Paleoindian) entails about a 60 percent decrease in the mean distances that groups move annually.

The Early Archaic (Thebes and Kirk) samples indicate an increase in raw material transport distances subsequent to the Late Paleoindian period. As was noted in Chapter 7, however, consideration of the available data suggests that some mechanism other than group residential mobility (perhaps exchange)

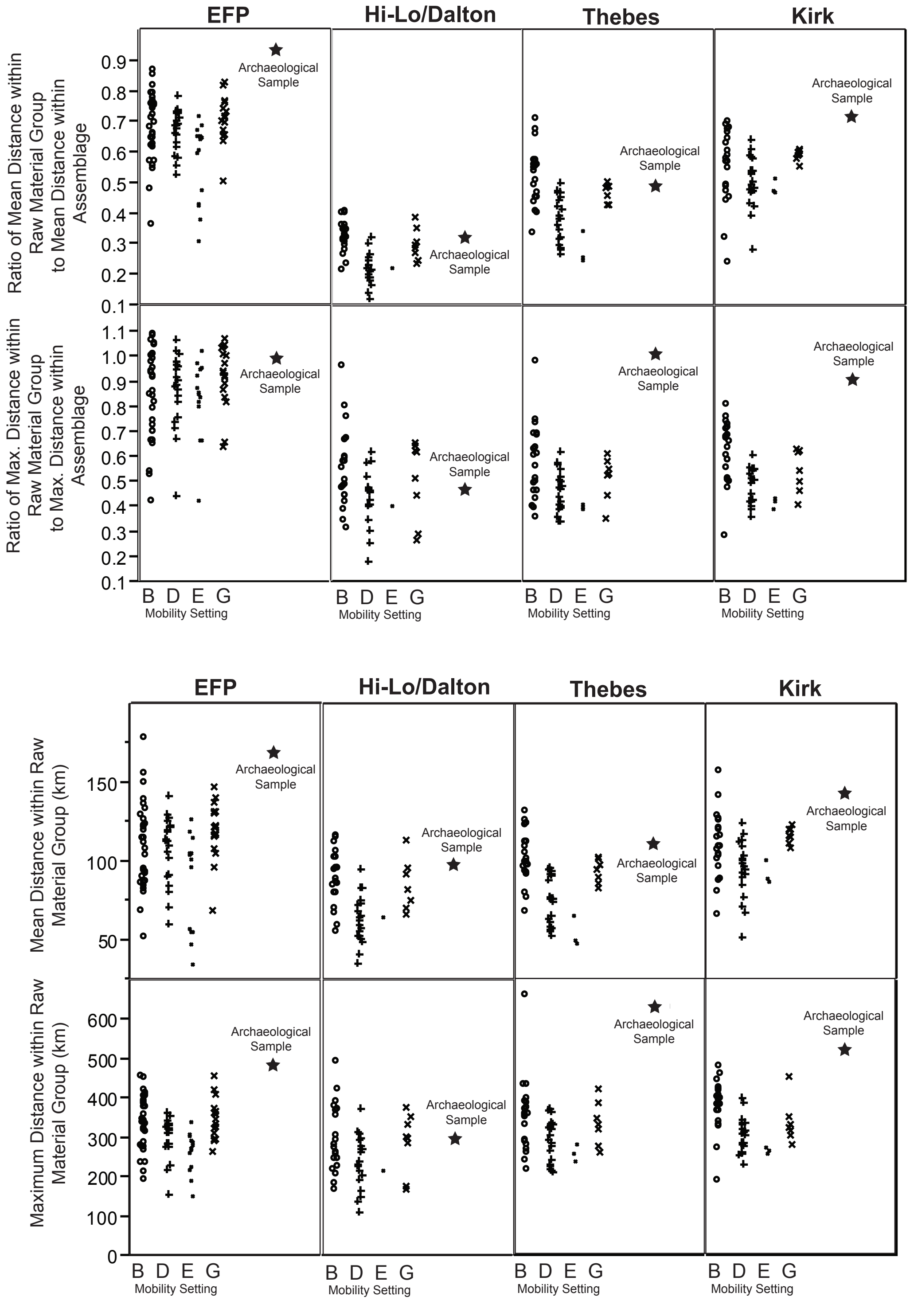


Figure 8.15. Comparison of raw material transport metrics for model and archaeological datasets.

Table 8.5. Comparison of Raw Material Transport Metrics of Archaeological Samples with Distributions Produced by Model Runs. "X" indicates that archaeological value falls within range of values produced by model runs.

Model Mobility Setting	**Distance Metric**	**Archaeological Sample**			
		EFP	**Hi-Lo/Dalton**	**Thebes**	**Kirk**
B	Mean	X	X	X	X
	Max.	-	X	X	-
	Ratio Mean	-	X	X	-
	Ratio Max	X	X	-	-
D	Mean	-	X	-	-
	Max.	-	X	-	-
	Ratio Mean	-	X	X	-
	Ratio Max	X	X	-	-
E	Mean	-	NA	NA	NA
	Max.	-	NA	NA	NA
	Ratio Mean	-	NA	NA	NA
	Ratio Max	X	NA	NA	NA
G	Mean	-	X	-	-
	Max.	-	X	-	-
	Ratio Mean	-	X	X	-
	Ratio Max	X	X	-	-

may have played a role in the long distance transport of some artifacts during this time. If we assume that group mobility was the primary mechanism of raw material transport, mobility setting B provides the best representation for group mobility associated with the Thebes sample: three of the four distance metrics for Thebes fall within the range produced by mobility setting B. While three of the four distance metrics associated with the Kirk sample exceed those of mobility setting B, mobility setting B is the only setting that provides values that are reasonably close to those associated with the Kirk sample.

If we consider that a mechanism such as exchange may have been serving to move a small number of artifacts very long distances during the Early Archaic period, mobility setting D is a more reasonable representation of group mobility. Maximum transport distances of most experimental runs in mobility setting D are less than 300 km, a figure consistent with the fall-off curves for transport of Kirk and Thebes points in southwestern Indiana provided by Cantin (2000) and data on Early Archaic raw material transport in the Savannah River Valley (Anderson and Hanson 1988). Exchange behaviors are not represented in the ForagerNet2 model, and no attempt was made to study the possible effects of exchange on raw material transport patterns. The suggestion that exchange may have played a role in the movement of artifacts during the Early Archaic period particularly is based on the impression that the Early Archaic dataset includes a few artifacts that appear to be genuine outliers in terms of transport distance.

Comparison of archaeological and model data suggests that the changes in the scale of raw material transport that characterize the Early Paleoindian → Late Paleoindian sequence can be reasonably represented in the model by changes from "high" to "low" mobility states represented by mobility settings B ("high") and D ("low"). These changes in mobility produce changes in the scale of raw material transport comparable to those documented in the archaeological data considered here and concordant with the results of previous studies (e.g., Ellis 2011; Koldehoff and Loebel 2009). Either mobility setting B or D could arguably serve to represent Early Archaic group mobility behaviors.

Patterns of Interaction and the Spatial Organization of Stylistic Variability

Using the archaeological record to make inferences about the characteristics of large-scale patterns of social interaction in hunter-gatherer systems requires understanding how patterns of interaction are related to patterns of artifact variability. This section uses experimental data from the ForagerNet2 model to determine how the presence of social boundaries affects the patterns of spatial organization of stylistic artifact variability produced by model systems. This discussion is oriented primarily in terms of social interaction between regions, as this is the situation that corresponds to most of the archaeological explanations which I seek to evaluate.

First, I explore how the existence and strength of a "passive" barrier to interaction between regions (i.e., a barrier that impedes social interaction but is not consciously marked by intentionally-produced stylistic differentiation) affects both the characteristics of social networks and the spatial organization of stylistic artifact variability. Second, I discuss the representation of mechanisms of intentional human behavior that serve to "actively" produce/reinforce stylistic differentiation between regions.

“Passive” Barriers to Interaction between Regions

A “passive” barrier to social interaction is defined here as a geographically-situated impediment to social interaction between regions that is not marked or reinforced by intentionally-produced stylistic differentiation. Passive barriers could include physical features of the landscape that impede human movement (such as mountains, deserts, or large bodies of water), disparate ecological circumstances that impede articulation of differently-adapted social/economic systems, linguistic differences that impede communication, etc.

While the existence of passive barriers may ultimately *affect* patterns of stylistic artifact variability, passive barriers are distinguished from “active” barriers in that they are neither produced nor reinforced by human behavior that intentionally promotes stylistic differentiation between regions. In this case, stylistic behavior is isochrestic rather than emblemic (see Chapter 3). Stylistic differentiation between regions separated by a passive barrier is the result of processes of drift.

Two geographic regions are defined in the world of the ForagerNet2 model: Region 1 includes all parcels north of UTM 4390700N and east of UTM 290600E; Region 2 includes all other parcels in the world. Figure 8.16 shows Regions 1 and 2 in relation to modern political boundaries in the archaeological data area. The configuration of these regions in the model is intended to mimic the approximate configuration of the stylistic regions that were discerned in the Hi-Lo/Dalton sample in the archaeological dataset (see Chapter 7). These regions are placed in the “world” of the model so that they may be used in experiments to investigate if the imposition of an impediment to interaction between the Hi-Lo and Dalton “regions” can produce patterns of stylistic variability comparable to those discerned in the archaeological data.

The presence of a passive barrier to social interaction between regions is represented in the model by the imposition of a probability affecting interactions between persons/groups residing (i.e., aggregating) in the two different regions. The probability of an interaction occurring across the boundary between regions is controlled by the continuous parameter *pBoundaryCross*. The value of *pBoundaryCross* affects marriage, the movement of persons from one group to another, and the fusion of groups when these actions are attempted across the regional boundary. When the value of *pBoundaryCross* = 0, there is no chance of marriage or transfer of persons or groups across the regional boundary. When

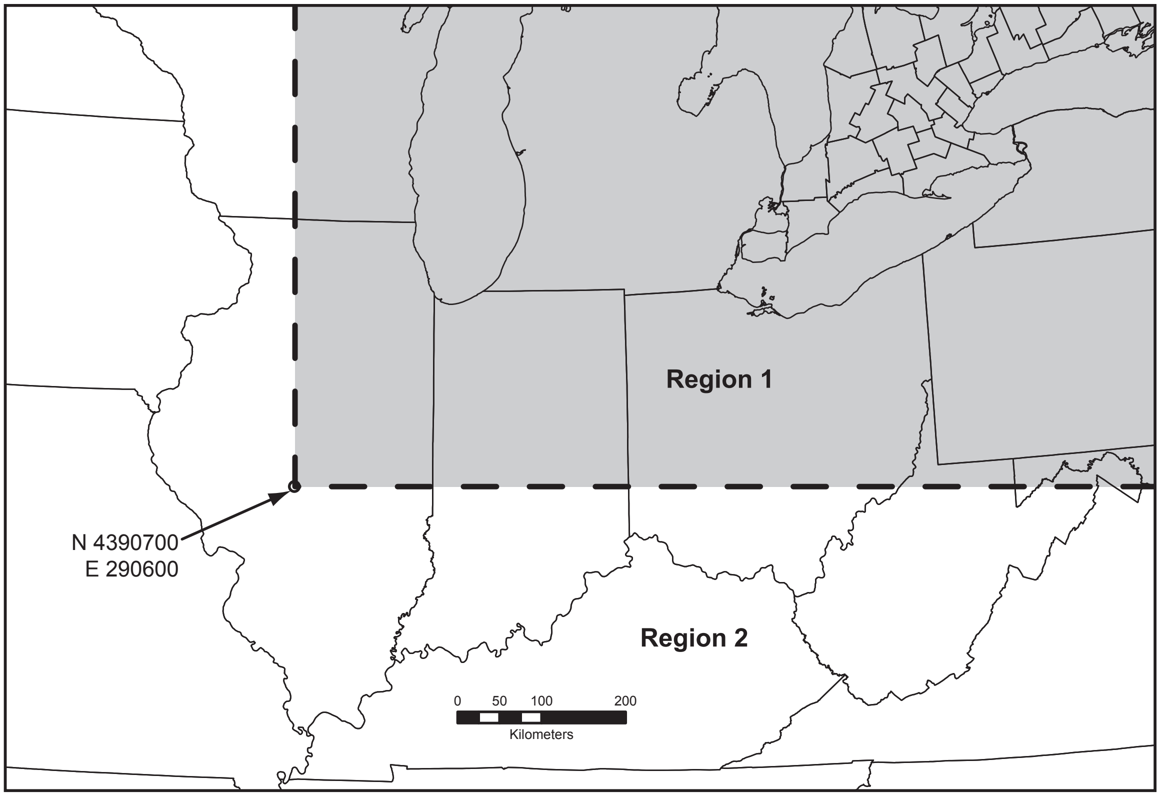


Figure 8.16. Map showing extent of Regions 1 and 2 used in model experiments.

the value of *pBoundaryCross* = 1, the presence of the regions has no effect on interactions. Values between 0 and 1 continuously vary the "strength" of the barrier. The value of *pBoundaryCross* does not directly affect the physical movements of groups during their annual travels: if a group's aggregation site is in Region 1, the group may still enter and travel in Region 2 during its annual movements without regard to the "strength" of the regional boundary. The boundary between Regions 1 and 2 is thus represented as a cultural/social impediment to interaction rather than a physical impediment to travel.

Network Characteristics and System Connectedness. A series of experiments was used to investigate how the strength of a "passive" barrier affects the characteristics of social networks and the interconnectedness between regions. Figure 8.17 shows the relationships between the value of *pBoundaryCross* and various system-level characteristics of networks in 121 experimental runs in mobility setting B, scale 3 (the values associated with the data points in these plots are provided in Appendix H). These measures of network characteristics were discussed in Chapters 2 and 5.

The plot of *pBoundaryCross* vs. the percentage of paths found (Figure 8.17B) clearly shows that low values of *pBoundaryCross* are sufficient to produce inter-connected networks. With the exception of a single outlier, all the runs with values of *pBoundaryCross* > 0.10 produced systems where at least 90 percent of the social paths between random individuals could be found. While

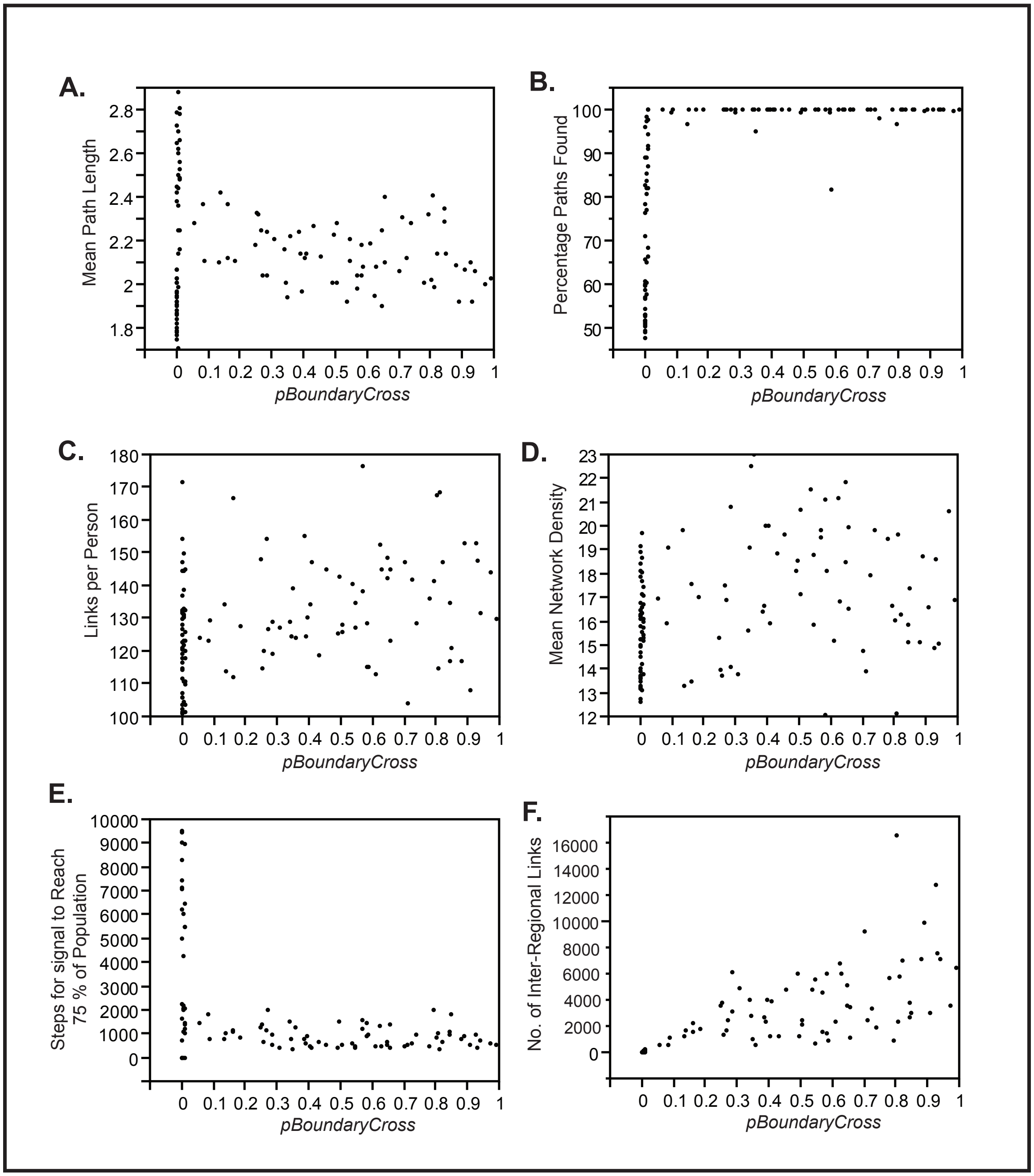


Figure 8.17. Relationships between the value of *pBoundaryCross* and various network characteristics in model experiments.

the maximum number of social links spanning the regional boundary increases linearly with increases in the value of *pBoundaryCross* (Figure 8.17F), these increases have no apparent effect on the rapidity with which information is spread (Figure 8.17E). In other words, creation of a relatively small number of social connections spanning the regional boundary appears to be sufficient to keep the systems in each region connected to one another. Increases in the number of inter-regional links over the number required to create inter-connectedness have no benefit in terms of the rapidity of information spread.

The value of *pBoundaryCross* does not appear to have patterned relationships with mean path length (Figure 8.17A), the mean number of links per person (Figure 8.17C), or mean network density (Figure 8.17D). The distribution of data points associated with very low values of *pBoundaryCross* in the plot vs. mean path length is the result of inclusion of results from runs where the social networks in the two regions were not connected (i.e., data points with a mean path length below 2.1 correspond to runs where less than approximately 60 percent of social paths could be found) along with those where there was greater inter-connectedness between regions.

Taken together, these results suggest that a barrier to social interaction between two regions must entail a very high degree of closure to have an effect on the inter-connectedness of social systems and the transfer of information between them. In the model, a “hard” barrier to the establishment of links (i.e., where the value of *pBoundaryCross* is effectively 0) is required to ensure that regions are not inter-connected. If the regions are inter-connected, the presence of a passive barrier to social interaction between regions has little if any effect on other general, system-level characteristics of social networks (e.g., mean path length, mean number of links per person, and mean network density).

Spatial Organization of Artifact Variability. The effects of the value of *pBoundaryCross* on the spatial patterns of stylistic artifact variability were investigated by processing the artifact data from the experimental runs in a manner similar to that of the archaeological dataset (see Chapter 7). The purpose of this analysis was to generate quantitative data about the degree of spatial organization of variability that could be compared to network characteristics and the strength of the barrier affecting interaction between regions.

A sample of 2000 model artifacts with non-zero values for variables E, F, and I was randomly selected from each run. As in the archaeological samples, variables E, F, and I are "stylistic" variables with relatively high coefficients of variation. A principal components analysis (PCA) was performed on the artifact sample using variables E, F, and I with the resulting variable named "EFI". Moran's I was calculated on variable EFI in ArcMap 9.2 using the default settings of the Spatial Autocorrelation tool. Spatial autocorrelation is the degree to which the value of a variable at a point in space is related to the values of the same variable in adjacent points in space (see Cliff and Ord 1973; Moran 1950). Moran's I is an index: values range from +1 (perfect correlation) to -1 (perfect dispersion). A value of 0 indicates a random arrangement in space (i.e., spatial proximity has no effect on the value of a variable). Values between 0 and 1 indicate some degree of spatial clustering, where similar values are located closer to each other in space than would be expected randomly. The standardized normal deviate (*z* score) is used to evaluate the statistical significance of a result. A *z* score greater than 1.96 or less than -1.96 is statistically significant at the $p = 0.05$ level.

A plot of Moran's I vs. the value of *pBoundaryCross* does not reveal a simple relationship between the strength of the barrier and the degree of spatial autocorrelation in the artifact samples (Figure 8.18A). The highest values of Moran's I were produced during experimental runs where the value of *pBoundaryCross* was between 0.10 and 0.40, rather than in runs where an "absolute" boundary between regions was present (i.e., *pBC* = 0). The data appear to show a general decrease in Moran's I as the value of *pBoundaryCross* increases from about 0.25 to 1. All but seven of the 121 experimental runs produced statistically significant values of Moran's I (Figure 8.18B), and the highest values were produced by inter-connected systems (Figure 8.18C) where information spread relatively rapidly (Figure 8.18D). Thus it appears that: (1) some degree of spatial organization of variability is a typical outcome of the mechanisms of social learning and network-mediated information transfer as they are represented in the model; and (2) the imposition of a "hard" boundary to inter-regional interaction does not guarantee a high degree of spatial organization of stylistic variability.

These observations are supported by visual examination of data from the three model runs producing the highest values of Moran's I (designated "A," "B," and "C" in Figure 8.18). Rasters of variable EFI from these runs are shown in Figures 8.19 through 8.21. It is not apparent from these spatial

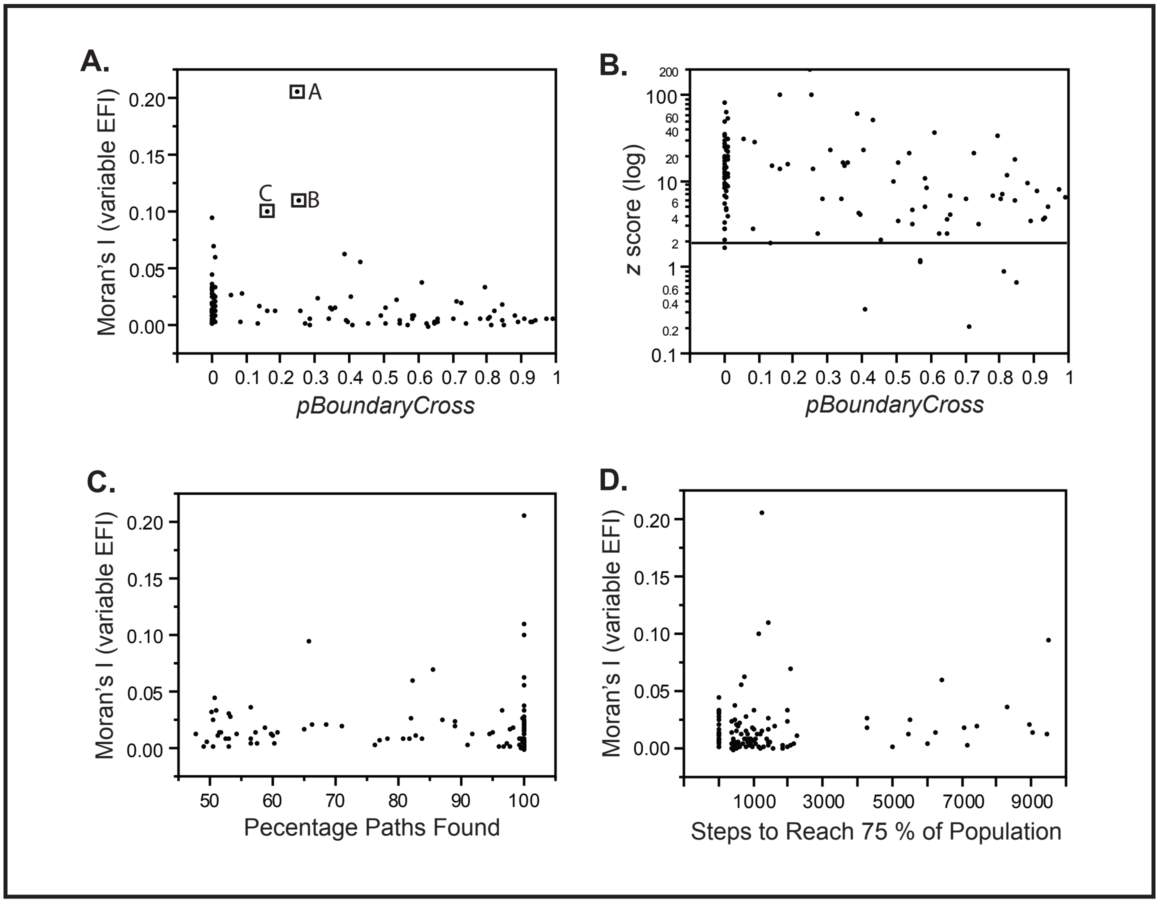


Figure 8.18. Relationships between the strength of barrier between regions and the value of Moran's I produced during model experiment runs (A and B); relationship between the percentage of social paths found and the value of Moran's I (C); relationship between the speed of information transfer and the value of Moran's I (D).

representations of the data that the position of the boundary between regions has any correspondence to the spatial organization of artifact variability in model experiments. While what might be termed "stylistic regions" are clearly present in all three figures, the boundaries of these stylistic regions do not appear to be congruent with the boundary between Regions 1 and 2. These stylistic regions emerged in the context of inter-connected systems where the boundary between Regions 1 and 2 was not a significant barrier to information flow.

The spatial distribution of stylistic variability in these runs was investigated by plotting the value of EFI vs. the UTM northing and easting in each run and calculating the value of R^2 for a regression line fit to each plot (calculations performed in JMP 9.0.3). These R^2 values provide a simple metric for describing

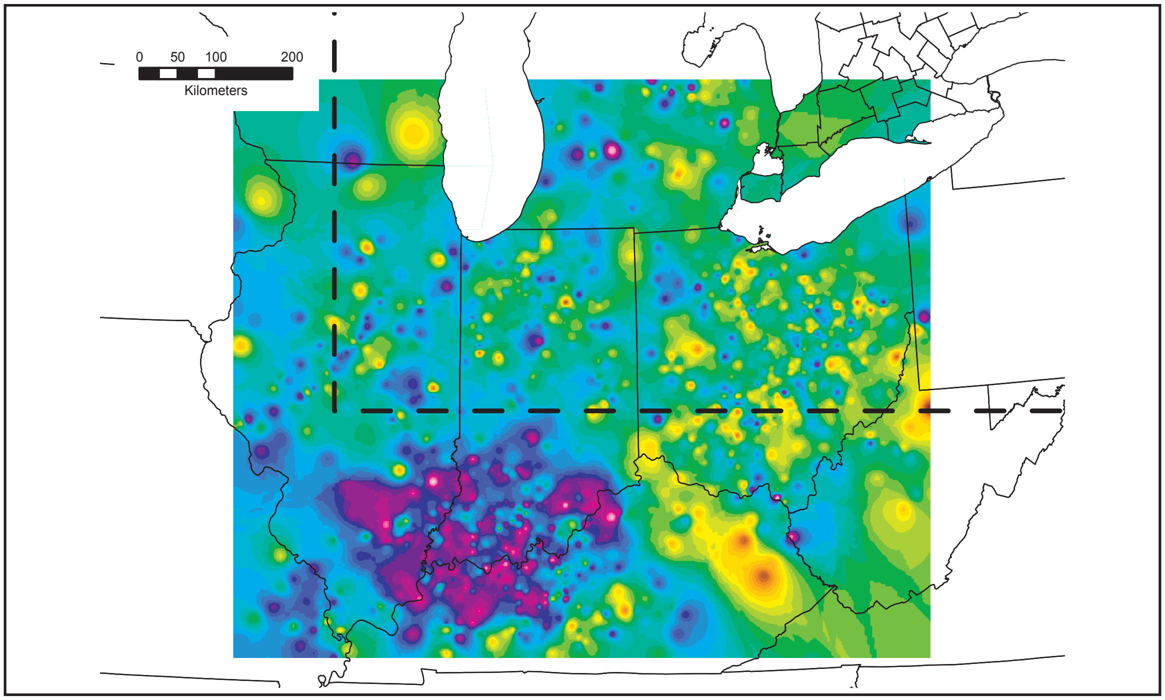


Figure 8.19. Raster image of EFI showing spatial organization of stylistic variability in Experiment 002-09-19-02, run 19 (designated “A” in Figure 8.18; Moran’s I = 0.205; *n* = 2000 tools). Dashed line is boundary between Regions 1 and 2.

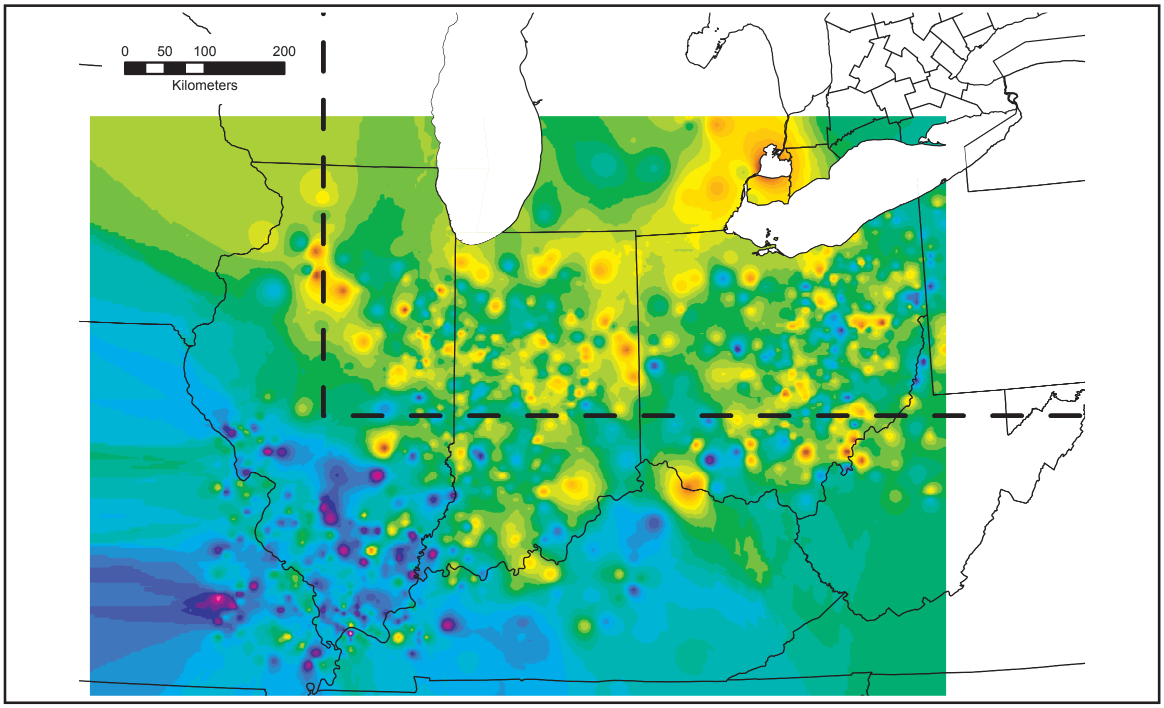


Figure 8.20. Raster image of EFI showing spatial organization of stylistic variability in Experiment 007-10-42-22, run 5 (designated “B” in Figure 8.18; Moran’s I = 0.110; *n* = 2000 tools). Dashed line is boundary between Regions 1 and 2.

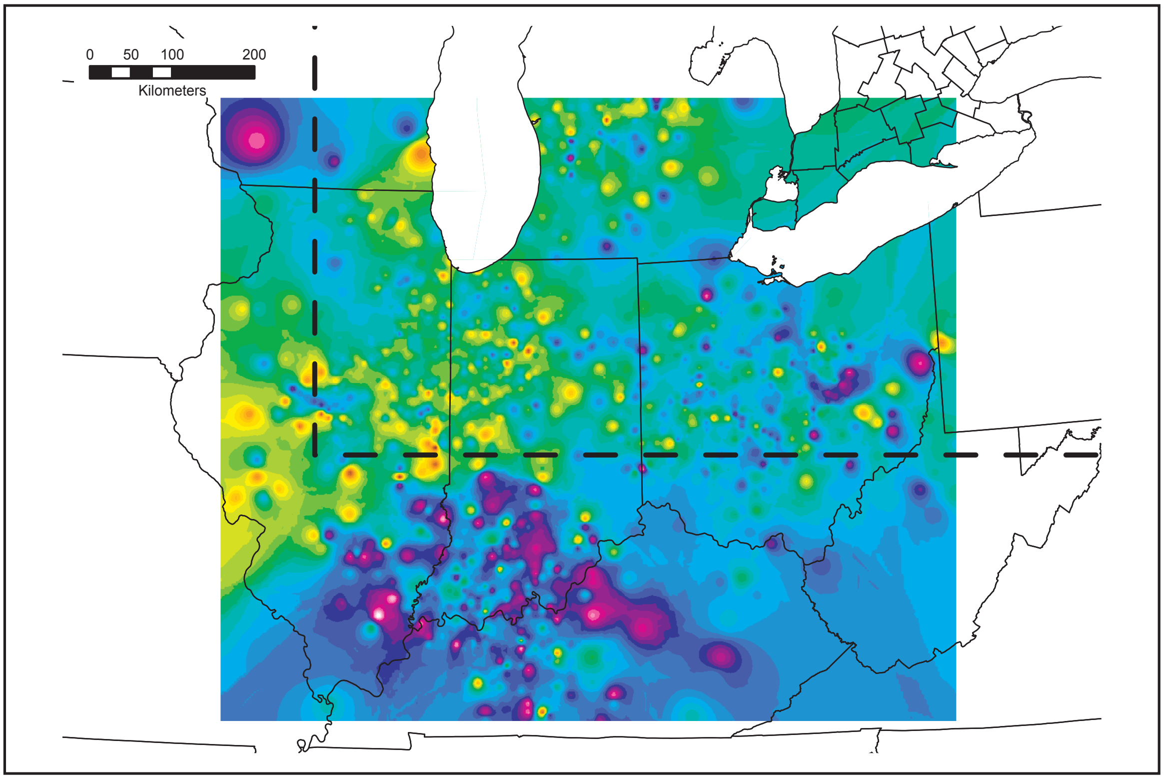


Figure 8.21. Raster image of EFI showing spatial organization of stylistic variability in Experiment 002-09-19-02, run 5 (designated “C” in Figure 8.18; Moran’s I = 0.100; *n* = 2000 tools). Dashed line is boundary between Regions 1 and 2.

the correlation between stylistic variability and space along two axes (north-south and east-west). A higher value of R^2 indicates a greater degree of correlation between position along a spatial axis and the value of variable EFI. This general kind of procedure is often used to detect/measure clinal variability (defined as continuous change across a geographic range) in studies attempting to understand the spatial structure of biological variability (e.g., Bogdanowicz 1990; Hayes and Richmond 1993; Piedra-Malagón et al. 2011; Schwartz and Odum 1957). Examples from three runs (two with relatively high values of R^2 and one with low values of R^2) are shown in Figure 8.22.

Figure 8.23 shows plots of R^2 vs. the calculated Moran’s I for all the experimental runs. A positive, linear relationship between the value of R^2 and the value of Moran’s I is apparent in each of these plots. Higher values of Moran’s I are associated with stronger correlations between “style” and space. The relationship is the tightest in the bottom plot (Figure 8.23C), which averages the R^2 values along the east-west and north-south axes. These relationships suggest that Moran’s I is capturing the “strength” of clinal variability in these

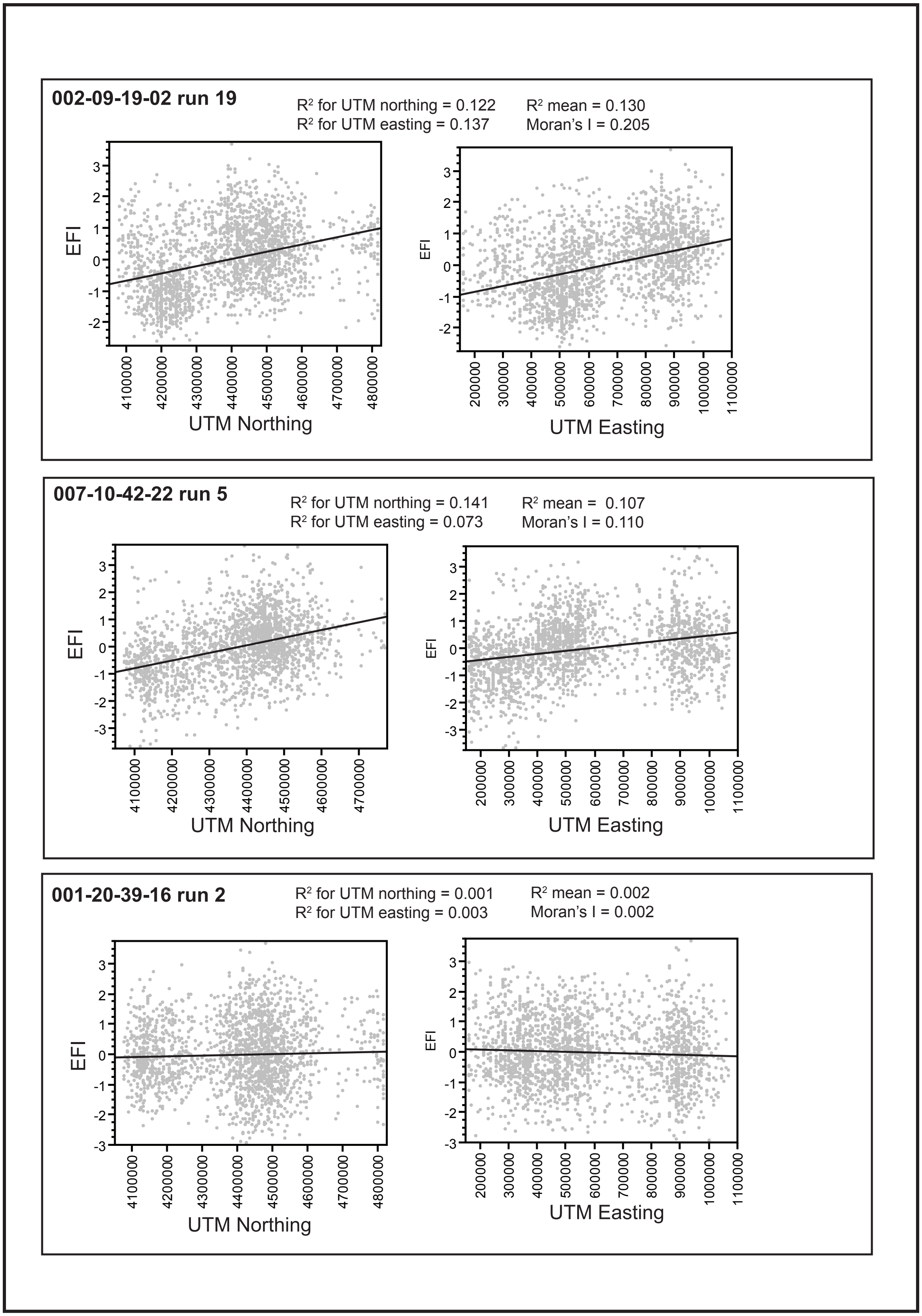


Figure 8.22. Plots of EFI vs. UTM northing and easting in three example runs producing various values of Moran's I.

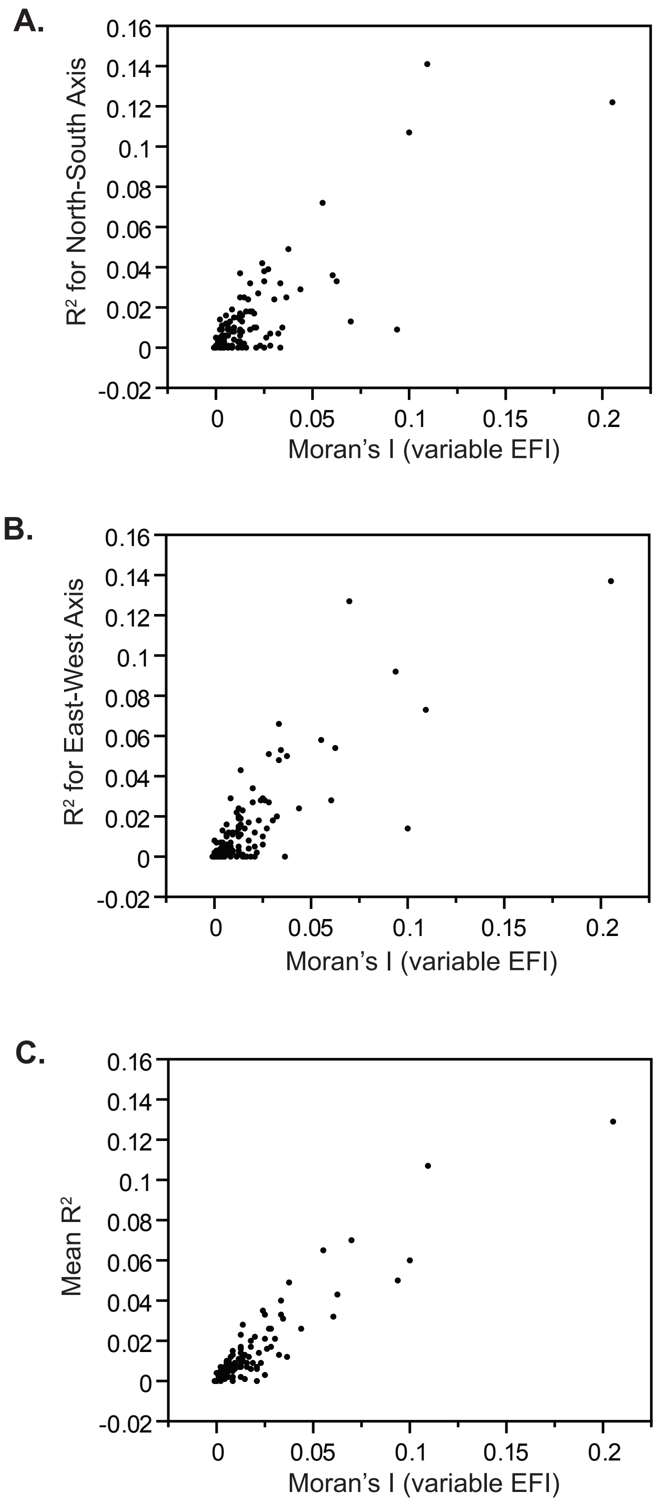


Figure 8.23. Relationships between Moran's I and R^2 values of north-south and east-west clines

experimental datasets.

The existence of clinal variability in the experimental datasets does not mean that stylistic "regions" are not present. Visual examination of the datasets suggests that relatively high values of R^2 can be produced when variability is organized into relatively distinct geographic "regions" with significant stylistic overlap but different means (e.g., see Figure 8.22, top right). When clines and/or regions of variability are present, any two spatially-exclusive samples are likely to be different in terms of their means, and the strength of the difference will tend to be related to the "strength" of the clines or regions. Higher values of Moran's I are associated with greater differences in the mean values of EFI in Regions 1 and 2 (Figure 8.24A), for example, even though the strength of the barrier between Regions 1 and 2 has little relationship to the differences in the mean values of EFI (Figure 8.24B) and is not the "cause" of the clines or regions. Again, the greatest inter-regional differences were produced in runs with inter-connected regions rather than runs with an "absolute" barrier to interaction between regions.

The experimental runs considered here were produced under two different settings of the parameter *pCopyGroup* (0.10 and 0.50). In these runs, the value of *pCopyGroup* specified the probability that an individual would copy the mean artifact variables in his group (rather than his father's mean artifact variables) when he learned to manufacture tools. Thus the value of *pCopyGroup* represents the "strength of bias" (Hamilton and Buchanan 2009) or "strength of conformance" (Eerkens and Lipo 2005) that is applied to social learning in cultural transmission models. Figure 8.25 plots the coefficients of variation (CV) for variables E, F, and I vs. the value of *pBoundaryCross* in the 121 runs. While there is no apparent relationship between the CVs of these variables and the value of *pBoundaryCross*, it is clear that lower CVs are produced by the higher setting of *pCopyGroup* in two of the variables (F and I). This is the expected outcome based on general models of cultural transmission, which specify that an increase in the "strength of conformance" tends to reduce the amount of variability that is created through copy error.

It is notable that the highest values of Moran's I (i.e., the highest degree of non-random spatial organization) were produced by runs where the value of *pCopyGroup* was 0.50 rather than 0.10 (Figure 8.26). Logically, higher values of *pCopyGroup* would be expected to constrain stylistic variability within bands (i.e., within social units characterized by a relatively high degree of inter-group transfer of individuals) while having relatively little constraining effect on variability

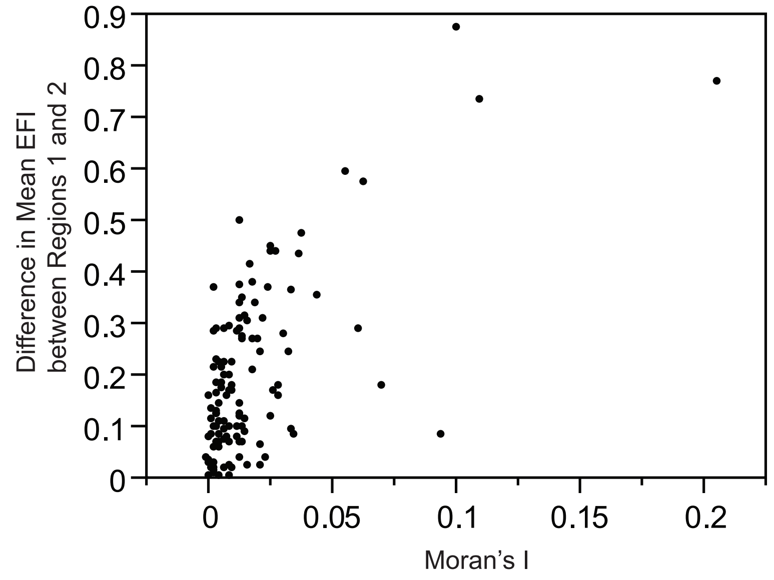


Figure 8.24. Relationship between Moran's I and the difference in the mean value of variable EFI between Region 1 and Region 2.

between bands (assuming the transfer of individuals is significantly less). This would tend to increase the strength of clinal patterns. Additional experiments could be performed to investigate the combined effects of the strength of conformance and amounts of inter-band and inter-group transfer of individuals on patterns of artifact variability.

The suggestion that clines/regions of stylistic artifact variability are generated by the ForagerNet2 model in the context of "open" networks with no absolute barriers to interaction is consistent with the results of other computational models. Axelrod's (1997) adaptive culture model demonstrated how polarized cultural regions can occur even though the only mechanism for interaction in the model is one of convergence. Schelling's (1978) self-forming neighborhood model demonstrated how relatively small preferences about the characteristics of one's neighbors at the local level result in total segregation. While neither of these models employed continuous variables that would have made possible the generation of clines of variability, they demonstrate that macro-scale regionalization is possible or even likely in the absence of

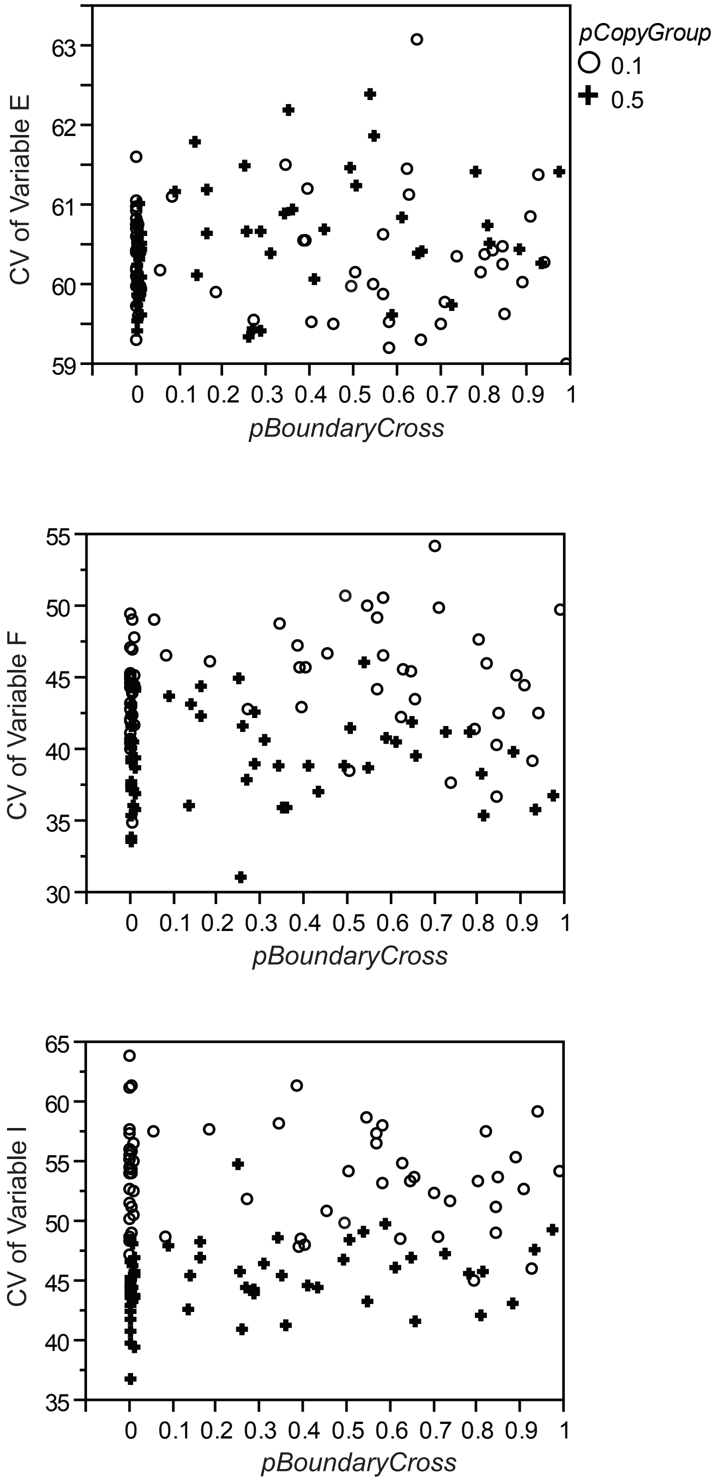


Figure 8.25. Relationships between the value of *pBoundaryCross* and the coefficients of variation (CV) of variables E, F, and I.

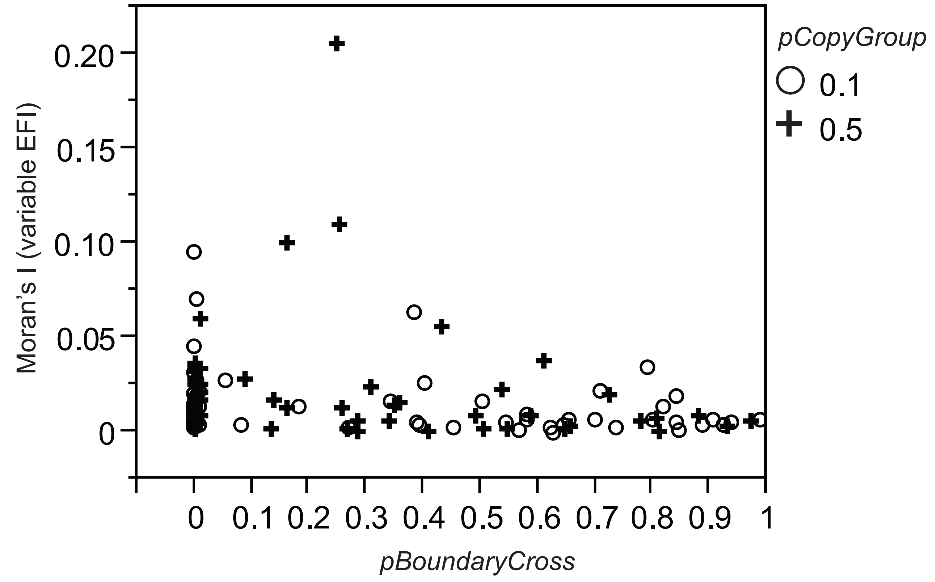


Figure 8.26. Relationship between the value of *pBoundaryCross* and Moran's I, datapoints coded by value of *pCopyGroup*.

boundaries to information transfer. Notably, interactions in both the Schelling (1978) model and Axelrod's (1997) model were local (i.e., between spatially adjacent neighbors). Mechanisms for social learning in the ForagerNet2 model are also "local" (i.e., involving interactions between persons in close spatial proximity).

In summary, the "strength" of a passive barrier to interaction between regions appears to have no simple relationship to the degree of spatial organization of stylistic artifact variability in the model runs discussed here. Nearly all runs produced statistically significant amounts of spatial autocorrelation as measured by Moran's I. Non-random spatial patterning of stylistic artifact variability appears to be clinal and/or regional, varying continuously across space along multiple axes. The strongest clinal/regional patterns emerged in the context of "open" systems with weak/moderate barriers to interaction. Higher values of conformist bias in the social learning process may contribute to the formation of stronger spatial patterning of variability.

"Active" Production and Maintenance of Regional Stylistic Differentiation

As defined here, an "active" social boundary is one that is produced and/or reinforced by human behavior that intentionally promotes stylistic differentiation between regions. Style is used as a way to indicate intra-region affiliation and inter-region differences: an individual employs stylistic variability to signal that he is like those in his region and unlike those outside his region. This is "emblemic" stylistic behavior (see Chapter 3).

The formation/maintenance of an active social boundary is represented in the ForagerNet2 model by a parameter (*pCopyRegion*) affecting whether or not an individual copies the mean artifact variables of the population in his region. A value of 1 causes an individual to copy the regional means every time he manufactures an artifact. A value of 0 means he will never copy the regional mean. Values between 0 and 1 continuously vary the probability of copying the regional mean. Each time an individual creates a new artifact, random "copying error" is generated for each variable that describes an aspect of the artifact. This error can be positive or negative. When an individual is copying the regional mean (subject to the value of *pCopyRegion*), the model compares whether application of this error would make the individual's new artifact more or less like the mean of the other region. If application of the error would make the individual's new artifact *more* like the mean of the other region, the sign of the error term is reversed. Thus when an individual copies the mean of his own region, he is certain to produce an artifact that is more like those typical of his region than those typical of the other region.

This representation of the "active" formation/maintenance of stylistically-differentiated regions is somewhat unrealistic in that individual persons accurately ascertain the "mean" artifact design of both his region and the other region, both of which are spatially-extensive. No attempt was made to represent how individuals might acquire information about the "mean" characteristics of artifacts from different regions based on spatial proximity and face-to-face interaction. The goal of the representations employed here was to provide a means of investigating the effects of "active" processes of stylistic differentiation that could be compared to patterns of variability produced by "passive" barriers to interaction. The geographic regions used in this analysis are the same as those discussed above. There was no boundary to interaction between regions in these runs (i.e., *pBoundaryCross* = 1) because it is regional affiliation, rather than the degree of interaction, that produces stylistic differentiation.

Figure 8.27 shows the relationship between the value of *pCopyRegion* and three measures of the spatial organization of artifact variability for a group of 26 runs. Analysis of the artifact data produced by these runs showed that stylistic differences between regions could often not be effectively quantified using variable EFI because the large degree of stylistic polarization that resulted from relatively high values of *pCopyRegion* often produced assemblages where points from one region did not have concave basal edges (and thus variable F had no value). The first principal component generated from variables C, G, and I (named variable CGI) was used for analysis in these runs. Moran's I, the mean value of R^2 for lines fit to plots of CGI vs. UTM northing and easting, and the mean difference in the means of CGI in Regions 1 and 2 were all calculated as described above for passive barriers to interaction.

The plots in Figure 8.27 clearly show positive relationships between the value of *pCopyRegion* and the spatial organization of variability. Nonlinearity is suggested by each plot: the degree of spatial organization increases relatively rapidly as the value of *pCopyRegion* is increased from 0. Figures 8.28 through 8.30 show examples of rasters produced from data from three runs (designated "A," "B," and "C" in Figure 8.27). Stylistic regions are plainly apparent in each case, as are differences in the "strength" of the stylistic discontinuity between regions. Note that the geographic position of the interface between stylistic regions does not correspond exactly to the position of the line demarcating Regions 1 and 2 in the model (marked with a dotted line in the figures). This is because the regional boundary in the model does not affect group mobility, allowing groups that aggregate in one region to travel across geographic space and deposit tools in the other region. Thus the position of the boundary between stylistic regions corresponds roughly to the location of the interface between the annual ranges of groups that aggregate in (and therefore identify with) Regions 1 and 2.

The representation of an "active" boundary in the model is capable of producing much greater values of Moran's I than the passive barriers discussed above. The linear relationship between the value of Moran's I and the mean R^2 values (describing the correlation between stylistic variability and space along north-south and east-west axes) holds among these higher values of Moran's I (Figure 8.31). While it appeared that Moran's I was measuring the degree of clinal variability among the passive barrier experiments, inspection of individual

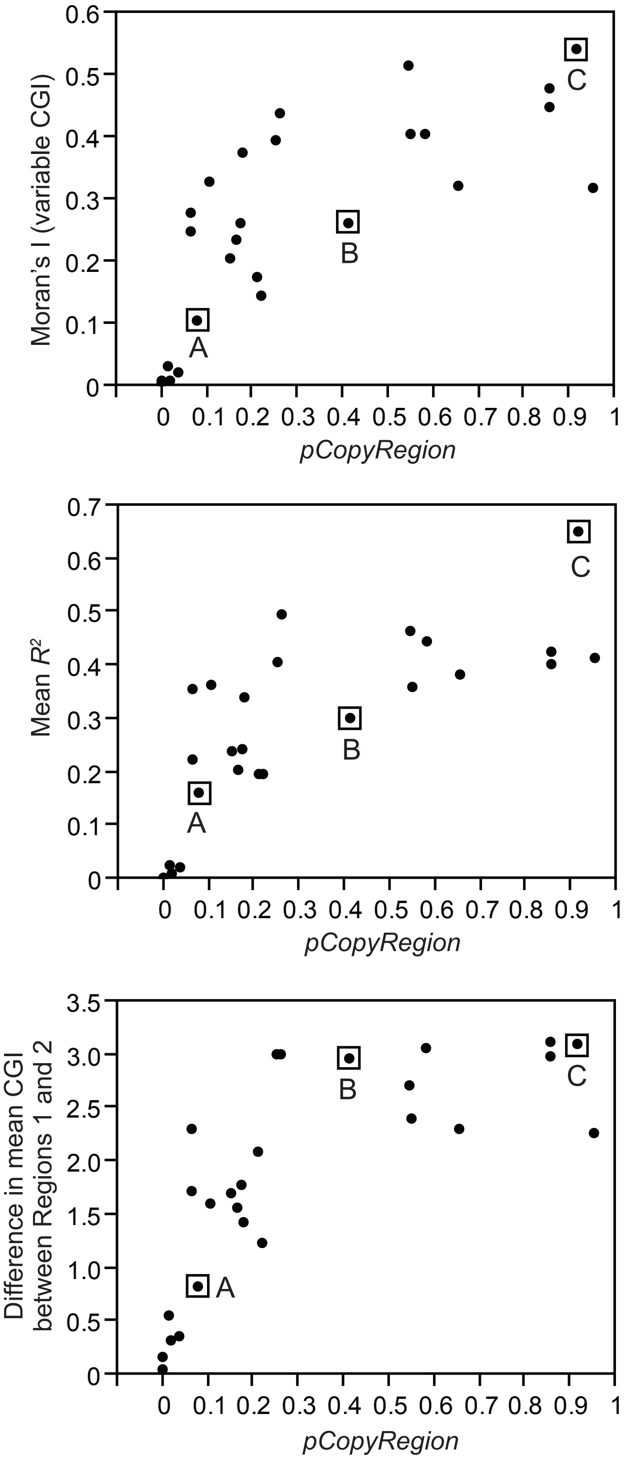


Figure 8.27. Relationships between value of *pCopyRegion* and Moran's I, mean R^2 of north-south and east-west "clines," and difference in mean value of variable CGI in Regions 1 and 2.

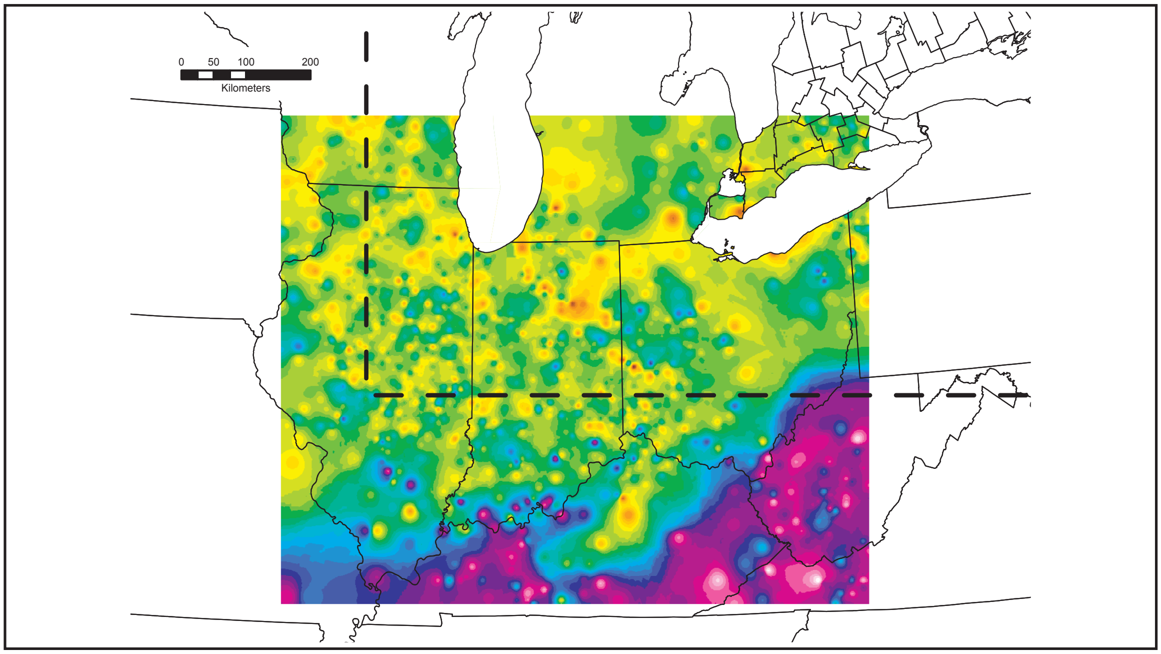


Figure 8.28. Raster image of CGI showing spatial organization of stylistic variability in Experiment 015-05-51-22, run 2 (designated “A” in Figure 8.27; Moran’s I = 0.105; *n* = 2000 tools; “active” boundary where *pCopyRegion* = 0.079). Dashed line is boundary between Regions 1 and 2.

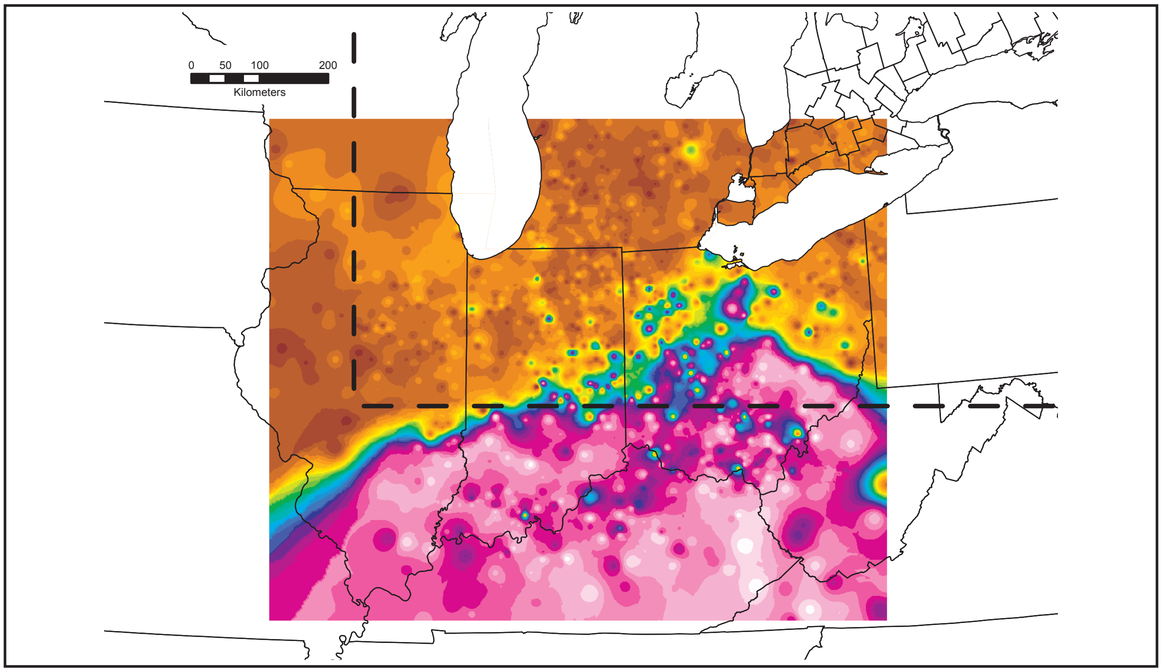


Figure 8.29. Raster image of CGI showing spatial organization of stylistic variability in Experiment 014-07-47-02, run 1 (designated “B” in Figure 8.27; Moran’s I = 0.259; *n* = 2000 tools; “active” boundary where *pCopyRegion* = 0.414). Dashed line is boundary between Regions 1 and 2.

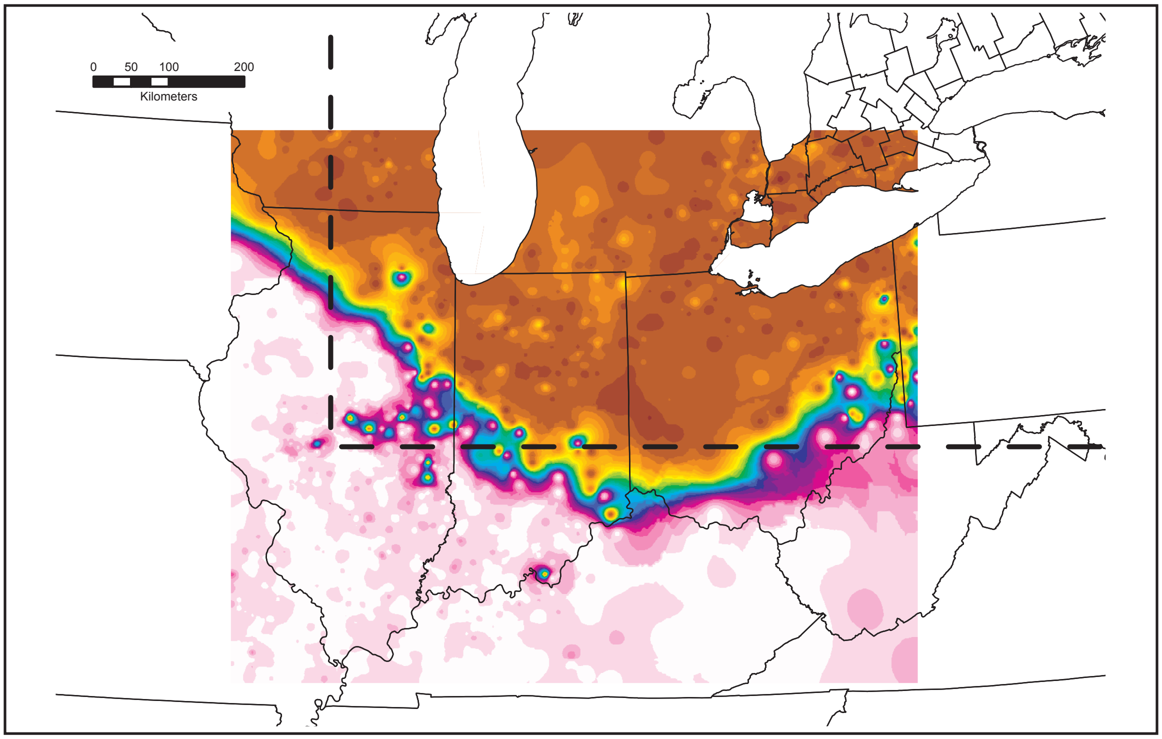


Figure 8.30. Raster image of CGI showing spatial organization of stylistic variability in Experiment 013-13-01-15, run 8 (designated “C” in Figure 8.27; Moran’s I = 0.540; *n* = 2000 tools; “active” boundary where *pCopyRegion* = 0.919). Dashed line is boundary between Regions 1 and 2.

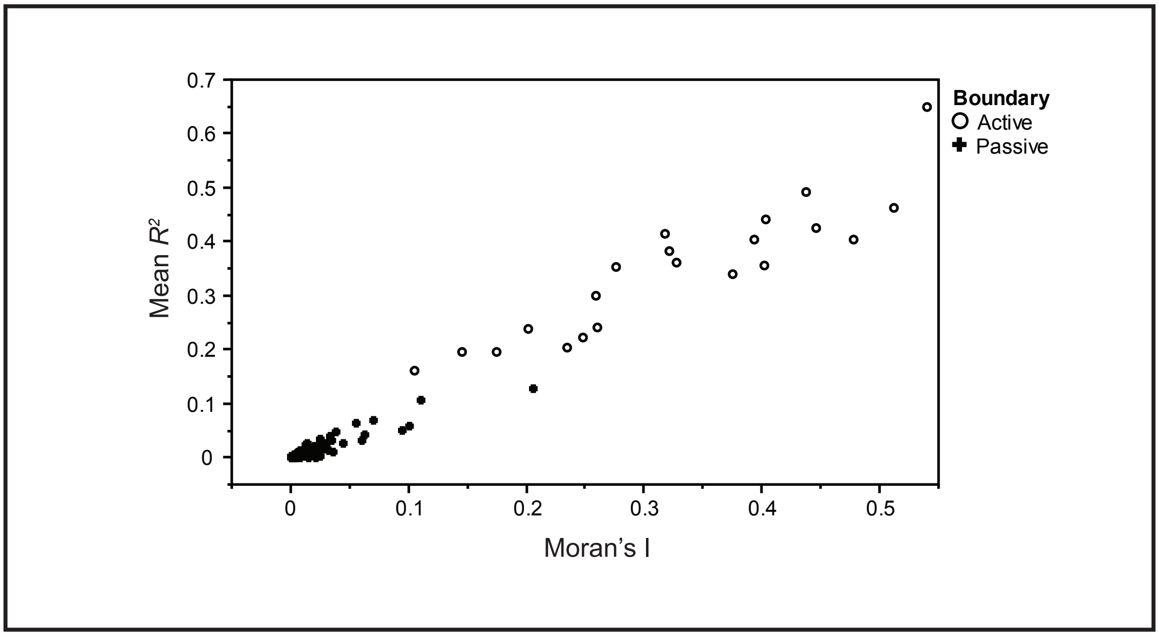


Figure 8.31. Relationship between Moran’s I and the mean R^2 of north-south and east-west clines including both “passive” barriers to interaction and “active” mechanisms of stylistic differentiation.

plots of data from “active boundary” experiments shows that higher values of Moran’s I are associated with stylistic variability that is *discontinuous* rather than continuous across space. Figure 8.32 plots values of CGI vs. UTM northing and easting for the same three example runs shown in Figures 8.28 through 8.30. Histograms of CGI for these three example experiments are shown in Figure 8.33. While lower values of Moran’s I produced by low values of *pCopyRegion* (e.g., example A) are associated with variability that appears continuous across space, higher values of Moran’s I produced by high values of *pCopyRegion* are clearly associated with stylistic variability that exhibits abrupt spatial discontinuities. Very sharp stylistic boundaries between regions are created by stylistic variability that is effectively polarized.

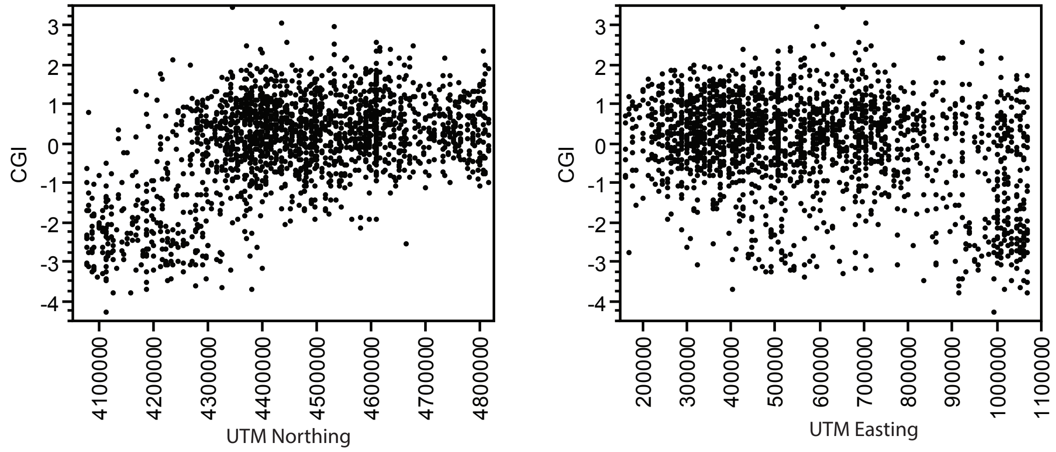
Summary

Significant levels of non-random spatial patterning in stylistic variability have been created in two main contexts in the ForagerNet2 model: (1) agents interacting across “open,” interconnected networks; and (2) agents intentionally using style to create and reinforce differences between regions. In the first case, continuous patterns of spatially-organized variability were produced in the context of inter-connected systems with no “hard” barriers to interaction between regions. Weak clines of variability were produced under all circumstances, regardless of the presence or strength of a barrier to interaction. The strongest clinal/regional patterns emerged when the probability of persons interacting across the regional boundary (i.e., the value of *pBoundaryCross*) was between 0.001 and 0.40. This suggests that a “weak” to “moderate” barrier to interaction may foster the formation of stronger clinal/regional patterns of variability to a greater degree than either a “hard” boundary or the complete absence of any barrier.

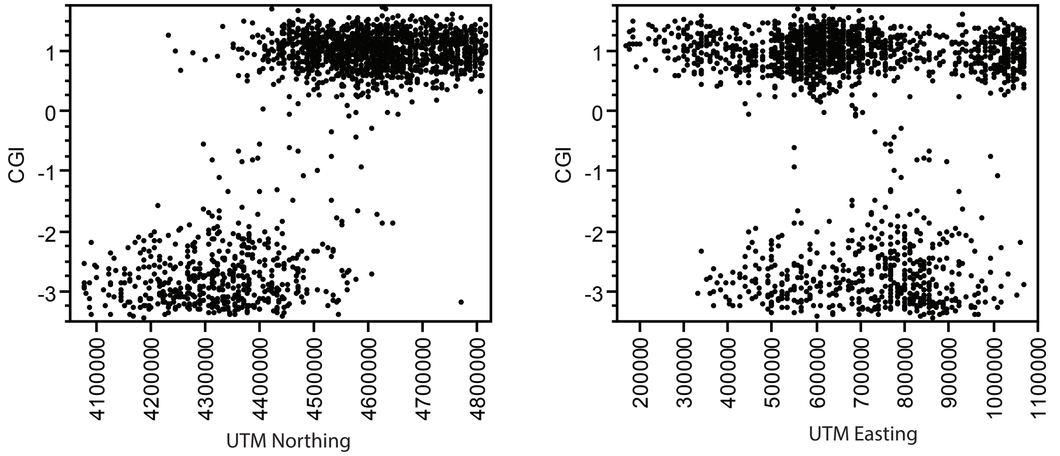
In the second case, “active” mechanisms of stylistic differentiation created patterns of variability that ranged from continuous to discontinuous depending on the value of the parameter *pCopyRegion*. Low values of *pCopyRegion* (e.g., < 0.10) produced continuous patterns of spatially-organized variability that appeared similar to those produced by weak/moderate passive barriers, while high values of *pCopyRegion* produced polarized stylistic regions with sharply demarcated boundaries.

These experiments indicate that there is a zone of overlap in the amount and structure of the spatial organization of stylistic variability produced by

Exp. 015-05-51-22 run 2 (Designated "A" in Figure 8.27)



Exp. 014-07-47-02 run 1 (Designated "B" in Figure 8.27)



Exp. 013-13-01-15 run 8 (Designated "C" in Figure 8.27)

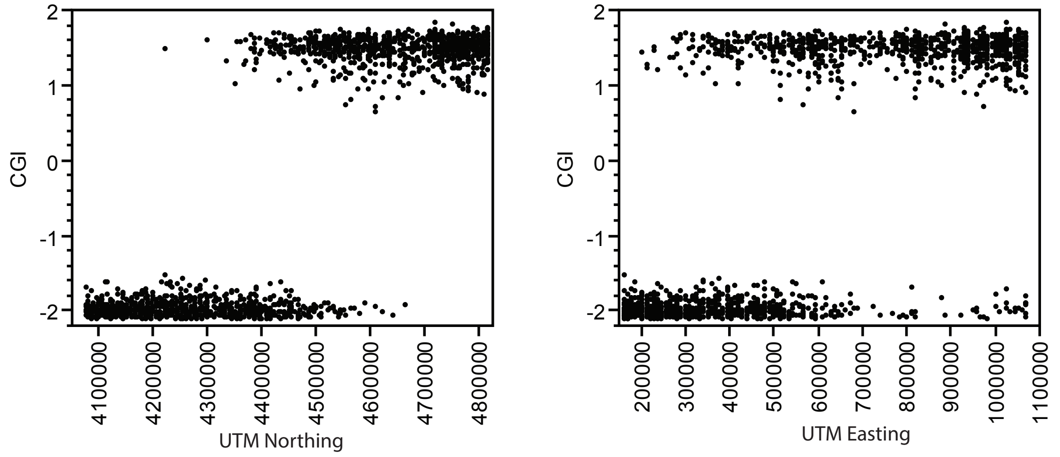
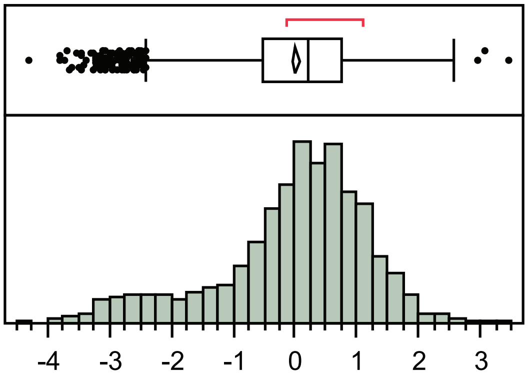
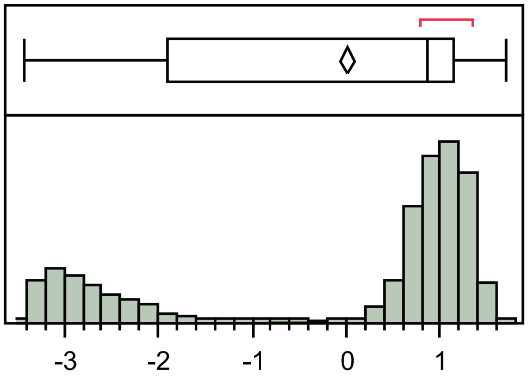


Figure 8.32. North-south and east-west "clines" in variable CGI produced by example runs under conditions of "active" stylistic differentiation.

Exp. 015-05-51-22 run 2 (Designated “A” in Figure 8.27)



Exp. 014-07-47-02 run 1 (Designated “B” in Figure 8.27)



Exp. 013-13-01-15 run 8 (Designated “C” in Figure 8.27)

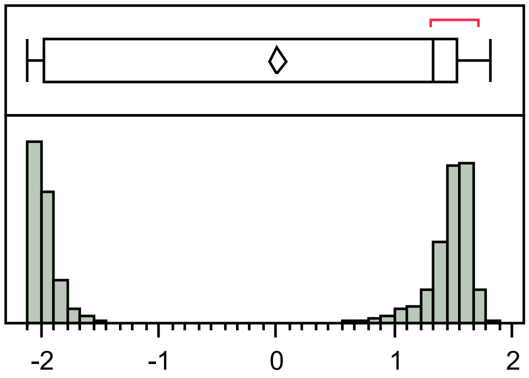


Figure 8.33. Histograms of variable CGI produced by example runs under conditions of “active” stylistic differentiation.

“passive” barriers to interaction and “active” processes of stylistic differentiation. This complicates the investigation of stylistic regionalization in archaeological cases, since the degree and structure of spatially-organized variability alone may not be sufficient to confidently discriminate between these two primary causal mechanisms.

Evaluation of Explanations of Archaeological Change

The main archaeological phenomenon of interest here is the appearance of stylistic regions during the Late Paleoindian period and the subsequent disappearance of those regions during the Early Archaic period. A number of explanations have been proposed for the appearance and disappearance of these stylistic regions (see Chapter 6). The purpose of this section is to compare results from the ForagerNet2 model to the archaeological dataset described in Chapter 7 in order to evaluate these explanations. Discussion will include both general information generated from analyses of model data and results from individual experiments designed to test the plausibility of specific explanatory scenarios.

Scenarios for the Appearance of Stylistic Regions during the Late Paleoindian Period

The stylistic regionalization that occurs during the Late Paleoindian period is recognized by the appearance of more-or-less stylistically distinctive hafted biface “types” (i.e., Hi-Lo and Dalton) that have geographic distributions that are largely non-overlapping (Figure 8.34). The two regions that are apparent when stylistic variability in these Late Paleoindian hafted biface forms is condensed to a single variable (variable EFI) and plotted across space are readily detected/ quantified in GIS by the Moran’s I statistic, which returns a result (Moran’s I = 0.326) much higher than that associated with either the Early Paleoindian or Early Archaic samples.

Consideration of the archaeological data suggests that stylistic variability in the Late Paleoindian period is clinal rather than discontinuous. Figure 8.35 plots the value of variable EFI for each Late Paleoindian hafted biface in the morphometric sample (*n*=287) vs. the UTM easting and northing of the artifact.

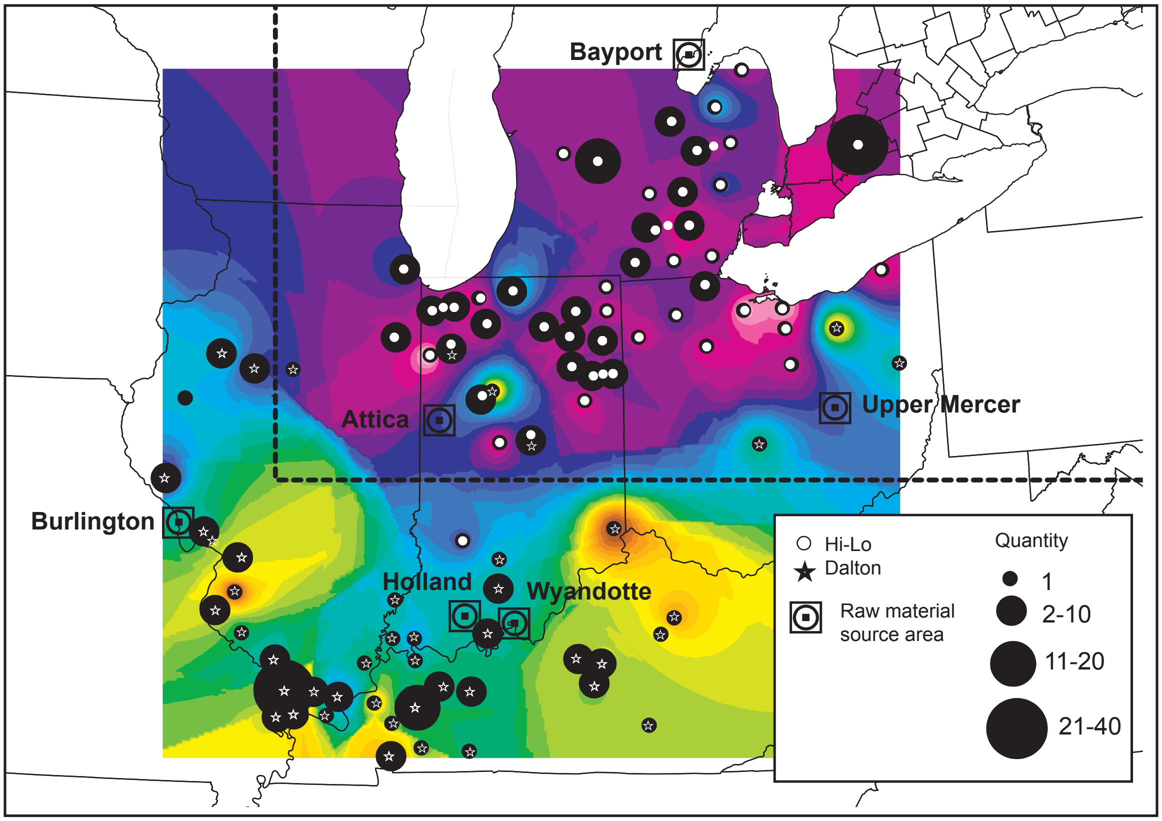


Figure 8.34. Map showing spatial relationship of Hi-Lo and Dalton samples, major raw material source areas, and stylistic regions as represented by raster of variable EFI.

Values of EFI vary continuously across the geographic range of the Hi-Lo/Dalton sample, and it is apparent that in the central portion of the geographic range some points classified variously as Hi-Lo or Dalton are very similar to one another with respect to the value of variable EFI. The stylistic gradient between the two "types" is also apparent when histograms of EFI are compared (Figure 8.36): while points identified as Hi-Lo and Dalton are clearly different at opposite extremes of the EFI distribution, there is significant overlap in the central portion of the distribution.

As discussed in Chapters 6, 7, and above, decreases in mean and maximum raw material transport distances relative to the Early Paleoindian period suggest a general reduction in the scale of group mobility during the Late Paleoindian period.

A potential geographic "gap" between Hi-Lo and Dalton groups was noted based on the spatial distributions of points assigned to the two types and the near total lack of use of the Holland and Upper Mercer chert sources (see

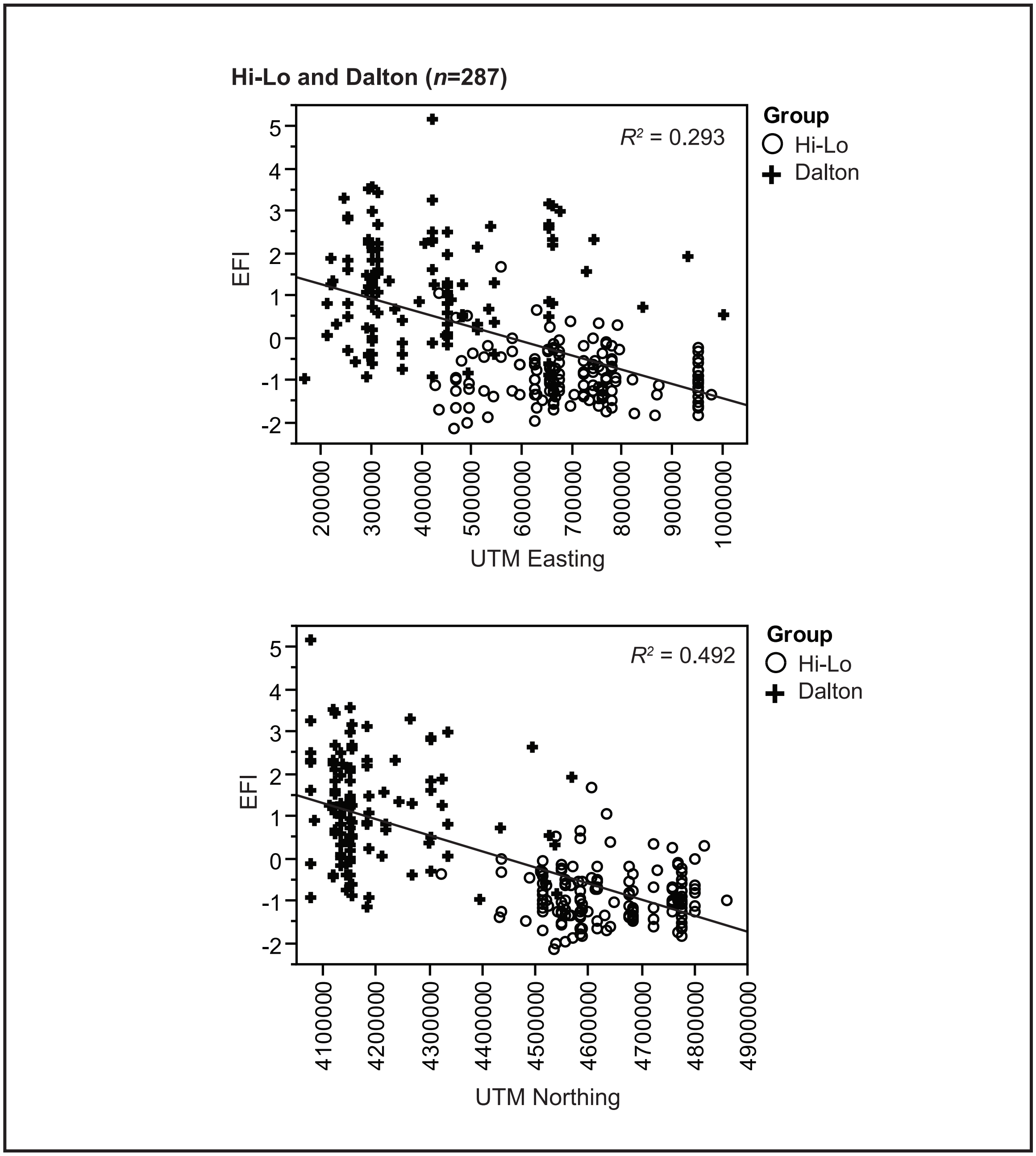


Figure 8.35. North-south and east-west clines in variable EFI, Late Paleoindian sample.

Chapter 7). While the non-systematic nature of the archaeological sample makes it important not to place too much weight on the existence of a spatial separation, it is worth noting that work with archaeological collections from central and southern Indiana and central Ohio was relatively extensive: it seems unlikely that the existence of moderate/high densities of Hi-Lo/Dalton points in these areas would have gone undetected. The perceived spatial gap

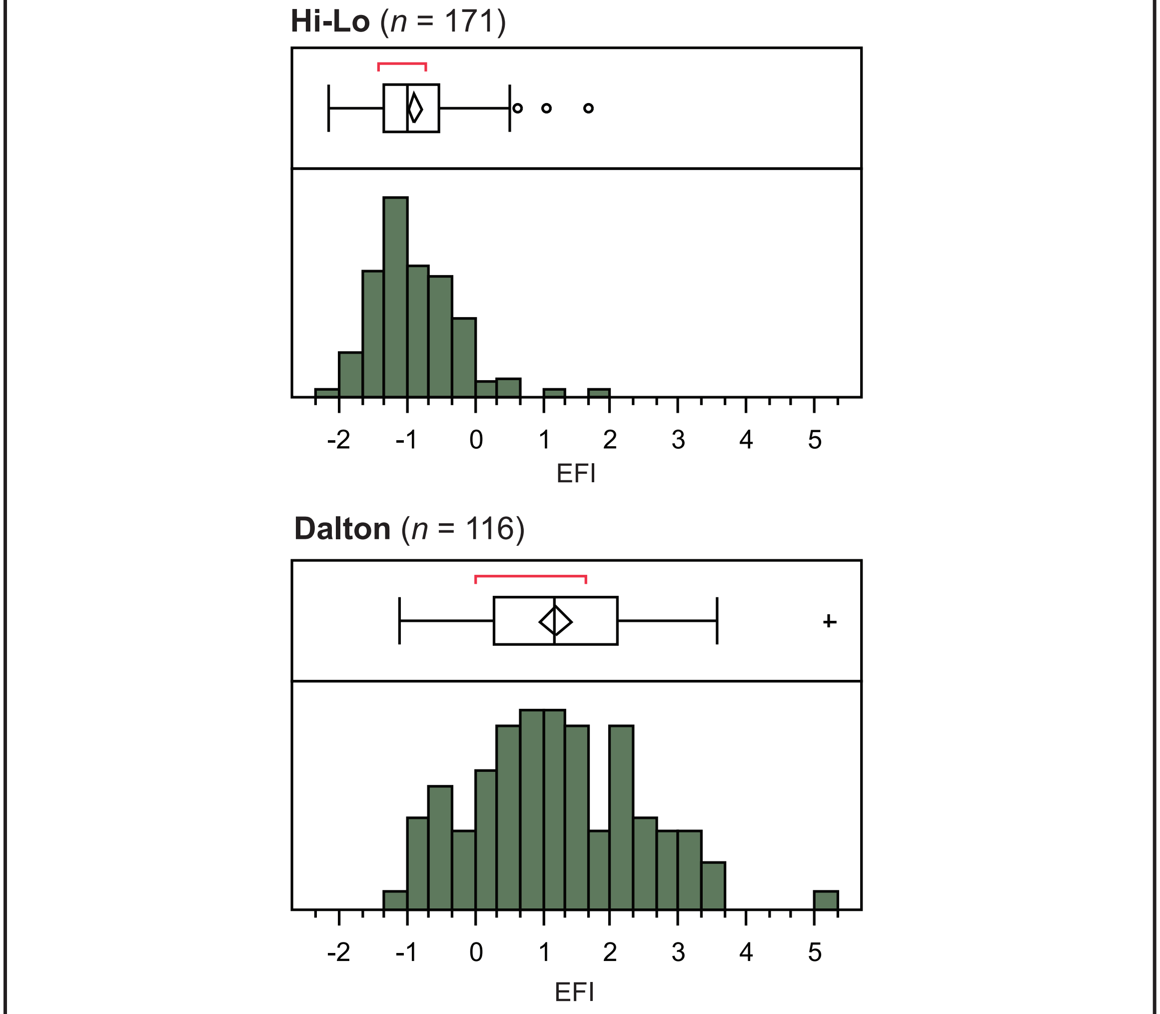


Figure 8.36. Comparison of distributions of variable EFI in the Hi-Lo and Dalton portions of the Late Paleoindian sample.

in the archaeological dataset may be the result of a real geographic separation between the habitual use areas of Hi-Lo and Dalton populations.

The regionalization that appears during the Late Paleoindian period is associated with four characteristics:

1. A significant increase in the spatial organization of stylistic variability (as measured by Moran's I);

2. Stylistic variability that varies continuously across space (i.e., stylistic

clines rather than abrupt discontinuities);

3. A decrease in the scale of raw material transport;

4. A possible geographic "gap" between the habitual use areas of Hi-Lo and Dalton peoples that was sometimes bridged through some mechanism allowing interaction between regions.

As demonstrated above, significant spatial organization of stylistic variability can be produced in the ForagerNet2 model under both "passive barrier" and "active stylistic differentiation" conditions. Both conditions are capable of producing continuous/clinal patterns like those seen in the Late Paleoindian archaeological sample. Thus two main scenarios can be proposed to explain Late Paleoindian stylistic regionalization: (1) a "weak passive barrier" scenario where regional styles emerge in the context of open, interconnected regional systems that are separated by a weak impediment to interaction; and (2) a "weak active differentiation" scenario where regional styles are the result of conscious human behaviors that seek to produce and reinforce a low degree of stylistic differentiation.

The "weak passive barrier" scenario requires the appearance during the Late Paleoindian period of some new feature that impedes but does not halt social interaction between populations in different regions. I propose that a geographic gap between hunter-gatherer population in the Great Lakes and Mississippi/Ohio valleys may have served as a weak passive barrier to interaction, increasing the cost and/or decreasing the frequency of social contacts that bridged the Hi-Lo and Dalton regions. A geographic gap in population could have been caused by reductions in the scale of group mobility in the Late Paleoindian period relative to the Early Paleoindian period if reductions in mobility were not preceded by or concurrent with population increase. If reductions in the scale of mobility preceded absolute increases in population, the need for groups/bands to maintain spatial proximity with a number of other groups/bands for demographic reasons would have precipitated the contraction of hunter-gatherer populations into one or more smaller units of space.

The archaeological data suggest that, within the area under consideration, Late Paleoindian hunter-gatherer populations contracted into major geographic regions: the lower Great Lakes (Hi-Lo) and the Mississippi and Ohio valleys (Dalton). While some areas between these regions do not appear to have been routinely used by either Hi-Lo or Dalton groups, the small number of Dalton points documented in northern Indiana and northern Ohio (see Chapters 6 and 7) suggests that the social systems of Hi-Lo and Dalton groups were not socially disconnected. Spatial gaps precipitated by the contraction of populations into major geographic regions, while an impediment to regular interaction, were bridged by some mechanism that allowed at least sporadic formation/ maintenance of social links. The "weak passive barrier" scenario, then, specifies that reductions in the scale of group mobility preceded increases in population, causing portions of the landscape to be vacated as regional populations contracted to maintain regular contact with neighboring bands.

The "weak active differentiation" scenario specifies that regional styles of hafted bifaces were produced as a result of intentional processes of inter-regional stylistic differentiation. General model results suggest that a relatively low level of "active" stylistic differentiation would be most consistent with the clinal patterns of variability evident in the archeological dataset. Active stylistic differentiation of regional populations presumes inter-regional interaction, both because style serves to send a message about the regional affiliation of an individual to a target population (e.g., Wobst 1977) and because regional populations must have knowledge of style in the target population in order to effectively distinguish themselves. Thus the "active" use of style to signal affiliation is logically associated with continuously distributed populations that are in regular contact with one another.

In contrast to the "weak passive barrier" scenario outlined above, then, the "weak active differentiation" scenario proposed here specifies that population growth preceded or was concurrent with reductions in group mobility. Population growth that "kept pace" with reductions in mobility would have helped maintain regular connectivity between regions by inhibiting the formation of geographic gaps separating regional populations. Note that this "active differentiation" scenario does not require specification of the motivation for inter-regional stylistic differentiation, only that differentiation occurred in the context of inter-connected, spatially adjacent populations.

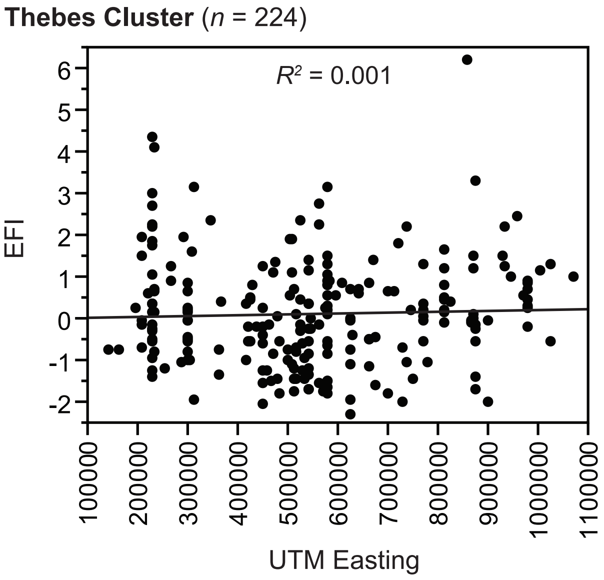
Scenarios for the Disappearance of Stylistic Regions during the Early Archaic Period

The stylistic regionalization that characterizes the Late Paleoindian period is eclipsed by relative stylistic homogeneity during the Early Archaic period. While there is substantial stylistic variability within both the Thebes and Kirk Corner Notched clusters (as formulated by Justice 1987), this variability does not partition spatially with the same degree of exclusivity as that of Hi-Lo and Dalton. This lack of spatial exclusivity is reflected in the relatively low values of Moran's I associated with the spatial distribution of variable EFI in these hafted biface forms (see Chapter 7). Strong indications of clinal variability are present in neither the Thebes nor the Kirk samples (Figures 8.37 and 8.38). Greater mean and maximum raw material transport distances relative to the Late Paleoindian period indicate increases in the scale of group mobility and/or the appearance of some other mechanism (e.g., exchange) that resulted in the long distance transport of raw materials. The continuous spatial distributions of hafted bifaces and use of all major raw material sources in both the Thebes and Kirk samples suggest that significant geographic "gaps" in the habitual use areas of these groups were not present.

Thus the transformation from stylistic regions in the Late Paleoindian period to stylistic homogeneity in the Early Archaic period is associated with four major characteristics:

1. A significant decrease in the spatial organization of stylistic variability (as measured by Moran's I);
2. Significant weakening of the clinal/regional spatial structure of stylistic variability;
3. An increase in the scale of raw material transport;
4. Lack of apparent geographic "gaps" in habitual use areas.

Considered in the context of the "weak passive barrier" scenario proposed above to explain the appearance of stylistic regionalization during the Late Paleoindian period, these characteristics suggest that the simplest explanation for the disappearance of stylistic regions during the Early Archaic period involves removal of a weak/moderate impediment to inter-regional interaction that was a causal factor in producing stylistic regions during the Late Paleoindian period. Assuming this impediment was related to the appearance of a geographic gap in population caused by the contraction of groups into two major geographic areas,



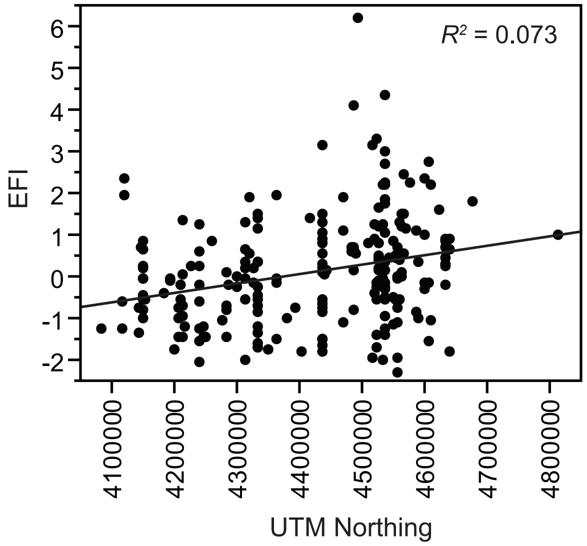


Figure 8.37. North-south and east-west clines in variable EFI, Thebes Cluster sample.

the gap could have been "filled in" by increases in population. If group mobility, aggregation behaviors, and carrying capacity stayed roughly the same from the Late Paleoindian through Early Archaic periods, increases in population would have resulted in the creation of new aggregation sites through band-level fission. Establishment of new aggregation sites eventually would "fill in" previously vacant areas of the landscape, erasing any geographic barriers to communication by

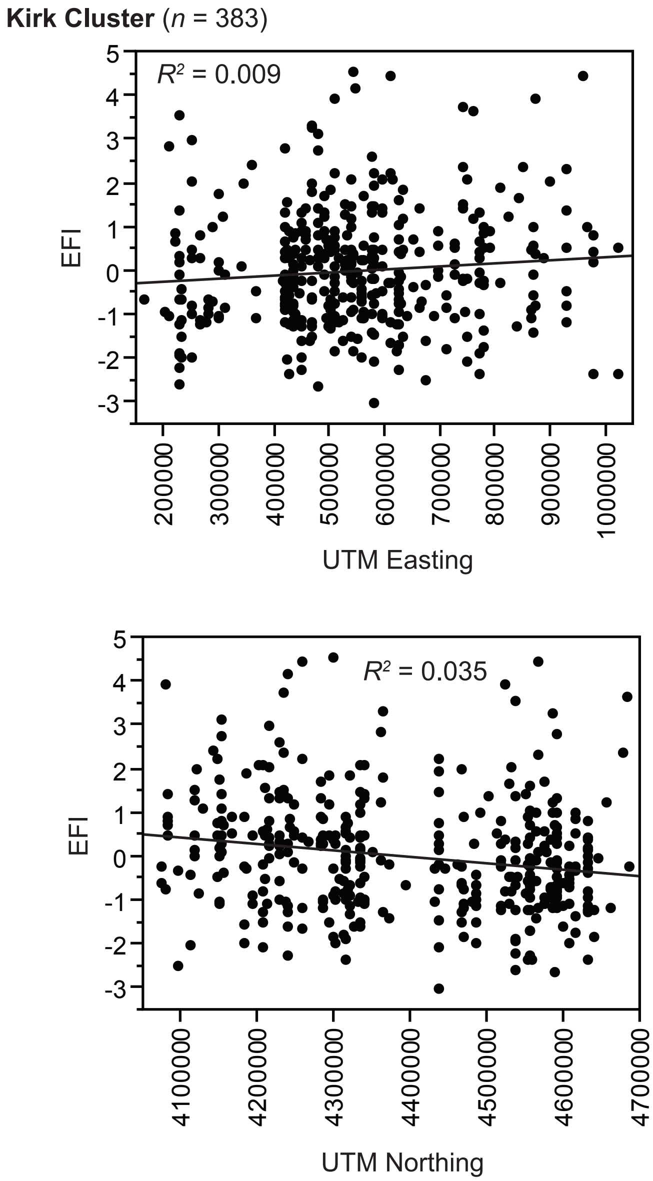


Figure 8.38. North-south and east-west clines in variable EFI, Kirk Cluster sample.

bringing elements of regional populations back into routine contact with one another. Based on the model results discussed above, the disappearance of a weak/moderate impediment to interaction would be expected to reduce the spatial organization of variability.

This scenario depends on increases in population to occupy areas of the landscape that were largely vacant during at least part of the Late Paleoindian period. Population increases associated with the Paleoindian-Early Archaic transition have been suggested by many researchers (e.g., Anderson 1995, 2005; Koldehoff and Walthall 2009; Munson 1986; Seeman 1994). Increases in population by the Early Archaic period are inferred from increases in numbers of sites and lost/discarded hafted bifaces dating to the Early Archaic period relative to the Paleoindian period. The commonness of Early Archaic points relative to Paleoindian points is reflected in the size of Thebes and Kirk samples in the present dataset (there is no doubt that these point types are significantly more common than any point types dating to the Paleoindian period). Further, it is apparent that Thebes and Kirk points were lost/discarded across the midcontinent in a wide variety of topographic settings, suggesting these groups were making regular use of almost all parts of the landscape in all parts of the Midwest (e.g., Munson 1986; Stafford 1994).

As discussed above, the Thebes and Kirk datasets suggest increases in the scale of transport of raw materials relative to the Late Paleoindian period. These increases may or may not have been associated with an increase in the scale of group mobility: it is plausible that the very long distance transport of a relatively small number of artifacts was the result of some mechanism other than group mobility (i.e., exchange). Because mechanisms for exchange are not currently represented in the ForagerNet2 model, explanations for raw material transport patterns involving exchange cannot be evaluated using model data. If exchange was a factor in increasing both the mean and maximum scales of raw material transport in the Early Archaic samples, then it is possible that group mobility behaviors stayed roughly the same during the Late Paleoindian and Early Archaic periods.

Experiments Evaluating Explanatory Scenarios

Specific model experimentation can be used to evaluate the plausibility of the explanatory scenarios discussed above. The changes evident in the archaeological data can be compared to results from individual experiments representing sequences of changes in mobility, population density, social learning behaviors, and “active” mechanisms of stylistic differentiation.

All the experiments discussed here were run at Scale 4 (see Chapter 4), a scale with a “world” that was 1700 km x 1700 km in size. Experiments at this scale representing a sequence of all three time periods required considerable time and computational resources to perform. These requirements limited the number of experiments that could be performed prior to the completion of this dissertation. The data discussed below include results both from experiments that were completed and experiments that were not completed at the time of analysis. While the available data are sufficient for some evaluation and discussion of scenarios explaining stylistic regionalization, they are less so for scenarios explaining stylistic homogenization. Discussion of homogenization will necessarily be more limited than discussion of regionalization.

A summary of key experimental settings is provided in Table 8.6. Note that the settings used for T1 were the same in all experiments: mobility setting = B; population density = 0.001; *pBoundaryCross* = 1; *pCopyGroup* = 0.10; *pCopyRegion* = 0; search radius for inter-band marriage (*iBMR*) = 1x mean annual range.

The settings for T2 in the experimental runs represent a range of conditions which have been hypothesized to enable or prevent stylistic regions from emerging from a state of relative homogeneity. In all cases, mobility in T2 was reduced from setting B to setting D. The strength of a barrier to interaction between Regions 1 and 2, imposed following T1, was controlled by the value of *pBoundaryCross* (*pBC* in Table 8.6). The strength of "conformance bias" was controlled by the value of *pCopyGroup* (*pCG*), set at either 0.10, 0.50, or 1 for T2. The strength of "active" mechanisms of stylistic differentiation was controlled by the value of *pCopyRegion* (*pCR*), which was set at 0, 0.20, or 1. Population

Table 8.6. Summary of T2 and T3 Settings for Experiments Discussed in the Text.

Experiment	***n* Runs**	**T2**						**T3**					
		Mob.	**Pop. Dens.**	***pBC***	***pCG***	***pCR***	**iBMR**	**Mob.**	**Pop. Dens.**	***pBC***	***pCG***	***pCR***	***iBMR***
001-21-07-04	3	D	0.002	0	1	0	2x	B	0.002	1	0.10	0	2x
002-09-06-36	3	D	0.001	0	1	0	2x	B	0.002	1	0.10	0	2x
003-12-30-35	2	D	0.002	0	0.10	1	2x	B	0.002	1	0.10	0	2x
004-06-11-04	3	D	0.001	1	0.10	0	2x	B	0.002	1	0.10	0	2x
005-06-15-05	3	D	0.002	1	0.10	0	2x	B	0.002	1	0.10	0	2x
006-11-21-30	3	D	0.001	0.25	0.50	0	2x	B	0.002	1	0.10	0	2x
007-11-30-21	3	D	0.002	0.25	0.50	0	2x	B	0.002	1	0.10	0	2x
008-18-48-01	3	D	0.002	0.25	0.50	0	2x	B	0.002	1	0.10	0	1x
009-13-02-27	4	D	0.001	0.25	0.50	0	1x	D	0.002	1	0.50	0	2x
010-05-47-33	4	D	0.002	1	0.10	0.20	2x	D	0.002	1	0.10	0	2x
011-06-33-39	4	D	0.001	0.25	0.50	0	2x	D	0.002	1	0.50	0	2x
012-06-44-43	4	D	0.002	1	0.10	0.20	2x	D	0.002	1	0.50	0	2x

density increased from 0.001 to 0.002 persons/km^2 between T1 and T2 in some runs and between T2 and T3 in others. Increase in population density was achieved by doubling the carrying capacity from that associated with T1 (where the population density was always 0.001 persons/km^2).

Settings in T3 represent several conditions of mobility and conformance bias. Population density in T3 was always 0.002 persons/km^2 and *pBoundaryCross* was always 1 (i.e., there was no imposed impediment to interaction between regions). Mobility in T3 was either B or D. The value of *pCopyGroup* was either 0.10 or 0.50.

Regionalization. The settings for T1 produced a relatively homogenous state that provides a reasonable representation of artifact variability during the Early Paleoindian period. Measures of the spatial organization of artifact variability (Moran's I and mean R^2 of north-south and east-west clines) are low in samples of size 2000 and samples of size 117 (i.e., matching the size of the Early Paleoindian sample). The Early Paleoindian sample falls comfortably in the range of values produced by model runs (Figure 8.39). In all cases, over 98 percent of social paths were found during T1. Histograms of Moran's I for the T1

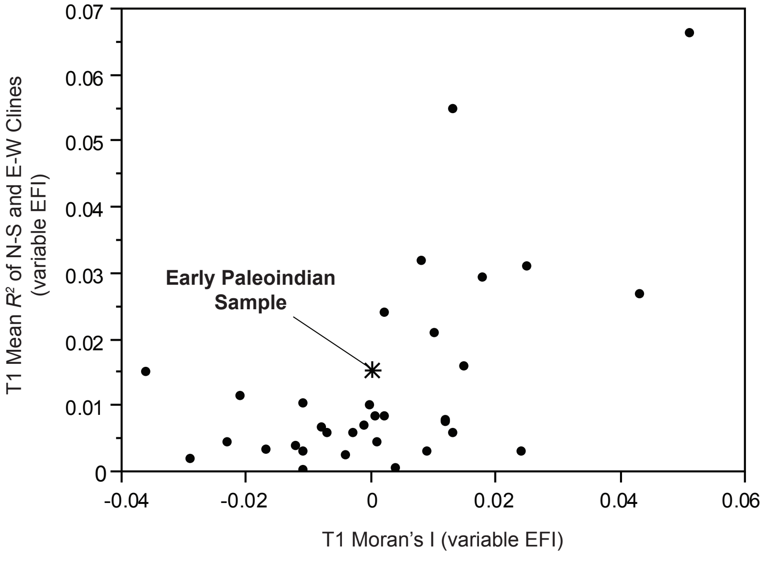


Figure 8.39. Plot of values of Moran's I and mean R^2 of north-south and east-west clines produced during T1 of model experiment runs. Values associated with Early Paleoindian sample shown for comparison.

samples are shown in Figure 8.40. The spread of outcomes is larger when the smaller samples matching the size of Early Paleoindian sample are considered.

Changes implemented between T1 and T2 (see Table 8.6) produced a range of values of Moran's I during T2. Values of Moran's I higher than any produced during T1 (i.e., I > 0.051) were produced in 11 of the 33 runs considered here (Figure 8.41). These cases represent scenarios where the changes instituted between T1 and T2 were associated with an increase in the degree of spatial organization of stylistic variability above that which was produced by T1 conditions. Five of these runs were conditions of "active" stylistic differentiation: "strong" in the case of Experiment 003 (*pCopyRegion* = 1), "weak" in the case of Experiment 010 (*pCopyRegion* = 0.20). The remainder of the runs producing significant spatial organization of stylistic variability were "weak passive barrier" runs (experiments 006, 007, 009, and 011).

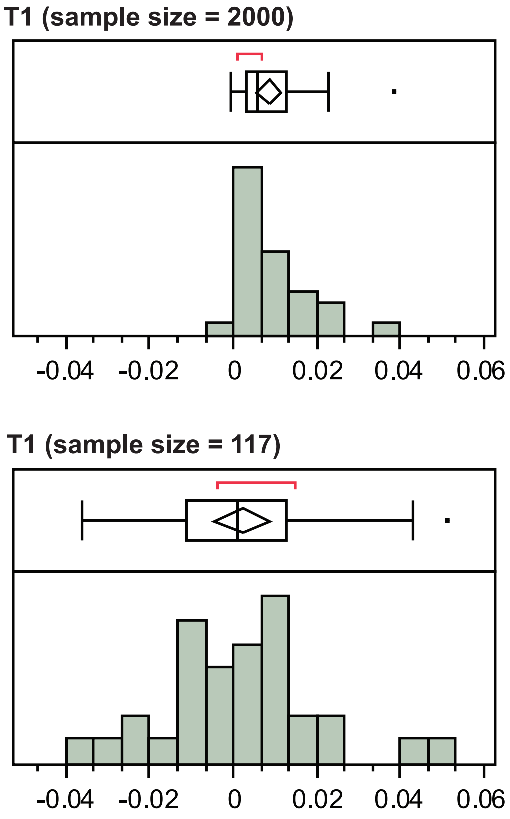


Figure 8.40. Histograms of Moran's I produced during T1 for samples of size 2000 (top) and 117 (bottom).

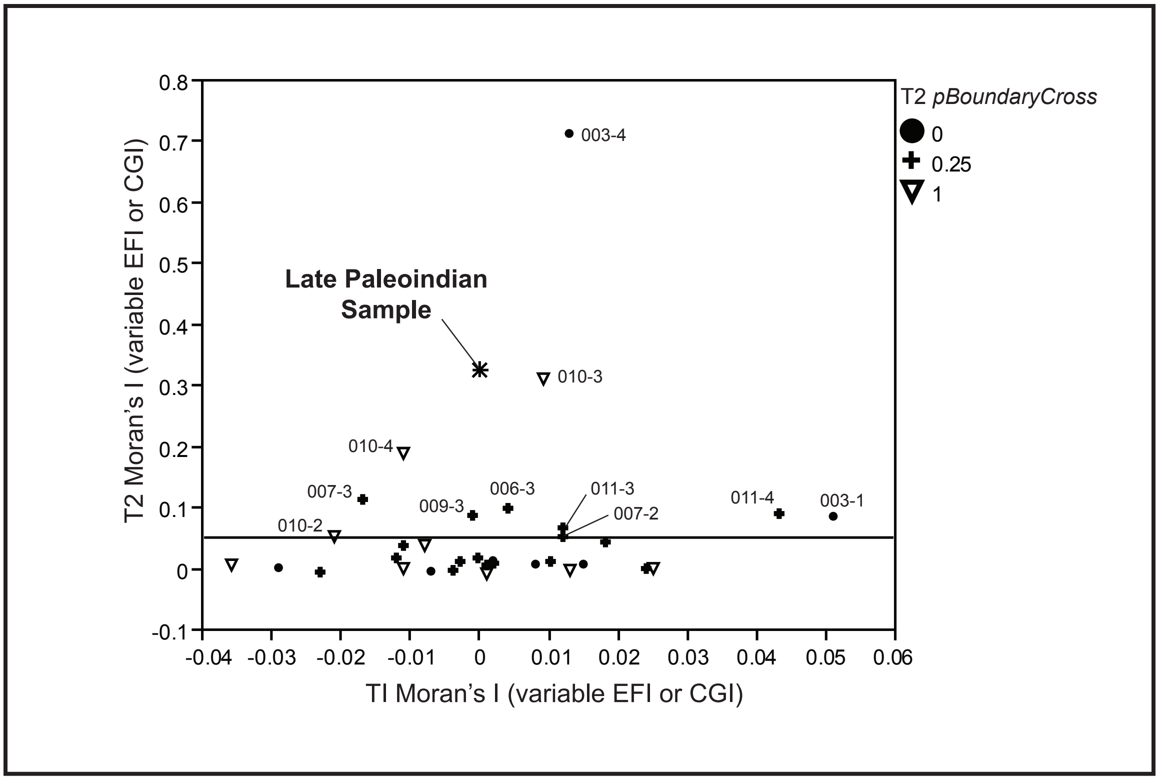


Figure 8.41. Plot of Moran's I produced in T1 vs. Moran's I produced in T2. Results above the horizontal line (at 0.051 on the Y axis) are higher values of Moran's I for T2 than any of the runs produced in T1. Numbers designate experiment and run in Table 8.6 (e.g, 007-3 refers to Experiment 007-11-30-21, run 3).

Run 4 of Experiment 003 produced the highest value of Moran's I (0.707). A raster image of the data from this run (sample size of 287 to match the size of the Late Paleoindian sample) shows the very strong stylistic regions that were produced during T2 as well as a large spatial gap in population (Figure 8.42A). In this run, population density did not change between T1 and T2, so populations contracted when mobility was reduced. Gaps in population are more evident when the sample of 2000 artifacts is considered (Figure 8.42B). The presence of Regions 1 and 2 in the model affect population contraction because aggregation sites only adjust their locations (i.e., moving closer or farther to adjacent aggregation sites) with respect to other aggregation sites that are in the same region. This encourages populations to contract into the two different regions when group mobility is reduced.

Data from run 3 of Experiment 010 are shown in Figure 8.43. The "weak" active stylistic differentiation in this run clearly produced a very sharp stylistic boundary between the regions. Fewer gaps in population are evident (compare

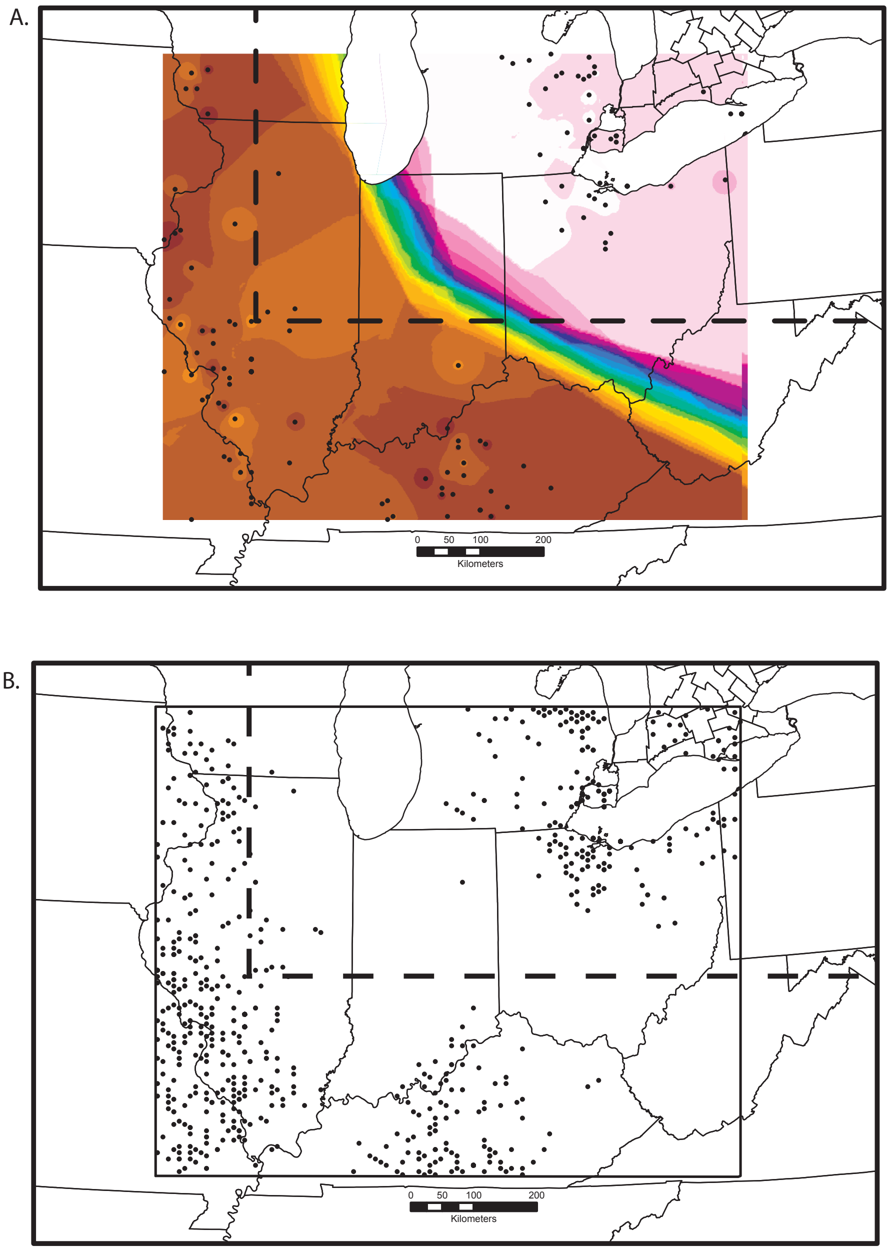


Figure 8.42. Model data from a run with conditions of “active” stylistic differentiation during T2 (Experiment 003, run 4). Raster image of variable CGI from archaeological-size sample (*n* = 287) (A); locations of discarded tools (*n* = 2000) showing spatial gaps in distribution of population during T2 (B).

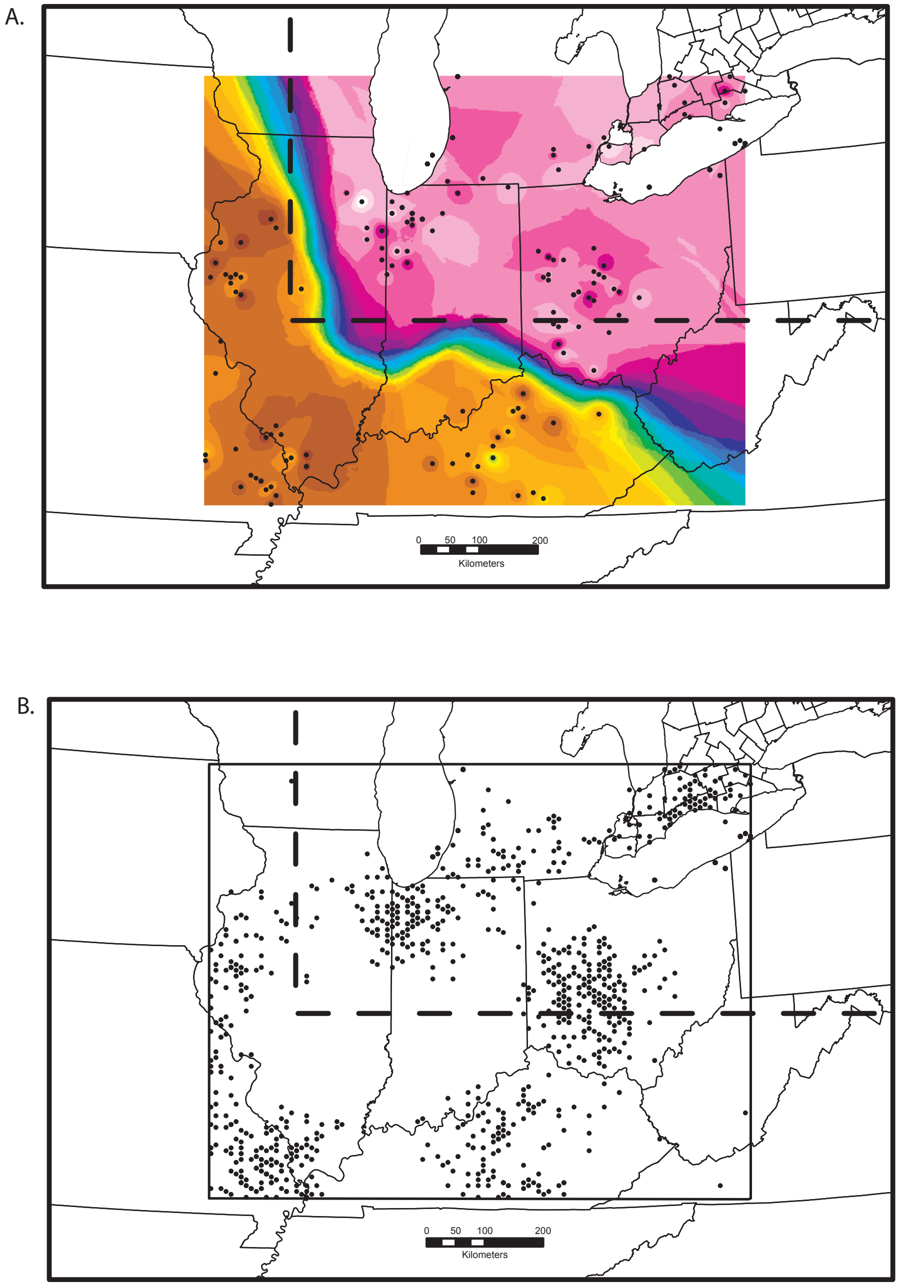
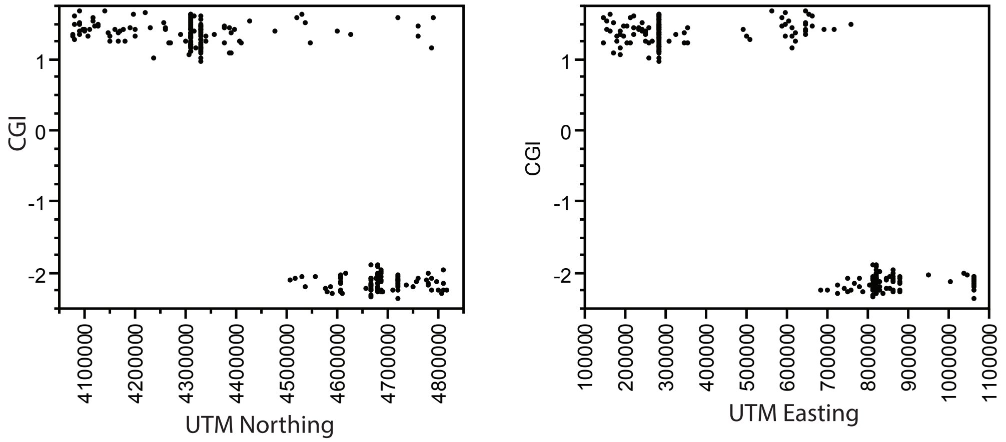


Figure 8.43. Model data from a run with conditions of “active” stylistic differentiation during T2 (Experiment 010, run 3). Raster image of variable CGI from archaeological size sample (*n* = 287) (A); locations of discarded tools (*n* = 2000) showing spatial gaps in distribution of population during T2 (B).

Figures 8.43B and 8.42B), as the population density increased to 0.002 at the between T1 and T2 in this run.

Examination of plots of CGI (variables C, G, and I flattened into a single stylistic variable using principal components analysis) vs. UTM northings and eastings in the two example “active” runs shows that stylistic variability in these cases is polarized by region rather than being continuously variable across space (Figure 8.44). This is unlike the spatial structure of variability seen in the Late Paleoindian sample (see Figure 8.35).

The value of *pBoundaryCross* was set to 0.25 for T2 in all the “weak


Experiment 003, run 4: Strong “active” stylistic differentiation

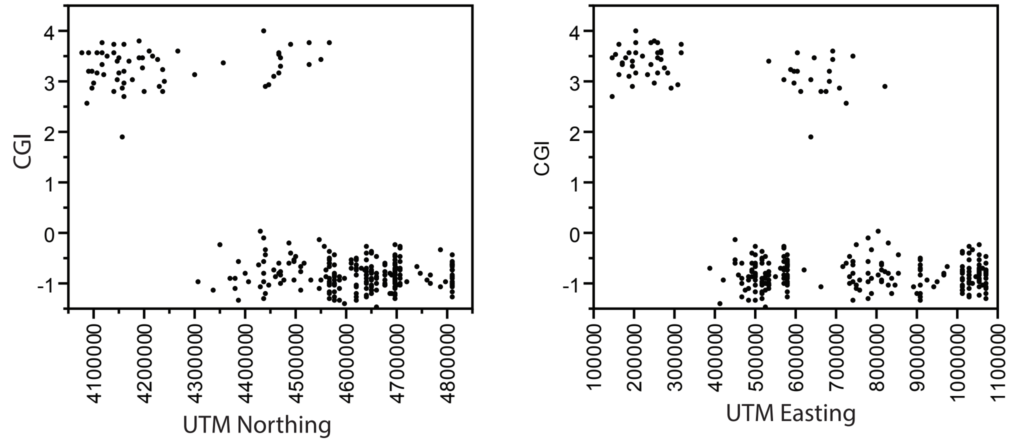

Experiment 010, run 3: Weak “active” stylistic differentiation

Figure 8.44. Examples of north-south and east-west distributions of variable CGI produced during T2 under conditions of strong “active” stylistic differentiation (top) and weak “active” stylistic differentiation (bottom) (*n* = 287).

passive barrier" runs that produced significant spatial organization of variability. Data from run 4 of Experiment 011 are shown in Figure 8.45. It appears that the distribution of population, rather than the imposed impediment to inter-regional interaction, was the genesis of spatially organized stylistic variability (i.e, the coherent "zones" of style appear to correspond more closely to patches of population rather than to the regions). Variability in EFI is continuous across space in this run (Figure 8.46), appearing reasonably similar to the Late Paleoindian sample (compare to Figure 8.35).

Available data suggest there is no relationship between the percentage of social paths found during T2 and the degree of spatial organization of stylistic variability (Figure 8.47). While the presence of a "hard" boundary between Regions 1 and 2 (*pBoundaryCross* = 0) produced disconnected systems where only between 35 and 65 percent of the social paths could be found, these runs did not produce any greater spatial organization of stylistic variability than during T1, when all or nearly all social paths could be found.

Homogenization. Changes in combinations of settings implemented at the beginning of T3 (i.e., step 31201) in various runs include increases in population density, changes in mobility, and changes in "conformance bias" (see Table 8.6). In all cases, the onset of T3 included removal of any "passive" barriers to interaction imposed by a value of *pBoundaryCross* less than 1 and any "active" mechanisms of stylistic differentiation represented by a value of *pCopyRegion* greater than 0.

Eight of the experiments listed in Table 8.6 progressed to the point where data were produced during the T3 data recording period. In all of these cases, no significant stylistic regionalization was apparent in T3 (Figure 8.48). In only one of the runs (Experiment 009, run 3) was there significant spatial organization of stylistic variability during T2: this is the only run that has the potential to tell us something about homogenization from a regionalized state. Data from this run are shown in Figures 8.49, 8.50, and 8.51.

The pattern of change in Moran's I from T1 to T2 to T3 is similar to that seen in the archaeological data (see Figure 8.49, top). The bottom portion of Figure 8.49 shows the population and the number of inter-regional links plotted against time. The number of inter-regional links (social links extending between Region 1 and Region 2) varies widely during T1 even as the population remains relatively steady. Following a reduction in the scale of mobility between T1

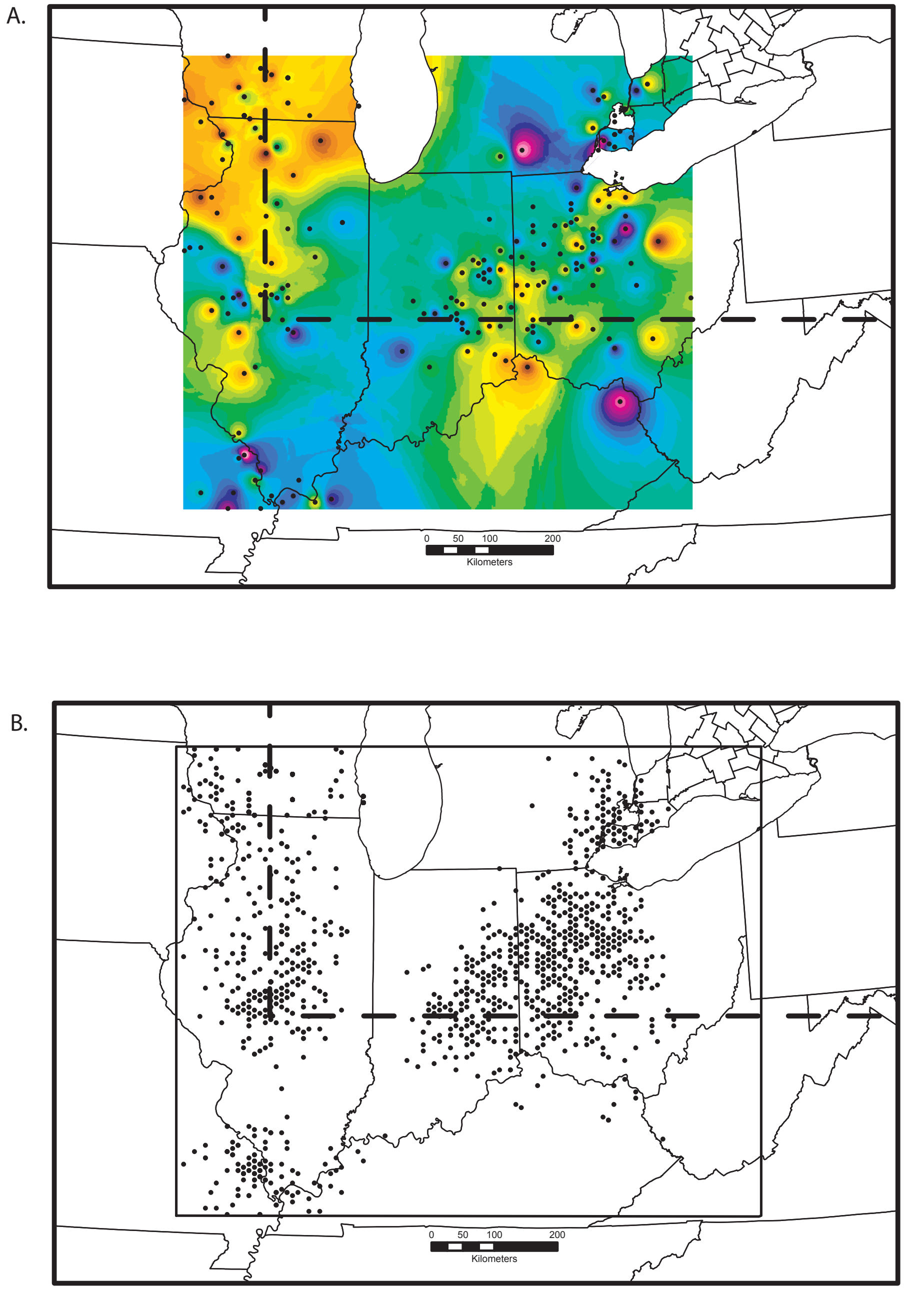


Figure 8.45. Model data from a run with conditions of a weak “passive” barrier during T2 (Experiment 011, run 4). Raster image of variable EFI from archaeological size sample (*n* = 287) (A); locations of discarded tools (*n* = 2000) showing spatial gaps in distribution of population during T2 (B).

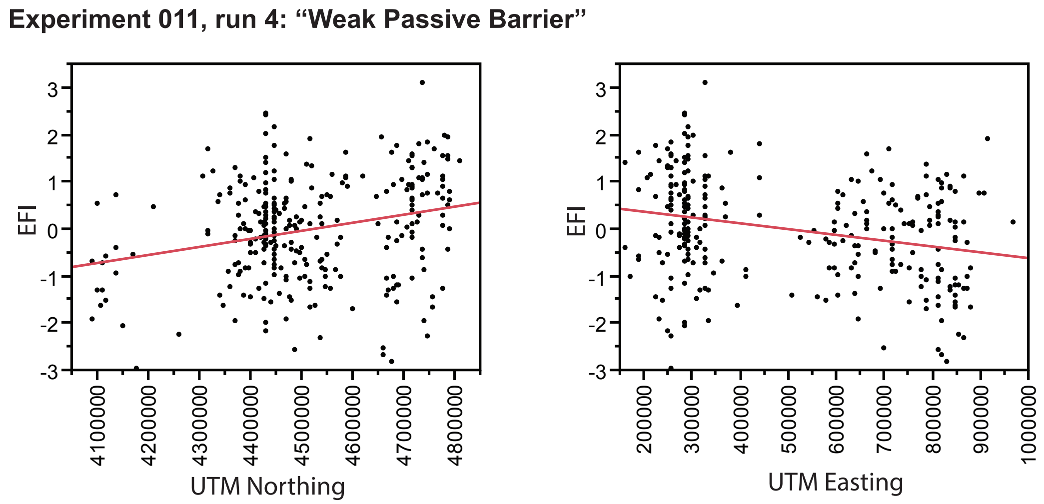

Experiment 011, run 4: “Weak Passive Barrier”

Figure 8.46. North-south and east-west “clines” in variable EFI produced during T2 under “weak passive barrier” conditions.

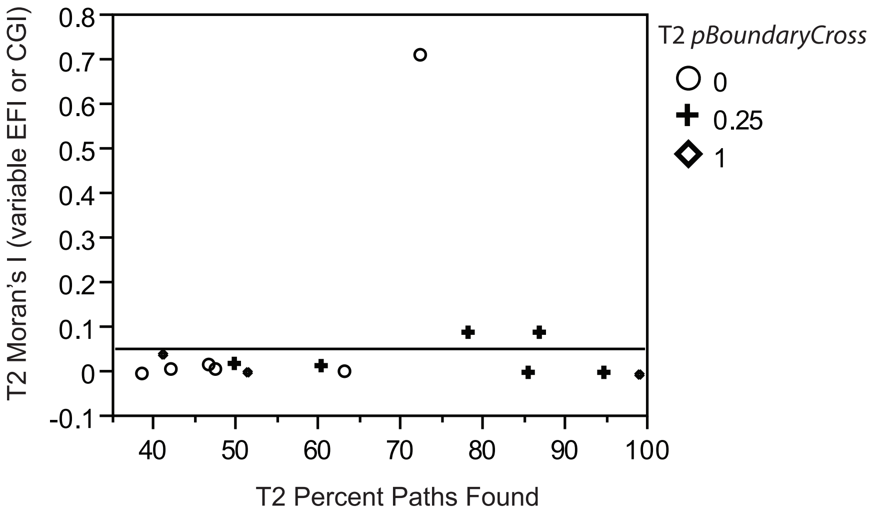


Figure 8.47. Relationship between the percentage of social paths found during T2 and the value of Moran’s I from artifact assemblages produced during T2.

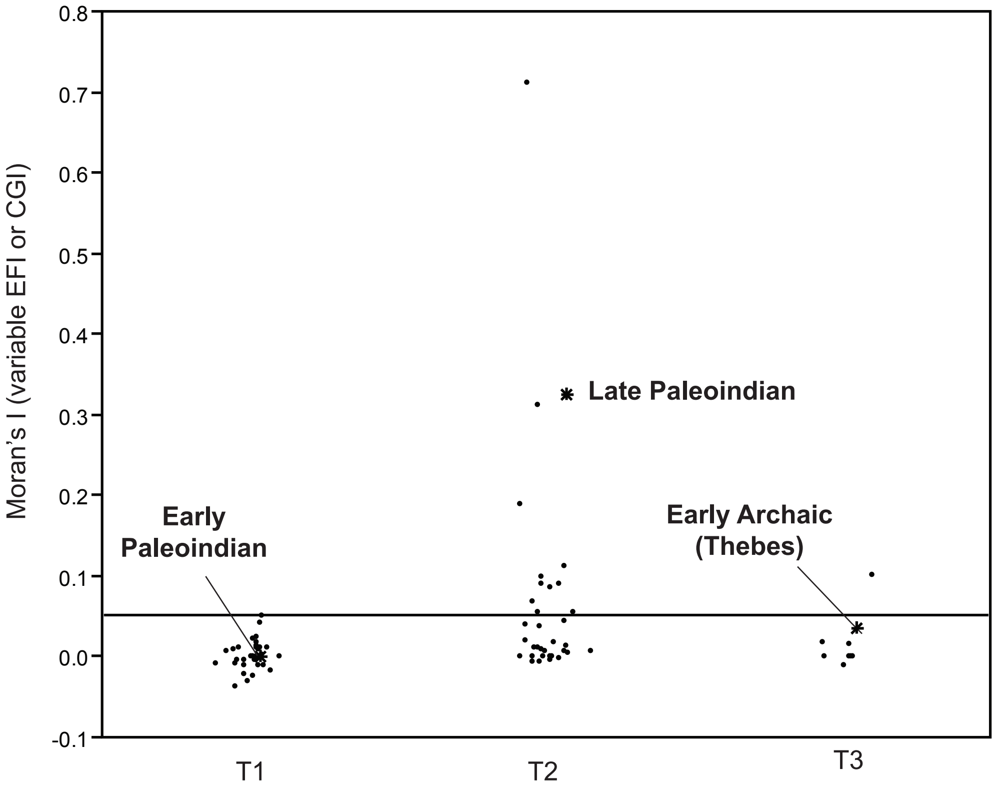


Figure 8.48. Values of Moran's I produced during T1, T2, and T3 in relation to values associated with Early Paleoindian, Late Paleoindian, and Early Archaic samples.

and T2, the number of inter-regional links drops precipitously. This occurs as persistent gaps develop in the spatial distribution of the population (see Figure 8.50). While the number of inter-regional links remains relatively low during T2, there is some variability. This was probably caused by fluctuations in the spatial contiguity of populations as bands fissioned and aggregation sites were repositioned to maintain spacing. The system remained largely inter-connected during this time, with about 87 percent of social paths found. The number of inter-regional links begins to rise as the population grows during T3, even though the landscape apparently does not "fill up." Histograms of source-to-discard distance for lost/discarded tools illustrate the mobility-linked differences in raw material transport in T1, T2, and T3 (Figure 8.51).

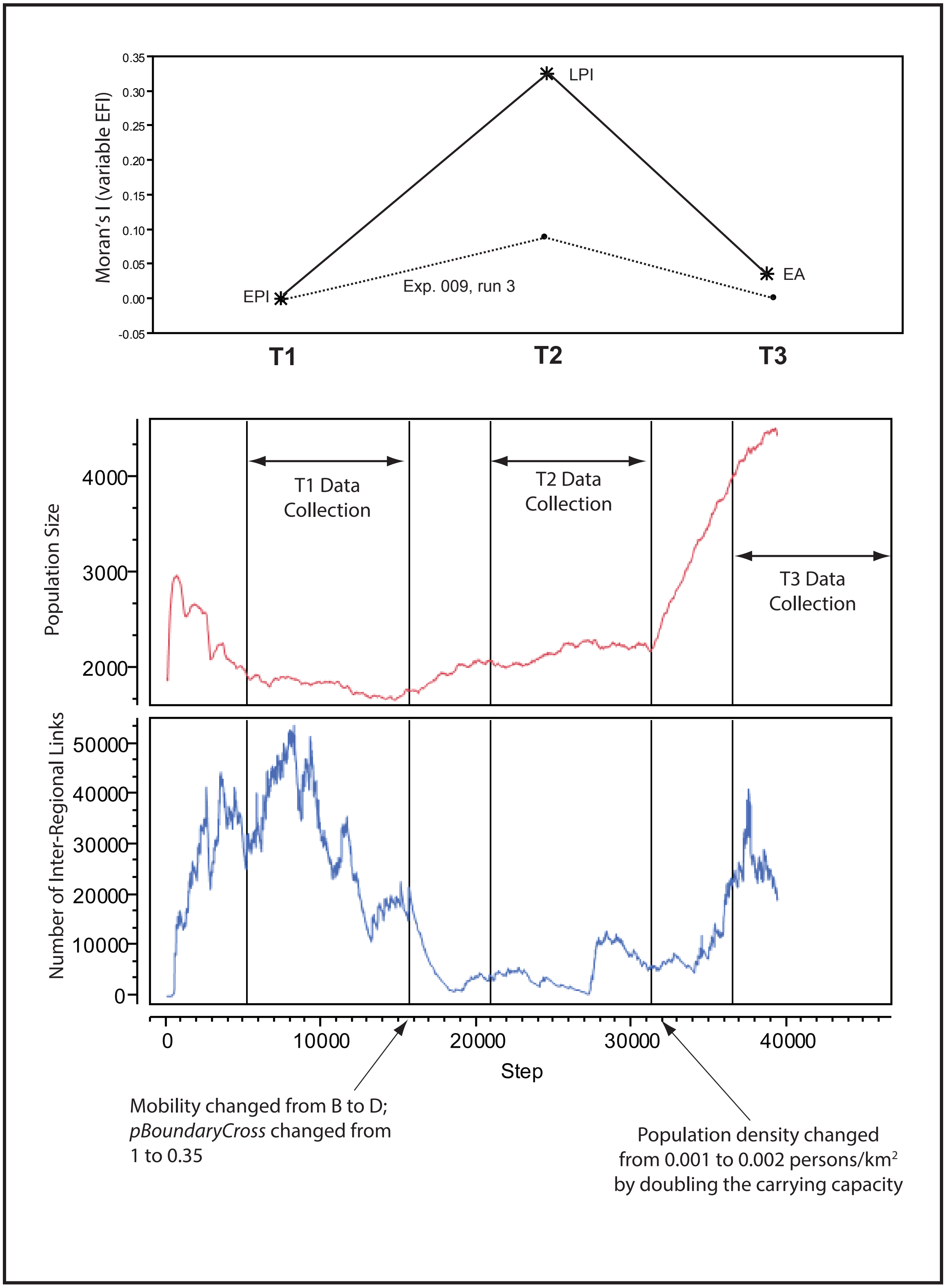
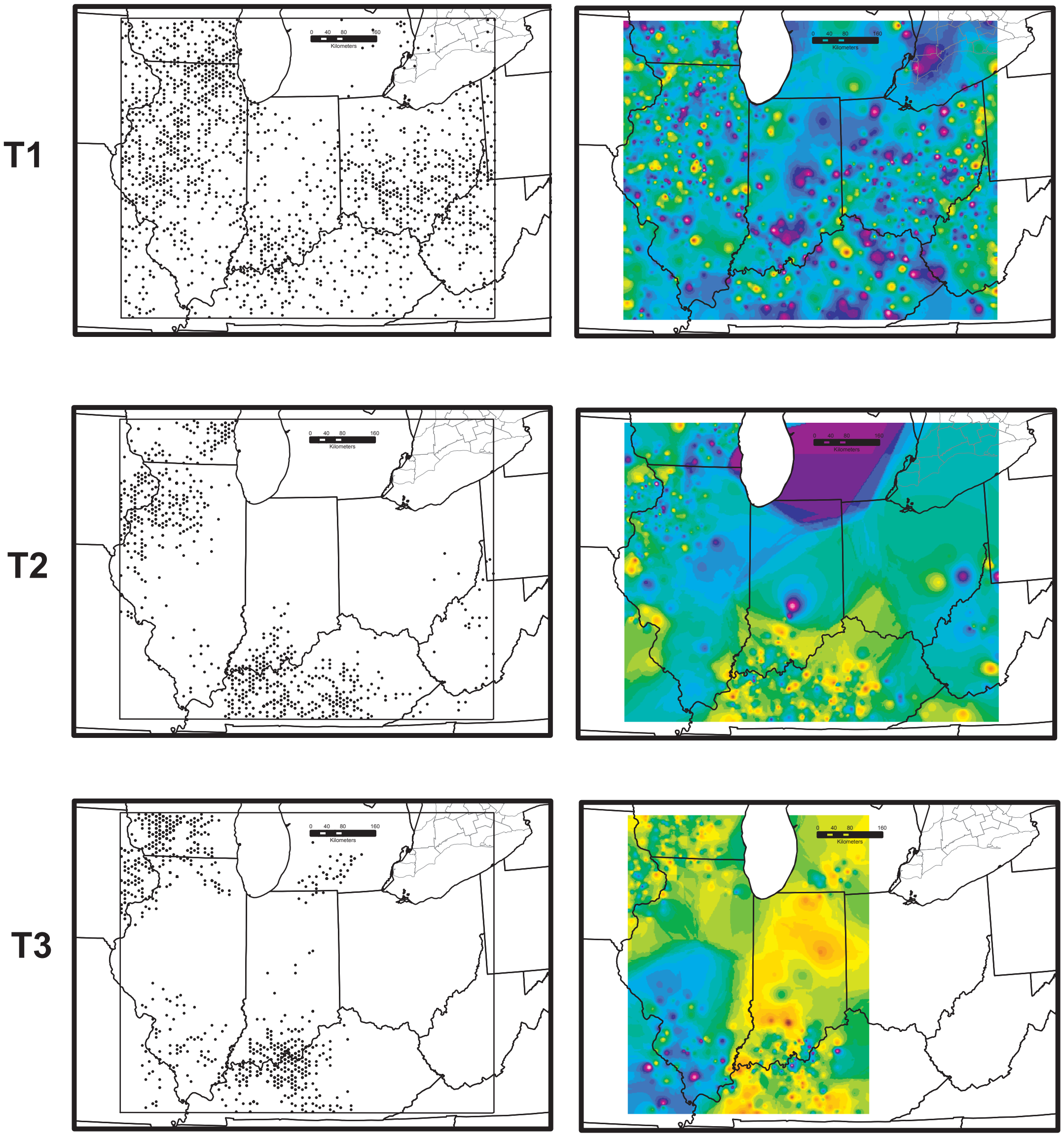


Figure 8.49. Comparison of pattern of change in Moran's I in archaeological data with that produced during T1, T2, and T3 of Experiment 009, run 3 (top); plot of changes in population size and the number of inter-regional social links through time in Experiment 009, run 3 (bottom).



Distribution of discarded artifacts (random sample of 2000 per time period)

Raster of EFI (random sample of 2000 artifacts)

Figure 8.50. Changes in the spatial distribution of population during T1, T2, and T3 as indicated by the locations of discarded artifacts (2000 per time period) (left column); raster images of variable EFI during T1, T2, and T3 (right column).

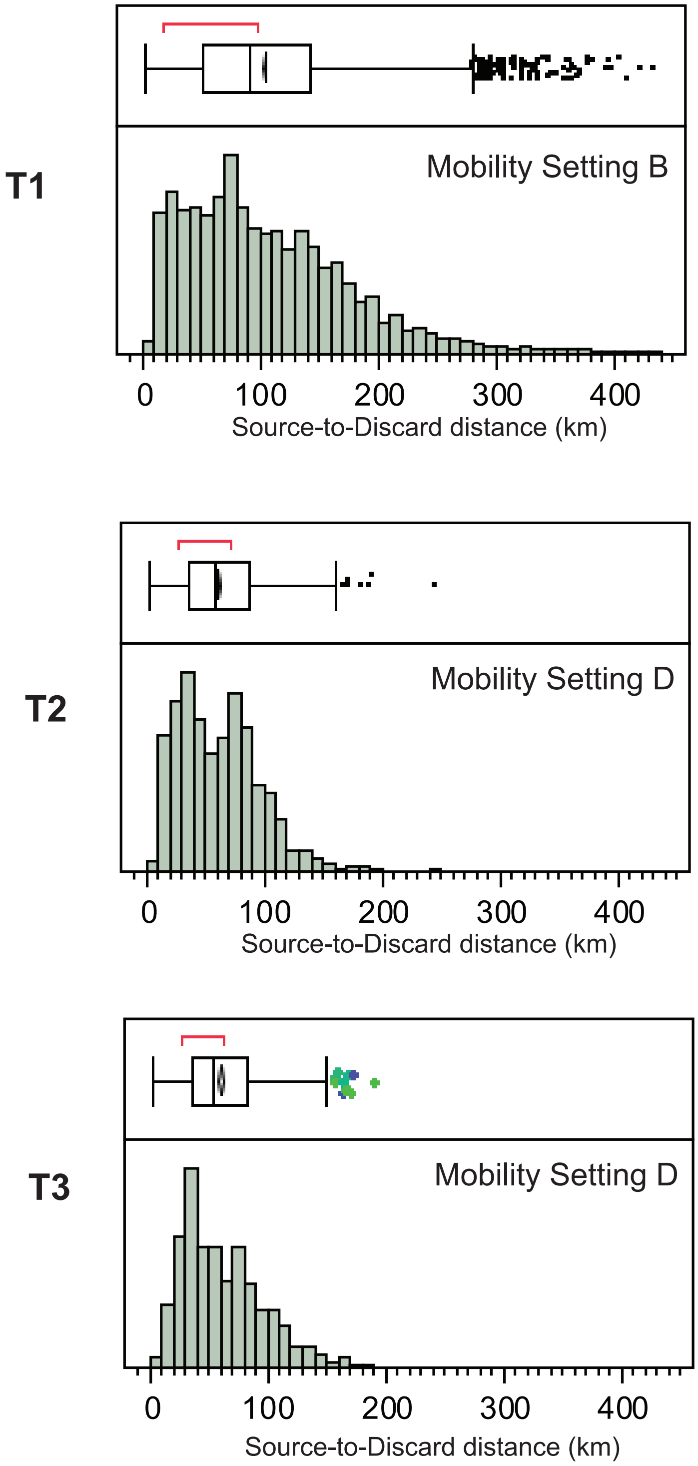


Figure 8.51. Comparison of source-to-discard histograms from T1, T2, and T3 of Experiment 009, run 3.

Conclusion

The comparisons conducted here were focused on evaluating the plausibility of explanations for the sequence of changes evident in the archaeological record of early hunter-gatherers in the North American midcontinent. An effort was made to construct and represent relatively simple alternative scenarios explaining stylistic regionalization. Simplicity was prioritized in order that comparisons between model and archaeological data could be usefully made at the level of *patterns* of change rather than at the level of specific details.

As was expected based on general model results, stylistic regions could be produced in the model (during T2) from a homogenous state (T1) by two different "pathways": (1) the initiation of "active" mechanisms of stylistic differentiation between regions; and (2) the imposition of a "weak passive barrier" to interaction. Neither of these mechanisms produced model data that are a perfect fit to the archaeological data. In the first case, the polarized patterns of stylistic variability produced by "active" mechanisms of stylistic differentiation (as represented in the model) appear quite different from the continuous, clinal pattern that is present in the Late Paleoindian sample. In the second case, while the "weak passive barrier" runs did produce clinal patterns of variability, they did not produce patterning that was a strong as in the Late Paleoindian sample.

In terms of overall patterning, data produced by the "weak passive barrier" runs are a better match to the archaeological data than those produced by the "active stylistic differentiation" runs. While the clinal patterns produced by the "weak passive barrier" runs are not as strong as those associated with the Late Paleoindian dataset, this is a difference of degree rather than quality. The polarized patterns of the "active stylistic differentiation" runs are qualitatively different than those of the archaeological dataset. If we understand the emergence of clinal patterns of variability to be somewhat time-dependent (as one would expect for a drift process), we may reasonably guess that the difference in degree between the archaeological and model datasets may be related to the representation of time rather than the representation of process. This idea is testable through further modeling.

The data suggest that the contraction of populations played a significant role in producing significant spatial organization of stylistic variability. Population contraction was evident in all cases during a shift from mobility setting B to mobility setting D, whether or not population increased at the time of this shift.

This is logical if one considers the difference in “approximate band range” between mobility settings B and D (see Table 5.1): the “band range” in mobility setting B is approximately 2.8 times greater than that in mobility setting D. This suggests that the population density would have to be tripled (rather than doubled) in order to “keep pace” with a reduction in mobility of that scale. The spatial gaps in population that result from the reduction in the scale of group mobility produce systems with a range of connectivity, even when no artificial boundary between regions is imposed (see Figure 8.47).

While additional experimentation will be needed to understand more fully what effects spatial gaps in population have on network characteristics and patterns of artifact variability, it is reasonable to suggest that the appearance of such gaps as a consequence of a reduction in the scale of group mobility without concurrent increases in population is a plausible context for the appearance of stylistic regions during the Late Paleoindian period. Spatial gaps in population are “weak passive barriers” that impede but do not prevent interaction. These impediments may encourage stylistic differentiation between populations by slowing down the transfer of information and allowing drift processes to produce variability that is spatially organized. Again, this is a testable proposition.

In summary, a comparison of archaeological data with both general and specific model results suggest a “weak passive barrier” scenario is plausible explanation for the stylistic regionalization that occurred during the Late Paleoindian period. Following a reduction in the scale of group mobility, stylistic clines/regions could have been produced by drift processes operating across a social landscape that, while largely interconnected, contained geographic gaps in population that acted as impediments to interaction. The spatial components of stylistic variability produced in this way could perhaps be erased by removing the impediments to interaction, either though some cultural mechanism to enhance information transfer or simply by increasing interconnectedness by filling gaps in the landscape through population growth. This scenario is concordant with the archaeological data.

The comparisons discussed here consider only a few simple scenarios that can be represented by the ForagerNet2 model. Scenarios other than those represented here may be plausible. Further modeling work will be required to develop and evaluate those scenarios.

Chapter 9

DISCUSSION AND CONCLUSION

The preceding chapters have developed a framework for discussing the characteristics of social networks among late Pleistocene and early Holocene hunter-gatherers in the North American midcontinent. This framework was built by:

- Consideration of the key mechanisms that contribute to the emergence of system-level social networks in hunter-gatherer systems;

- Construction of an agent-based model which allows system-level social networks *and* material assemblages to emerge from the "bottom up" through lower-level (i.e, person-, family-, and group-level) behaviors and interactions at spatial and temporal scales comparable to those which we can consider archaeologically;

- Analysis of general relationships between lower-level behaviors and the characteristics of the emergent system-level social networks;

- Identification of large-scale patterns of variability and change in archaeological data pertaining to late Pleistocene and early Holocene hunter-gatherers in the North American midcontinent;

- Development and evaluation of scenarios for the regionalization and homogenization of stylistic variability during this period through comparison between model and archaeological data.

In this final chapter, I consider the scenario that is most concordant with existing archaeological and model data (the "weak passive barrier" scenario) and discuss how such a scenario would articulate with the culture history of the area and what it might suggest about the characteristics of social networks of the early hunter-gatherers of midcontinental North America. I then briefly summarize the theoretical contributions of this study in terms of both general theory and archaeological theory and discuss limitations of the analysis related to the ForagerNet2 model as it is currently implemented as well as deficiencies in available archaeological data.

A "Weak Passive Barrier" Scenario as an Explanation for Stylistic Regionalization during the Late Paleoindian Period

In this section, I present a synthetic discussion of how a "weak passive barrier" scenario for stylistic regionalization articulates with many aspects of the archaeological record of late Pleistocene and early Holocene hunter-gatherers in midcontinental North America. The goal of this section is not to argue every point where my interpretations of the available data might differ from those of others, but to present what I see as the most likely narrative of the culture history of the Pleistocene-Holocene transition in this part of the world. Because many parts of this discussion have been considered elsewhere in this dissertation, I avoid excessive citation here.

Based on a comparison of model and archaeological datasets, the analysis in Chapter 8 identified a "weak passive barrier" scenario as a plausible explanation for the appearance of stylistic regions during the Late Paleoindian period in midcontinental North America. In this scenario, stylistic regions emerge without human intention through the normal operation of processes of social learning. The emergence of regionalized styles results from the appearance of one or more "passive" barriers to interaction within a network that was previously characterized by a relatively high degree of routine contact and interaction across its extent. The appearance of these impediments to interaction defines the extent of "regions" within the network and allows processes of drift (i.e., the accumulation of random copy error) in different regions to act somewhat independently, eventually producing regional "styles" of artifacts.

In this scenario, the regional styles that emerge are related in that they share a common stylistic ancestor. In model data pertaining to this scenario and in the Late Paleoindian dataset, style varies continuously across space, appearing clinal rather than discontinuous. This continuous variability can be reduced to "types" if one approaches it with the goal of constructing nominal categories. The stronger the relationship between space and style, the easier this exercise becomes. In the case of Hi-Lo and Dalton, we recognize distinct types based on patterns of morphometric variability that appear to have distinctive geographic distributions. We also recognize, however, that the two “types” are related and that there other forms which can be included in a general Dalton “horizon” (Justice 1987; Koldehoff and Walthall 2009).

The continuous patterns of stylistic variability produced by the model under “passive barrier” conditions and the continuous patterns of variability evident in the archaeological dataset are an important point of similarity that suggests stylistic differentiation during the Late Paleoindian period was not related to “active” symboling of group identities. In general, the small size and short use-lives of utilitarian stone tools makes them poor vehicles for the conveyance of social information (see Barton 1997; Sackett 1977; Sinopoli 1991; Wobst 1977). Further, variability in the haft region of a stone projectile point would be hidden from view during normal use of the tool, rendering impossible the communication of a message about social affiliation encoded in the morphology of the haft (unless the tools were exchanged while unhafted). Thus there is little reason to suspect that any of the dimensions of variability in the lithic tools considered here were related to “active” stylistic messaging of the kind described by Wiessner (1983) and Wobst (1977). Stylistic differentiation in these tools was a “passive” result of patterns and processes of social interaction and social learning.

The simplest explanation for the appearance of barriers or impediments to interaction during the Middle/Late Paleoindian periods is the geographic contraction of hunter-gatherer populations into two or more regions of the midcontinent. Environmental changes associated with the Pleistocene/Holocene transition (i.e., changes in the kinds and spatial/seasonal distributions of flora and fauna) may have been the ultimate cause of reductions in the scale of group mobility. In the absence of substantial increases in population, the significant reduction in group mobility that is suggested by decreases in the scale of raw material transport between the Early and Middle/Late Paleoindian periods would have necessitated the geographic contraction of populations in order for groups and bands to maintain routine interaction with a sufficient number of other groups and bands. Routine, inter-band interactions would have been necessary in order to ensure access to mates, exchange information, and buffer risk resulting from environmental unpredictability (e.g., see Whallon 2006; Whallon et al. 2011; Wobst 1974).

If the scale of group mobility decreased by fifty percent between the Early and Middle/Late Paleoindian periods but other key aspects of mobility behavior remained unchanged, a quadrupling of the population would have been required to maintain a “filled” landscape with no spatial gaps in the distribution of population. Based on very crude indicators like the number of discarded hafted bifaces, there is little evidence for such substantial increases in population during the Middle/Late Paleoindian periods (see Anderson et al. 2009). In fact, the Paleoindian Database of the Americas reports fewer Middle Paleoindian points than Early Paleoindian points in eastern North America (see Anderson et al. 2009). The spatial distributions of Barnes and Cumberland points suggest that indigenous hunter-gatherer populations largely contracted into the eastern Great Lakes and to areas south of the Ohio River during the Middle Paleoindian period.

Information about the secondary productivity of modern environments offers clues as to why Middle Paleoindian hunter-gatherer populations would have contracted specifically to the Great Lakes and parts of the Southeast at the very end of the Pleistocene, largely depopulating much of Illinois, Indiana, and Ohio. Binford (2001) ranks different vegetative communities based on their secondary productivity (the generation of biomass of consumer organisms – e.g., herbivorous animals) and the density of expected prey. Figure 9.1 displays these data for the modern vegetative communities that are most relevant to late Pleistocene/early Holocene midcontinental North America: deciduous forest, boreal forest, and grassland/prairie environments.

Modern boreal forest environments rank below deciduous and mixed deciduous/boreal forest environments in terms of both secondary productivity and mean expected prey. If the differences in the modern figures are applicable, the boreal environments that covered a large swath of the midcontinent north of the Ohio River between about 10,800 and 10,000 RCYBP (see Delcourt and Delcourt 1981; Whitehead et al. 1982) contained a lower density of animal resources than the deciduous forest environments to the south. Deciduous or mixed boreal/deciduous forests were present in Tennessee during the full glacial, and would have been present there during the Middle Paleoindian period (see Delcourt and Delcourt 1985; Whitehead et al. 1982).

The open boreal parkland environments of the Great Lakes may have also been “richer” in terms of secondary biomass than the more closed boreal forests to the south. While these Late Pleistocene boreal parkland environments were probably not as productive as Binford’s (2001) prairie/forest steppe environments

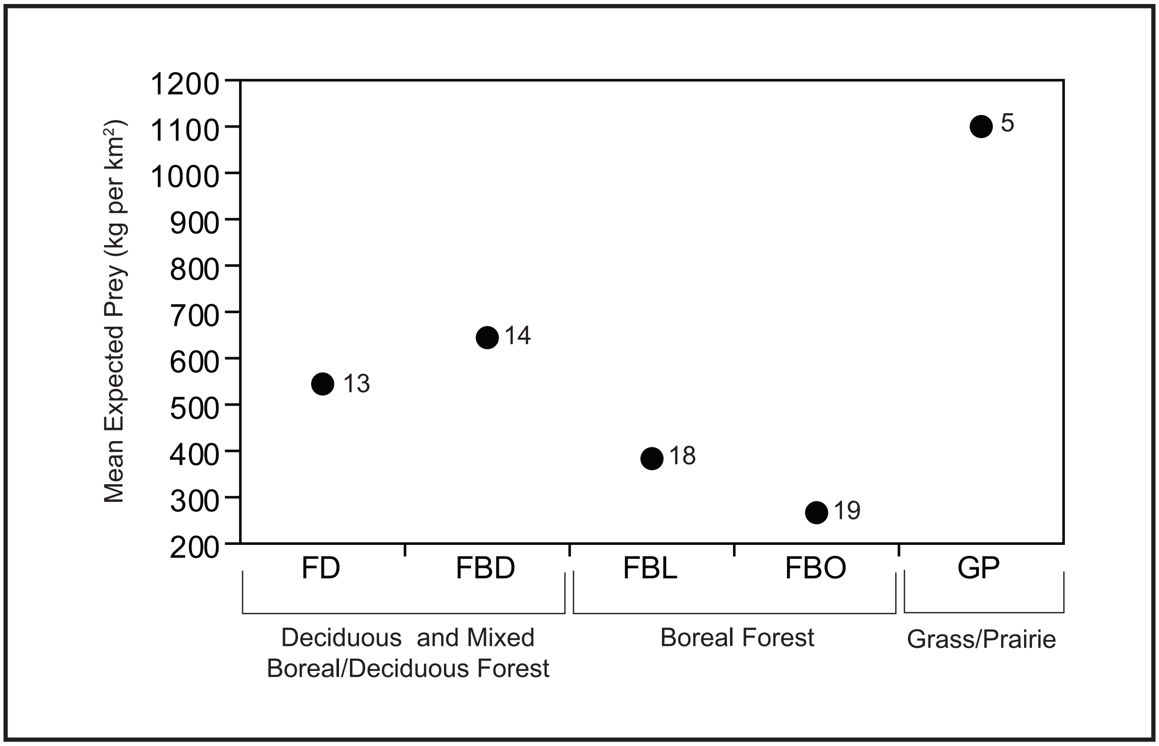


Figure 9.1. Mean expected prey and ordinal rankings of secondary productivity of selected vegetative communities. Data from Binford (2001:Tables 4.08 and 5.05). FD = Midlatitude deciduous forest; FBD = Mixed boreal and deciduous forest; FBL = Boreal forest dominated by deciduous larch-aspen; FBO = Boreal forest; GP = Tall grass prairie-forest steppe. Numerals adjacent to data points are ordinal rankings of secondary productivity (lower value indicates greater secondary productivity).

(see Figure 9.1), they would have supported caribou (Jackson 1988; Whitehead et al. 1982), perhaps in large numbers. Late survival of mastodon in these areas has also been suggested (see Woodman and Athfield 2009).

Given this general division of the midcontinent into three more-or-less distinctive vegetative zones during the Middle Paleoindian period, it is reasonable to suggest that hunter-gatherer systems that were contracting in spatial scale because of reductions in mobility would have contracted into the more productive environments. Deciduous forests would have been “richer” environments than boreal forests to terrestrial hunter-gatherers with a subsistence economy incorporating large game animals. Open boreal parkland environments would have likely been “richer” than closed boreal forests. Whether the transitions between these environmental zones were gradients or were sharply delineated, richer environments would have exerted a “pull” on hunter-gatherer systems as they re-organized in response to environmental change, stretching and perhaps tearing the fabric of social ties linking all midcontinental hunter-gatherers into a single system.

A Middle Paleoindian contraction of populations into the eastern Great Lakes and southern deciduous forests is consistent with the appearance of Barnes and Cumberland points in these regions, respectively. Again (similar to Dalton and Hi-Lo), these two forms of projectile points are recognized as being essentially very similar (Justice 1987) but also distinctive from one another (Deller and Ellis 1992a). Both appear to have been developed directly from Early Paleoindian fluted points, their constricted haft morphology serving to reduce the hafting width while maintaining blade width. Reductions in haft size are consistent with a reduction in the size of game for which these points were intended (see Chapter 7). The primary game animals would have been deer in the deciduous forests, caribou in the boreal parkland. A scarcity of either of these point forms between the Great Lakes and the Ohio Valley suggests this area may have been largely unpopulated at this time. The incursion of Folsom into northern Illinois and Wisconsin at this time appears to be associated with the expansion of prairie habitats into those areas.

Immediately following this geographic “split” of Middle Paleoindian populations, hunter-gatherer systems in the Great Lakes and Mississippi/Ohio Valley regions are characterized by distinct stylistic/economic trajectories. In the Great Lakes, the continuation of a caribou-focused economy into the Late Paleoindian period produced an archaeological record characterized by the presence of large sites whose structure suggests they were created by multiple families aggregating for communal hunting activities. The trend towards the production of thinner, narrower projectile points continues with Holcombe. These points are gracile, finely flaked, unfluted forms. Points similar to Holcombe have been dated to around 10,200 RCYBP in New England (Bradley et al. 2008:150). The time-transgressive northeastward shifting of parkland and tundra environments may have “pulled” caribou (and, therefore, caribou-focused populations of hunter-gatherers) out of the Great Lakes and into northern New England. The occurrence of some of the youngest radiocarbon dated fluted point sites in the northeast (e.g., see Hamilton and Buchanan 2007) is the result of the late continuation of hunting traditions originally associated with the Early Paleoindian period.

In the southeast, the earliest point forms associated with the Dalton cluster date to around 10,500 RCYBP and can be reasonably inferred to have developed from Cumberland on stylistic grounds (e.g. see Justice 1987:35). As stated above, the simplest explanation for the stylistic similarities between Dalton and Hi-Lo is their differentiation from a common "ancestor." Perhaps the best candidate for such an ancestor is Quad, an early point type in the Dalton cluster that may predate both Hi-Lo and "classic" Dalton (i.e., the Central Mississippi Valley form of Dalton that is most likely to be contemporary with Hi-Lo) (see Justice 1987; Sherwood et al. 2004). The distribution of Quad is clearly centered south of the Ohio River in what would have been deciduous forest environments. These points do occur in low frequency in central Illinois, southern Indiana, and southern Ohio (see Justice 1987), indicating that people making and using Quad points were ranging northward into what may have been transitional deciduous/boreal environments.

Given the apparent association between the distribution of early forms of Dalton (such as Beaver Lake and Quad) and deciduous forest environments, the appearance of "Dalton horizon" technologies in the Great Lakes may signal the expansion of populations associated with an environmental change from the boreal environments of the Middle Paleoindian period to deciduous or mixed deciduous/boreal forests. In this case, the transition from Holcombe to Hi-Lo in the Great Lakes would have been associated with a population replacement coincident with an environmental shift at around 10,200 RCYBP: Hi-Lo peoples move in (perhaps via the Illinois River valley) after Holcombe peoples move out (shifting their range to the northeast). An alternative explanation for the appearance of Hi-Lo is that it developed in the Great Lakes from Holcombe, the projectile point type that immediately preceded it there (see Ellis 2004a, 2004b; Ellis and Deller 1982; Stothers 1996). In my opinion, the clear morphometric affinities of Dalton and Hi-Lo, the specifics of changing environments in the Great Lakes and northeast, and the general contrasts in settlement/subsistence suggested by the differences between Holcombe and Hi-Lo all suggest that the appearance of Hi-Lo in the Great Lakes is most likely the results of a population expansion associated with the shift from boreal parkland to mixed deciduous/boreal forest.

While a population expansion associated with the Dalton horizon would suggest some degree of population growth at this time, we do not have a clear understanding of the processes that would operate during such an expansion. Whatever processes resulted in the presence of Dalton horizon populations across Kentucky, Illinois, and Indiana, and southern Ontario, the resulting distribution of population was clearly not uniform. Relatively dense Dalton occupations in the Central Mississippi Valley were associated with cemeteries and ritualized exchange, possibly triggered by the demographic “packing” of hunter-gatherer groups. Population densities were presumably lower among peoples in the Great Lakes, where no evidence of these phenomena has been recovered.   Still other areas of the midcontinent appear to be largely devoid of projectile points dating to this period, suggesting the presence of spatial gaps in population.

Assuming differentiation from a common origin, model results suggests that stylistic differentiation of the degree exhibited by Hi-Lo and Dalton is likely to develop over time in the context of weak, passive barriers to interaction between regions. These barriers may take the form of spatial gaps in population that impede routine interaction. Archaeological data suggest gaps in population between the Great Lakes and Mississippi/Ohio Valleys that would have impeded routine interaction between regions without preventing it, passively allowing drift processes to produce differentiation in non-functional variation of the haft morphology of projectile points. If both stylistic differentiation and population expansion into the Great lakes were time-transgressive phenomena, we might expect Hi-Lo points at the northeastern extent of the range of Hi-Lo (i.e., in eastern Ontario) to be among the youngest examples.

Geographic gaps in population during the Late Paleoindian period might have encouraged the emergence of cultural mechanisms for bridging those gaps. More formalized relationships of exchange (perhaps including marriage and/or exchange of material goods) may have served to allow portions of fractured Late Paleoindian networks to remain inter-connected. In this scenario, more formalized mechanisms for between-group exchange during the Middle/Late Paleoindian periods would have initially arisen in the context of an under-populated rather than a “filled” landscape: these mechanisms would have served to increase interaction between groups removed from one another in space rather than alleviate tension caused by too much interaction between groups “packed” together in space.

Population growth throughout the Late Paleoindian period and into the Early Archaic period would have resulted in a “filling in” of the landscape through band fissioning. The replacement of the transitional Pleistocene/Holocene environmental zones of the midcontinent with deciduous forest environments that extended across much of eastern North America would have encouraged population growth and made regional differences in environment less significant. The common presence of Early Archaic projectile points (i.e., Thebes and Kirk cluster points) in all areas and all physiographic settings of the midcontinent suggests that Early Archaic peoples were using all portions of the landscape.

Population growth, with or without an increase in group mobility relative to the Late Paleoindian period, could have produced a more inter-connected system, allowing routine interaction between portions of the system that were formerly separated by geographic gaps that acted as passive barriers. Limited model results suggest that removal of passive barriers may both: (1) erase stylistic differentiation that had developed when the barriers were present; and (2) largely negate the capacity of drift processes to produce stylistically differentiated regions.

While available model results suggest that stylistic convergence is a reasonable explanation for the homogenization that is associated with the Early Archaic, population replacement remains a plausible alternative. More experimentation (and adjustments to the ForagerNet2 model – see below) will be needed to explore differences in the patterns produced by stylistic convergence and population movements. Whatever the cause of the initial homogenization of style that characterizes the Early Archaic, the horizon-like successions of geographically-widespread projectile point styles that follow suggests that the social fabric Early Archaic networks extended without significant interruption across much of eastern North America for much of the early Holocene. Formalized mechanisms of exchange between groups that may have originated in the context of the fractured networks of the Late Paleoindian period served to maintain and preserve the inter-connectedness of this far-reaching social network.

Characteristics of the Social Networks of Early Hunter-Gatherers in Midcontinental North America

The scenario presented above can be considered in light of what it suggests about the characteristics of the social networks of early hunter-gatherers in midcontinental North America. The emphasis here is on using model and archaeological data to identify the probable direction of changes in network characteristics and understanding what those changes might mean for individuals in the hunter-gatherer systems that were associated with those changes.

The low population densities and high scales of group mobility generally thought to characterize the Early Paleoindian period would likely have been associated with periodic, scheduled aggregations. These aggregations would have likely been a key mechanism for facilitating the formation and maintenance of social links between individuals residing in different foraging groups. This mechanism would likely have been especially important to Early Paleoindian systems *because* of the combination of high mobility and low population density: “chance” encounters between small groups moving across a vast landscape would probably have been insufficient to produce and maintain personal networks of a size that is typical of humans.

Model results do suggest, however, that occasional interactions between Paleoindian groups at the furthest extent of their ranges may have been sufficient to produce social connectivity across a sparse system through mechanisms such as inter-band marriage. Marriages between persons from different bands would have produced arrays of social ties through kinship. These ties would have provided a means for other individuals who did not know each other personally to determine and understand their relationship during a chance encounter in the future.

In hunter-gatherer systems characterized by low population density, this combination of mechanisms for producing both inter-connectedness and personal networks of an appropriate size would have resulted in a social network with a relatively low mean path length and a high network density. In other words, any Early Paleoindian in the midcontinent was probably no more than a few social steps away from any other Early Paleoindian in the midcontinent. This would have facilitated the transfer of individuals and families between and among foraging groups, as it would be likely that an individual would either personally know or be able to trace a relationship to a person in another group under most circumstances. Fluidity of group membership would serve to maintain high network density as well as allowing transfer of information across the network via serial face-to-face interactions.

In the absence of significant population grown, reductions in the scale of group mobility associated with the Middle and Late Paleoindian periods would have disrupted the system-level connectedness of the Early Paleoindian social network by producing spatial gaps in population. Model results show a range of effects that this may have had on the system-level characteristics of hunter-gatherer social networks (Figure 9.2). Most of these effects may not have been apparent at the level of the individual.

As measured across a social system comparable in spatial scale to that of the Early Paleoindian period in midcontinental North America, mean path length almost certainly increased during the Middle/Late Paleoindian periods. The spatial gaps in population that were a consequence of reduced group mobility would have decreased the frequency of interactions between separated populations and lowered the frequency of “chance” encounters occurring between groups. While Figure 9.2A shows that mean path length

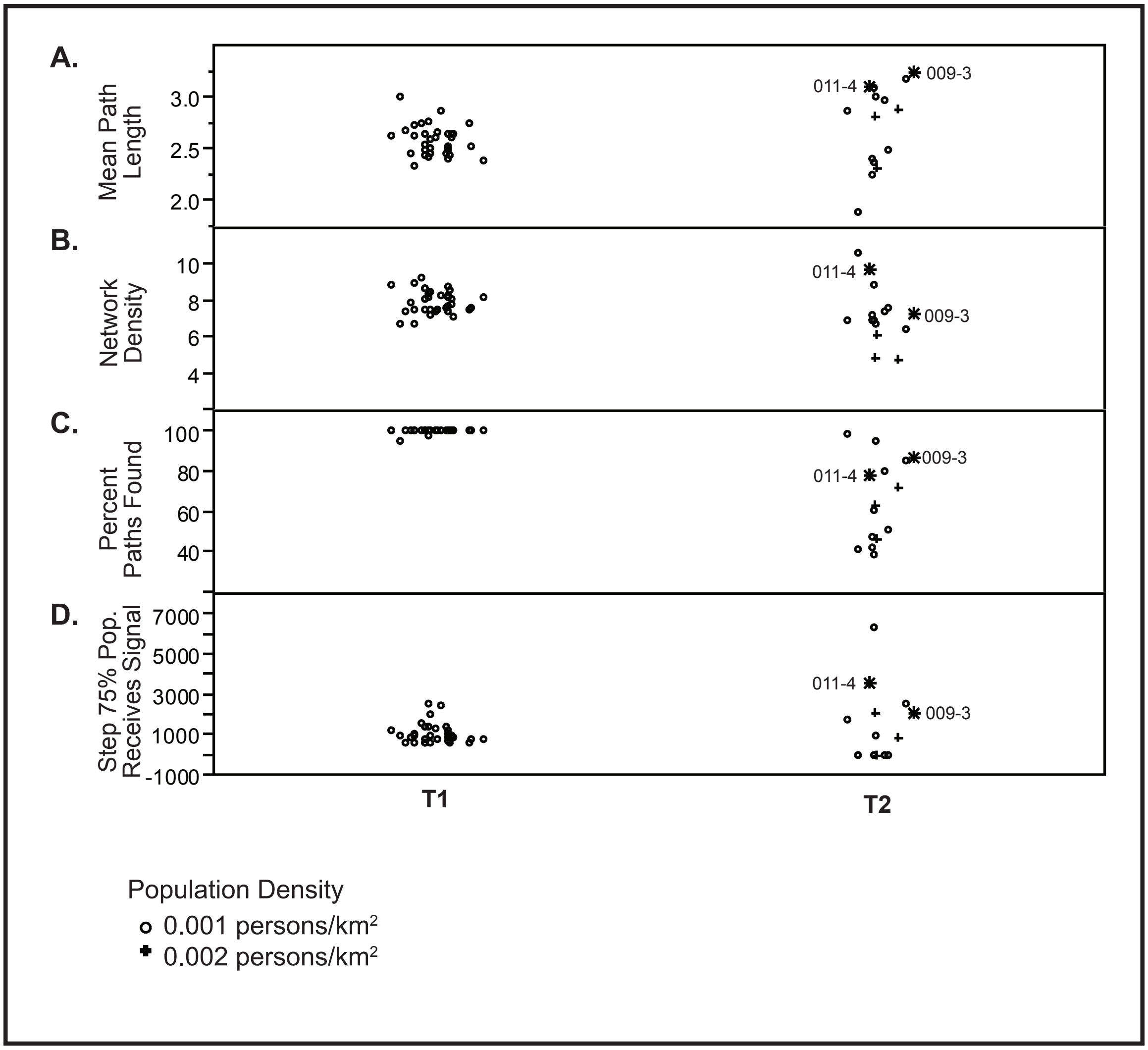


Figure 9.2. Characteristics of networks produced during T1 and T2. Data points symbolized by an asterix are from runs that produced patterns of material culture most similar to those in the Late Paleoindian archaeological dataset.

actually decreased during T2 in some of the experiments, data points with low mean path lengths were only produced in runs where the social network was effectively broken into several discrete, non-articulating pieces (i.e., where less than about 50 percent of the social paths could be found) (Figure 9.3). Where inter-connectedness was over 50 percent, mean path length increased between T1 and T2. The highest mean path lengths were produced by the two runs that produced patterns of artifact variability that appeared most similar to those in the archaeological data (011-4 and 009-3).

Changes in network density (the proportion of social ties that exist relative to those that are possible) were likely dependent on changes in population density. As shown in Figure 9.2B, decreases in network density are associated with increases in population. This is because *mechanisms* of personal network formation in the model (personal mobility, inter-band marriage, etc.) remain constant regardless of the density or distribution of population. If the mean size of the personal networks produced by these mechanisms remains the same,

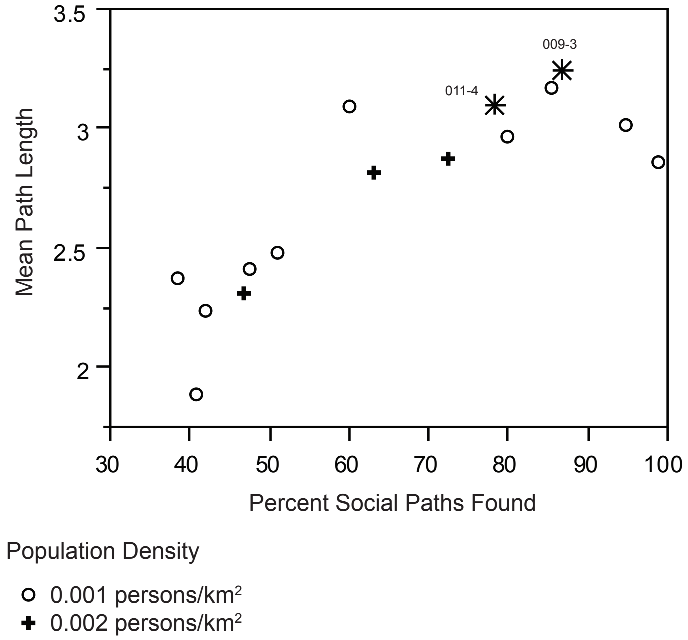


Figure 9.3. Relationship between the percentage of social paths found and the mean path length during T2. Data points symbolized by an asterix are from runs that produced patterns of material culture most similar to those in the Late Paleoindian archaeological dataset.

network density will decrease as population rises: each person will know about the same number of people but that number will constitute a smaller percentage of the population.

It is likely that Middle/Late Paleoindian social networks extending across eastern North America were characterized by significantly greater degree of disconnectedness than social networks during the Early Paleoindian period. Networks with a greater number of pairs of individuals that could not be connected by a social path would have transferred information both more slowly and less reliably. The range of values of the percentage of social paths found and the number of steps required to spread the "signal" to 75 percent of the population (see Chapters 4 and 5) during T2 are shown in Figure 9.2C and 9.2D. These two variables are related: networks with less connectivity tend to transmit information more slowly (Figure 9.4).

Based on the scenario outlined above, it is likely that Middle and Late Paleoindian social networks were characterized by higher mean path lengths and lower degrees of inter-connectivity than Early Paleoindian social networks. These networks would have transferred information more slowly and less reliably until either population growth or cultural mechanisms enabled spatial gaps in population to be erased or routinely bridged. Network density would have decreased as population size increased.

While these changes may have allowed stylistic differentiation in material culture to occur at the regional level, it seems unlikely that any of these changes in the characteristics of system-level social networks would have been perceptible at the level of day-to-day human experience. Individual persons would have had personal networks of about the same size and composition, produced and maintained through many of the same mechanisms. The majority of social links that were important at a day-to-day "operational" level would have been between individuals that interacted frequently on a face-to-face basis. A desire to maintain social connectedness with individuals in more distant populations may have encouraged the elaboration of formalized mechanisms for doing so.

The social networks that emerged from Early Archaic systems were likely more like those of Early Paleoindians than Middle/Late Paleoindian peoples. The direction of the suite of changes associated with the Middle/Late Paleoindian period was likely reversed as highly inter-connected networks were re-established across eastern North America. As populations grew, network

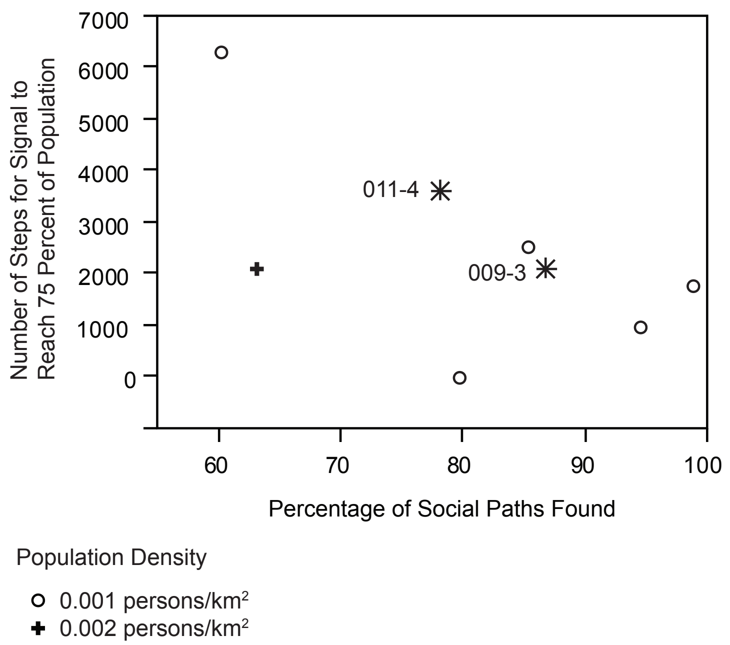


Figure 9.4. Relationship between the percentage of social paths found and the number of steps taken to spread a signal to 75 percent of the population during T2. Data points symbolized by an asterix are from runs that produced patterns of material culture most similar to those in the Late Paleoindian archaeological dataset.

density would have decreased and mean path length would have increased. The filling in of the landscape would have enabled a high degree of inter-connectivity through marriage and exchange. Again, it seems unlikely that any of these system-level changes would have been perceptible at the level of day-to-day human experience.

Conclusions

This study has integrated ethnographic data, computational modeling, and archaeological data to construct a framework for building theory and evaluating network-based explanations for change within a specific archaeological case: late Pleistocene and early Holocene hunter-gatherer systems in midcontinental North America. I have proposed a plausible scenario for the appearance and disappearance of stylistic regions during the Pleistocene-Holocene transition in the midcontinent and described changes in the social networks of hunter-gathers in this area based on that scenario.

This study required the development of both *general theory* about hunter-gather social networks and *archaeological theory* about how the large-scale characteristics of those networks are related to patterns of variability in material culture. Development of both of these kinds of theory was based on the idea that system-level social networks and patterns of variability in material culture are emergent phenomena that are generated from the “bottom up” by human-scale interactions and behaviors. Agent-based modeling was used to understand how these emergent phenomena are related to one another and to the lower-level interactions and behaviors that generate them. Thus the ForagerNet2 model was a tool for developing theory.

In terms of general theory, the model was used to identify and a describe a number of patterned relationships among the person- and group-level behaviors in model systems and the characteristics of the system-level social networks that emerge through those behaviors (see Chapter 5). Of particular note are: (1) the patterned relationships between mobility, population density, and the creation of viable social networks; (2) the association of different ethnographically-documented mechanisms for the formation of social ties (inter-band marriage and personal mobility) with different aspects of system-level social networks (connectivity and mean personal network size, respectively); and (3) the suggestion that relatively low levels of personal mobility and inter-band marriage will often produce viable system-level social networks with the best trade-off in terms of the ratio of “benefit” to “cost.” The idea that we should expect patterned relationships between mobility, demography, and the characteristics of social networks is not new (see Anderson 1995:7). What is new in this study is the identification of some of these basic patterns of relationship and an understanding of the relationship between changes in lower-level behaviors and changes in system-level characteristics.

In terms of archaeological theory, this study works toward developing firm grounds for making inferences about the system-level characteristics of social networks (and changes in those characteristics) based on patterns of variability in material culture. Although general results from the model suggest that skepticism about the two main assumptions/assertions of the “logical” models (Chapter 3) is justified, there are some points of agreement. The model suggests that social boundaries can be clearly identified, for example, if they were marked and maintained by “active” stylistic differentiation. Social boundaries that were not “actively” marked or maintained, however, may not be readily apparent in material culture. Even in cases where there was an absolute barrier to interaction between two regions in the model, drift processes acting independently did not necessarily produce a sufficient amount of stylistic differentiation to recognize the presence of boundary. This gives support to the idea that we cannot assume that where there is a discontinuity there was a boundary and where there is continuity there was no boundary.

Model results do suggest, however, that discontinuities, differentials, or bottlenecks in the fabric of a social network can create the conditions that allow stylistic differentiation to occur through passive mechanisms. Impediments to interaction in the form of spatial gaps between regions appeared to slow the transfer of information across a network sufficiently that stylistic diversity could emerge. The amount of stylistic differentiation between regions did not have a simple relationship with the degree of inter-connectedness in the system as a whole, not supporting the expectation of a proportional relationship between the degree of interaction and the degree of similarity (i.e., the second major proposition of the “logical” models). If stylistic differentiation within an inter-connected network is the result of some kind of drift process, one might expect that time would be an important variable in explaining the degree of differentiation. One might also expect that consideration of more variables would provide more opportunities for differentiation to be recognized.

Both the agent-based model and the archaeological dataset used in this study imposed limitations on the nature of the questions that could be addressed. The ForagerNet2 model was built to allow the investigation of general questions about hunter-gatherer social networks as well as questions about a specific case of change in material culture potentially related to change in hunter-gatherer social networks. As currently implemented, there are numerous behaviors and conditions that cannot be modeled and therefore cannot be explored. Significant limitations include:

- The representation of mobility is explicitly terrestrial and contains no provisions for orienting group behavior with respect to raw material sources, specific environmental zones, or the past movements of the group;

- Mobility is the only mechanism of raw material transport (there is no representation of exchange);

- There is no representation of region-specific environmental parameters or representations of ways in which environmental differences affect mobility or the distribution of population;

- There is no representation of “decay” of social links through time and no representation of mechanisms for maintaining social links;

- A single basic kinship system is represented;

- Representation of “active” mechanisms of stylistic differentiation is rudimentary.

Augmenting the ForagerNet2 model to include representations of more facets of mobility, environmental variability, demography, and social interaction would reduce the general utility of the model but allow it to be used for the simulation of more specific scenarios. Components could also be added to the model to make it a tool for exploring more precisely the conditions in which boundaries (both “active” and “passive”) may emerge, persist, and collapse in hunter-gatherer systems.

The general potential of the archaeological dataset is limited by many of the same weaknesses that characterize the archaeological record from this period: the scarcity of supporting information on subsistence and settlement, the lack of even data across time and space, and the coarse nature of our chronological information. While an attempt was made to minimize the importance of these limitations by comparing broad patterns of change among relatively large samples gathered from a wide geographic area, there is no question that more and better data would be of benefit. Future attempts to use this dataset could incorporate analysis of assemblages from radiocarbon dated or stratified sites to attempt to attempt to analyze dimensions of stylistic variability in narrower slices of time. Additional measures of stylistic variability could be devised which may aid in describing patterns of variability and recognizing stylistic differentiation.

The nature of the Paleoindian to Archaic transition around 10,000-9500 RCYBP is one of the fundamental questions of cultural development in eastern North America (Ellis et al. 1998). The appearance and disappearance of stylistic regions during this transition may provide important clues about the characteristics of the social networks that linked individuals, families, groups, and bands during the late Pleistocene and early Holocene. These networks both emerged from and affected human-scale behaviors and interactions, forming the “backbone” of social structures that articulated with significant demographic, economic, and environmental changes during the Pleistocene-Holocene transition.

The complex nature of hunter-gatherer social networks makes them a challenging object of study. Looking twelve thousand years into the past, we will never be able to collect the kind of detailed, particularistic ethnohistorical data that many archaeologists and anthropologists might claim are required to understand social interaction through material culture (e.g., see Stark 1998). This study has attempted to improve our ability to recognize changes in prehistoric social networks and understand the implications of those changes based on information and insights that we *do* have. It provides neither a complete historical account nor a precise explanation of process, but rather attempts to present a plausible, large-scale narrative that is concordant with diverse strands of information derived from ethnography, model results, and archaeological data. It is intended not as an answer, but as a starting point for a new conversation about hunter-gatherer social networks at the scales at which we can understand them archaeologically.

Appendix A

DEFAULT SETTINGS USED IN MODEL EXPERIMENTS

This appendix lists the values of model parameters that did not change in the experiments discussed in this dissertation. Parameters and related methods are more fully described in Chapter 4.

Parameter	**Description**	**Default Value**
sustainableCP	Ratio of consumers to producers within a family (dependency ratio) that constitutes a "sustainable" family situation	1.75
perMeanRangeOverlap	Percentage of mean band range that overlaps with mean range of adjacent band	0.10 (10 percent)
maxGroupSize	Maximum size of a foraging group; foraging groups larger than *maxGroupSize* will fission	40
minGroupSize	Minimum size of a foraging group; foraging groups smaller than *minGroupSize* will attempt to fuse with another group	10
personMobilityRadiusCells	Maximum number of cells that a person (and associated family) can move to switch foraging groups	2
foragingRadiusCells	Radius (in cells) that define the "local neighborhood" of a foraging group	1
interBandSteering	Boolean parameter controlling whether or not groups intentionally "steer" toward groups from other bands that are in close spatial proximity	true
season1Ticks	Number of steps in season 1 of the annual cycle	22

Parameter	**Description**	**Default Value**
maxAge	Maximum age (in years) that a person may reach	70
ageAtProduction	Age at which persons become producers (years)	14
ageAtReproduction	Age at which females can begin to reproduce; age when males and females can be married (years)	16
reproductiveMax	Age at which females can no longer reproduce (years)	35
maxFertility	Maximum number of children per reproductive span	10
childMortality	Total probability of death between birth and *ageAtReproduction*	0.40
adultMortality	Probability of death each year as an adult (i.e., at or above *ageAtReproduction*)	0.02
avoidanceOn	Boolean parameter controlling whether reproduction is avoided at the family level based on dependency ratio	true
infanticideOn	Boolean parameter controlling whether infanticide occurs at the family level based on dependency ratio	true
bridePriceMultiplier	Parameter used to incentivize polygynous marriage (value of 0 means this parameter has no effect)	0
upperBPLimit	Maximum permitted value of *bridePrice*	10
lowerBPLimit	Minimum permitted value of *bridePrice*	-10
brideInfoTransferPercent	Percentage of bride information that is transferred during person-person interactions per step	0.10 (10 percent)
pathSearchTiers	Maximum number of social tiers searched to find social path between two persons during mean path length calculation	60
pMPLCalc	Probability that mean path length will be calculated each step during a data collection period	0.01 (1 percent)
numMPLSample	Number of person-person paths used to calculate mean path length	2000

Parameter	**Description**	**Default Value**
rmProcurementRadius	Radius (in cells) within which lithic raw material sources can be exploited	2
toolInventorySize	Number of tools in a “full” personal tool inventory	10
toolProdMultiplier	Parameter controlling “over production” of tools at lithic raw material sources; value of parameter is multiplied by *toolInventorySize* to determine number of tools needed to replenish a tool inventory	2
newToolUseLife	Number of uses before a tool is automatically discarded	10
toolLossProb	Probability that a tool will be lost each step	0.01 (1 percent)
usesPerStep	Number of tools in a personal inventory that are “used” each step	1

Appendix B

PROVENIENCE AND DATA SOURCE OF PROJECTILE POINTS IN ARCHAEOLOGICAL DATASET

This appendix lists the hafted biface group, provenience, and data source for projectile points included in the analysis in Chapter 7. Projectile points are ordered by their unique identification numbers (“Point ID” column) assigned during data collection. The column “Group” specifies which hafted biface group the point belongs to (EFP = Early Fluted Point). The column “County” lists the provenience (county and state) of the point (see Appendix F for UTM coordinates associated with county-level proveniences). The column “Data Source” indicates whether the point was inspected firsthand (I) or data were collected from a published drawing (D) or photograph (P). The column “Coll. ID” (Collection ID) lists the numerical code indicating the institution or private collection/collector where the point was analyzed (see Appendix C). The column “Illustrated” lists a references to published illustrations of the point. The last three columns provide identifying designations of points (mostly fluted points) that have been included in previous studies by Tankersley (1989), Prufer (2010), and/or Lepper (1986).

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
10	EFP	Kosciusko IN	I	4	White 2006a:Fig. 2	-	-	-
15	EFP	Kosciusko IN	I	4	White 2006a:Fig. 2	-	-	-
83	EFP	Kosciusko IN	I	4	White 2006a:Fig. 2	-	-	-
112	Hi-Lo	Paulding OH	I	9	White 2006:Fig. 5	-	-	-
129	Hi-Lo	Huntington IN	I	52	White 2006a:Fig. 5	-	-	-
130	Hi-Lo	Huntington IN	I	52	White 2006a:Fig. 5	-	-	-
143	Hi-Lo	Allen IN	I	10	White 2006a:Fig. 6	-	-	-
149	Hi-Lo	Allen IN	I	6	Justice 1987:45e	-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
169	EFP	Whitley IN	I	3	White 2006a:Fig. 2	-	-	-
179	Hi-Lo	Wells IN	I	3	White 2006a:Fig. 5	-	-	-
190	Hi-Lo	Saint Joseph IN	I	3	White 2006a:Fig. 5	-	-	-
217	EFP	Huntington IN	I	52	White 2005:Fig. 9.3	-	-	-
220	EFP	Defiance OH	I	24	White 2006b:Fig. 6.4	-	-	-
229	Hi-Lo	DeKalb IN	I	24		-	-	-
234	EFP	Jasper IN	I	33	White 2006b:Fig. 6.4	-	-	-
238	Hi-Lo	Boone IN	I	6	White 2006b:Fig. 6.13	-	-	-
264	Hi-Lo	Noble IN	I	23	White 2006b:Fig. 6.13	-	-	-
265	Thebes	Wayne IN	I	52		-	-	-
267	Kirk	Whitley IN	I	3		-	-	-
268	Thebes	Whitley IN	I	3		-	-	-
274	Hi-Lo	Whitley IN	I	3	White 2006b:Fig. 6.13	-	-	-
275	Hi-Lo	Whitley IN	I	3		-	-	-
277	Hi-Lo	Whitley IN	I	3	White 2006b:Fig. 6.13	-	-	-
285	Hi-Lo	Whitley IN	I	3	White 2006b:Fig. 6.13	-	-	-
286	Hi-Lo	Whitley IN	I	3		-	-	-
288	Hi-Lo	Whitley IN	I	3	White 2006b:Fig. 6.13	-	-	-
289	Hi-Lo	Whitley IN	I	3	White 2006b:Fig. 6.14	-	-	-
298	EFP	Marion OH	I	3	White 2006b:Fig. 6.4	-	-	-
299	EFP	Kosciusko IN	I	13	White 2006b:Fig. 6.4	-	-	-
301	EFP	Marshall IN	I	38	White 2006b:Fig. 6.4	-	-	-
303	Thebes	Marshall IN	I	38		-	-	-
307	EFP	Union IN	I	15	Tankersley 1989; White 2006b:Fig. 6.4	650	-	-
337	Hi-Lo	Adams IN	I	14	White 2006b:Fig. 6.14	-	-	-
339	Hi-Lo	Adams IN	I	14		-	-	-
342	Hi-Lo	Adams IN	I	14		-	-	-
345	Hi-Lo	Steuben IN	I	14	White 2006b:Fig. 6.14	-	-	-
347	EFP	Steuben IN	I	14	White 2006b:Fig. 6.5	-	-	-
352	EFP	Warrick IN	I	6	Tankersley 1989; White 2006b:Fig. 6.5	25	-	-
353	Dalton	Perry IN	I	6	White 2006b:Fig. 6.18	-	-	-
354	EFP	Monroe IN	I	6	Tankersley 1989	26	-	-
355	EFP	Bartholomew IN	I	6	White 2006b:Fig. 6.5	-	-	-
358	Dalton	Perry IN	I	6	White 2006b:Fig. 6.18	-	-	-

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361	EFP	Clark IN	I	6	Tankersley 1989; White 2006b:Fig. 6.6	36	-	-
362	EFP	Clark IN	I	6	Tankersley 1989; White 2006b:Fig. 6.6	35	-	-
364	EFP	Clark IN	I	6	Tankersley 1989; White 2006b:Fig. 6.6	22	-	-
365	EFP	Delaware IN	I	6	White 2006b:Fig. 6.6	-	-	-
370	EFP	Clark IN	I	6	White 2006b:Fig. 6.7	-	-	-
376	EFP	Vanderburgh IN	I	6	Tankersley 1989; White 2006b:Fig. 6.7	15	-	-
378	EFP	Bartholomew IN	I	6	Tankersley 1989; White 2006b:Fig. 6.7	19	-	-
379	EFP	Vanderburgh IN	I	6	Tankersley 1989; White 2006b:Fig. 6.7	14	-	-
399	Dalton	Vanderburgh IN	I	6	White 2006b:Fig. 6.20	-	-	-
400	Hi-Lo	Adams IN	I	14	White 2006b:Fig. 6.14	-	-	-
410	Hi-Lo	Adams/Wells IN	I	30	White 2006b:Fig. 6.15	-	-	-
413	Hi-Lo	Adams/Wells IN	I	30	White 2006b:Fig. 6.15	-	-	-
414	Hi-Lo	Adams/Wells IN	I	30	White 2006b:Fig. 6.15	-	-	-
454	Hi-Lo	Adams IN	I	52	White 2006b:Fig. 6.15	-	-	-
457	Hi-Lo	Whitley IN	I	52	White 2006b:Fig. 6.15	-	-	-
461	EFP	Wells IN	P	47	White 2006b:Fig. 6.8	-	-	-
463	Hi-Lo	Adams IN	P	48	White 2006b:Fig. 6.16	-	-	-
471	Hi-Lo	Allen IN	P	42	White 2006b:Fig. 6.16	-	-	-
473	Hi-Lo	Allen IN	P	42	White 2006b:Fig. 6.16	-	-	-
477	Hi-Lo	Allen IN	P	31		-	-	-
480	EFP	Allen IN	P	37	White 2006b:Fig. 6.8	-	-	-
482	Hi-Lo	Allen IN	P	37	White 2006b:Fig. 6.16	-	-	-
489	Hi-Lo	Adams IN	P	48	White 2006b:Fig. 6.16	-	-	-
502	Hi-Lo	Wells IN	P	47		-	-	-
527	Hi-Lo	Adams IN	P	47		-	-	-
533	Hi-Lo	Wells IN	P	47		-	-	-
552	Hi-Lo	Marshall IN	P	36		-	-	-
578	Hi-Lo	Adams IN	I	20	White 2006b:Fig. 6.17	-	-	-
579	Hi-Lo	Adams IN	I	20	White 2006b:Fig. 6.17	-	-	-
591	EFP	Tippecanoe IN	P	19		-	-	-
598	Hi-Lo	Allen IN	D	-	Moore 1987:Figure 31C	-	-	-

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602	Hi-Lo	Allen IN	D	-	Moore 1987:Figure 31G	-	-	-
613	Hi-Lo	Lake IN	I	93	White 2007:Fig. 4.10	-	-	-
631	Hi-Lo	Porter IN	I	98	White 2007:Fig. 4.10	-	-	-
637	Thebes	Pulaski IN	I	99	White 2007:Fig. 4.23	-	-	-
638	Thebes	Pulaski IN	I	99	White 2007:Fig. 4.23	-	-	-
640	Hi-Lo	Jasper IN	I	103	White 2007:Fig. 4.10	-	-	-
642	Hi-Lo	Newton IN	I	103	White 2007:Fig. 4.10	-	-	-
648	Hi-Lo	Jasper IN	I	103	White 2007:Fig. 4.10	-	-	-
649	Hi-Lo	Jasper IN	I	103	White 2007:Fig. 4.10	-	-	-
653	Hi-Lo	Lake IN	I	103	White 2007:Fig. 4.10	-	-	-
654	Hi-Lo	Lake IN	I	103		-	-	-
662	Hi-Lo	Lake IN	I	103	White 2007:Fig. 4.10	-	-	-
673	Hi-Lo	Lake IN	I	111	White 2007:Fig. 4.11	-	-	-
676	Kirk	Lake IN	I	111	White 2007:Fig. 4.25	-	-	-
677	Thebes	Lake IN	I	111	White 2007:Fig. 4.23	-	-	-
679	Thebes	Lake IN	I	111	White 2007:Fig. 4.23	-	-	-
681	Thebes	Lake IN	I	111	White 2007:Fig. 4.23	-	-	-
684	Thebes	Lake IN	I	111	White 2007:Fig. 4.23	-	-	-
686	Thebes	Lake IN	I	111	White 2007:Fig. 4.24	-	-	-
690	Kirk	Lake IN	I	111	White 2007:Fig. 4.25	-	-	-
742	Kirk	Porter IN	I	124	White 2007:Fig. 4.25	-	-	-
749	EFP	Kosciusko IN	I	123	White 2007:Fig. 4.3	-	-	-
750	Hi-Lo	Kosciusko IN	I	123		-	-	-
751	EFP	Carroll IN	I	123	White 2007:Fig. 4.3	-	-	-
753	Dalton	Carroll IN	I	123	White 2007:Fig. 4.14	-	-	-
754	EFP	Franklin IN	I	123	White 2007:Fig. 4.3	-	-	-
755	Hi-Lo	Carroll/ Tippecanoe IN	I	123	White 2007:Fig. 4.11	-	-	-
756	Hi-Lo	Carroll/ Tippecanoe IN	I	123		-	-	-
768	Hi-Lo	Kosciusko IN	I	123	White 2007:Fig. 4.11	-	-	-
769	Hi-Lo	Kosciusko IN	I	123	White 2007:Fig. 4.11	-	-	-
781	Hi-Lo	Starke IN	I	129	White 2007:Fig. 4.12	-	-	-
788	EFP	Lake IN	I	121	White 2007:Fig. 4.4	-	-	-
791	EFP	Porter IN	I	133	White 2007:Fig. 4.4	-	-	-
792	Hi-Lo	Porter IN	I	133	White 2007:Fig. 4.12	-	-	-

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794	Hi-Lo	Lake IN	I	106	White 2007:Fig. 4.12	-	-	-
795	Hi-Lo	Porter IN	I	106	White 2007:Fig. 4.12	-	-	-
796	Hi-Lo	Lake IN	I	106	White 2007:Fig. 4.12	-	-	-
799	EFP	Cook IL	I	106	White 2007:Fig. 4.5	-	-	-
801	Hi-Lo	Kankakee IL	I	106	White 2007:Fig. 4.12	-	-	-
802	Hi-Lo	Kankakee IL	I	106	White 2007:Fig. 4.12	-	-	-
808	Hi-Lo	Kankakee IL	I	106		-	-	-
811	EFP	Kankakee IL	I	133	White 2007:Fig. 4.5	-	-	-
812	EFP	Kankakee IL	I	133	White 2007:Fig. 4.5	-	-	-
813	EFP	Will IL	I	133	White 2007:Fig. 4.5	-	-	-
814	EFP	Will IL	I	133	White 2007:Fig. 4.5	-	-	-
815	EFP	Tazewell IL	I	133	White 2007:Fig. 4.5	-	-	-
817	EFP	Kankakee IL	I	103	White 2007:Fig. 4.5	-	-	-
818	EFP	Lake IN	I	103	White 2007:Fig. 4.5	-	-	-
820	EFP	Porter IN	I	103	White 2007:Fig. 4.6	-	-	-
822	EFP	Parke IN	I	103	White 2007:Fig. 4.6	-	-	-
823	EFP	Fountain IN	I	103	White 2007:Fig. 4.6	-	-	-
824	EFP	White IN	I	103	White 2007:Fig. 4.6	-	-	-
825	EFP	White IN	I	103	White 2007:Fig. 4.6	-	-	-
826	EFP	White IN	I	103	White 2007:Fig. 4.6	-	-	-
828	Dalton	Jasper IN	I	103	White 2007:Fig. 4.20	-	-	-
830	EFP	Jasper IN	I	103	White 2007:Fig. 4.6	-	-	-
841	EFP	LaPorte IN	I	104	White 2007:Fig. 4.7	-	-	-
852	Hi-Lo	LaPorte IN	I	139		-	-	-
860	Hi-Lo	Allen IN	I	141		-	-	-
904	Kirk	Lake IN	I	52		-	-	-
911	EFP	Clark IN	D	-	Tankersley 1989	5	-	-
912	EFP	Decatur IN	D	-	Tankersley 1989	6	-	-
913	EFP	Clark IN	I	6	Tankersley 1989	7	-	-
914	EFP	Clark IN	D	-	Tankersley 1989	8	-	-
915	EFP	Jefferson IN	I	6	Tankersley 1989	9	-	-
916	EFP	Rush/Shelby IN	D	-	Tankersley 1989	10	-	-
923	EFP	Clark IN	I	6	Tankersley 1989	21	-	-
926	EFP	Gibson IN	D	-	Tankersley 1989	27	-	-
927	EFP	Hamilton IN	I	6	Tankersley 1989	28	-	-
928	EFP	Perry IN	D	-	Tankersley 1989	29	-	-
931	EFP	Floyd IN	D	-	Tankersley 1989	32	-	-
934	EFP	Clark IN	I	6	Tankersley 1989	39	-	-
935	EFP	Clark IN	D	-	Tankersley 1989	40	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
938	EFP	Hamilton OH	I	6	Tankersley 1989	43	-	-
946	EFP	Crawford IN	D	-	Tankersley 1989	53	-	-
948	EFP	Hamilton OH	D	-	Tankersley 1989	55	-	-
949	EFP	Clermont OH	D	-	Tankersley 1989	56	-	-
950	EFP	Hamilton OH	D	-	Tankersley 1989	57	-	-
951	EFP	Clermont OH	D	-	Tankersley 1989	58	-	-
954	EFP	Kenton KY	D	-	Tankersley 1989	61	-	-
955	EFP	Kenton KY	D	-	Tankersley 1989	62	-	-
956	EFP	Kenton KY	D	-	Tankersley 1989	63	-	-
957	EFP	Boone KY	D	-	Tankersley 1989; Tankersley et al. 2009	64	-	-
960	EFP	Adams OH	D	-	Tankersley 1989	67	-	-
961	EFP	Boone KY	D	-	Tankersley 1989; Tankersley et al. 2009	68	-	-
962	EFP	Clermont OH	D	-	Tankersley 1989	69	-	-
963	EFP	Vigo IN	D	-	Tankersley 1989	70	-	-
964	EFP	Vigo IN	D	-	Tankersley 1989	71	-	-
965	EFP	Warrick IN	D	-	Tankersley 1989	72	-	-
966	EFP	Vigo IN	D	-	Tankersley 1989	73	-	-
968	EFP	Johnson IN	D	-	Tankersley 1989	75	-	-
969	EFP	Vanderburgh IN	D	-	Tankersley 1989	76	-	-
972	EFP	Carroll KY	D	-	Tankersley 1989	79	-	-
975	EFP	Warrick IN	D	-	Tankersley 1989	82	-	-
976	EFP	Hamilton IN	D	-	Tankersley 1989	83	-	-
977	EFP	Madison IN	D	-	Tankersley 1989	84	-	-
978	EFP	Hopkins KY	D	-	Tankersley 1989	85	-	-
980	EFP	Greene OH	D	-	Tankersley 1989	87	-	-
982	EFP	Wayne IN	D	-	Tankersley 1989	89	-	-
985	EFP	Miami OH	D	-	Tankersley 1989	92	-	-
986	EFP	Greene OH	D	-	Tankersley 1989	93	-	-
989	EFP	Cuyahoga OH	D	-	Tankersley 1989	96	-	-
991	EFP	Boone KY	D	-	Tankersley 1989; Tankersley et al. 2009	98	-	-
992	EFP	Orange IN	D	-	Tankersley 1989	99	-	-
993	EFP	Orange IN	D	-	Tankersley 1989	100	-	-
994	EFP	Perry IN	D	-	Tankersley 1989	101	-	-
997	EFP	Spencer IN	D	-	Tankersley 1989	104	-	-
1003	EFP	Harrison IN	D	-	Tankersley 1989	110	-	-
1005	EFP	Washington IN	D	-	Tankersley 1989	112	-	-
1006	EFP	Harrison IN	D	-	Tankersley 1989	113	-	-
1009	EFP	Vanderburgh IN	D	-	Tankersley 1989	116	-	-

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1010	EFP	Vanderburgh IN	D	-	Tankersley 1989	117	-	-
1011	EFP	Posey IN	D	-	Tankersley 1989	118	-	-
1012	EFP	Spencer IN	D	-	Tankersley 1989	119	-	-
1017	EFP	Spencer IN	D	-	Tankersley 1989	124	-	-
1018	EFP	Spencer IN	D	-	Tankersley 1989	125	-	-
1020	EFP	Spencer IN	D	-	Tankersley 1989	127	-	-
1021	EFP	Spencer IN	D	-	Tankersley 1989	128	-	-
1023	EFP	Spencer IN	D	-	Tankersley 1989	130	-	-
1024	EFP	Spencer IN	D	-	Tankersley 1989	131	-	-
1025	EFP	Spencer IN	D	-	Tankersley 1989	132	-	-
1026	EFP	Warrick IN	D	-	Tankersley 1989	133	-	-
1028	EFP	Spencer IN	D	-	Tankersley 1989	135	-	-
1030	EFP	Spencer IN	D	-	Tankersley 1989	137	-	-
1034	EFP	Spencer IN	D	-	Tankersley 1989	141	-	-
1035	EFP	Spencer IN	D	-	Tankersley 1989	142	-	-
1036	EFP	Spencer IN	D	-	Tankersley 1989	143	-	-
1037	EFP	Clark IN	D	-	Tankersley 1989	144	-	-
1038	EFP	Dubois IN	D	-	Tankersley 1989	145	-	-
1039	EFP	Monroe IN	D	-	Tankersley 1989	146	-	-
1041	EFP	Lawrence IN	D	-	Tankersley 1989	148	-	-
1042	EFP	Lawrence IN	D	-	Tankersley 1989	149	-	-
1043	EFP	Monroe IN	D	-	Tankersley 1989	150	-	-
1044	EFP	Warrick IN	D	-	Tankersley 1989	151	-	-
1046	EFP	Warrick IN	D	-	Tankersley 1989	153	-	-
1047	EFP	Warrick IN	D	-	Tankersley 1989	154	-	-
1048	EFP	Warrick IN	D	-	Tankersley 1989	155	-	-
1049	EFP	Warrick IN	D	-	Tankersley 1989	156	-	-
1051	EFP	Tippecanoe IN	I	6	Tankersley 1989	159	-	-
1052	EFP	Spencer IN	D	-	Tankersley 1989	160	-	-
1053	EFP	Warrick IN	D	-	Tankersley 1989	161	-	-
1054	EFP	Spencer IN	D	-	Tankersley 1989	162	-	-
1055	EFP	Spencer IN	D	-	Tankersley 1989	163	-	-
1056	EFP	Vanderburgh IN	D	-	Tankersley 1989	164	-	-
1057	EFP	Webster KY	D	-	Tankersley 1989	165	-	-
1058	EFP	Webster KY	D	-	Tankersley 1989	166	-	-
1061	EFP	Warrick IN	D	-	Tankersley 1989	169	-	-
1062	EFP	Warrick IN	D	-	Tankersley 1989	170	-	-
1063	EFP	Posey IN	D	-	Tankersley 1989	176	-	-
1065	EFP	Gibson IN	D	-	Tankersley 1989	178	-	-
1066	EFP	Clark IN	D	-	Tankersley 1989	179	-	-

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1067	EFP	Clark IN	D	-	Tankersley 1989	180	-	-
1069	EFP	Vanderburgh IN	D	-	Tankersley 1989	172	-	-
1072	EFP	Gibson IN	D	-	Tankersley 1989	175	-	-
1080	EFP	Harrison IN	D	-	Tankersley 1989	183	-	-
1082	EFP	Monroe IN	I	6	Tankersley 1989	185	-	-
1083	EFP	Putnam OH	I	166	Tankersley 1989	186	-	-
1086	EFP	Hamilton OH	D	-	Tankersley 1989	189	-	-
1087	EFP	Posey IN	D	-	Tankersley 1989	190	-	-
1088	EFP	Monroe IN	D	-	Tankersley 1989	191	-	-
1089	EFP	Wayne OH	D	-	Tankersley 1989	192	-	-
1090	EFP	Franklin OH	D	-	Tankersley 1989	193	-	-
1091	EFP	Franklin OH	D	-	Tankersley 1989	194	-	-
1095	EFP	Fairfield OH	D	-	Tankersley 1989	198	-	-
1096	EFP	Montgomery OH	D	-	Tankersley 1989	199	-	-
1097	EFP	Adams OH	D	-	Tankersley 1989; Prufer and Baby 1963:Fig. 3 (2nd from left)	200	-	-
1098	EFP	Greene OH	D	-	Tankersley 1989	201	-	-
1099	EFP	Cuyahoga OH	D	-	Tankersley 1989; Prufer and Baby 1963:Fig. 3 (3rd from left)	202	-	-
1100	EFP	Ross OH	D	-	Tankersley 1989; Prufer and Baby 1963:Fig. 5 (right)	203	-	-
1101	EFP	Ross OH	D	-	Tankersley 1989; Prufer and Baby 1963:Fig. 5 (left)	204	-	-
1104	EFP	Fayette/Ross OH	D	-	Tankersley 1989; Prufer and Baby 1963:Fig. 4 (left)	207	-	-
1105	EFP	Adams IN	D	-	Tankersley 1989	208	-	-
1106	EFP	Madison IN	D	-	Tankersley 1989	209	-	-
1107	EFP	Ross OH	D	-	Tankersley 1989; Prufer and Baby 1963; Fig. 6 (right)	210	-	-
1108	EFP	Pickaway OH	D	-	Tankersley 1989; Prufer and Baby 1963:Fig. 5 (middle)	211	-	-
1110	EFP	Fairfield OH	D	-	Tankersley 1989; Prufer and Baby 1963:Fig. 3 (left)	213	-	-
1112	EFP	Licking OH	D	-	Tankersley 1989	215	-	-
1113	EFP	Wayne OH	D	-	Tankersley 1989	216	-	-
1114	EFP	Miami OH	D	-	Tankersley 1989; Prufer and Baby 1963 (Fig. 3, 7th from left)	217	-	-
1116	EFP	Pike/Ross OH	D	-	Tankersley 1989	219	-	-
1118	EFP	Ross OH	D	-	Tankersley 1989	221	-	-

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1120	EFP	Fairfield OH	D	-	Tankersley 1989	223	-	-
1123	EFP	Fayette/Ross OH	I	163	Tankersley 1989	226	-	-
1125	EFP	Gallia OH	D	-	Tankersley 1989	228	-	-
1126	EFP	Miami OH	D	-	Tankersley 1989	229	-	-
1127	EFP	Pickaway OH	D	-	Tankersley 1989	230	-	-
1128	EFP	Fairfield OH	D	-	Tankersley 1989	231	-	-
1129	EFP	Highland OH	D	-	Tankersley 1989	232	-	-
1130	EFP	Gallia OH	D	-	Tankersley 1989	233	-	-
1134	EFP	Miami OH	D	-	Tankersley 1989	237	-	-
1140	EFP	Pickaway OH	D	-	Tankersley 1989	243	-	-
1141	EFP	Wayne OH	I	163	Tankersley 1989	244	-	-
1142	EFP	Wayne OH	I	163	Tankersley 1989	245	-	-
1144	EFP	Gallia OH	D	-	Tankersley 1989	247	-	-
1146	EFP	Hancock IN	D	-	Tankersley 1989	249	-	-
1148	EFP	Cuyahoga OH	D	-	Tankersley 1989	251	-	-
1150	EFP	Scioto OH	D	-	Tankersley 1989	253	-	-
1152	EFP	Miami OH	D	-	Tankersley 1989	255	-	-
1153	EFP	Adams OH	I	163	Tankersley 1989	256	-	-
1154	EFP	Franklin OH	D	-	Tankersley 1989	257	-	-
1155	EFP	Gallia OH	I	163	Tankersley 1989	258	-	-
1156	EFP	Perry OH	I	163	Tankersley 1989	259	-	-
1157	EFP	Ross OH	I	163	Tankersley 1989	260	-	-
1159	EFP	Highland OH	D	-	Tankersley 1989	262	-	-
1161	EFP	Ross OH	I	163	Tankersley 1989	264	-	-
1164	EFP	Mahoning OH	D	-	Tankersley 1989	267	-	-
1166	EFP	Hopkins KY	D	-	Tankersley 1989	269	-	-
1167	EFP	Franklin OH	I	163	Tankersley 1989	270	-	-
1168	EFP	Hancock OH	D	-	Tankersley 1989	271	-	-
1169	EFP	Hamilton OH	I	163	Tankersley 1989	272	-	-
1170	EFP	Perry OH	D	-	Tankersley 1989	273	-	-
1171	EFP	Madison OH	I	163	Tankersley 1989	274	-	-
1173	EFP	Ross OH	D	-	Tankersley 1989	276	-	-
1174	EFP	Franklin OH	I	163	Tankersley 1989	277	-	-
1177	EFP	Webster KY	D	-	Tankersley 1989	280	-	-
1180	EFP	Adams OH	D	-	Tankersley 1989	283	-	-
1183	EFP	Adams OH	D	-	Tankersley 1989	286	-	-
1185	EFP	Adams OH	D	-	Tankersley 1989	288	-	-
1189	EFP	Adams OH	D	-	Tankersley 1989	292	-	-
1190	EFP	Adams OH	D	-	Tankersley 1989	293	-	-
1192	EFP	Adams OH	D	-	Tankersley 1989	295	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
1193	EFP	Adams OH	D	-	Tankersley 1989	296	-	-
1200	EFP	Adams OH	D	-	Tankersley 1989	303	-	-
1201	EFP	Adams OH	D	-	Tankersley 1989	304	-	-
1204	EFP	Coshocton OH	D	-	Tankersley 1989	307	-	-
1209	EFP	Coshocton OH	D	-	Tankersley 1989	312	-	-
1210	EFP	Coshocton OH	D	-	Tankersley 1989	313	-	-
1222	EFP	Medina OH	D	-	Tankersley 1989	325	-	-
1225	EFP	Coshocton OH	D	-	Tankersley 1989	328	-	-
1228	EFP	Coshocton OH	D	-	Tankersley 1989	331	-	-
1232	EFP	Coshocton OH	D	-	Tankersley 1989	335	-	-
1233	EFP	Coshocton OH	D	-	Tankersley 1989	336	-	-
1234	EFP	Coshocton OH	D	-	Tankersley 1989	337	-	-
1238	EFP	Coshocton OH	D	-	Tankersley 1989	341	-	-
1239	EFP	Coshocton OH	D	-	Tankersley 1989	342	-	-
1241	EFP	Coshocton OH	D	-	Tankersley 1989	344	-	-
1245	EFP	Coshocton OH	D	-	Tankersley 1989	348	-	-
1246	EFP	Crawford OH	D	-	Tankersley 1989	349	-	-
1248	EFP	Coshocton OH	D	-	Tankersley 1989	351	-	-
1249	EFP	Coshocton OH	D	-	Tankersley 1989	352	-	-
1250	EFP	Coshocton OH	D	-	Tankersley 1989	353	-	-
1251	EFP	Coshocton OH	D	-	Tankersley 1989	354	-	-
1252	EFP	Coshocton OH	D	-	Tankersley 1989	355	-	-
1254	EFP	Coshocton OH	D	-	Tankersley 1989	357	-	-
1258	EFP	Coshocton OH	D	-	Tankersley 1989	361	-	-
1259	EFP	Coshocton OH	D	-	Tankersley 1989	362	-	-
1260	EFP	Coshocton OH	D	-	Tankersley 1989	363	-	-
1262	EFP	Coshocton OH	D	-	Tankersley 1989	365	-	-
1263	EFP	Fayette OH	D	-	Tankersley 1989	366	-	-
1264	EFP	Williams OH	D	-	Tankersley 1989	367	-	-
1273	EFP	Coshocton OH	D	-	Tankersley 1989	376	-	-
1275	EFP	Richland OH	D	-	Tankersley 1989	378	-	-
1277	EFP	Coshocton OH	D	-	Tankersley 1989	380	-	-
1279	EFP	Franklin OH	D	-	Tankersley 1989	382	-	-
1280	EFP	Coshocton OH	D	-	Tankersley 1989	383	-	-
1282	EFP	Ross OH	D	-	Tankersley 1989	385	-	-
1283	EFP	Coshocton OH	D	-	Tankersley 1989	386	-	-
1284	EFP	Coshocton OH	D	-	Tankersley 1989	387	-	-
1287	EFP	Coshocton OH	D	-	Tankersley 1989	390	-	-
1295	EFP	Coshocton OH	D	-	Tankersley 1989	398	-	-
1301	EFP	Daviess KY	D	-	Tankersley 1989	404	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
1304	EFP	Floyd IN	D	-	Tankersley 1989	407	-	-
1308	EFP	Lucas OH	D	-	Tankersley 1989	411	-	-
1309	EFP	Brown OH	D	-	Tankersley 1989	412	-	-
1310	EFP	Union OH	D	-	Tankersley 1989; Prufer 1960	413	78	44 80 078.11.2122
1311	EFP	Medina OH	D	-	Tankersley 1989	414	-	-
1312	EFP	Ross OH	D	-	Tankersley 1989	415	-	-
1313	EFP	Union OH	D	-	Tankersley 1989	416	-	-
1314	EFP	Knox OH	D	-	Tankersley 1989	417	-	-
1315	EFP	Richland OH	D	-	Tankersley 1989	418	-	-
1316	EFP	Spencer IN	D	-	Tankersley 1989	419	-	-
1320	EFP	Spencer IN	D	-	Tankersley 1989	423	-	-
1322	EFP	Monroe IN	D	-	Tankersley 1989	425	-	-
1323	EFP	Monroe IN	D	-	Tankersley 1989	426	-	-
1324	EFP	Monroe IN	D	-	Tankersley 1989	427	-	-
1328	EFP	Pickaway OH	D	-	Tankersley 1989; Prufer 1962	431	509	44 65 509.31.2154
1330	EFP	Muskingum OH	D	-	Tankersley 1989; Prufer 1962	433	502	66 60 502.11.4222
1331	EFP	Knox OH	D	-	Tankersley 1989	434	-	-
1332	EFP	Morrow OH	D	-	Tankersley 1989	435	-	-
1333	EFP	Lucas OH	D	-	Tankersley 1989	436	-	-
1336	EFP	Montgomery OH	D	-	Tankersley 1989	439	-	-
1341	EFP	Hamilton OH	D	-	Tankersley 1989	444	-	-
1345	EFP	Tuscarawas OH	D	-	Tankersley 1989; Prufer 1960	448	80	66 79 080.11.1222
1346	EFP	Montgomery OH	D	-	Tankersley 1989	449	-	-
1348	EFP	Madison OH	D	-	Tankersley 1989	451	-	-
1352	EFP	Montgomery OH	D	-	Tankersley 1989	455	-	-
1356	EFP	Fairfield OH	D	-	Tankersley 1989	459	-	-
1358	EFP	Monroe IN	D	-	Tankersley 1989	461	-	-
1359	EFP	Carroll OH	D	-	Tankersley 1989	462	-	-
1362	EFP	Harrison IN	D	-	Tankersley 1989	465	-	-
1366	EFP	Crawford IN	D	-	Tankersley 1989	469	-	-
1367	EFP	Crawford IN	D	-	Tankersley 1989	470	-	-
1371	EFP	Christian KY	D	-	Tankersley 1989	474	-	-
1375	EFP	Christian KY	D	-	Tankersley 1989	478	-	-
1376	EFP	Christian KY	D	-	Tankersley 1989	479	-	-
1383	EFP	Christian KY	D	-	Tankersley 1989	486	-	-
1384	EFP	Christian KY	D	-	Tankersley 1989	487	-	-
1388	EFP	Christian KY	D	-	Tankersley 1989	491	-	-
1405	EFP	Christian KY	D	-	Tankersley 1989	508	-	-
1478	EFP	Harrison IN	D	-	Tankersley 1989	581	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
1485	EFP	Harrison IN	D	-	Tankersley 1989	588	-	-
1489	EFP	Harrison IN	D	-	Tankersley 1989	592	-	-
1492	EFP	Harrison IN	D	-	Tankersley 1989	595	-	-
1493	EFP	Harrison IN	D	-	Tankersley 1989	596	-	-
1494	EFP	Jefferson IN	D	-	Tankersley 1989	597	-	-
1496	EFP	Harrison IN	D	-	Tankersley 1989	599	-	-
1497	EFP	Crawford IN	D	-	Tankersley 1989	600	-	-
1498	EFP	Crawford IN	D	-	Tankersley 1989	601	-	-
1500	EFP	Vanderburgh IN	D	-	Tankersley 1989	603	-	-
1502	EFP	Perry IN	D	-	Tankersley 1989	605	-	-
1503	EFP	Grayson KY	D	-	Tankersley 1989	606	-	-
1504	EFP	Grayson KY	D	-	Tankersley 1989	607	-	-
1505	EFP	Perry IN	D	-	Tankersley 1989	608	-	-
1506	EFP	Perry IN	D	-	Tankersley 1989	609	-	-
1507	EFP	Perry IN	D	-	Tankersley 1989	610	-	-
1508	EFP	Perry IN	D	-	Tankersley 1989	611	-	-
1510	EFP	Breckinridge KY	D	-	Tankersley 1989	613	-	-
1511	EFP	Spencer IN	D	-	Tankersley 1989	614	-	-
1512	EFP	Breckinridge KY	D	-	Tankersley 1989	615	-	-
1513	EFP	Perry IN	D	-	Tankersley 1989	616	-	-
1514	EFP	Perry IN	D	-	Tankersley 1989	617	-	-
1517	EFP	Perry IN	D	-	Tankersley 1989	620	-	-
1520	EFP	Perry IN	D	-	Tankersley 1989	623	-	-
1521	EFP	Orange IN	D	-	Tankersley 1989	624	-	-
1522	EFP	Lawrence IN	D	-	Tankersley 1989	625	-	-
1523	EFP	Lawrence IN	D	-	Tankersley 1989	626	-	-
1524	EFP	Harrison IN	D	-	Tankersley 1989	627	-	-
1525	EFP	Lawrence IN	D	-	Tankersley 1989	628	-	-
1526	EFP	Lawrence IN	D	-	Tankersley 1989	629	-	-
1527	EFP	Martin IN	D	-	Tankersley 1989	630	-	-
1530	EFP	Lawrence IN	D	-	Tankersley 1989	633	-	-
1531	EFP	Lawrence IN	D	-	Tankersley 1989	634	-	-
1532	EFP	Lawrence IN	D	-	Tankersley 1989	635	-	-
1533	EFP	Lawrence IN	D	-	Tankersley 1989	636	-	-
1535	EFP	Lawrence IN	D	-	Tankersley 1989	638	-	-
1536	EFP	Lawrence IN	D	-	Tankersley 1989	639	-	-
1541	EFP	Logan KY	D	-	Tankersley 1989	644	-	-
1543	EFP	Allen IN	D	-	Tankersley 1989	647	-	-
1546	EFP	Woodford KY	D	-	Tankersley 1989	658	-	-
1547	EFP	Edmonson KY	D	-	Tankersley 1989	659	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
1548	EFP	Harrison KY	D	-	Tankersley 1989	660	-	-
1551	EFP	Hardin KY	D	-	Tankersley 1989	663	-	-
1557	EFP	Boyle KY	D	-	Tankersley 1989	669	-	-
1558	EFP	Ross OH	D	-	Tankersley 1989	670	-	-
1559	EFP	Allen IN	D	-	Tankersley 1989	671	-	-
1560	EFP	Boyle KY	D	-	Tankersley 1989	672	-	-
1562	EFP	Boyle KY	D	-	Tankersley 1989	674	-	-
1563	EFP	Boone KY	D	-	Tankersley 1989; Tankersley et al. 2009	675	-	-
1564	EFP	Marion KY	D	-	Tankersley 1989	676	-	-
1567	EFP	Boone KY	D	-	Tankersley 1989; Tankersley et al. 2009	679	-	-
1568	EFP	Boyle KY	D	-	Tankersley 1989	680	-	-
1569	EFP	Ross OH	D	-	Tankersley 1989	681	-	-
1570	EFP	Kenton KY	D	-	Tankersley 1989	682	-	-
1579	EFP	Christian KY	D	-	Tankersley 1989	691	-	-
1580	EFP	Todd KY	D	-	Tankersley 1989	692	-	-
1581	EFP	Christian KY	D	-	Tankersley 1989	693	-	-
1582	EFP	Monroe IN	D	-	Tankersley 1989	694	-	-
1584	EFP	Pulaski KY	D	-	Tankersley 1989	696	-	-
1585	EFP	Vanderburgh IN	D	-	Tankersley 1989	697	-	-
1588	EFP	Trigg KY	D	-	Tankersley 1989	700	-	-
1590	EFP	Martin IN	D	-	Tankersley 1989	702	-	-
1592	EFP	Delaware IN	D	-	Tankersley 1989	704	-	-
1593	EFP	Hamilton IN	D	-	Tankersley 1989	705	-	-
1595	EFP	Grant IN	D	-	Tankersley 1989	707	-	-
1597	Hi-Lo	Livingston MI	I	142		-	-	-
1598	Hi-Lo	Livingston MI	I	142		-	-	-
1599	Hi-Lo	Livingston MI	I	142		-	-	-
1601	Hi-Lo	Lapeer MI	I	142		-	-	-
1602	Hi-Lo	Genesee/ Lapeer MI	I	142		-	-	-
1604	Hi-Lo	Lenawee MI	I	142		-	-	-
1606	Hi-Lo	Livingston MI	I	142		-	-	-
1610	Hi-Lo	Ingham MI	I	142		-	-	-
1612	Hi-Lo	Saginaw MI	I	142		-	-	-
1618	Thebes	Lenawee MI	I	142		-	-	-
1622	Hi-Lo	Ionia MI	I	142		-	-	-
1625	Thebes	Jackson MI	I	142		-	-	-
1626	Hi-Lo	Jackson MI	I	142		-	-	-
1627	Hi-Lo	Jackson MI	I	142		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
1628	Hi-Lo	Jackson MI	I	142		-	-	-
1629	Hi-Lo	Saginaw MI	I	142		-	-	-
1630	Hi-Lo	Ionia MI	I	142		-	-	-
1632	Hi-Lo	Ionia MI	I	142		-	-	-
1638	EFP	Berrien MI	I	142		-	-	-
1642	Hi-Lo	Jackson MI	I	142		-	-	-
1643	Hi-Lo	Jackson MI	I	142		-	-	-
1644	Hi-Lo	Jackson MI	I	142		-	-	-
1646	Hi-Lo	Huron MI	I	142		-	-	-
1647	Hi-Lo	Jackson/ Washtenaw MI	I	142		-	-	-
1649	Hi-Lo	Saginaw MI	I	142		-	-	-
1650	Hi-Lo	Jackson MI	I	142		-	-	-
1653	Hi-Lo	Saginaw MI	I	142		-	-	-
1654	Thebes	Tuscola MI	I	142		-	-	-
1655	Thebes	Tuscola MI	I	142		-	-	-
1656	Hi-Lo	Saginaw MI	I	142		-	-	-
1666	Thebes	Essex ON	I	142		-	-	-
1667	Kirk	Essex ON	I	142		-	-	-
1668	Hi-Lo	Washtenaw MI	I	142		-	-	-
1670	Hi-Lo	Jackson MI	I	142		-	-	-
1671	Hi-Lo	Hillsdale MI	I	142		-	-	-
1673	Hi-Lo	Washtenaw MI	I	142		-	-	-
1674	Hi-Lo	Washtenaw MI	I	142		-	-	-
1675	Hi-Lo	Washtenaw MI	I	142		-	-	-
1676	Hi-Lo	Washtenaw MI	I	142		-	-	-
1678	Thebes	Cass MI	I	142		-	-	-
1683	Hi-Lo	Starke IN	I	142		-	-	-
1684	Hi-Lo	Saginaw MI	I	142		-	-	-
1686	Hi-Lo	Washtenaw MI	I	142		-	-	-
1688	Hi-Lo	Washtenaw MI	I	142		-	-	-
1690	Hi-Lo	Washtenaw MI	I	142		-	-	-
1692	Hi-Lo	Saginaw MI	I	142		-	-	-
1693	Thebes	Hillsdale MI	I	142		-	-	-
1694	Thebes	Hillsdale MI	I	142		-	-	-
1695	Thebes	Hillsdale MI	I	142		-	-	-
1696	Thebes	Hillsdale MI	I	142		-	-	-
1697	Hi-Lo	Hillsdale MI	I	142		-	-	-
1711	Hi-Lo	Saginaw MI	I	142		-	-	-
1717	EFP	Washtenaw MI	I	142		-	-	-
1721	EFP	Washtenaw MI	I	142		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
1722	EFP	Washtenaw MI	I	142		-	-	-
1776	Dalton	Lawrence IN	I	147		-	-	-
1778	EFP	Lawrence IN	I	147		-	-	-
1779	Kirk	Lawrence IN	I	147		-	-	-
1780	Kirk	Lawrence IN	I	147		-	-	-
1783	Dalton	Ohio KY	I	148	Rolingson 1967:Fig. 27B	-	-	-
1784	EFP	Butler KY	I	148	Rolingson 1967:Fig. 27A(left)	-	-	-
1786	Dalton	McLean KY	I	148	Rolingson 1967:Fig. 28A	-	-	-
1787	Dalton	Ohio KY	I	148	Rolingson 1967:Fig. 28B	-	-	-
1788	Dalton	McLean KY	I	148	Rolingson 1967:Fig. 28A	-	-	-
1789	Dalton	McLean KY	I	148	Rolingson 1967:Fig. 28A	-	-	-
1790	Dalton	Hopkins KY	I	148	Rolingson and Schwartz 1966:Fig. 56	-	-	-
1791	Dalton	Hopkins KY	I	148	Rolingson and Schwartz 1966:Fig. 56	-	-	-
1792	Dalton	Hopkins KY	I	148		-	-	-
1794	Dalton	Hopkins KY	I	148		-	-	-
1795	Dalton	Hopkins KY	I	148		-	-	-
1796	Dalton	Hopkins KY	I	148		-	-	-
1797	Dalton	Hopkins KY	I	148	Rolingson and Schwartz 1966:Fig. 56	-	-	-
1798	Dalton	Hopkins KY	I	148	Rolingson and Schwartz 1966:Fig. 56	-	-	-
1799	Dalton	Hopkins KY	I	148		-	-	-
1800	Dalton	Hopkins KY	I	148	Rolingson and Schwartz 1966:Fig. 56	-	-	-
1801	Dalton	Hopkins KY	I	148		-	-	-
1802	Dalton	Trigg KY	I	148	Rolingson and Schwartz 1966:Fig. 25	-	-	-
1803	Dalton	Trigg KY	I	148	Rolingson and Schwartz 1966:Fig. 25	-	-	-
1805	EFP	Trigg KY	I	148	Rolingson and Schwartz 1966:Fig. 25	-	-	-
1806	Dalton	Trigg KY	I	148	Rolingson and Schwartz 1966:Fig. 25	-	-	-
1807	Dalton	Trigg KY	I	148	Rolingson and Schwartz 1966:Fig. 25	-	-	-
1809	Dalton	Trigg KY	I	148		-	-	-
1810	Dalton	Trigg KY	I	148	Rolingson and Schwartz 1966:Fig. 25	-	-	-
1811	Dalton	Trigg KY	I	148	Rolingson and Schwartz 1966:Fig.	-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
					25			
1812	Dalton	Trigg KY	I	148		-	-	-
1813	Dalton	Trigg KY	I	148	Rolingson and Schwartz 1966:Fig. 25	-	-	-
1820	Dalton	Hopkins KY	I	148	Rolingson and Schwartz 1966:Fig. 56	-	-	-
1821	Dalton	Hopkins KY	I	148	Rolingson and Schwartz 1966:Fig. 56	-	-	-
1823	Dalton	Hopkins KY	I	148	Rolingson and Schwartz 1966:Fig. 56	-	-	-
1824	Dalton	Hopkins KY	I	148		-	-	-
1827	Kirk	Hopkins KY	I	148		-	-	-
1833	Dalton	Hopkins KY	I	148		-	-	-
1835	Thebes	McLean KY	I	148		-	-	-
1836	Thebes	Butler KY	I	148		-	-	-
1837	Thebes	Butler KY	I	148		-	-	-
1838	Kirk	Butler KY	I	148		-	-	-
1839	Kirk	Butler KY	I	148		-	-	-
1840	Kirk	Ohio KY	I	148		-	-	-
1841	Kirk	Ohio KY	I	148		-	-	-
1842	Kirk	Ohio KY	I	148		-	-	-
1843	Kirk	Ohio KY	I	148		-	-	-
1844	Kirk	McLean KY	I	148		-	-	-
1847	Kirk	Ohio KY	I	148		-	-	-
1848	Kirk	Butler KY	I	148		-	-	-
1849	Kirk	Ohio KY	I	148		-	-	-
1850	Kirk	Butler KY	I	148		-	-	-
1851	Kirk	Butler KY	I	148		-	-	-
1854	Kirk	Ohio KY	I	148		-	-	-
1856	Thebes	Butler KY	I	148		-	-	-
1866	Thebes	Ohio KY	I	148		-	-	-
1869	Kirk	McLean KY	I	148		-	-	-
1870	Dalton	Ohio KY	I	148		-	-	-
1871	Kirk	McLean KY	I	148		-	-	-
1872	Hi-Lo	Middlesex ON	I	149		-	-	-
1873	Hi-Lo	Middlesex ON	I	149		-	-	-
1874	Hi-Lo	Middlesex ON	I	149		-	-	-
1875	Hi-Lo	Middlesex ON	I	149		-	-	-
1876	Hi-Lo	Middlesex ON	I	149		-	-	-
1877	Hi-Lo	Middlesex ON	I	149		-	-	-
1879	Hi-Lo	Middlesex ON	I	149		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
1880	Hi-Lo	Middlesex ON	I	149		-	-	-
1881	Hi-Lo	Middlesex ON	I	149		-	-	-
1882	Hi-Lo	Middlesex ON	I	149		-	-	-
1886	Hi-Lo	Middlesex ON	I	149		-	-	-
1887	Hi-Lo	Middlesex ON	I	149		-	-	-
1888	Hi-Lo	Middlesex ON	I	149		-	-	-
1889	Hi-Lo	Middlesex ON	I	149		-	-	-
1891	Hi-Lo	Middlesex ON	I	149		-	-	-
1893	Hi-Lo	Middlesex ON	I	149		-	-	-
1894	Hi-Lo	Middlesex ON	I	149		-	-	-
1895	Hi-Lo	Middlesex ON	I	149		-	-	-
1896	Hi-Lo	Middlesex ON	I	149		-	-	-
1899	Hi-Lo	Middlesex ON	I	149		-	-	-
1900	Hi-Lo	Middlesex ON	I	149		-	-	-
1901	Hi-Lo	Middlesex ON	I	149		-	-	-
1902	Hi-Lo	Middlesex ON	I	149		-	-	-
1903	Hi-Lo	Middlesex ON	I	149		-	-	-
1905	Hi-Lo	Middlesex ON	I	149		-	-	-
1907	Hi-Lo	Middlesex ON	I	149		-	-	-
1909	Hi-Lo	Middlesex ON	I	149		-	-	-
1913	Hi-Lo	Middlesex ON	I	149		-	-	-
1915	Hi-Lo	Middlesex ON	I	149		-	-	-
1916	Hi-Lo	Middlesex ON	I	149		-	-	-
1918	Hi-Lo	Middlesex ON	I	149		-	-	-
1920	Hi-Lo	Middlesex ON	I	149		-	-	-
1925	Hi-Lo	Middlesex ON	I	149		-	-	-
1927	Hi-Lo	Middlesex ON	I	149		-	-	-
1928	Hi-Lo	Middlesex ON	I	149		-	-	-
1929	Hi-Lo	Middlesex ON	I	149		-	-	-
1930	Hi-Lo	Middlesex ON	I	149		-	-	-
1931	Hi-Lo	Middlesex ON	I	149		-	-	-
1932	Hi-Lo	Middlesex ON	I	149		-	-	-
1971	Hi-Lo	Noble IN	I	151		-	-	-
1972	Hi-Lo	Noble IN	I	151		-	-	-
1973	Hi-Lo	Noble IN	I	151		-	-	-
1974	Kirk	Noble IN	I	151		-	-	-
1979	Thebes	Noble IN	I	151		-	-	-
1980	Kirk	Noble IN	I	151		-	-	-
1981	Kirk	Noble IN	I	151		-	-	-
1987	Hi-Lo	Genesee MI	I	150		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
1988	Hi-Lo	Genesee MI	I	150		-	-	-
1989	Hi-Lo	Livingston MI	I	150		-	-	-
1990	Hi-Lo	Tuscola MI	I	150		-	-	-
1991	Hi-Lo	Saginaw MI	I	150		-	-	-
1992	Hi-Lo	Saginaw MI	I	150		-	-	-
1993	Thebes	Hillsdale MI	I	150		-	-	-
1994	Hi-Lo	Saginaw MI	I	150		-	-	-
1995	Hi-Lo	Monroe MI	I	150		-	-	-
1996	Hi-Lo	Tuscola MI	I	150		-	-	-
1999	Hi-Lo	Genesee MI	I	150		-	-	-
2000	Kirk	Saginaw MI	I	150		-	-	-
2001	Hi-Lo	Genesee MI	I	150		-	-	-
2003	Hi-Lo	Genesee MI	I	150		-	-	-
2004	Hi-Lo	Oakland MI	I	150		-	-	-
2017	EFP	Fulton IN	I	6		-	-	-
2019	Dalton	Orange IN	I	6		-	-	-
2020	EFP	Floyd IN	I	6		-	-	-
2022	Dalton	Dearborn IN	I	6		-	-	-
2025	EFP	Posey IN	I	6		-	-	-
2028	Thebes	Martin IN	I	6		-	-	-
2029	Thebes	Martin IN	I	6		-	-	-
2031	Thebes	Martin IN	I	6		-	-	-
2032	Thebes	Martin IN	I	6		-	-	-
2034	Kirk	Martin IN	I	6		-	-	-
2036	Thebes	Martin IN	I	6		-	-	-
2037	Kirk	Martin IN	I	6		-	-	-
2038	Kirk	Martin IN	I	6		-	-	-
2040	Thebes	Hamilton IN	I	6		-	-	-
2042	Kirk	Madison IN	I	6		-	-	-
2047	Kirk	Hamilton IN	I	6		-	-	-
2056	Kirk	Hamilton IN	I	6		-	-	-
2057	Hi-Lo	Hamilton IN	I	6		-	-	-
2058	Thebes	Hamilton IN	I	6		-	-	-
2059	Thebes	Hamilton IN	I	6		-	-	-
2060	Thebes	Hamilton IN	I	6		-	-	-
2062	Thebes	Vigo IN	I	6		-	-	-
2066	Kirk	Porter IN	I	6		-	-	-
2069	Kirk	Porter IN	I	6		-	-	-
2071	EFP	Gibson IN	I	6		-	-	-
2072	Kirk	Gibson IN	I	6		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
2073	Thebes	Gibson IN	I	6		-	-	-
2075	Thebes	Owen IN	I	6		-	-	-
2079	Kirk	Dubois IN	I	6		-	-	-
2080	Kirk	Dubois IN	I	6		-	-	-
2081	Kirk	Dubois IN	I	6		-	-	-
2082	Thebes	Warrick IN	I	6		-	-	-
2084	Kirk	Hamilton IN	I	6		-	-	-
2085	Hi-Lo	Hamilton IN	I	6		-	-	-
2086	Thebes	Greene IN	I	6		-	-	-
2087	Kirk	Greene IN	I	6		-	-	-
2088	Kirk	Greene IN	I	6		-	-	-
2089	Hi-Lo	Greene IN	I	6		-	-	-
2097	Kirk	Marshall IN	I	6		-	-	-
2099	Thebes	Spencer IN	I	6		-	-	-
2101	Kirk	Spencer IN	I	6		-	-	-
2103	Kirk	Spencer IN	I	6		-	-	-
2106	Kirk	Spencer IN	I	6		-	-	-
2108	Thebes	Perry IN	I	6		-	-	-
2110	Kirk	Perry IN	I	6		-	-	-
2111	Dalton	Perry IN	I	6		-	-	-
2112	Kirk	Perry IN	I	6		-	-	-
2113	Kirk	Marshall IN	I	6		-	-	-
2114	Kirk	Marshall IN	I	6		-	-	-
2117	Kirk	Marshall IN	I	6		-	-	-
2118	Kirk	Marshall IN	I	6		-	-	-
2120	Kirk	Marshall IN	I	6		-	-	-
2125	Thebes	Huntington IN	I	6		-	-	-
2129	Thebes	Fountain IN	I	6		-	-	-
2131	Thebes	Hamilton IN	I	6		-	-	-
2132	Dalton	Hamilton IN	I	6		-	-	-
2134	Thebes	Hamilton IN	I	6		-	-	-
2135	Kirk	Hamilton IN	I	6		-	-	-
2136	Thebes	Hamilton IN	I	6		-	-	-
2137	Thebes	Hamilton IN	I	6		-	-	-
2138	Thebes	Hamilton IN	I	6		-	-	-
2143	Thebes	Hamilton IN	I	6		-	-	-
2146	Thebes	Hamilton IN	I	6		-	-	-
2147	Thebes	Hamilton IN	I	6		-	-	-
2149	Kirk	Harrison IN	I	6		-	-	-
2151	Kirk	Jefferson IN	I	6		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
2152	Kirk	Jefferson IN	I	6		-	-	-
2156	Thebes	Switzerland IN	I	6		-	-	-
2159	Kirk	Harrison IN	I	6		-	-	-
2162	Kirk	Clark IN	I	6		-	-	-
2164	Thebes	Sullivan IN	I	6		-	-	-
2167	Kirk	Greene IN	I	6		-	-	-
2171	Kirk	Greene IN	I	6		-	-	-
2173	Kirk	Dearborn IN	I	6		-	-	-
2175	Thebes	Greene IN	I	6		-	-	-
2178	Thebes	Orange IN	I	6		-	-	-
2180	Kirk	Allen IN	I	6		-	-	-
2183	Thebes	Allen IN	I	6		-	-	-
2184	Thebes	Allen IN	I	6		-	-	-
2185	Kirk	Allen IN	I	6		-	-	-
2186	Kirk	Allen IN	I	6		-	-	-
2187	Thebes	Allen IN	I	6		-	-	-
2191	Kirk	Tippecanoe IN	I	6		-	-	-
2192	Kirk	Tippecanoe IN	I	6		-	-	-
2193	Kirk	Monroe IN	I	6		-	-	-
2194	Kirk	Monroe IN	I	6		-	-	-
2195	Kirk	Jefferson IN	I	6		-	-	-
2197	Kirk	Monroe IN	I	6		-	-	-
2199	Kirk	Jefferson IN	I	6		-	-	-
2202	Kirk	Lawrence IN	I	147		-	-	-
2204	Kirk	Lawrence IN	I	147		-	-	-
2210	Thebes	Lawrence IN	I	147		-	-	-
2211	Kirk	Lawrence IN	I	147		-	-	-
2212	Kirk	Lawrence IN	I	147		-	-	-
2214	Kirk	Lawrence IN	I	147		-	-	-
2219	Thebes	Lawrence IN	I	147		-	-	-
2220	Thebes	Lawrence IN	I	147		-	-	-
2221	Kirk	Lawrence IN	I	147		-	-	-
2222	EFP	Lawrence IN	I	147		-	-	-
2223	Thebes	Lawrence IN	I	147		-	-	-
2227	Kirk	Lawrence IN	I	147		-	-	-
2228	Thebes	Lawrence IN	I	147		-	-	-
2230	Kirk	Lawrence IN	I	147		-	-	-
2233	EFP	Richland OH	I	152		-	-	-
2250	Thebes	Richland OH	I	152		-	-	-
2252	Kirk	Richland OH	I	152		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
2253	Thebes	Ashland OH	I	152		-	-	-
2254	Thebes	Richland OH	I	152		-	-	-
2262	Kirk	Richland OH	I	152		-	-	-
2264	Thebes	Richland OH	I	152		-	-	-
2266	Thebes	Richland OH	I	152		-	-	-
2267	Thebes	Richland OH	I	152		-	-	-
2271	Kirk	Richland OH	I	152		-	-	-
2273	Hi-Lo	Richland OH	I	152		-	-	-
2274	Thebes	Licking OH	I	152		-	-	-
2276	Thebes	Morrow OH	I	152		-	-	-
2277	Thebes	Richland OH	I	152		-	-	-
2302	Kirk	Richland OH	I	153		-	-	-
2303	Kirk	Richland OH	I	153		-	-	-
2314	Thebes	Montgomery OH	I	153		-	-	-
2316	Kirk	Knox OH	I	153		-	-	-
2322	Thebes	Ashland OH	I	153		-	-	-
2337	Thebes	Morrow OH	I	154		-	-	-
2338	Kirk	Wayne OH	I	154		-	-	-
2341	Thebes	Richland OH	I	154		-	-	-
2342	Thebes	Richland OH	I	154		-	-	-
2343	Thebes	Ashland OH	I	154		-	-	-
2344	Kirk	Richland OH	I	154		-	-	-
2350	Kirk	Holmes OH	I	154		-	-	-
2353	Thebes	Wayne OH	I	154		-	-	-
2354	Kirk	Wayne OH	I	154		-	-	-
2360	Kirk	Ashland OH	I	154		-	-	-
2365	Kirk	Holmes/Wayne OH	I	154		-	-	-
2370	EFP	Pickaway OH	I	136		-	-	-
2382	EFP	Franklin OH	I	136		-	-	-
2385	EFP	Ashland OH	I	136		-	-	-
2388	EFP	Lawrence OH	I	136		-	-	-
2391	EFP	Darke OH	I	136		-	-	-
2392	EFP	Hancock OH	I	136		-	-	-
2396	EFP	Brown OH	I	136		-	-	-
2398	Dalton	Carroll/Columbiana/Starke OH	I	136		-	-	-
2400	EFP	Scioto OH	I	136		-	-	-
2405	EFP	Union OH	I	136		-	-	-
2407	Hi-Lo	Hancock OH	I	136		-	-	-
2414	Hi-Lo	Erie OH	I	136		-	-	-
2421	Thebes	Montgomery IN	I	155		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
2422	Kirk	Hamilton IN	I	156		-	-	-
2428	Kirk	Hamilton IN	I	156		-	-	-
2429	Kirk	Hamilton IN	I	156		-	-	-
2437	Kirk	Hamilton IN	I	156		-	-	-
2438	Thebes	Hamilton IN	I	156		-	-	-
2439	Thebes	Hamilton IN	I	156		-	-	-
2440	Thebes	Hamilton IN	I	156		-	-	-
2441	Hi-Lo	Hamilton IN	I	156		-	-	-
2442	EFP	Hamilton IN	I	156		-	-	-
2443	Thebes	Hamilton IN	I	156		-	-	-
2444	Thebes	Hamilton IN	I	156		-	-	-
2446	Thebes	Hamilton IN	I	156		-	-	-
2450	Thebes	Hamilton IN	I	156		-	-	-
2451	Kirk	Hamilton IN	I	156		-	-	-
2452	Kirk	Hamilton IN	I	156		-	-	-
2454	Kirk	Berrien MI	I	156		-	-	-
2455	Kirk	Saint Joseph IN	I	156		-	-	-
2470	Kirk	Hamilton IN	I	156		-	-	-
2474	Kirk	Hamilton IN	I	156		-	-	-
2477	EFP	Hamilton IN	I	157		-	-	-
2482	Thebes	Madison IN	I	157		-	-	-
2483	Thebes	Hamilton IN	I	157		-	-	-
2484	Kirk	Hamilton IN	I	157		-	-	-
2485	Thebes	Hamilton IN	I	157		-	-	-
2486	Thebes	Hamilton IN	I	157		-	-	-
2487	Thebes	Hamilton IN	I	157		-	-	-
2489	Thebes	Hamilton IN	I	157		-	-	-
2491	Kirk	Hamilton IN	I	157		-	-	-
2492	Kirk	Hamilton IN	I	157		-	-	-
2498	Kirk	Hamilton IN	I	157		-	-	-
2502	Kirk	Madison IN	I	157		-	-	-
2510	Thebes	Allen IN	I	157		-	-	-
2512	Thebes	Madison IN	I	157		-	-	-
2516	Kirk	Tipton IN	I	157		-	-	-
2517	Kirk	Tipton IN	I	157		-	-	-
2518	Thebes	Tipton IN	I	157		-	-	-
2519	Thebes	Blackford IN	I	157		-	-	-
2520	Thebes	Blackford IN	I	157		-	-	-
2521	Hi-Lo	Blackford IN	I	157		-	-	-
2522	Kirk	Blackford IN	I	157		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
2523	Thebes	Madison IN	I	157		-	-	-
2527	Thebes	Hamilton IN	I	158		-	-	-
2528	Thebes	Hamilton IN	I	158		-	-	-
2529	Thebes	Hamilton IN	I	158		-	-	-
2532	Thebes	Hamilton IN	I	158		-	-	-
2534	Kirk	Hamilton IN	I	158		-	-	-
2540	Kirk	Hamilton IN	I	158		-	-	-
2541	Kirk	Hamilton IN	I	158		-	-	-
2544	Kirk	Hamilton IN	I	158		-	-	-
2545	Thebes	Hamilton IN	I	158		-	-	-
2546	Thebes	Hamilton IN	I	158		-	-	-
2547	Thebes	Hamilton IN	I	158		-	-	-
2550	Thebes	Hamilton IN	I	158		-	-	-
2551	Thebes	Hamilton IN	I	158		-	-	-
2555	Thebes	Hamilton IN	I	158		-	-	-
2556	Thebes	Hamilton IN	I	158		-	-	-
2564	Thebes	Dubois IN	I	159		-	-	-
2565	Thebes	Spencer IN	I	159		-	-	-
2566	Thebes	Pike IN	I	159		-	-	-
2567	Thebes	Gibson IN	I	159		-	-	-
2570	Thebes	Warrick IN	I	159		-	-	-
2571	Thebes	Greene IN	I	159		-	-	-
2573	Thebes	Spencer IN	I	159		-	-	-
2577	Thebes	Gibson IN	I	159		-	-	-
2578	Thebes	Spencer IN	I	159		-	-	-
2579	Thebes	Gibson IN	I	159		-	-	-
2580	Thebes	Perry IN	I	159		-	-	-
2581	Kirk	Parke IN	I	159		-	-	-
2582	Kirk	Vigo IN	I	159		-	-	-
2584	Kirk	Greene IN	I	159		-	-	-
2585	Kirk	Greene IN	I	159		-	-	-
2586	Kirk	Spencer IN	I	159		-	-	-
2587	Kirk	Warrick IN	I	159		-	-	-
2589	Kirk	Spencer IN	I	159		-	-	-
2591	Kirk	Clay IN	I	159		-	-	-
2592	Kirk	Sullivan IN	I	159		-	-	-
2593	Kirk	Clay IN	I	159		-	-	-
2594	Kirk	Knox IN	I	159		-	-	-
2595	Kirk	Spencer IN	I	159		-	-	-
2597	Kirk	Daviess IN	I	159		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
2598	Kirk	Knox IN	I	159		-	-	-
2599	Kirk	Spencer IN	I	159		-	-	-
2600	Kirk	Spencer IN	I	159		-	-	-
2601	Kirk	Greene IN	I	159		-	-	-
2602	Kirk	Daviess IN	I	159		-	-	-
2604	Kirk	Spencer IN	I	159		-	-	-
2605	Kirk	Greene IN	I	159		-	-	-
2606	Kirk	Clay IN	I	159		-	-	-
2607	Kirk	Daviess IN	I	159		-	-	-
2608	Kirk	Dubois IN	I	159		-	-	-
2609	Kirk	Spencer IN	I	159		-	-	-
2610	Kirk	Greene IN	I	159		-	-	-
2612	Kirk	Sullivan IN	I	159		-	-	-
2614	Kirk	Martin IN	I	159		-	-	-
2615	Kirk	Vigo IN	I	159		-	-	-
2616	Kirk	Daviess IN	I	159		-	-	-
2617	Kirk	Martin IN	I	159		-	-	-
2618	Kirk	Sullivan IN	I	159		-	-	-
2620	Kirk	Greene IN	I	159		-	-	-
2621	Kirk	Spencer IN	I	159		-	-	-
2624	Kirk	Clay IN	I	159		-	-	-
2625	Kirk	Vigo IN	I	159		-	-	-
2626	Kirk	Knox IN	I	159		-	-	-
2628	Kirk	Daviess IN	I	159		-	-	-
2629	Thebes	Gibson IN	I	159		-	-	-
2630	Thebes	Daviess IN	I	159		-	-	-
2632	Kirk	Clay IN	I	159		-	-	-
2633	Kirk	Spencer IN	I	159		-	-	-
2634	Kirk	Knox IN	I	159		-	-	-
2635	Thebes	Gibson IN	I	159		-	-	-
2637	Kirk	Gibson IN	I	159		-	-	-
2638	Kirk	Gibson IN	I	159		-	-	-
2639	Thebes	Gibson IN	I	159		-	-	-
2640	Kirk	Gibson IN	I	159		-	-	-
2642	Kirk	Gibson IN	I	159		-	-	-
2645	Kirk	Gibson IN	I	159		-	-	-
2647	Thebes	Gibson IN	I	159		-	-	-
2648	Thebes	Gibson IN	I	159		-	-	-
2649	Kirk	Gibson IN	I	159		-	-	-
2650	Thebes	Gibson IN	I	159		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
2651	Thebes	Gibson IN	I	159		-	-	-
2652	Kirk	Gibson IN	I	159		-	-	-
2653	Kirk	Gibson IN	I	159		-	-	-
2654	Kirk	Gibson IN	I	159		-	-	-
2655	EFP	Miami OH	P	-	Prufer and Baby 1963:Fig 3 (4th from left)	-	-	-
2657	EFP	Franklin OH	P	-	Prufer and Baby 1963:Fig 3 (6th from left)	-	-	-
2662	EFP	Ross OH	P	-	Prufer and Baby 1963:Fig 6 (middle)	-	-	-
2664	EFP	Pike OH	P	-	Prufer and Baby 1963:Fig 7 (2nd from left)	-	-	-
2665	EFP	Sandusky OH	P	-	Prufer and Baby 1963:Fig 7 (3rd from left)	-	-	-
2666	EFP	Miami/ Montgomery OH	P	-	Prufer and Baby 1963:Fig 7 (right)	-	-	-
2677	Dalton	Medina OH	P	-	Prufer and Baby 1963:Fig 11 (left)	-	-	-
2678	Dalton	Franklin OH	P	-	Prufer and Baby 1963:Fig 11 (right)	-	-	-
2683	EFP	Lucas OH	D	-	Payne 1982:Fig 5A	-	-	-
2686	EFP	Wood OH	D	-	Payne 1982:Fig 5D	-	-	-
2702	Hi-Lo	Henry OH	D	-	Payne 1982:Fig 11B	-	-	-
2703	Hi-Lo	Lucas OH	D	-	Payne 1982:Fig 11C	-	-	-
2708	Hi-Lo	Lucas OH	D	-	Payne 1982:Fig 11H	-	-	-
2711	Hi-Lo	Lucas OH	D	-	Payne 1982:Fig 11K	-	-	-
2712	Hi-Lo	Lucas OH	D	-	Payne 1982:Fig 11L	-	-	-
2715	Hi-Lo	Lucas OH	D	-	Payne 1982:Fig 11O	-	-	-
2716	Hi-Lo	Lucas OH	D	-	Payne 1982:Fig 11P	-	-	-
2718	Hi-Lo	Lucas OH	D	-	Payne 1982:Fig 11R	-	-	-
2722	Hi-Lo	Lucas OH	D	-	Payne 1982:Fig 11V	-	-	-
2735	Kirk	Henry OH	D	-	Payne 1982:Fig 22C	-	-	-
2736	Kirk	Lucas OH	D	-	Payne 1982:Fig 22E	-	-	-
2737	Kirk	Lucas OH	D	-	Payne 1982:Fig 22F	-	-	-
2742	Kirk	Lucas OH	D	-	Payne 1982:Fig 22K	-	-	-
2743	Kirk	Wood OH	D	-	Payne 1982:Fig 22L	-	-	-
2744	Kirk	Fulton OH	D	-	Payne 1982:Fig 24A	-	-	-
2745	Kirk	Lucas OH	D	-	Payne 1982:Fig 24B	-	-	-
2746	Kirk	Lucas OH	D	-	Payne 1982:Fig 24C	-	-	-
2747	Kirk	Lucas OH	D	-	Payne 1982:Fig 24D	-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
2750	Kirk	Lucas OH	D	-	Payne 1982:Fig 24G	-	-	-
2752	Kirk	Lucas OH	D	-	Payne 1982:Fig 24I	-	-	-
2753	Kirk	Lucas OH	D	-	Payne 1982:Fig 24J	-	-	-
2826	Thebes	Fulton OH	D	-	Payne 1982:Fig 38A	-	-	-
2827	Thebes	Fulton OH	D	-	Payne 1982:Fig 38B	-	-	-
2829	Thebes	Lucas OH	D	-	Payne 1982:Fig 38D	-	-	-
2830	Thebes	Lucas OH	D	-	Payne 1982:Fig 38E	-	-	-
2837	Kirk	Allen IN	I	52		-	-	-
2838	Kirk	Allen IN	I	52		-	-	-
2848	Kirk	Allen IN	I	52		-	-	-
2852	Kirk	Adams IN	I	52		-	-	-
2861	Thebes	Adams IN	I	52	Jeske 1996:Fig 3.6 right)	-	-	-
2866	Thebes	Adams IN	I	52		-	-	-
2867	Kirk	Allen IN	I	52		-	-	-
2871	Kirk	Noble IN	I	52		-	-	-
2874	Kirk	DeKalb IN	I	52		-	-	-
2875	Kirk	DeKalb IN	I	52		-	-	-
2895	Kirk	Huntington IN	I	52		-	-	-
2897	Kirk	Allen IN	I	52		-	-	-
2905	Thebes	Whitley IN	I	3		-	-	-
2907	Kirk	Whitley IN	I	3		-	-	-
2908	Kirk	Whitley IN	I	3		-	-	-
2910	Thebes	Whitley IN	I	3		-	-	-
2915	Thebes	Whitley IN	I	3		-	-	-
2917	Kirk	Whitley IN	I	3		-	-	-
2918	Thebes	Whitley IN	I	3		-	-	-
2920	Kirk	Whitley IN	I	3		-	-	-
2928	Kirk	Whitley IN	I	3		-	-	-
2929	Kirk	Whitley IN	I	3		-	-	-
2930	Thebes	Whitley IN	I	3		-	-	-
2934	Kirk	Whitley IN	I	3		-	-	-
2935	Kirk	Pulaski IN	I	3		-	-	-
2936	Kirk	Whitley IN	I	3		-	-	-
2939	Thebes	Whitley IN	I	3		-	-	-
2941	Kirk	Whitley IN	I	3		-	-	-
2942	Kirk	Whitley IN	I	3		-	-	-
2943	Kirk	Whitley IN	I	3		-	-	-
2945	Kirk	Whitley IN	I	3		-	-	-
2946	Thebes	Whitley IN	I	3		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
2947	Kirk	Whitley IN	I	3		-	-	-
2948	Kirk	Whitley IN	I	3		-	-	-
2959	Kirk	Whitley IN	I	3		-	-	-
2961	Thebes	Whitley IN	I	3		-	-	-
2962	Thebes	Whitley IN	I	3		-	-	-
2964	Thebes	Whitley IN	I	3		-	-	-
2967	Thebes	Whitley IN	I	3		-	-	-
2969	Kirk	Whitley IN	I	3		-	-	-
2970	Thebes	Whitley IN	I	3		-	-	-
2971	Thebes	Whitley IN	I	3		-	-	-
2972	Kirk	Whitley IN	I	3		-	-	-
2978	Kirk	Orange IN	I	6		-	-	-
2979	Kirk	Orange IN	I	6		-	-	-
2986	Thebes	Allen IN	I	6		-	-	-
2987	Kirk	Orange IN	I	6		-	-	-
2990	Kirk	Whitley IN	I	6		-	-	-
2991	Thebes	Decatur IN	I	6		-	-	-
2993	Kirk	Owen IN	I	6		-	-	-
2995	Thebes	Owen IN	I	6		-	-	-
3000	Thebes	Posey IN	I	6		-	-	-
3002	Kirk	Jefferson IN	I	6		-	-	-
3003	Kirk	Jefferson IN	I	6		-	-	-
3004	Kirk	Jefferson IN	I	6		-	-	-
3006	Kirk	Clark IN	I	6		-	-	-
3007	Kirk	Clark IN	I	6		-	-	-
3008	Kirk	Clark IN	I	6		-	-	-
3009	Kirk	Clark IN	I	6		-	-	-
3011	Kirk	Clark IN	I	6		-	-	-
3013	Thebes	Posey IN	I	6		-	-	-
3014	Thebes	Posey IN	I	6		-	-	-
3016	Kirk	Posey IN	I	6		-	-	-
3017	Kirk	Jefferson IN	I	6		-	-	-
3018	Kirk	Jackson IN	I	6		-	-	-
3020	Thebes	Allen IN	I	6		-	-	-
3022	Thebes	Posey IN	I	6		-	-	-
3025	Kirk	Posey IN	I	6		-	-	-
3026	Kirk	Harrison IN	I	6		-	-	-
3027	Thebes	Harrison IN	I	6		-	-	-
3029	Kirk	Harrison IN	I	6		-	-	-
3030	Kirk	Harrison IN	I	6		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
3035	Thebes	Tippecanoe IN	I	6		-	-	-
3038	Kirk	Tippecanoe IN	I	6		-	-	-
3039	Thebes	Tippecanoe IN	I	6		-	-	-
3043	Kirk	Tippecanoe IN	I	6		-	-	-
3044	Kirk	Tippecanoe IN	I	6		-	-	-
3046	Kirk	Tippecanoe IN	I	6		-	-	-
3047	Kirk	Tippecanoe IN	I	6		-	-	-
3048	Kirk	Tippecanoe IN	I	6		-	-	-
3049	Thebes	Tippecanoe IN	I	6		-	-	-
3053	Kirk	Tippecanoe IN	I	6		-	-	-
3057	Kirk	Tippecanoe IN	I	6		-	-	-
3059	Thebes	Tippecanoe IN	I	6		-	-	-
3068	Kirk	Monroe IN	I	6		-	-	-
3070	Thebes	Monroe IN	I	6		-	-	-
3074	Thebes	Monroe IN	I	6		-	-	-
3075	Thebes	Monroe IN	I	6		-	-	-
3076	Kirk	Gibson IN	I	6		-	-	-
3079	Kirk	Warrick IN	I	6		-	-	-
3080	Kirk	Warrick IN	I	6		-	-	-
3083	Kirk	Johnson IN	I	6		-	-	-
3089	Kirk	Johnson IN	I	6		-	-	-
3091	Kirk	Monroe IN	I	6		-	-	-
3096	Kirk	Clark IN	I	6		-	-	-
3098	Kirk	Warren IN	I	6		-	-	-
3099	Kirk	Warren IN	I	6		-	-	-
3101	Kirk	Warren IN	I	6		-	-	-
3102	Kirk	Warren IN	I	6		-	-	-
3103	Thebes	Warren IN	I	6		-	-	-
3104	Thebes	Warren IN	I	6		-	-	-
3105	Kirk	Warren IN	I	6		-	-	-
3106	Kirk	Warren IN	I	6		-	-	-
3108	Kirk	Warren IN	I	6		-	-	-
3110	Kirk	Warren IN	I	6		-	-	-
3112	Thebes	Warren IN	I	6		-	-	-
3119	Kirk	Orange IN	I	6		-	-	-
3123	Kirk	Monroe IN	I	6		-	-	-
3125	Kirk	Bartholomew IN	I	6		-	-	-
3126	Kirk	Bartholomew IN	I	6		-	-	-
3127	Kirk	Bartholomew IN	I	6		-	-	-
3128	Kirk	Bartholomew IN	I	6		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
3129	Kirk	Bartholomew IN	I	6		-	-	-
3131	Kirk	Bartholomew IN	I	6		-	-	-
3132	Kirk	Bartholomew IN	I	6		-	-	-
3133	Kirk	Bartholomew IN	I	6		-	-	-
3134	Kirk	Bartholomew IN	I	6		-	-	-
3137	Thebes	Bartholomew IN	I	6		-	-	-
3141	Thebes	Bartholomew IN	I	6		-	-	-
3142	Kirk	Bartholomew IN	I	6		-	-	-
3143	Kirk	Bartholomew IN	I	6		-	-	-
3145	Kirk	Bartholomew IN	I	6		-	-	-
3153	Kirk	Bartholomew IN	I	6		-	-	-
3178	Kirk	Monroe IN	I	6		-	-	-
3179	Kirk	Monroe IN	I	6		-	-	-
3181	Kirk	Monroe IN	I	6		-	-	-
3182	Kirk	Monroe IN	I	6		-	-	-
3185	Kirk	Monroe IN	I	6		-	-	-
3186	Kirk	Monroe IN	I	6		-	-	-
3187	Kirk	Monroe IN	I	6		-	-	-
3190	Kirk	Monroe IN	I	6		-	-	-
3191	Thebes	Monroe IN	I	6		-	-	-
3192	Thebes	Monroe IN	I	6		-	-	-
3194	Kirk	Monroe IN	I	6		-	-	-
3198	Kirk	Monroe IN	I	6		-	-	-
3200	Kirk	Monroe IN	I	6		-	-	-
3201	Kirk	Monroe IN	I	6		-	-	-
3202	Kirk	Monroe IN	I	6		-	-	-
3203	Kirk	Monroe IN	I	6		-	-	-
3204	Thebes	Monroe IN	I	6		-	-	-
3205	Thebes	Monroe IN	I	6		-	-	-
3206	Kirk	Monroe IN	I	6		-	-	-
3208	Thebes	Monroe IN	I	6		-	-	-
3210	Kirk	Monroe IN	I	6		-	-	-
3212	Kirk	Hamilton IN	I	6		-	-	-
3216	Thebes	Hamilton IN	I	6		-	-	-
3218	Kirk	Hamilton IN	I	6		-	-	-
3221	Kirk	Orange IN	I	6		-	-	-
3222	Kirk	Orange IN	I	6		-	-	-
3223	Dalton	Orange IN	I	6		-	-	-
3225	Kirk	Montgomery IN	I	6		-	-	-
3226	Kirk	Montgomery IN	I	6		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
3228	Kirk	Montgomery IN	I	6		-	-	-
3229	Kirk	Montgomery IN	I	6		-	-	-
3230	Kirk	Johnson IN	I	6		-	-	-
3234	Kirk	Tippecanoe IN	I	6		-	-	-
3235	Kirk	Tippecanoe IN	I	6		-	-	-
3236	Kirk	Crawford IN	I	6		-	-	-
3238	Kirk	Monroe IN	I	6		-	-	-
3240	Thebes	Monroe IN	I	6		-	-	-
3241	Kirk	Monroe IN	I	6		-	-	-
3246	Thebes	Owen IN	I	6		-	-	-
3249	Kirk	Vanderburgh IN	I	6		-	-	-
3250	Kirk	Posey IN	I	6		-	-	-
3251	Thebes	Clark IN	I	6		-	-	-
3253	Kirk	Harrison IN	I	6		-	-	-
3254	Kirk	Harrison IN	I	6		-	-	-
3255	Kirk	Harrison IN	I	6		-	-	-
3256	Kirk	Harrison IN	I	6		-	-	-
3257	Kirk	Harrison IN	I	6		-	-	-
3258	Kirk	Harrison IN	I	6		-	-	-
3259	Kirk	Harrison IN	I	6		-	-	-
3260	Kirk	Harrison IN	I	6		-	-	-
3261	Kirk	Harrison IN	I	6		-	-	-
3263	Kirk	Harrison IN	I	6		-	-	-
3264	Kirk	Harrison IN	I	6		-	-	-
3265	Kirk	Harrison IN	I	6		-	-	-
3266	Kirk	Harrison IN	I	6		-	-	-
3267	Kirk	Harrison IN	I	6		-	-	-
3268	Kirk	Harrison IN	I	6		-	-	-
3269	Thebes	Monroe IN	I	6		-	-	-
3270	Thebes	Monroe IN	I	6		-	-	-
3271	Thebes	Monroe IN	I	6		-	-	-
3274	Thebes	Monroe IN	I	6		-	-	-
3275	Thebes	Monroe IN	I	6		-	-	-
3276	Thebes	Monroe IN	I	6		-	-	-
3277	Thebes	Monroe IN	I	6		-	-	-
3278	Thebes	Monroe IN	I	6		-	-	-
3279	Thebes	Monroe IN	I	6		-	-	-
3280	Thebes	Monroe IN	I	6		-	-	-
3281	Thebes	Monroe IN	I	6		-	-	-
3282	Thebes	Monroe IN	I	6		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
3283	Thebes	Monroe IN	I	6		-	-	-
3284	Kirk	Monroe IN	I	6		-	-	-
3285	Kirk	Monroe IN	I	6		-	-	-
3287	Thebes	Monroe IN	I	6		-	-	-
3288	Kirk	Monroe IN	I	6		-	-	-
3297	Thebes	Monroe IN	I	6		-	-	-
3300	Thebes	Dubois IN	I	6		-	-	-
3302	Thebes	Dubois IN	I	6		-	-	-
3305	Kirk	Harrison IN	I	6		-	-	-
3306	Kirk	Harrison IN	I	6		-	-	-
3307	Kirk	Harrison IN	I	6		-	-	-
3308	Kirk	Harrison IN	I	6		-	-	-
3309	Kirk	Harrison IN	I	6		-	-	-
3310	Kirk	Harrison IN	I	6		-	-	-
3315	Thebes	Hamilton-Wentworth ON	I	6		-	-	-
3316	Thebes	Hamilton-Wentworth ON	I	6		-	-	-
3320	Dalton	Union IL	I	6		-	-	-
3326	Thebes	Rush IN	I	6		-	-	-
3327	Kirk	Rush IN	I	6		-	-	-
3328	Kirk	Dearborn IN	I	6		-	-	-
3329	Kirk	Dearborn IN	I	6		-	-	-
3330	Thebes	Dearborn IN	I	6		-	-	-
3331	Kirk	Dearborn IN	I	6		-	-	-
3332	Kirk	Harrison IN	I	6		-	-	-
3334	Kirk	Harrison IN	I	6		-	-	-
3335	Kirk	Harrison IN	I	6		-	-	-
3336	Kirk	Harrison IN	I	6		-	-	-
3337	Kirk	Harrison IN	I	6		-	-	-
3338	Kirk	Harrison IN	I	6		-	-	-
3339	Kirk	Harrison IN	I	6		-	-	-
3340	Kirk	Harrison IN	I	6		-	-	-
3341	Kirk	Harrison IN	I	6		-	-	-
3342	Kirk	Harrison IN	I	6		-	-	-
3343	Kirk	Harrison IN	I	6		-	-	-
3344	Kirk	Harrison IN	I	6		-	-	-
3346	Kirk	Harrison IN	I	6		-	-	-
3347	Kirk	Harrison IN	I	6		-	-	-
3348	Kirk	Harrison IN	I	6		-	-	-
3349	Kirk	Jackson IN	I	6		-	-	-
3352	Kirk	Lake/Porter IN	I	6		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
3355	Hi-Lo	Lake/Porter IN	I	6		-	-	-
3366	Kirk	Brown IN	I	6		-	-	-
3367	Kirk	Daviess IN	I	6		-	-	-
3368	Kirk	Daviess IN	I	6		-	-	-
3371	Thebes	Jersey IL	I	6		-	-	-
3372	Thebes	Brown IL	I	6		-	-	-
3373	Thebes	Pike IL	I	6		-	-	-
3376	Kirk	Lawrence IN	I	6		-	-	-
3377	Dalton	Posey IN	I	6		-	-	-
3380	Hi-Lo	Kankakee IL	I	106		-	-	-
3385	Kirk	Kankakee IL	I	106		-	-	-
3386	Kirk	Lake IN	I	106		-	-	-
3387	Thebes	Cook IL	I	106		-	-	-
3395	Kirk	Pike IL	I	106		-	-	-
3396	Kirk	Lake IN	I	134		-	-	-
3397	Thebes	Kankakee IL	I	106		-	-	-
3399	Kirk	Kankakee IL	I	106		-	-	-
3402	Thebes	Kankakee IL	I	106		-	-	-
3403	Thebes	Parke IN	I	106		-	-	-
3404	Kirk	Kankakee IL	I	106		-	-	-
3405	Thebes	Iroquois IL	I	106		-	-	-
3407	Thebes	Kankakee IL	I	106		-	-	-
3411	Kirk	Cook IL	I	134		-	-	-
3413	Kirk	Cook IL	I	134		-	-	-
3415	Thebes	Cook IL	I	134		-	-	-
3428	Kirk	Cook IL	I	134		-	-	-
3430	Kirk	Cook IL	I	134		-	-	-
3433	Kirk	Cook IL	I	134		-	-	-
3436	Kirk	Cook IL	I	134		-	-	-
3438	Kirk	Cook IL	I	134		-	-	-
3441	Kirk	Will IL	I	134		-	-	-
3442	Kirk	Kankakee IL	I	134		-	-	-
3446	Kirk	Will IL	I	134		-	-	-
3448	Kirk	Kankakee IL	I	134		-	-	-
3449	Kirk	Kankakee IL	I	134		-	-	-
3450	Kirk	Will IL	I	134		-	-	-
3452	Kirk	Kankakee IL	I	134		-	-	-
3460	Kirk	Jasper IN	I	134		-	-	-
3461	Kirk	Will IL	I	134		-	-	-
3463	Thebes	Will IL	I	134		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
3464	Thebes	Kankakee IL	I	134		-	-	-
3466	Thebes	Kankakee IL	I	134		-	-	-
3467	Thebes	Kankakee IL	I	134		-	-	-
3468	EFP	Kankakee IL	I	134		-	-	-
3470	Kirk	Will IL	I	134		-	-	-
3473	Thebes	Wyandot OH	I	160		-	-	-
3474	Thebes	Wyandot OH	I	160		-	-	-
3475	Thebes	Sandusky OH	I	160		-	-	-
3476	Thebes	Wyandot OH	I	160		-	-	-
3477	Thebes	Wyandot OH	I	160		-	-	-
3478	Thebes	Richland OH	I	160		-	-	-
3479	Thebes	Wyandot OH	I	160		-	-	-
3480	Thebes	Wyandot OH	I	160		-	-	-
3481	Thebes	Wyandot OH	I	160		-	-	-
3482	Thebes	Wyandot OH	I	160		-	-	-
3483	Thebes	Wyandot OH	I	160		-	-	-
3484	Thebes	Wyandot OH	I	160		-	-	-
3485	Thebes	Wyandot OH	I	160		-	-	-
3486	Thebes	Wyandot OH	I	160		-	-	-
3487	Thebes	Wyandot OH	I	160		-	-	-
3488	Thebes	Wyandot OH	I	160		-	-	-
3489	Thebes	Wyandot OH	I	160		-	-	-
3490	Thebes	Wyandot OH	I	160		-	-	-
3491	Thebes	Sandusky OH	I	160		-	-	-
3492	Thebes	Seneca OH	I	160		-	-	-
3493	Kirk	Sandusky OH	I	160		-	-	-
3494	Thebes	Sandusky OH	I	160		-	-	-
3495	Kirk	Crawford OH	I	160		-	-	-
3496	Kirk	Sandusky OH	I	160		-	-	-
3497	Kirk	Delaware OH	I	160		-	-	-
3515	Hi-Lo	Sandusky OH	I	160		-	-	-
3520	Hi-Lo	Ionia MI	I	161	Fitting 1963:Plate1.O	-	-	-
3521	Hi-Lo	Ionia MI	I	161	Fitting 1963:Plate1.M	-	-	-
3522	Hi-Lo	Ionia MI	I	161	Fitting 1963:Plate1.N	-	-	-
3526	Hi-Lo	Ionia MI	I	161	Fitting 1963:Plate1.D	-	-	-
3530	Hi-Lo	Ionia MI	I	161	Fitting 1963:Plate1.C	-	-	-
3531	Hi-Lo	Ionia MI	I	161		-	-	-
3533	Hi-Lo	Ionia MI	I	161	Fitting 1963:Plate1.A	-	-	-
3534	Hi-Lo	Ionia MI	I	161	Fitting 1963:Plate1.F	-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
3536	Hi-Lo	Ionia MI	I	161	Fitting 1963:Plate1.E	-	-	-
3537	Hi-Lo	Ionia MI	I	161	Fitting 1963:Plate1.G	-	-	-
3540	Hi-Lo	Kent MI	I	161		-	-	-
3556	EFP	Franklin OH	I	163		-	-	-
3560	EFP	Coshocton/Muskingam OH	I	163		-	-	-
3580	EFP	Pickaway OH	I	163		-	-	-
3615	EFP	Ross OH	I	163		-	-	-
3828	Thebes	Christian IL	I	164		-	-	-
3830	Thebes	Christian IL	I	164		-	-	-
3831	Thebes	Sangamon IL	I	164		-	-	-
3837	Dalton	Jersey/Madison IL	I	164		-	-	-
3841	EFP	Union IL	I	164		-	-	-
3842	EFP	Jersey IL	I	164		-	-	-
3850	Kirk	Randolph IL	I	164		-	-	-
3852	Kirk	Randolph IL	I	164		-	-	-
3853	Dalton	Randolph IL	I	164		-	-	-
3854	Thebes	Randolph IL	I	164		-	-	-
3886	Thebes	Monroe IL	I	164		-	-	-
3887	Dalton	Jersey IL	I	164		-	-	-
3888	Dalton	Jersey IL	I	164		-	-	-
3889	Dalton	Jersey IL	I	164		-	-	-
3890	Thebes	Jersey IL	I	164		-	-	-
3892	Thebes	Jersey IL	I	164		-	-	-
3893	Kirk	Jersey IL	I	164		-	-	-
3895	Kirk	Jersey IL	I	164		-	-	-
3896	Kirk	Jersey IL	I	164		-	-	-
3898	Thebes	Jersey IL	I	164		-	-	-
3899	Thebes	Lee IL	I	164		-	-	-
3903	EFP	Berrien MI	I	164		-	-	-
3907	Kirk	Berrien MI	I	164		-	-	-
3910	Thebes	Bureau IL	I	164		-	-	-
3913	Kirk	LaSalle IL	I	164		-	-	-
3917	Thebes	Saint Joseph IN	I	164		-	-	-
3922	Kirk	Saint Joseph IN	I	164		-	-	-
3926	Kirk	Saint Joseph IN	I	164		-	-	-
3927	Kirk	Saint Joseph IN	I	164		-	-	-
3931	Thebes	Saint Joseph IN	I	164		-	-	-
3933	Kirk	LaPorte IN	I	164		-	-	-
3934	Thebes	LaPorte IN	I	164		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
3936	Thebes	LaPorte IN	I	164		-	-	-
3937	Kirk	LaPorte IN	I	164		-	-	-
3939	Kirk	LaPorte IN	I	164		-	-	-
3941	Kirk	LaPorte IN	I	164		-	-	-
3946	Kirk	LaPorte IN	I	164		-	-	-
3948	Kirk	LaPorte IN	I	164		-	-	-
3949	Kirk	LaPorte IN	I	164		-	-	-
3950	Thebes	LaPorte IN	I	164		-	-	-
3959	Hi-Lo	Saint Joseph IN	I	164		-	-	-
3963	Thebes	Saint Joseph IN	I	164		-	-	-
3966	Kirk	LaPorte IN	I	164		-	-	-
3967	Thebes	LaPorte IN	I	164		-	-	-
3969	Kirk	LaPorte IN	I	164		-	-	-
3975	Kirk	LaPorte IN	I	164		-	-	-
3977	Kirk	LaPorte IN	I	164		-	-	-
3980	Dalton	Jersey/Madison IL	I	164		-	-	-
3982	Thebes	Jersey/Madison IL	I	164		-	-	-
3984	Kirk	Jersey/Madison IL	I	164		-	-	-
3986	Thebes	Jersey/Madison IL	I	164		-	-	-
3988	Thebes	Jersey/Madison IL	I	164		-	-	-
3989	Thebes	Jersey/Madison IL	I	164		-	-	-
3992	Kirk	Jersey IL	I	164		-	-	-
3993	Thebes	Jersey IL	I	164		-	-	-
3994	Thebes	Union IL	I	164		-	-	-
3995	Thebes	Union IL	I	164		-	-	-
3998	Thebes	Alexander IL	I	164		-	-	-
3999	Kirk	Massac IL	I	164		-	-	-
4001	Kirk	Union IL	I	164		-	-	-
4003	Thebes	Pulaski IL	I	164		-	-	-
4011	Kirk	Will IL	I	164		-	-	-
4023	Kirk	Will IL	I	164		-	-	-
4025	Kirk	Will IL	I	164		-	-	-
4029	Kirk	Crawford IL	I	164		-	-	-
4033	Kirk	Crawford IL	I	164		-	-	-
4037	Kirk	Crawford IL	I	164		-	-	-
4040	Kirk	Clark IL	I	164		-	-	-
4044	Dalton	Wabash IL	I	164		-	-	-
4045	Kirk	Rock Island IL	I	164		-	-	-
4050	Thebes	Lawrence IL	I	164		-	-	-
4051	Thebes	Lawrence IL	I	164		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
4052	Kirk	Lawrence IL	I	164		-	-	-
4054	Kirk	Lawrence IL	I	164		-	-	-
4057	Kirk	Lawrence IL	I	164		-	-	-
4058	Kirk	Lawrence IL	I	164		-	-	-
4059	Kirk	Lawrence IL	I	164		-	-	-
4060	Thebes	Lawrence IL	I	164		-	-	-
4061	Kirk	Lawrence IL	I	164		-	-	-
4063	Kirk	Lawrence IL	I	164		-	-	-
4064	Kirk	Lawrence IL	I	164		-	-	-
4065	Kirk	Lawrence IL	I	164		-	-	-
4068	Thebes	Fulton IL	I	165		-	-	-
4069	Thebes	Fulton IL	I	165		-	-	-
4079	Thebes	Knox IL	I	165		-	-	-
4080	Thebes	Knox IL	I	165		-	-	-
4082	Thebes	Knox IL	I	165		-	-	-
4086	Thebes	Knox IL	I	165		-	-	-
4087	Thebes	Knox IL	I	165		-	-	-
4088	Thebes	Knox IL	I	165		-	-	-
4089	Thebes	Fulton IL	I	165		-	-	-
4090	Thebes	Fulton IL	I	165		-	-	-
4091	Thebes	Knox IL	I	165		-	-	-
4092	Thebes	Knox IL	I	165		-	-	-
4093	Thebes	Knox IL	I	165		-	-	-
4094	Thebes	Knox IL	I	165		-	-	-
4095	Thebes	Knox IL	I	165		-	-	-
4096	Thebes	Knox IL	I	165		-	-	-
4097	Thebes	Knox IL	I	165		-	-	-
4099	Thebes	Knox IL	I	165		-	-	-
4100	Kirk	Knox IL	I	165		-	-	-
4101	Kirk	Knox IL	I	165		-	-	-
4103	Kirk	Fulton IL	I	165		-	-	-
4111	Thebes	Fulton IL	I	165		-	-	-
4115	Thebes	Knox IL	I	165		-	-	-
4117	Thebes	Knox IL	I	165		-	-	-
4118	Thebes	Knox IL	I	165		-	-	-
4119	Thebes	Knox IL	I	165		-	-	-
4120	Thebes	Fulton IL	I	165		-	-	-
4121	EFP	Fulton IL	I	165		-	-	-
4124	Kirk	Fulton IL	I	165		-	-	-
4131	Thebes	Fulton IL	I	165		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
4134	Kirk	Knox IL	I	165		-	-	-
4135	Kirk	Knox IL	I	165		-	-	-
4136	Thebes	Fulton IL	I	165		-	-	-
4137	Kirk	Fulton IL	I	165		-	-	-
4148	Thebes	Fulton IL	I	165		-	-	-
4153	Dalton	Union IL	I	166		-	-	-
4154	Dalton	Union IL	I	166		-	-	-
4160	Kirk	Cook IL	I	166		-	-	-
4163	Kirk	Cook IL	I	166		-	-	-
4165	Kirk	Cook IL	I	166		-	-	-
4166	Kirk	Cook IL	I	166		-	-	-
4167	Kirk	Cook IL	I	166		-	-	-
4172	Kirk	Cook IL	I	166		-	-	-
4183	Kirk	Cook IL	I	166		-	-	-
4184	Kirk	Cook IL	I	166		-	-	-
4187	Hi-Lo	Cook IL	I	166		-	-	-
4192	Thebes	Union IL	I	166		-	-	-
4193	Kirk	Union IL	I	166		-	-	-
4195	Kirk	Union IL	I	166		-	-	-
4197	Kirk	Union IL	I	166		-	-	-
4198	Thebes	Pike IL	I	166		-	-	-
4199	Thebes	Pike IL	I	166		-	-	-
4201	Kirk	Pike IL	I	166		-	-	-
4203	Thebes	Pike IL	I	166		-	-	-
4204	Dalton	Woodford IL	I	166		-	-	-
4205	Kirk	Woodford IL	I	166		-	-	-
4209	Thebes	Woodford IL	I	166		-	-	-
4213	Thebes	Woodford IL	I	166		-	-	-
4215	Kirk	Woodford IL	I	166		-	-	-
4216	Thebes	Woodford IL	I	166		-	-	-
4221	Dalton	Peoria IL	I	166		-	-	-
4228	Dalton	Pope IL	I	166		-	-	-
4229	Thebes	Pope IL	I	166		-	-	-
4231	Thebes	Hardin IL	I	166		-	-	-
4232	Dalton	Pope IL	I	166		-	-	-
4233	Thebes	Pope IL	I	166		-	-	-
4236	Thebes	Adams IL	I	166		-	-	-
4237	Thebes	Adams IL	I	166		-	-	-
4238	Kirk	Adams IL	I	166		-	-	-
4239	Thebes	Adams IL	I	166		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
4241	Thebes	Lake IL	I	166		-	-	-
4242	Kirk	Lake IL	I	166		-	-	-
4243	Thebes	Lake IL	I	166		-	-	-
4248	Kirk	Saint Joseph IN	I	166		-	-	-
4249	Kirk	Saint Joseph IN	I	166		-	-	-
4251	Kirk	Saint Joseph IN	I	166		-	-	-
4256	Thebes	Union IL	I	166		-	-	-
4260	Thebes	Union IL	I	166		-	-	-
4261	Kirk	Union IL	I	166		-	-	-
4263	Thebes	Union IL	I	166		-	-	-
4265	Thebes	Union IL	I	166		-	-	-
4267	Dalton	Union IL	I	166		-	-	-
4269	Dalton	Union IL	I	166		-	-	-
4270	Dalton	Union IL	I	166		-	-	-
4271	Dalton	Union IL	I	166		-	-	-
4273	Dalton	Union IL	I	166		-	-	-
4275	Dalton	Union IL	I	166		-	-	-
4276	Dalton	Union IL	I	166		-	-	-
4277	Thebes	Union IL	I	166		-	-	-
4278	Thebes	Union IL	I	166		-	-	-
4280	Thebes	Union IL	I	166		-	-	-
4284	Thebes	Union IL	I	166		-	-	-
4285	Kirk	Union IL	I	166		-	-	-
4286	Kirk	Union IL	I	166		-	-	-
4287	Thebes	Union IL	I	166		-	-	-
4289	Dalton	Union IL	I	166		-	-	-
4291	Kirk	Union IL	I	166		-	-	-
4292	Thebes	Union IL	I	166		-	-	-
4293	Kirk	Union IL	I	166		-	-	-
4294	Kirk	Union IL	I	166		-	-	-
4295	Thebes	Dearborn IN	I	166	"Fig 27"	-	-	-
4297	Kirk	Harrison IN	I	166		-	-	-
4299	Kirk	Saint Joseph IN	I	166		-	-	-
4302	Thebes	Saint Joseph IN	I	166		-	-	-
4303	Kirk	Saint Joseph IN	I	166		-	-	-
4307	Kirk	Saint Joseph IN	I	166		-	-	-
4312	Thebes	Saint Joseph IN	I	166		-	-	-
4315	Kirk	Saint Joseph IN	I	166		-	-	-
4318	Thebes	Kosciusko IN	I	166		-	-	-
4319	Thebes	Kosciusko IN	I	166		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
4320	Kirk	Kosciusko IN	I	166		-	-	-
4321	Thebes	Kosciusko IN	I	166		-	-	-
4322	Thebes	Kosciusko IN	I	166		-	-	-
4323	Thebes	Kosciusko IN	I	166		-	-	-
4324	Hi-Lo	Kosciusko IN	I	166	"Figure 30d p44"	-	-	-
4327	Thebes	Eaton MI	I	166		-	-	-
4328	Kirk	Eaton MI	I	166		-	-	-
4331	Kirk	Nicholas KY	I	166		-	-	-
4334	Thebes	Mason KY	I	166		-	-	-
4335	Thebes	Mason KY	I	166		-	-	-
4336	Kirk	Kenton KY	I	166		-	-	-
4337	Thebes	Boone KY	I	166		-	-	-
4341	Kirk	Boone KY	I	166		-	-	-
4342	Kirk	Boone KY	I	166		-	-	-
4343	Kirk	Boone KY	I	166		-	-	-
4345	Kirk	Boone KY	I	166		-	-	-
4347	Thebes	Clermont OH	I	166		-	-	-
4349	Thebes	Huron OH	I	166		-	-	-
4356	Thebes	Campbell KY	I	166		-	-	-
4357	Kirk	Campbell KY	I	166		-	-	-
4358	Kirk	Campbell KY	I	166		-	-	-
4361	Kirk	Campbell KY	I	166		-	-	-
4362	Kirk	Campbell KY	I	166		-	-	-
4363	Thebes	Kenton KY	I	166		-	-	-
4364	Thebes	Kenton KY	I	166		-	-	-
4365	Kirk	Kenton KY	I	166		-	-	-
4366	Kirk	Kenton KY	I	166		-	-	-
4370	EFP	Saline IL	I	166		-	-	-
4371	EFP	Clinton OH	I	166		-	-	-
4372	EFP	Adams IL	I	166		-	-	-
4373	EFP	White IL	I	166		-	-	-
4374	EFP	Johnson IL	I	166		-	-	-
4376	EFP	Madison IN	I	166		-	-	-
4378	EFP	Fayette IN	I	166		-	-	-
4379	EFP	Franklin IN	I	166		-	-	-
4381	EFP	Saline IL	I	166		-	-	-
4384	EFP	Washington PA	I	166		-	-	-
4386	EFP	Delaware IN	I	166		-	-	-
4387	EFP	Johnson IL	I	166		-	-	-
4390	EFP	Madison IL	I	166		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
4391	Thebes	Boone KY	I	166		-	-	-
4394	Kirk	Boone KY	I	166		-	-	-
4397	Thebes	Daviess KY	I	166		-	-	-
4400	Hi-Lo	Cook IL	I	166		-	-	-
4402	EFP	Saline IL	I	166		-	-	-
4410	Kirk	Saint Joseph MI	I	166		-	-	-
4411	Kirk	Saint Joseph MI	I	166		-	-	-
4412	Thebes	Saint Joseph IN	I	166		-	-	-
4413	Thebes	Saint Joseph IN	I	166		-	-	-
4414	Kirk	Berrien MI	I	166		-	-	-
4415	Thebes	Saint Joseph MI	I	166		-	-	-
4416	Thebes	Saint Joseph IN	I	166		-	-	-
4418	Thebes	Saint Joseph IN	I	166		-	-	-
4427	Kirk	Saint Joseph IN	I	166		-	-	-
4435	EFP	Clark IL	I	164		-	-	-
4437	Kirk	Tazewell IL	I	164		-	-	-
4441	Kirk	Tazewell IL	I	164		-	-	-
4442	Kirk	Tazewell IL	I	164		-	-	-
4443	Kirk	Tazewell IL	I	164		-	-	-
4447	Kirk	Tazewell IL	I	164		-	-	-
4451	Kirk	Tazewell IL	I	164		-	-	-
4452	Thebes	Tazewell IL	I	164		-	-	-
4455	Thebes	Pike IL	I	164		-	-	-
4458	Thebes	Pike IL	I	164		-	-	-
4465	Dalton	Pike IL	I	164		-	-	-
4466	Dalton	Pike IL	I	164		-	-	-
4467	Dalton	Pike IL	I	164		-	-	-
4468	Dalton	Pike IL	I	164		-	-	-
4471	Thebes	Massac IL	I	164		-	-	-
4472	Kirk	Hardin IL	I	164		-	-	-
4476	Kirk	Greene IL	I	164		-	-	-
4477	Kirk	Greene IL	I	164		-	-	-
4480	Thebes	Clinton IL	I	164		-	-	-
4486	Kirk	Kankakee IL	I	164		-	-	-
4489	Kirk	Kankakee IL	I	164		-	-	-
4492	Kirk	Kankakee IL	I	164		-	-	-
4501	Thebes	LaSalle IL	I	164		-	-	-
4506	Kirk	Livingston IL	I	164		-	-	-
4509	Thebes	Livingston IL	I	164		-	-	-
4510	Kirk	Livingston IL	I	164		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
4525	Thebes	Iroquois IL	I	164		-	-	-
4528	Kirk	Fulton IL	I	165		-	-	-
4529	Kirk	Fulton IL	I	165		-	-	-
4530	Kirk	Fulton IL	I	165		-	-	-
4531	Thebes	Fulton IL	I	165		-	-	-
4532	Thebes	Knox IL	I	165		-	-	-
4537	Kirk	Fulton IL	I	165		-	-	-
4538	Thebes	Warren IL	I	165		-	-	-
4540	Kirk	Knox IL	I	165		-	-	-
4541	Kirk	Knox IL	I	165		-	-	-
4550	Kirk	Knox IL	I	165		-	-	-
4551	Thebes	Knox IL	I	165		-	-	-
4553	Kirk	Knox IL	I	165		-	-	-
4554	Kirk	Knox IL	I	165		-	-	-
4557	Thebes	Knox IL	I	165		-	-	-
4558	Thebes	Knox IL	I	165		-	-	-
4559	Thebes	Knox IL	I	165		-	-	-
4560	Thebes	Knox IL	I	165		-	-	-
4561	Kirk	Fulton IL	I	165		-	-	-
4563	EFP	Knox IL	I	165		-	-	-
4575	Kirk	Knox IL	I	165		-	-	-
4579	Thebes	Knox IL	I	165		-	-	-
4582	Kirk	Knox IL	I	165		-	-	-
4584	Thebes	Knox IL	I	165		-	-	-
4585	Thebes	Knox IL	I	165		-	-	-
4589	Kirk	Knox IL	I	165		-	-	-
4591	Dalton	Knox IL	I	165		-	-	-
4593	Thebes	Knox IL	I	165		-	-	-
4594	Thebes	Knox IL	I	165		-	-	-
4595	Thebes	Knox IL	I	165		-	-	-
4597	Thebes	Knox IL	I	165		-	-	-
4600	Dalton	Knox IL	I	165		-	-	-
4602	Thebes	Knox IL	I	165		-	-	-
4605	Kirk	Knox IL	I	165		-	-	-
4606	Thebes	Knox IL	I	165		-	-	-
4608	Dalton	Knox IL	I	165		-	-	-
4611	Thebes	Knox IL	I	165		-	-	-
4613	Thebes	Knox IL	I	165		-	-	-
4614	Thebes	Knox IL	I	165		-	-	-
4615	Thebes	Knox IL	I	165		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
4617	Kirk	Knox IL	I	165		-	-	-
4620	Dalton	Knox IL	I	165		-	-	-
4624	Thebes	Knox IL	I	165		-	-	-
4625	Kirk	Knox IL	I	165		-	-	-
4626	Thebes	Knox IL	I	165		-	-	-
4629	Kirk	Knox IL	I	165		-	-	-
4637	Thebes	Peoria IL	I	165		-	-	-
4638	Kirk	Peoria IL	I	165		-	-	-
4639	Kirk	Peoria IL	I	165		-	-	-
4640	Kirk	Peoria IL	I	165		-	-	-
4643	Dalton	Peoria IL	I	165		-	-	-
4644	Thebes	Peoria IL	I	165		-	-	-
4646	Thebes	Peoria IL	I	165		-	-	-
4647	Kirk	Peoria IL	I	165		-	-	-
4649	Thebes	Peoria IL	I	165		-	-	-
4650	Thebes	Fulton IL	I	165		-	-	-
4652	Dalton	McDonough IL	I	165		-	-	-
4653	EFP	Pike IL	I	165		-	-	-
4658	Thebes	Warren IL	I	165		-	-	-
4659	Thebes	Knox IL	I	165		-	-	-
4660	Thebes	Fulton IL	I	165		-	-	-
4661	Thebes	Logan IL	I	165		-	-	-
4663	Kirk	Fulton IL	I	165		-	-	-
4664	Kirk	Peoria IL	I	165		-	-	-
4665	Kirk	Fulton IL	I	165		-	-	-
4666	Kirk	Peoria IL	I	165		-	-	-
4668	Kirk	Peoria IL	I	165		-	-	-
4671	Thebes	Will IL	I	165		-	-	-
4672	Thebes	Will IL	I	165		-	-	-
4673	Kirk	Will IL	I	165		-	-	-
4674	Kirk	Will IL	I	165		-	-	-
4675	Kirk	Will IL	I	165		-	-	-
4677	Kirk	Will IL	I	165		-	-	-
4678	Kirk	Will IL	I	165		-	-	-
4680	Kirk	Will IL	I	165		-	-	-
4682	Kirk	Will IL	I	165		-	-	-
4683	Thebes	Will IL	I	165		-	-	-
4684	Kirk	Will IL	I	165		-	-	-
4685	Kirk	Will IL	I	165		-	-	-
4686	Kirk	Will IL	I	165		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
4689	Kirk	Will IL	I	165		-	-	-
4694	Thebes	Will IL	I	165		-	-	-
4699	Kirk	Ogle IL	I	167		-	-	-
4700	Thebes	Ogle IL	I	167		-	-	-
4709	Thebes	Ogle IL	I	167		-	-	-
4710	Kirk	Ogle IL	I	167		-	-	-
4712	Thebes	Ogle IL	I	167		-	-	-
4716	Thebes	Ogle IL	I	167		-	-	-
4717	Thebes	Ogle IL	I	167		-	-	-
4724	Kirk	Carroll/Ogle IL	I	167		-	-	-
4726	Kirk	Bureau IL	I	167		-	-	-
4728	Kirk	Bureau IL	I	167		-	-	-
4744	Kirk	Whitley IN	I	5		-	-	-
4745	Kirk	Whitley IN	I	5		-	-	-
4746	Kirk	Whitley IN	I	5		-	-	-
4747	Kirk	Whitley IN	I	5		-	-	-
4751	Kirk	Whitley IN	I	5		-	-	-
4755	Kirk	Whitley IN	I	5		-	-	-
4756	Thebes	Whitley IN	I	5		-	-	-
4757	Thebes	Whitley IN	I	5		-	-	-
4758	Thebes	Whitley IN	I	5		-	-	-
4759	Thebes	Whitley IN	I	5		-	-	-
4764	Thebes	Whitley IN	I	5		-	-	-
4770	Thebes	Ohio KY	I	148		-	-	-
4771	Thebes	Ohio KY	I	148		-	-	-
4772	Kirk	McLean KY	I	148		-	-	-
4773	Kirk	McLean KY	I	148		-	-	-
4774	Kirk	McLean KY	I	148		-	-	-
4775	Kirk	McLean KY	I	148		-	-	-
4782	Thebes	Breckinridge KY	I	148	Turnbow et al. 19080:Fig 6.14	-	-	-
4783	Kirk	Breckinridge KY	I	148	Turnbow et al. 1980:Fig 6.21	-	-	-
4784	Kirk	Breckinridge KY	I	148	Turnbow et al. 1980:Fig 6.23	-	-	-
4785	Kirk	Breckinridge KY	I	148		-	-	-
4787	Kirk	Breckinridge KY	I	148	Turnbow et al. 1980:Fig 6.19	-	-	-
4792	Thebes	Clark KY	I	148	Turnbow et al. 1983:Fig V-31 C	-	-	-
4797	Kirk	Clark KY	I	148		-	-	-
4798	Kirk	Clark KY	I	148		-	-	-
4801	Kirk	Clark KY	I	148	Turnbow et al. 1983:Fig V-31 A	-	-	-
4804	Thebes	Clark KY	I	148	Turnbow and Jobe 1981:Fig 9	-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
4805	Kirk	Clark KY	I	148	Turnbow and Jobe 1981:Fig 10A	-	-	-
4806	Kirk	Franklin KY	I	148		-	-	-
4808	EFP	Hancock KY	I	148	Turnbow et al. 1980:Fig 6.26	-	-	-
4809	EFP	Hancock KY	I	148	Turnbow et al. 1980:Fig 6.25	-	-	-
4810	Thebes	Hardin KY	I	148		-	-	-
4811	Kirk	Hardin KY	I	148		-	-	-
4812	Kirk	Henderson KY	I	148		-	-	-
4814	Kirk	Henderson KY	I	148		-	-	-
4816	Kirk	Henderson KY	I	148		-	-	-
4817	Thebes	Henderson KY	I	148		-	-	-
4818	Kirk	Henderson KY	I	148		-	-	-
4819	EFP	Henderson KY	I	148		-	-	-
4820	Kirk	Henderson KY	I	148		-	-	-
4821	Kirk	Henderson KY	I	148		-	-	-
4824	Kirk	Henderson KY	I	148		-	-	-
4826	Kirk	Henderson KY	I	148		-	-	-
4829	Dalton	Henderson KY	I	148		-	-	-
4831	Thebes	Madison KY	I	148		-	-	-
4834	Kirk	Breckinridge KY	I	148		-	-	-
4839	Dalton	Fayette KY	I	148		-	-	-
4841	Kirk	Jessamine KY	I	148		-	-	-
4842	Kirk	Jessamine KY	I	148		-	-	-
4845	Kirk	Menifee KY	I	148		-	-	-
4850	Kirk	Logan KY	I	148		-	-	-
4851	Kirk	Logan KY	I	148		-	-	-
4852	Dalton	Logan KY	I	148		-	-	-
4854	Kirk	Bourbon KY	I	148		-	-	-
4863	Kirk	Wolfe KY	I	148		-	-	-
4864	Kirk	Wolfe KY	I	148		-	-	-
4865	Kirk	Wolfe KY	I	148		-	-	-
4866	Kirk	Wolfe KY	I	148		-	-	-
4869	Kirk	Montgomery KY	I	148		-	-	-
4872	Kirk	Johnson KY	I	148		-	-	-
4873	Kirk	Johnson KY	I	148		-	-	-
4876	Kirk	Johnson KY	I	148		-	-	-
4877	Thebes	Johnson KY	I	148		-	-	-
4880	Kirk	Johnson KY	I	148		-	-	-
4881	Kirk	Johnson KY	I	148		-	-	-
4885	Kirk	Johnson KY	I	148		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
4893	Kirk	Johnson KY	I	148		-	-	-
4896	Thebes	Johnson KY	I	148		-	-	-
4901	Kirk	Montgomery KY	I	148		-	-	-
4903	Kirk	Montgomery KY	I	148		-	-	-
4905	Kirk	Montgomery KY	I	148		-	-	-
4908	Thebes	Montgomery KY	I	148		-	-	-
4910	Kirk	Montgomery KY	I	148		-	-	-
4911	Thebes	Montgomery KY	I	148		-	-	-
4916	Kirk	McLean KY	I	148		-	-	-
4918	Kirk	McLean KY	I	148		-	-	-
4919	Kirk	McLean KY	I	148		-	-	-
4922	Kirk	McLean KY	I	148		-	-	-
4923	Kirk	McLean KY	I	148		-	-	-
4925	Kirk	McLean KY	I	148		-	-	-
4926	Kirk	McLean KY	I	148		-	-	-
4929	Kirk	McLean KY	I	148		-	-	-
4930	Kirk	McLean KY	I	148		-	-	-
4938	Kirk	Russell KY	I	148		-	-	-
4946	Kirk	Russell KY	I	148		-	-	-
4949	Dalton	Crittenden KY	I	148		-	-	-
4951	Kirk	Fayette KY	I	148		-	-	-
4952	Kirk	Fayette KY	I	148		-	-	-
4954	Thebes	Fayette KY	I	148		-	-	-
4960	Thebes	Marion KY	I	148		-	-	-
4964	Kirk	Marion KY	I	148		-	-	-
4966	Kirk	Marion KY	I	148		-	-	-
4967	Kirk	Marion KY	I	148		-	-	-
4968	Kirk	Marion KY	I	148		-	-	-
4969	Kirk	Marion KY	I	148		-	-	-
4975	Kirk	Marion KY	I	148		-	-	-
4976	Kirk	Marion KY	I	148		-	-	-
4978	Kirk	Caldwell KY	I	148		-	-	-
4979	Dalton	Caldwell KY	I	148		-	-	-
4981	Kirk	Caldwell KY	I	148		-	-	-
4984	Kirk	Caldwell KY	I	148		-	-	-
4985	Kirk	Caldwell KY	I	148		-	-	-
4987	Kirk	Bullitt KY	I	148		-	-	-
4992	Kirk	Lee KY	I	148		-	-	-
4999	Dalton	Pulaski KY	I	148		-	-	-
5001	Kirk	Trigg KY	I	148		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
5002	Kirk	Trigg KY	I	148		-	-	-
5003	Kirk	Trigg KY	I	148		-	-	-
5004	Kirk	Trigg KY	I	148		-	-	-
5012	Kirk	Lee KY	I	148		-	-	-
5015	Kirk	Lee KY	I	148		-	-	-
5016	Kirk	Lee KY	I	148		-	-	-
5017	Kirk	Lee KY	I	148		-	-	-
5018	Kirk	Lee KY	I	148		-	-	-
5019	Kirk	Lee KY	I	148		-	-	-
5020	Kirk	Lee KY	I	148		-	-	-
5022	Kirk	Lee KY	I	148		-	-	-
5027	Kirk	Bourbon KY	I	148		-	-	-
5029	Kirk	Bourbon KY	I	148		-	-	-
5030	Kirk	Bourbon KY	I	148		-	-	-
5031	Kirk	Bourbon KY	I	148		-	-	-
5032	Kirk	Bourbon KY	I	148		-	-	-
5033	Kirk	Bourbon KY	I	148		-	-	-
5034	Dalton	Bourbon KY	I	148		-	-	-
5035	Kirk	Christian KY	I	148		-	-	-
5036	Kirk	Christian KY	I	148		-	-	-
5038	Kirk	Christian KY	I	148		-	-	-
5039	Kirk	Christian KY	I	148		-	-	-
5041	Dalton	Christian KY	I	148		-	-	-
5042	Thebes	Christian KY	I	148		-	-	-
5044	Thebes	Christian KY	I	148		-	-	-
5047	Kirk	Christian KY	I	148		-	-	-
5048	Kirk	Christian KY	I	148		-	-	-
5049	Kirk	Christian KY	I	148		-	-	-
5050	Kirk	Christian KY	I	148		-	-	-
5051	Kirk	Christian KY	I	148		-	-	-
5053	Kirk	Christian KY	I	148		-	-	-
5056	Kirk	Henry KY	I	148		-	-	-
5059	Thebes	Meade KY	I	148		-	-	-
5082	EFP	Portage OH	D	-	Prufer 1960a	-	1	55 67 001.11.1132
5086	EFP	Lake OH	D	-	Prufer 1960a	-	5	33 43 005.31.2142
5095	EFP	Stark OH	D	-	Prufer 1960a	-	14	55.76 014.11.2122
5096	EFP	Columbiana OH	D	-	Prufer 1960a	-	15	55 15 015.11.1122
5097	EFP	Huron OH	D	-	Prufer 1960a	-	16	44 39 016.31.1122
5099	EFP	Boone KY	D	-	Prufer 1960a	-	18	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
5105	EFP	Trumbull OH	D	-	Prufer 1960b	-	24	55 78 024.11.1122
5106	EFP	Ashtabula OH	D	-	Prufer 1960b	-	25	55 04 025.11.1122
5121	EFP	Adams OH	D	-	Prufer 1960b	-	40	77 01 040.11.1142
5125	Dalton	Saint Clair IL	D	-	Prufer 1960b	-	44	-
5128	EFP	Ross OH	D	-	Prufer 1960c	-	47	55 71 047.31.1422
5130	EFP	Ross OH	D	-	Prufer 1960c	-	49	55 71 049.31.1422
5131	EFP	Ross OH	D	-	Prufer 1960c	-	50	55 71 050.31.1122
5132	EFP	Ashland OH	D	-	Prufer 1960c	-	51	55 03 051.11.1122
5133	EFP	Trumbull OH	D	-	Prufer 1960c	-	52	55 78 052.11.1242
5139	EFP	Seneca OH	D	-	Prufer 1960c	-	58	44 74 058.11.1122
5145	EFP	Preble OH	D	-	Prufer 1961a	-	64	44 68 064.11.1122
5146	EFP	Preble OH	D	-	Prufer 1961a	-	65	44 68 065.11.1132
5147	EFP	Huron OH	D	-	Prufer 1961a	-	66	55 39 066.11.1122
5148	EFP	Huron OH	D	-	Prufer 1961a	-	67	55 39 067.11.1121
5150	EFP	Holmes OH	D	-	Prufer 1961a	-	69	66 38 069.11.1121
5151	EFP	Holmes OH	D	-	Prufer 1961a	-	70	66 38 070.11.1122
5152	EFP	Holmes OH	D	-	Prufer 1961a	-	71	66 38 071.11.1122
5154	EFP	Huron OH	D	-	Prufer 1961a	-	73	44 39 073.11.2122
5157	EFP	Hamilton OH	D	-	Prufer 1961a	-	79	44 31 079.11.1133
5158	EFP	Marion OH	D	-	Prufer 1961a	-	81	44 51 081.11.4123
5160	EFP	Delaware OH	D	-	Prufer 1961a	-	83	44 21 083.11.1132
5161	EFP	Marion OH	D	-	Prufer 1961a	-	84	44 51 084.11.1122
5162	EFP	Marion OH	D	-	Prufer 1961a	-	85	44 51 085.11.1221
5166	EFP	Ashland OH	D	-	Prufer 1961a	-	89	55 03 089.31.2132
5168	EFP	Union OH	D	-	Prufer 1961a	-	91	44 80 091.11.1222
5170	EFP	Marion OH	D	-	Prufer 1961a	-	93	44 51 093.11.2122
5173	EFP	Scioto OH	D	-	Prufer 1961b	-	96	66 73 096.11.4123
5184	EFP	Franklin OH	D	-	Prufer 1961b	-	107	44 25 107.31.1222
5187	EFP	Coshocton OH	D	-	Prufer 1961b	-	110	-
5188	EFP	Geauga OH	D	-	Prufer 1961b	-	111	-
5189	EFP	Geauga OH	D	-	Prufer 1961b	-	112	55 28 112.31.1122
5191	EFP	Perry OH	D	-	Prufer 1961b	-	114	66 64 114.11.2232
5195	EFP	Hardin OH	D	-	Prufer 1961c	-	118	44 33 118.50.0000

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
5208	EFP	Marion OH	D	-	Prufer 1962b	-	496	44 51 496.__.2132
5210	EFP	Seneca OH	D	-	Prufer 1962b	-	498	44 74 498.11.1122
5215	EFP	Franklin OH	D	-	Prufer 1962b	-	504	44 25 504.11.3122
5216	EFP	Seneca OH	D	-	Prufer 1962b	-	505	44 74 505.11.4123
5219	EFP	Clark OH	D	-	Prufer 1962b	-	508	44 12 508.11.1122
5229	EFP	Fayette OH	D	-	Prufer 1963	-	519	44 24 519.11.2122
5232	EFP	Columbiana OH	D	-	Prufer 1963	-	522	55 15 522.11.1122
5235	EFP	Tuscarawas OH	D	-	Prufer 1963	-	525	66 79 525.30.2154
5237	EFP	Wayne OH	D	-	Prufer 1963	-	527	55 85 527.11.1132
5241	EFP	Wayne OH	D	-	Prufer 1964	-	531	55 85 531.31.1432
5247	EFP	Morgan OH	D	-	Prufer 1964	-	537	66 58 537.11.2142
5248	EFP	Medina OH	D	-	Prufer 1964	-	538	55 52 538.31.2221
5254	EFP	Trumbull OH	D	-	Prufer 1964	-	545	55 78 545.11.1222
5258	EFP	Medina OH	I	168	Barrish 1995:FP #1	-	-	-
5261	EFP	Medina OH	I	168	Barrish 1995:FP #4	-	-	-
5262	EFP	Medina OH	I	168	Barrish 1995:FP #5	-	-	-
5266	EFP	Medina OH	I	168	Barrish 1995:FP #9	-	-	-
5279	EFP	Medina OH	I	168		-	-	-
5285	EFP	Medina OH	I	168		-	-	-
5295	Kirk	Medina OH	I	168		-	-	-
5296	Thebes	Medina OH	I	168		-	-	-
5301	Thebes	Medina OH	I	168		-	-	-
5303	Kirk	Medina OH	I	168		-	-	-
5307	Kirk	Medina OH	I	168		-	-	-
5309	Kirk	Medina OH	I	168		-	-	-
5311	Kirk	Medina OH	I	168		-	-	-
5314	Thebes	Huron OH	I	168		-	-	-
5315	Kirk	Huron OH	I	168		-	-	-
5316	Thebes	Huron OH	I	168		-	-	-
5317	Thebes	Huron OH	I	168		-	-	-
5318	Thebes	Huron OH	I	168		-	-	-
5321	Hi-Lo	Huron OH	I	168		-	-	-
5322	Kirk	Huron OH	I	168		-	-	-
5325	Kirk	Huron OH	I	168		-	-	-
5328	Kirk	Huron OH	I	168		-	-	-
5329	Kirk	Huron OH	I	168		-	-	-
5331	Thebes	Huron OH	I	168		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
5333	Kirk	Huron OH	I	168		-	-	-
5334	Thebes	Huron OH	I	168		-	-	-
5335	Thebes	Huron OH	I	168		-	-	-
5341	Kirk	Huron OH	I	168		-	-	-
5344	Thebes	Huron OH	I	168		-	-	-
5345	Thebes	Huron OH	I	168		-	-	-
5349	Kirk	Cuyahoga OH	I	168		-	-	-
5350	Thebes	Cuyahoga OH	I	168		-	-	-
5361	Kirk	Lake OH	I	168		-	-	-
5374	Hi-Lo	Lake OH	I	168		-	-	-
5376	Kirk	Lake OH	I	168		-	-	-
5378	Thebes	Lake OH	I	168		-	-	-
5382	Thebes	Lake OH	I	168		-	-	-
5383	Thebes	Lake OH	I	168		-	-	-
5384	Thebes	Lake OH	I	168		-	-	-
5385	Thebes	Lake OH	I	168		-	-	-
5387	Thebes	Lake OH	I	168		-	-	-
5388	Thebes	Lake OH	I	168		-	-	-
5389	Kirk	Lake OH	I	168		-	-	-
5392	Thebes	Lake OH	I	168		-	-	-
5396	Thebes	Lake OH	I	168		-	-	-
5397	Kirk	Lake OH	I	168		-	-	-
5399	Thebes	Lake OH	I	168		-	-	-
5400	Kirk	Lake OH	I	168		-	-	-
5401	Kirk	Lake OH	I	168		-	-	-
5402	Kirk	Lake OH	I	168		-	-	-
5403	Kirk	Lake OH	I	168		-	-	-
5404	Kirk	Lake OH	I	168		-	-	-
5408	Kirk	Lake OH	I	168		-	-	-
5409	Kirk	Lorain OH	I	168		-	-	-
5415	Kirk	Summit OH	I	168		-	-	-
5416	Thebes	Summit OH	I	168		-	-	-
5419	Kirk	Summit OH	I	168		-	-	-
5420	Thebes	Summit OH	I	168		-	-	-
5422	Thebes	Summit OH	I	168		-	-	-
5424	Kirk	Summit OH	I	168		-	-	-
5425	EFP	Marion KY	P	-	Ray 2003:A1.1.a	-	-	-
5427	EFP	Washington KY	P	-	Ray 2003:A1.1.c	-	-	-
5430	Dalton	Washington KY	P	-	Ray 2003:A1.2.b	-	-	-
5431	Dalton	Washington KY	P	-	Ray 2003:A1.2.c	-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
5434	Dalton	Washington KY	P	-	Ray 2003:A1.2.f	-	-	-
5437	Dalton	Marion KY	P	-	Ray 2003:A1.3	-	-	-
5443	Dalton	Nelson KY	P	-	Ray 2003:A1.4.f	-	-	-
5445	Dalton	Marion KY	P	-	Ray 2003:A1.5.b	-	-	-
5446	Dalton	Washington KY	P	-	Ray 2003:A1.5.c	-	-	-
5448	Dalton	Marion KY	P	-	Ray 2003:A1.b.a	-	-	-
5449	Dalton	Marion KY	P	-	Ray 2003:A1.6.b	-	-	-
5451	EFP	Marion KY	P	-	Ray 2003:A1.8.a	-	-	-
5453	EFP	Marion KY	P	-	Ray 2003:A1.9.a	-	-	-
5456	Dalton	Marion KY	P	-	Ray 2003:A1.9.d	-	-	-
5457	Dalton	Marion KY	P	-	Ray 2003:A1.9.e	-	-	-
5459	EFP	Marion KY	P	-	Ray 2003:A1.10.b	-	-	-
5461	Dalton	Marion KY	P	-	Ray 2003:A1.11.a	-	-	-
5462	Dalton	Nelson KY	P	-	Ray 2003:A1.11.b	-	-	-
5463	Dalton	Nelson KY	P	-	Ray 2003:A1.11.c	-	-	-
5465	Dalton	Marion KY	P	-	Ray 2003:A1.13	-	-	-
5469	Dalton	Washington KY	P	-	Ray 2003:A1.14.d	-	-	-
5474	Kirk	Trumbull OH	I	168		-	-	-
5475	Kirk	Trumbull OH	I	168		-	-	-
5476	Kirk	Trumbull OH	I	168		-	-	-
5479	Thebes	Mahoning/ Portage/Trumbull OH	I	168		-	-	-
5485	Kirk	Allen OH	I	168		-	-	-
5486	Kirk	Allen OH	I	168		-	-	-
5487	Thebes	Allen OH	I	168		-	-	-
5488	Kirk	Allen OH	I	168		-	-	-
5498	Kirk	Richland OH	I	168		-	-	-
5499	Thebes	Licking OH	I	168		-	-	-
5501	Thebes	Richland OH	I	168		-	-	-
5503	Kirk	Richland OH	I	168		-	-	-
5506	Thebes	Tuscarawas OH	I	168		-	-	-
5507	Thebes	Tuscarawas OH	I	168		-	-	-
5508	Kirk	Tuscarawas OH	I	168		-	-	-
5509	Thebes	Tuscarawas OH	I	168		-	-	-
5511	Kirk	Wayne OH	I	168		-	-	-
5517	Thebes	Wayne OH	I	168		-	-	-
5518	Kirk	Wayne OH	I	168		-	-	-
5520	Thebes	Columbiana OH	I	168		-	-	-
5521	Thebes	Mahoning OH	I	168		-	-	-
5523	Thebes	Mahoning OH	I	168		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
5526	Thebes	Mahoning OH	I	168		-	-	-
5527	Thebes	Mahoning OH	I	168		-	-	-
5529	Kirk	Mahoning OH	I	168		-	-	-
5530	Thebes	Mahoning OH	I	168		-	-	-
5531	Thebes	Mahoning OH	I	168		-	-	-
5547	Thebes	Mahoning OH	I	168		-	-	-
5551	Thebes	Brown OH	I	168		-	-	-
5552	Thebes	Brown OH	I	168		-	-	-
5553	Thebes	Brown OH	I	168		-	-	-
5554	Thebes	Brown OH	I	168		-	-	-
5555	Thebes	Brown OH	I	168		-	-	-
5558	Thebes	Lake OH	I	168		-	-	-
5559	Thebes	Lake OH	I	168		-	-	-
5560	Thebes	Lake OH	I	168		-	-	-
5561	Thebes	Lake OH	I	168		-	-	-
5563	EFP	Lake OH	I	168		-	-	-
5570	Thebes	Lake OH	I	168		-	-	-
5578	Kirk	Brown OH	I	168		-	-	-
5581	Thebes	Brown OH	I	168		-	-	-
5583	Kirk	Brown OH	I	168		-	-	-
5584	Thebes	Brown OH	I	168		-	-	-
5585	Kirk	Brown OH	I	168		-	-	-
5586	Kirk	Brown OH	I	168		-	-	-
5589	Kirk	Brown OH	I	168		-	-	-
5592	Kirk	Brown OH	I	168		-	-	-
5593	Thebes	Brown OH	I	168		-	-	-
5594	Thebes	Brown OH	I	168		-	-	-
5596	Kirk	Brown OH	I	168		-	-	-
5597	Thebes	Brown OH	I	168		-	-	-
5601	Hi-Lo	Washtenaw MI	I	169		-	-	-
5602	Hi-Lo	Washtenaw MI	I	169		-	-	-
5604	Thebes	Washtenaw MI	I	169		-	-	-
5605	Kirk	Washtenaw MI	I	169		-	-	-
5615	Dalton	Alexander IL	I	170		-	-	-
5617	Dalton	Massac IL	I	170		-	-	-
5619	Dalton	Union IL	I	170		-	-	-
5626	Dalton	Johnson IL	I	170		-	-	-
5627	Dalton	Pulaski IL	I	170		-	-	-
5629	Dalton	Johnson IL	I	170		-	-	-
5630	Dalton	Pulaski IL	I	170		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
5635	Dalton	Union IL	I	170		-	-	-
5636	Dalton	Pulaski IL	I	170		-	-	-
5637	Dalton	Union IL	I	170		-	-	-
5638	Dalton	Pulaski IL	I	170		-	-	-
5640	Dalton	Union IL	I	170		-	-	-
5643	Dalton	Pulaski IL	I	170		-	-	-
5648	Dalton	Union IL	I	170		-	-	-
5650	Dalton	Union IL	I	170		-	-	-
5652	Dalton	Pulaski IL	I	170		-	-	-
5653	Dalton	Union IL	I	170		-	-	-
5657	Dalton	Pulaski IL	I	170		-	-	-
5658	Dalton	Union IL	I	170		-	-	-
5660	Dalton	Union IL	I	170		-	-	-
5661	Dalton	Union IL	I	170		-	-	-
5663	EFP	Massac IL	I	170		-	-	-
5665	EFP	Johnson IL	I	170		-	-	-
5669	Dalton	Alexander IL	I	170		-	-	-
5670	Dalton	Union IL	I	170		-	-	-
5672	Dalton	Jackson IL	I	170		-	-	-
5676	Dalton	Jackson IL	I	170		-	-	-
5677	Dalton	Jackson IL	I	170		-	-	-
5678	Dalton	Jackson IL	I	170		-	-	-
5680	Dalton	Jackson IL	I	170		-	-	-
5684	Dalton	Jackson IL	I	170		-	-	-
5685	Dalton	Pope IL	I	170		-	-	-
5687	Dalton	Gallatin IL	I	170		-	-	-
5689	Dalton	Jackson IL	I	170		-	-	-
5691	Dalton	Alexander IL	I	170		-	-	-
5694	Dalton	Alexander IL	I	170		-	-	-
5695	Dalton	Alexander IL	I	170		-	-	-
5699	Dalton	Alexander IL	I	170		-	-	-
5702	Dalton	Alexander IL	I	170		-	-	-
5704	Dalton	Williamson IL	I	170		-	-	-
5705	Dalton	Williamson IL	I	170		-	-	-
5709	Dalton	Jackson IL	I	170		-	-	-
5715	Dalton	Pulaski IL	I	170		-	-	-
5717	Dalton	Alexander IL	I	170		-	-	-
5722	Dalton	Johnson IL	I	170		-	-	-
5723	Dalton	Jackson IL	I	170		-	-	-
5725	Dalton	Pulaski IL	I	170		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
5727	Dalton	Pulaski IL	I	170		-	-	-
5730	Dalton	Pulaski IL	I	170		-	-	-
5732	Dalton	Pulaski IL	I	170		-	-	-
5736	EFP	Massac IL	I	170		-	-	-
5740	Dalton	Saline IL	I	170		-	-	-
5744	Thebes	Johnson IL	I	170		-	-	-
5745	Thebes	Union IL	I	170		-	-	-
5747	Thebes	Union IL	I	170		-	-	-
5749	Dalton	Union IL	I	170		-	-	-
5754	Kirk	Union IL	I	170		-	-	-
5756	Thebes	Union IL	I	170		-	-	-
5757	Thebes	Pulaski IL	I	170		-	-	-
5758	Dalton	Union IL	I	170		-	-	-
5759	Thebes	Union IL	I	170		-	-	-
5762	Kirk	Pulaski IL	I	170		-	-	-
5765	Kirk	Williamson IL	I	170		-	-	-
5769	Kirk	Monroe IL	I	172		-	-	-
5775	Kirk	Monroe IL	I	172		-	-	-
5777	Dalton	Monroe IL	I	172		-	-	-
5780	Dalton	Monroe IL	I	172		-	-	-
5782	Dalton	Monroe IL	I	172		-	-	-
5783	Dalton	Monroe IL	I	172		-	-	-
5785	Dalton	Monroe IL	I	172		-	-	-
5787	Dalton	Monroe IL	I	172		-	-	-
5788	Kirk	Greene IL	I	164		-	-	-
5796	Dalton	Pope IL	I	164		-	-	-
5797	Dalton	Pope IL	I	164		-	-	-
5798	Kirk	Pope IL	I	164		-	-	-
5801	Kirk	Pope IL	I	164		-	-	-
5802	Kirk	Pope IL	I	164		-	-	-
5810	Thebes	Greene IL	I	164		-	-	-
5811	Thebes	Greene IL	I	164		-	-	-
5814	Thebes	Greene IL	I	164		-	-	-
5815	Thebes	Greene IL	I	164		-	-	-
5816	Thebes	Greene IL	I	164		-	-	-
5818	Thebes	Greene IL	I	164		-	-	-
5819	Thebes	Greene IL	I	164		-	-	-
5820	Thebes	Greene IL	I	164		-	-	-
5823	Thebes	Greene IL	I	164		-	-	-
5824	Thebes	Greene IL	I	164		-	-	-

Point ID	Group	County	Data Source	Coll. ID	Illustrated	Tank. No.	Prufer No.	Lepper No.
5825	Thebes	Greene IL	I	164		-	-	-
5827	Thebes	Greene IL	I	164		-	-	-
5828	Thebes	Greene IL	I	164		-	-	-
5829	Thebes	Greene IL	I	164		-	-	-
5835	Dalton	Madison IL	P	-	Higgins 1990: Plate 6a	-	-	-
5836	Dalton	Madison IL	P	-	Higgins 1990: Plate 6b	-	-	-
5837	Dalton	Madison IL	P	-	Higgins 1990: Plate 6c	-	-	-
5838	Dalton	Madison IL	P	-	Higgins 1990: Plate 6d	-	-	-
5840	Dalton	Madison IL	P	-	Higgins 1990: Plate 6f	-	-	-
5841	Dalton	Madison IL	P	-	Higgins 1990: Plate 6g	-	-	-
5842	Dalton	Madison IL	P	-	Higgins 1990: Plate 6h	-	-	-
5843	Dalton	Madison IL	P	-	Higgins 1990: Plate 6i	-	-	-
5867	Kirk	Madison IL	P	-	Higgins 1990: Plate 14b	-	-	-
5868	Kirk	Madison IL	P	-	Higgins 1990: Plate 14c	-	-	-
5869	Kirk	Madison IL	P	-	Higgins 1990: Plate 14d	-	-	-
5870	Kirk	Madison IL	P	-	Higgins 1990: Plate 14e	-	-	-
5872	Kirk	Madison IL	P	-	Higgins 1990: Plate 14g	-	-	-
5874	Kirk	Madison IL	P	-	Higgins 1990: Plate 14i	-	-	-
5875	Kirk	Madison IL	P	-	Higgins 1990: Plate 14j	-	-	-
5876	Kirk	Madison IL	P	-	Higgins 1990: Plate 14k	-	-	-
5878	Kirk	Madison IL	P	-	Higgins 1990: Plate 14m	-	-	-
5880	Kirk	Madison IL	P	-	Higgins 1990: Plate 14o	-	-	-

Appendix C

CURATION INFORMATION FOR PROJECTILE POINTS IN THE ARCHAEOLOGICAL DATASET

This appendix identifies the institutional collections and accession/catalog numbers of points in the archaeological dataset. Points are ordered by first institutional collection then Point ID. The numeric designations in the column "Collection ID" correspond to those in the "Coll. ID" column in Appendix B. The column "Institution/Collection" lists the institution where a projectile point was analyzed. The column "Accession/Catalog" contains information about numbers/codes used to curate/identify a point at the institution where it is curated.

Collection ID	Point ID	Institution/Collection	Accession/Catalog
5	4744	Whitley County History Museum	99.075-26-24
5	4745	Whitley County History Museum	99.075-26-33
5	4746	Whitley County History Museum	99.075-26-25
5	4747	Whitley County History Museum	99.075-26.23
5	4751	Whitley County History Museum	99.075-26-32
5	4755	Whitley County History Museum	99.075-26-15
5	4756	Whitley County History Museum	99.075-26-19
5	4757	Whitley County History Museum	99.075-26-20
5	4758	Whitley County History Museum	99.075-26-10
5	4759	Whitley County History Museum	99.075-26-8
5	4764	Whitley County History Museum	
6	149	Glenn A. Black Laboratory of Archaeology	2681/30
6	238	Glenn A. Black Laboratory of Archaeology	21/366
6	352	Glenn A. Black Laboratory of Archaeology	606/1
6	353	Glenn A. Black Laboratory of Archaeology	5043/2
6	354	Glenn A. Black Laboratory of Archaeology	10591/1

Collection ID	Point ID	Institution/Collection	Accession/Catalog
6	355	Glenn A. Black Laboratory of Archaeology	10973/1
6	358	Glenn A. Black Laboratory of Archaeology	5059/1
6	361	Glenn A. Black Laboratory of Archaeology	165/8
6	362	Glenn A. Black Laboratory of Archaeology	165/4
6	364	Glenn A. Black Laboratory of Archaeology	165/7
6	365	Glenn A. Black Laboratory of Archaeology	21/301
6	370	Glenn A. Black Laboratory of Archaeology	21/279
6	376	Glenn A. Black Laboratory of Archaeology	1448/421
6	378	Glenn A. Black Laboratory of Archaeology	5523/1
6	379	Glenn A. Black Laboratory of Archaeology	1448/421
6	399	Glenn A. Black Laboratory of Archaeology	1448/468
6	913	Glenn A. Black Laboratory of Archaeology	165/3
6	915	Glenn A. Black Laboratory of Archaeology	
6	923	Glenn A. Black Laboratory of Archaeology	165/2
6	927	Glenn A. Black Laboratory of Archaeology	1722/29
6	934	Glenn A. Black Laboratory of Archaeology	185/1
6	938	Glenn A. Black Laboratory of Archaeology	6861/212
6	1051	Glenn A. Black Laboratory of Archaeology	4351/1
6	1082	Glenn A. Black Laboratory of Archaeology	6572/1
6	2017	Glenn A. Black Laboratory of Archaeology	21/311
6	2019	Glenn A. Black Laboratory of Archaeology	
6	2020	Glenn A. Black Laboratory of Archaeology	21/288
6	2022	Glenn A. Black Laboratory of Archaeology	422/75
6	2025	Glenn A. Black Laboratory of Archaeology	187/1
6	2028	Glenn A. Black Laboratory of Archaeology	335/25
6	2029	Glenn A. Black Laboratory of Archaeology	335/5 (or 3)
6	2031	Glenn A. Black Laboratory of Archaeology	335/7
6	2032	Glenn A. Black Laboratory of Archaeology	335/15 (or 16)
6	2034	Glenn A. Black Laboratory of Archaeology	335/7
6	2036	Glenn A. Black Laboratory of Archaeology	344/7
6	2037	Glenn A. Black Laboratory of Archaeology	344/7
6	2038	Glenn A. Black Laboratory of Archaeology	359/6
6	2040	Glenn A. Black Laboratory of Archaeology	446/4
6	2042	Glenn A. Black Laboratory of Archaeology	460/1
6	2047	Glenn A. Black Laboratory of Archaeology	463/23
6	2056	Glenn A. Black Laboratory of Archaeology	473/3
6	2057	Glenn A. Black Laboratory of Archaeology	473/3
6	2058	Glenn A. Black Laboratory of Archaeology	484/22
6	2059	Glenn A. Black Laboratory of Archaeology	484/22
6	2060	Glenn A. Black Laboratory of Archaeology	484/22

Collection ID	Point ID	Institution/Collection	Accession/Catalog
6	2062	Glenn A. Black Laboratory of Archaeology	482/296
6	2066	Glenn A. Black Laboratory of Archaeology	620/47
6	2069	Glenn A. Black Laboratory of Archaeology	620/41
6	2071	Glenn A. Black Laboratory of Archaeology	654/1
6	2072	Glenn A. Black Laboratory of Archaeology	663/4
6	2073	Glenn A. Black Laboratory of Archaeology	661/6
6	2075	Glenn A. Black Laboratory of Archaeology	714/5
6	2079	Glenn A. Black Laboratory of Archaeology	817/344
6	2080	Glenn A. Black Laboratory of Archaeology	817/190
6	2081	Glenn A. Black Laboratory of Archaeology	817/350
6	2082	Glenn A. Black Laboratory of Archaeology	820/1
6	2084	Glenn A. Black Laboratory of Archaeology	872/558
6	2085	Glenn A. Black Laboratory of Archaeology	872/1248
6	2086	Glenn A. Black Laboratory of Archaeology	963/75
6	2087	Glenn A. Black Laboratory of Archaeology	963/12
6	2088	Glenn A. Black Laboratory of Archaeology	963/23
6	2089	Glenn A. Black Laboratory of Archaeology	963/75
6	2097	Glenn A. Black Laboratory of Archaeology	1068/2
6	2099	Glenn A. Black Laboratory of Archaeology	1163/1
6	2101	Glenn A. Black Laboratory of Archaeology	1175/6
6	2103	Glenn A. Black Laboratory of Archaeology	1188/8
6	2106	Glenn A. Black Laboratory of Archaeology	1213/1
6	2108	Glenn A. Black Laboratory of Archaeology	1318/1
6	2110	Glenn A. Black Laboratory of Archaeology	1361/4
6	2111	Glenn A. Black Laboratory of Archaeology	1376/1
6	2112	Glenn A. Black Laboratory of Archaeology	1361/4
6	2113	Glenn A. Black Laboratory of Archaeology	1404/26
6	2114	Glenn A. Black Laboratory of Archaeology	1406/3
6	2117	Glenn A. Black Laboratory of Archaeology	1406/3
6	2118	Glenn A. Black Laboratory of Archaeology	1404/9
6	2120	Glenn A. Black Laboratory of Archaeology	1455/2
6	2125	Glenn A. Black Laboratory of Archaeology	1558/3
6	2129	Glenn A. Black Laboratory of Archaeology	1642/4
6	2131	Glenn A. Black Laboratory of Archaeology	1722/1
6	2132	Glenn A. Black Laboratory of Archaeology	1722/1
6	2134	Glenn A. Black Laboratory of Archaeology	1722/21
6	2135	Glenn A. Black Laboratory of Archaeology	1722/1
6	2136	Glenn A. Black Laboratory of Archaeology	1722/3
6	2137	Glenn A. Black Laboratory of Archaeology	1722/10
6	2138	Glenn A. Black Laboratory of Archaeology	1722/4

Collection ID	Point ID	Institution/Collection	Accession/Catalog
6	2143	Glenn A. Black Laboratory of Archaeology	1722/1
6	2146	Glenn A. Black Laboratory of Archaeology	1722/16
6	2147	Glenn A. Black Laboratory of Archaeology	1722/21
6	2149	Glenn A. Black Laboratory of Archaeology	1788/5
6	2151	Glenn A. Black Laboratory of Archaeology	1856/4
6	2152	Glenn A. Black Laboratory of Archaeology	1910/1
6	2156	Glenn A. Black Laboratory of Archaeology	1985/1
6	2159	Glenn A. Black Laboratory of Archaeology	2136/11
6	2162	Glenn A. Black Laboratory of Archaeology	2203/5
6	2164	Glenn A. Black Laboratory of Archaeology	2234/3
6	2167	Glenn A. Black Laboratory of Archaeology	2390/4
6	2171	Glenn A. Black Laboratory of Archaeology	2471/7
6	2173	Glenn A. Black Laboratory of Archaeology	2565/15
6	2175	Glenn A. Black Laboratory of Archaeology	2501/10
6	2178	Glenn A. Black Laboratory of Archaeology	2620/2
6	2180	Glenn A. Black Laboratory of Archaeology	2667/3
6	2183	Glenn A. Black Laboratory of Archaeology	2681/33
6	2184	Glenn A. Black Laboratory of Archaeology	2681/42
6	2185	Glenn A. Black Laboratory of Archaeology	2682/1
6	2186	Glenn A. Black Laboratory of Archaeology	2683/1
6	2187	Glenn A. Black Laboratory of Archaeology	2687/52
6	2191	Glenn A. Black Laboratory of Archaeology	2916/4
6	2192	Glenn A. Black Laboratory of Archaeology	2938/7
6	2193	Glenn A. Black Laboratory of Archaeology	2970/1
6	2194	Glenn A. Black Laboratory of Archaeology	3023/3
6	2195	Glenn A. Black Laboratory of Archaeology	3086/87
6	2197	Glenn A. Black Laboratory of Archaeology	2992/1
6	2199	Glenn A. Black Laboratory of Archaeology	3106/1
6	2978	Glenn A. Black Laboratory of Archaeology	3114/1247
6	2979	Glenn A. Black Laboratory of Archaeology	3114/1200
6	2986	Glenn A. Black Laboratory of Archaeology	3117/27
6	2987	Glenn A. Black Laboratory of Archaeology	3118/514
6	2990	Glenn A. Black Laboratory of Archaeology	3222/1
6	2991	Glenn A. Black Laboratory of Archaeology	3303/7
6	2993	Glenn A. Black Laboratory of Archaeology	3363/2
6	2995	Glenn A. Black Laboratory of Archaeology	3385/4
6	3000	Glenn A. Black Laboratory of Archaeology	3503/17
6	3002	Glenn A. Black Laboratory of Archaeology	3575/16
6	3003	Glenn A. Black Laboratory of Archaeology	3575/7
6	3004	Glenn A. Black Laboratory of Archaeology	3575/18

Collection ID	Point ID	Institution/Collection	Accession/Catalog
6	3006	Glenn A. Black Laboratory of Archaeology	3604/17
6	3007	Glenn A. Black Laboratory of Archaeology	3604/33
6	3008	Glenn A. Black Laboratory of Archaeology	3607/8
6	3009	Glenn A. Black Laboratory of Archaeology	3651/11
6	3011	Glenn A. Black Laboratory of Archaeology	3665/2
6	3013	Glenn A. Black Laboratory of Archaeology	3798/2
6	3014	Glenn A. Black Laboratory of Archaeology	3846/1
6	3016	Glenn A. Black Laboratory of Archaeology	3858/12
6	3017	Glenn A. Black Laboratory of Archaeology	3927/1
6	3018	Glenn A. Black Laboratory of Archaeology	3932/62
6	3020	Glenn A. Black Laboratory of Archaeology	3972/3
6	3022	Glenn A. Black Laboratory of Archaeology	4028/1
6	3025	Glenn A. Black Laboratory of Archaeology	4130/1
6	3026	Glenn A. Black Laboratory of Archaeology	4272/9
6	3027	Glenn A. Black Laboratory of Archaeology	4273/1
6	3029	Glenn A. Black Laboratory of Archaeology	4289/97
6	3030	Glenn A. Black Laboratory of Archaeology	4297/13
6	3035	Glenn A. Black Laboratory of Archaeology	4302/47
6	3038	Glenn A. Black Laboratory of Archaeology	4303/22
6	3039	Glenn A. Black Laboratory of Archaeology	4305/35
6	3043	Glenn A. Black Laboratory of Archaeology	4305/37
6	3044	Glenn A. Black Laboratory of Archaeology	4305/63
6	3046	Glenn A. Black Laboratory of Archaeology	4307/19
6	3047	Glenn A. Black Laboratory of Archaeology	4308/38
6	3048	Glenn A. Black Laboratory of Archaeology	4308/34
6	3049	Glenn A. Black Laboratory of Archaeology	4312/4
6	3053	Glenn A. Black Laboratory of Archaeology	4317/5
6	3057	Glenn A. Black Laboratory of Archaeology	4323/60
6	3059	Glenn A. Black Laboratory of Archaeology	4359/99
6	3068	Glenn A. Black Laboratory of Archaeology	4465/17
6	3070	Glenn A. Black Laboratory of Archaeology	4523/1
6	3074	Glenn A. Black Laboratory of Archaeology	4559/20
6	3075	Glenn A. Black Laboratory of Archaeology	4559/21
6	3076	Glenn A. Black Laboratory of Archaeology	4605/2
6	3079	Glenn A. Black Laboratory of Archaeology	4725/1
6	3080	Glenn A. Black Laboratory of Archaeology	4770/3
6	3083	Glenn A. Black Laboratory of Archaeology	4786/16
6	3089	Glenn A. Black Laboratory of Archaeology	4786/75
6	3091	Glenn A. Black Laboratory of Archaeology	4904/22
6	3096	Glenn A. Black Laboratory of Archaeology	5076/20

Collection ID	Point ID	Institution/Collection	Accession/Catalog
6	3098	Glenn A. Black Laboratory of Archaeology	5081/5
6	3099	Glenn A. Black Laboratory of Archaeology	5081/6
6	3101	Glenn A. Black Laboratory of Archaeology	5081/7
6	3102	Glenn A. Black Laboratory of Archaeology	5081/15
6	3103	Glenn A. Black Laboratory of Archaeology	5085/1
6	3104	Glenn A. Black Laboratory of Archaeology	5086/5
6	3105	Glenn A. Black Laboratory of Archaeology	5086/3
6	3106	Glenn A. Black Laboratory of Archaeology	5086/7
6	3108	Glenn A. Black Laboratory of Archaeology	5132/1
6	3110	Glenn A. Black Laboratory of Archaeology	5148/1
6	3112	Glenn A. Black Laboratory of Archaeology	5161/1
6	3119	Glenn A. Black Laboratory of Archaeology	5363/1
6	3123	Glenn A. Black Laboratory of Archaeology	5553/2
6	3125	Glenn A. Black Laboratory of Archaeology	5523/29
6	3126	Glenn A. Black Laboratory of Archaeology	5523/14
6	3127	Glenn A. Black Laboratory of Archaeology	5523/15
6	3128	Glenn A. Black Laboratory of Archaeology	5523/22
6	3129	Glenn A. Black Laboratory of Archaeology	5523/25
6	3131	Glenn A. Black Laboratory of Archaeology	5523/33
6	3132	Glenn A. Black Laboratory of Archaeology	5523/21
6	3133	Glenn A. Black Laboratory of Archaeology	5523/23
6	3134	Glenn A. Black Laboratory of Archaeology	5523/31
6	3137	Glenn A. Black Laboratory of Archaeology	5523/8
6	3141	Glenn A. Black Laboratory of Archaeology	5523/13
6	3142	Glenn A. Black Laboratory of Archaeology	5523/41
6	3143	Glenn A. Black Laboratory of Archaeology	5523/47
6	3145	Glenn A. Black Laboratory of Archaeology	5523/28
6	3153	Glenn A. Black Laboratory of Archaeology	5523/35
6	3178	Glenn A. Black Laboratory of Archaeology	5554/2
6	3179	Glenn A. Black Laboratory of Archaeology	5555/18
6	3181	Glenn A. Black Laboratory of Archaeology	5556/2
6	3182	Glenn A. Black Laboratory of Archaeology	5556/5
6	3185	Glenn A. Black Laboratory of Archaeology	5560/3
6	3186	Glenn A. Black Laboratory of Archaeology	5557/3
6	3187	Glenn A. Black Laboratory of Archaeology	5557/1
6	3190	Glenn A. Black Laboratory of Archaeology	5586/5
6	3191	Glenn A. Black Laboratory of Archaeology	5573/1
6	3192	Glenn A. Black Laboratory of Archaeology	5580/3
6	3194	Glenn A. Black Laboratory of Archaeology	5590/4
6	3198	Glenn A. Black Laboratory of Archaeology	5612/47

Collection ID	Point ID	Institution/Collection	Accession/Catalog
6	3200	Glenn A. Black Laboratory of Archaeology	5616/2
6	3201	Glenn A. Black Laboratory of Archaeology	5617/5
6	3202	Glenn A. Black Laboratory of Archaeology	5617/74
6	3203	Glenn A. Black Laboratory of Archaeology	5617/6
6	3204	Glenn A. Black Laboratory of Archaeology	5617/1
6	3205	Glenn A. Black Laboratory of Archaeology	5617/2
6	3206	Glenn A. Black Laboratory of Archaeology	5618/2
6	3208	Glenn A. Black Laboratory of Archaeology	5634/10
6	3210	Glenn A. Black Laboratory of Archaeology	5706/2
6	3212	Glenn A. Black Laboratory of Archaeology	5736/3
6	3216	Glenn A. Black Laboratory of Archaeology	5745/33
6	3218	Glenn A. Black Laboratory of Archaeology	5771/1
6	3221	Glenn A. Black Laboratory of Archaeology	5826/2
6	3222	Glenn A. Black Laboratory of Archaeology	5826/3
6	3223	Glenn A. Black Laboratory of Archaeology	5829/1
6	3225	Glenn A. Black Laboratory of Archaeology	5841/2
6	3226	Glenn A. Black Laboratory of Archaeology	5845/1
6	3228	Glenn A. Black Laboratory of Archaeology	5870/1
6	3229	Glenn A. Black Laboratory of Archaeology	5880/1
6	3230	Glenn A. Black Laboratory of Archaeology	5900/1
6	3234	Glenn A. Black Laboratory of Archaeology	5993/1
6	3235	Glenn A. Black Laboratory of Archaeology	6017/1
6	3236	Glenn A. Black Laboratory of Archaeology	6032/1
6	3238	Glenn A. Black Laboratory of Archaeology	6173/135
6	3240	Glenn A. Black Laboratory of Archaeology	6173/32
6	3241	Glenn A. Black Laboratory of Archaeology	6173/93
6	3246	Glenn A. Black Laboratory of Archaeology	6220/24
6	3249	Glenn A. Black Laboratory of Archaeology	6364/3
6	3250	Glenn A. Black Laboratory of Archaeology	6389/2
6	3251	Glenn A. Black Laboratory of Archaeology	6555/1
6	3253	Glenn A. Black Laboratory of Archaeology	6558/1J-8-1
6	3254	Glenn A. Black Laboratory of Archaeology	6558/1J-8-2
6	3255	Glenn A. Black Laboratory of Archaeology	6558/1O-7-1
6	3256	Glenn A. Black Laboratory of Archaeology	6558/1A-7-1
6	3257	Glenn A. Black Laboratory of Archaeology	6558/1B-2-1
6	3258	Glenn A. Black Laboratory of Archaeology	6558/1G-3-1
6	3259	Glenn A. Black Laboratory of Archaeology	6558/1I-8-3
6	3260	Glenn A. Black Laboratory of Archaeology	6558/1B-7-1
6	3261	Glenn A. Black Laboratory of Archaeology	6558/1I-8-2
6	3263	Glenn A. Black Laboratory of Archaeology	6558/1A-8-2

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6	3264	Glenn A. Black Laboratory of Archaeology	6558/1M-9-2
6	3265	Glenn A. Black Laboratory of Archaeology	6558/1A-2-1
6	3266	Glenn A. Black Laboratory of Archaeology	6558/1A-5-1
6	3267	Glenn A. Black Laboratory of Archaeology	6558/1H-9-1
6	3268	Glenn A. Black Laboratory of Archaeology	6558/1J-6-2
6	3269	Glenn A. Black Laboratory of Archaeology	6572/19
6	3270	Glenn A. Black Laboratory of Archaeology	6572/28
6	3271	Glenn A. Black Laboratory of Archaeology	6572/26
6	3274	Glenn A. Black Laboratory of Archaeology	6572/34
6	3275	Glenn A. Black Laboratory of Archaeology	6572/59
6	3276	Glenn A. Black Laboratory of Archaeology	6572/29
6	3277	Glenn A. Black Laboratory of Archaeology	6572/33
6	3278	Glenn A. Black Laboratory of Archaeology	6572/41
6	3279	Glenn A. Black Laboratory of Archaeology	6572/12
6	3280	Glenn A. Black Laboratory of Archaeology	6572/11
6	3281	Glenn A. Black Laboratory of Archaeology	6572/42
6	3282	Glenn A. Black Laboratory of Archaeology	6572/125
6	3283	Glenn A. Black Laboratory of Archaeology	6572/115
6	3284	Glenn A. Black Laboratory of Archaeology	6572/97
6	3285	Glenn A. Black Laboratory of Archaeology	6572/105
6	3287	Glenn A. Black Laboratory of Archaeology	6572/95
6	3288	Glenn A. Black Laboratory of Archaeology	6572/99
6	3297	Glenn A. Black Laboratory of Archaeology	6572/9
6	3300	Glenn A. Black Laboratory of Archaeology	6764/142
6	3302	Glenn A. Black Laboratory of Archaeology	6764/34
6	3305	Glenn A. Black Laboratory of Archaeology	6614/56
6	3306	Glenn A. Black Laboratory of Archaeology	6614/49
6	3307	Glenn A. Black Laboratory of Archaeology	6614/46
6	3308	Glenn A. Black Laboratory of Archaeology	6614/60
6	3309	Glenn A. Black Laboratory of Archaeology	6614/3
6	3310	Glenn A. Black Laboratory of Archaeology	6614/48
6	3315	Glenn A. Black Laboratory of Archaeology	6861/48
6	3316	Glenn A. Black Laboratory of Archaeology	6861/23
6	3320	Glenn A. Black Laboratory of Archaeology	6873/1
6	3326	Glenn A. Black Laboratory of Archaeology	6882/1
6	3327	Glenn A. Black Laboratory of Archaeology	6882/4
6	3328	Glenn A. Black Laboratory of Archaeology	6983/4747
6	3329	Glenn A. Black Laboratory of Archaeology	6983/5498
6	3330	Glenn A. Black Laboratory of Archaeology	6983/5563
6	3331	Glenn A. Black Laboratory of Archaeology	6983/5363

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6	3332	Glenn A. Black Laboratory of Archaeology	7061/68
6	3334	Glenn A. Black Laboratory of Archaeology	7115/3
6	3335	Glenn A. Black Laboratory of Archaeology	7115/10
6	3336	Glenn A. Black Laboratory of Archaeology	7115/20
6	3337	Glenn A. Black Laboratory of Archaeology	7115/48
6	3338	Glenn A. Black Laboratory of Archaeology	7115/14
6	3339	Glenn A. Black Laboratory of Archaeology	7115/9
6	3340	Glenn A. Black Laboratory of Archaeology	7115/23
6	3341	Glenn A. Black Laboratory of Archaeology	7115/2
6	3342	Glenn A. Black Laboratory of Archaeology	7115/8
6	3343	Glenn A. Black Laboratory of Archaeology	7115/11
6	3344	Glenn A. Black Laboratory of Archaeology	7115/18
6	3346	Glenn A. Black Laboratory of Archaeology	7116/1
6	3347	Glenn A. Black Laboratory of Archaeology	7116/2
6	3348	Glenn A. Black Laboratory of Archaeology	7116/3
6	3349	Glenn A. Black Laboratory of Archaeology	7158/1
6	3352	Glenn A. Black Laboratory of Archaeology	7179/195
6	3355	Glenn A. Black Laboratory of Archaeology	7179/811
6	3366	Glenn A. Black Laboratory of Archaeology	7252/2
6	3367	Glenn A. Black Laboratory of Archaeology	7240/1
6	3368	Glenn A. Black Laboratory of Archaeology	7240/1
6	3371	Glenn A. Black Laboratory of Archaeology	7438/848 (Plank)
6	3372	Glenn A. Black Laboratory of Archaeology	7438/847 (Plank)
6	3373	Glenn A. Black Laboratory of Archaeology	7438/850 (Plank)
6	3376	Glenn A. Black Laboratory of Archaeology	7664/2
6	3377	Glenn A. Black Laboratory of Archaeology	7762/22
15	307	Ball State University	BSU 38F-4
36	552	Marshall County Historical Society	
52	129	IPFW Archaeological Survey	Ht-w-9
52	130	IPFW Archaeological Survey	Ht-t
52	217	IPFW Archaeological Survey	1515/1
52	265	IPFW Archaeological Survey	1250/19
52	454	IPFW Archaeological Survey	1103/
52	457	IPFW Archaeological Survey	1388/12
52	904	IPFW Archaeological Survey	1563/5
52	2837	IPFW Archaeological Survey	779/ (Al-pb-9)
52	2838	IPFW Archaeological Survey	722/ (Al-j-7)
52	2848	IPFW Archaeological Survey	738/ (Al-z-15)
52	2852	IPFW Archaeological Survey	1123/ (12A341-02)
52	2861	IPFW Archaeological Survey	1071/ (12A270-15)

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52	2866	IPFW Archaeological Survey	1133/ (12A358-01)
52	2867	IPFW Archaeological Survey	1180/ (12Al1934-22)
52	2871	IPFW Archaeological Survey	1368/
52	2874	IPFW Archaeological Survey	1307/
52	2875	IPFW Archaeological Survey	1310/
52	2895	IPFW Archaeological Survey	847/ (Ht-g-1)
52	2897	IPFW Archaeological Survey	1551/94
142	1597	Univ. of Michigan Museum of Anthropology	2893/64871
142	1598	Univ. of Michigan Museum of Anthropology	2893/64871
142	1599	Univ. of Michigan Museum of Anthropology	2893/64871
142	1601	Univ. of Michigan Museum of Anthropology	27673
142	1602	Univ. of Michigan Museum of Anthropology	2018
142	1604	Univ. of Michigan Museum of Anthropology	23558
142	1606	Univ. of Michigan Museum of Anthropology	5340
142	1610	Univ. of Michigan Museum of Anthropology	65485
142	1612	Univ. of Michigan Museum of Anthropology	3986
142	1618	Univ. of Michigan Museum of Anthropology	2237
142	1622	Univ. of Michigan Museum of Anthropology	_____
142	1625	Univ. of Michigan Museum of Anthropology	2337
142	1626	Univ. of Michigan Museum of Anthropology	2337
142	1627	Univ. of Michigan Museum of Anthropology	2337
142	1628	Univ. of Michigan Museum of Anthropology	2337
142	1629	Univ. of Michigan Museum of Anthropology	64836
142	1630	Univ. of Michigan Museum of Anthropology	1244
142	1632	Univ. of Michigan Museum of Anthropology	1244
142	1638	Univ. of Michigan Museum of Anthropology	29088
142	1642	Univ. of Michigan Museum of Anthropology	2341
142	1643	Univ. of Michigan Museum of Anthropology	2341
142	1644	Univ. of Michigan Museum of Anthropology	2341
142	1646	Univ. of Michigan Museum of Anthropology	39743
142	1647	Univ. of Michigan Museum of Anthropology	4403
142	1649	Univ. of Michigan Museum of Anthropology	40061
142	1650	Univ. of Michigan Museum of Anthropology	61213
142	1653	Univ. of Michigan Museum of Anthropology	30387
142	1654	Univ. of Michigan Museum of Anthropology	39030
142	1655	Univ. of Michigan Museum of Anthropology	40264
142	1656	Univ. of Michigan Museum of Anthropology	87123/3433
142	1666	Univ. of Michigan Museum of Anthropology	121
142	1667	Univ. of Michigan Museum of Anthropology	46
142	1668	Univ. of Michigan Museum of Anthropology	2953

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142	1670	Univ. of Michigan Museum of Anthropology	2333
142	1671	Univ. of Michigan Museum of Anthropology	38979
142	1673	Univ. of Michigan Museum of Anthropology	27736
142	1674	Univ. of Michigan Museum of Anthropology	27736
142	1675	Univ. of Michigan Museum of Anthropology	27736
142	1676	Univ. of Michigan Museum of Anthropology	57151
142	1678	Univ. of Michigan Museum of Anthropology	39851
142	1683	Univ. of Michigan Museum of Anthropology	29048
142	1684	Univ. of Michigan Museum of Anthropology	39995 (?)
142	1686	Univ. of Michigan Museum of Anthropology	2976
142	1688	Univ. of Michigan Museum of Anthropology	2976
142	1690	Univ. of Michigan Museum of Anthropology	2289
142	1692	Univ. of Michigan Museum of Anthropology	87228
142	1693	Univ. of Michigan Museum of Anthropology	39860
142	1694	Univ. of Michigan Museum of Anthropology	38978
142	1695	Univ. of Michigan Museum of Anthropology	39860
142	1696	Univ. of Michigan Museum of Anthropology	39860
142	1697	Univ. of Michigan Museum of Anthropology	1301 (1946)
142	1711	Univ. of Michigan Museum of Anthropology	3791 (6-4)
142	1717	Univ. of Michigan Museum of Anthropology	27737
142	1721	Univ. of Michigan Museum of Anthropology	1439
142	1722	Univ. of Michigan Museum of Anthropology	27737
148	1783	William S. Webb Museum of Anthropology	37
148	1784	William S. Webb Museum of Anthropology	916
148	1786	William S. Webb Museum of Anthropology	207
148	1787	William S. Webb Museum of Anthropology	176
148	1788	William S. Webb Museum of Anthropology	273
148	1789	William S. Webb Museum of Anthropology	168
148	1790	William S. Webb Museum of Anthropology	4
148	1791	William S. Webb Museum of Anthropology	5
148	1792	William S. Webb Museum of Anthropology	6
148	1794	William S. Webb Museum of Anthropology	7656
148	1795	William S. Webb Museum of Anthropology	5891
148	1796	William S. Webb Museum of Anthropology	582
148	1797	William S. Webb Museum of Anthropology	5961
148	1798	William S. Webb Museum of Anthropology	3823
148	1799	William S. Webb Museum of Anthropology	1
148	1800	William S. Webb Museum of Anthropology	2
148	1801	William S. Webb Museum of Anthropology	3
148	1802	William S. Webb Museum of Anthropology	4

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148	1803	William S. Webb Museum of Anthropology	8
148	1805	William S. Webb Museum of Anthropology	9
148	1806	William S. Webb Museum of Anthropology	6
148	1807	William S. Webb Museum of Anthropology	19
148	1809	William S. Webb Museum of Anthropology	2174
148	1810	William S. Webb Museum of Anthropology	2
148	1811	William S. Webb Museum of Anthropology	16
148	1812	William S. Webb Museum of Anthropology	3
148	1813	William S. Webb Museum of Anthropology	15
148	1820	William S. Webb Museum of Anthropology	1462
148	1821	William S. Webb Museum of Anthropology	2773
148	1823	William S. Webb Museum of Anthropology	2178
148	1824	William S. Webb Museum of Anthropology	2321
148	1827	William S. Webb Museum of Anthropology	4404
148	1833	William S. Webb Museum of Anthropology	1035
148	1835	William S. Webb Museum of Anthropology	568
148	1836	William S. Webb Museum of Anthropology	1010
148	1837	William S. Webb Museum of Anthropology	281
148	1838	William S. Webb Museum of Anthropology	4515
148	1839	William S. Webb Museum of Anthropology	5186
148	1840	William S. Webb Museum of Anthropology	1793-2
148	1841	William S. Webb Museum of Anthropology	137
148	1842	William S. Webb Museum of Anthropology	1563-3
148	1843	William S. Webb Museum of Anthropology	1744
148	1844	William S. Webb Museum of Anthropology	412
148	1847	William S. Webb Museum of Anthropology	1725-2
148	1848	William S. Webb Museum of Anthropology	4914
148	1849	William S. Webb Museum of Anthropology	35
148	1850	William S. Webb Museum of Anthropology	1085
148	1851	William S. Webb Museum of Anthropology	468
148	1854	William S. Webb Museum of Anthropology	432
148	1856	William S. Webb Museum of Anthropology	713
148	1866	William S. Webb Museum of Anthropology	91
148	1869	William S. Webb Museum of Anthropology	156
148	1870	William S. Webb Museum of Anthropology	579-2
148	1871	William S. Webb Museum of Anthropology	119
148	4770	William S. Webb Museum of Anthropology	631-1
148	4771	William S. Webb Museum of Anthropology	5908
148	4772	William S. Webb Museum of Anthropology	381
148	4773	William S. Webb Museum of Anthropology	395

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148	4774	William S. Webb Museum of Anthropology	43
148	4775	William S. Webb Museum of Anthropology	603
148	4782	William S. Webb Museum of Anthropology	15Bc42/41
148	4783	William S. Webb Museum of Anthropology	15Bc44/2
148	4784	William S. Webb Museum of Anthropology	15Bc76/2
148	4785	William S. Webb Museum of Anthropology	15Bc35/7
148	4787	William S. Webb Museum of Anthropology	15Bc63/6
148	4792	William S. Webb Museum of Anthropology	15Ck89/1384
148	4797	William S. Webb Museum of Anthropology	15Ck132/50
148	4798	William S. Webb Museum of Anthropology	15Ck132/44
148	4801	William S. Webb Museum of Anthropology	15Ck146/392
148	4804	William S. Webb Museum of Anthropology	15Ck101/43
148	4805	William S. Webb Museum of Anthropology	15Ck101/39
148	4806	William S. Webb Museum of Anthropology	15Fr101/62410
148	4808	William S. Webb Museum of Anthropology	15Ha159/66
148	4809	William S. Webb Museum of Anthropology	15Ha000/1
148	4810	William S. Webb Museum of Anthropology	15Hd158/7
148	4811	William S. Webb Museum of Anthropology	15Hd144/1
148	4812	William S. Webb Museum of Anthropology	15He275/4
148	4814	William S. Webb Museum of Anthropology	15He279/1
148	4816	William S. Webb Museum of Anthropology	15He281/1
148	4817	William S. Webb Museum of Anthropology	15He296/2
148	4818	William S. Webb Museum of Anthropology	15He296/19
148	4819	William S. Webb Museum of Anthropology	15He323/1
148	4820	William S. Webb Museum of Anthropology	15He320/3
148	4821	William S. Webb Museum of Anthropology	15He327/2
148	4824	William S. Webb Museum of Anthropology	15He336/3
148	4826	William S. Webb Museum of Anthropology	15He341/2
148	4829	William S. Webb Museum of Anthropology	15He400/1
148	4831	William S. Webb Museum of Anthropology	15Ma144/18
148	4834	William S. Webb Museum of Anthropology	Bc/17-20
148	4839	William S. Webb Museum of Anthropology	15Fa199/50
148	4841	William S. Webb Museum of Anthropology	Js/14-32
148	4842	William S. Webb Museum of Anthropology	Ja/14-33
148	4845	William S. Webb Museum of Anthropology	83999
148	4850	William S. Webb Museum of Anthropology	Lo-19
148	4851	William S. Webb Museum of Anthropology	Lo-2
148	4852	William S. Webb Museum of Anthropology	Lo-2
148	4854	William S. Webb Museum of Anthropology	Bb/00 2-3
148	4863	William S. Webb Museum of Anthropology	Wo-39

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148	4864	William S. Webb Museum of Anthropology	Wo/10-32
148	4865	William S. Webb Museum of Anthropology	Wo/10-32
148	4866	William S. Webb Museum of Anthropology	Wo/10-32
148	4869	William S. Webb Museum of Anthropology	Mm/7-32
148	4872	William S. Webb Museum of Anthropology	Jo/2-24 "453-R8"
148	4873	William S. Webb Museum of Anthropology	Jo/2-37 "978-R7"
148	4876	William S. Webb Museum of Anthropology	Jo/2-45
148	4877	William S. Webb Museum of Anthropology	Jo/2-56 "806-DP"
148	4880	William S. Webb Museum of Anthropology	Jo/2-80
148	4881	William S. Webb Museum of Anthropology	Jo/2-88 "949-DP"
148	4885	William S. Webb Museum of Anthropology	Jo/2-137 "662-R12"
148	4893	William S. Webb Museum of Anthropology	Jo/2-208
148	4896	William S. Webb Museum of Anthropology	Jo/2-249
148	4901	William S. Webb Museum of Anthropology	Mm/6-1
148	4903	William S. Webb Museum of Anthropology	Mm/6-43
148	4905	William S. Webb Museum of Anthropology	Mm/6-84
148	4908	William S. Webb Museum of Anthropology	Mm/6-152
148	4910	William S. Webb Museum of Anthropology	Mm/6-188
148	4911	William S. Webb Museum of Anthropology	Mm/6-195
148	4916	William S. Webb Museum of Anthropology	McL/8-75
148	4918	William S. Webb Museum of Anthropology	McL/8-65
148	4919	William S. Webb Museum of Anthropology	McL/8-57/1
148	4922	William S. Webb Museum of Anthropology	McL/19-46
148	4923	William S. Webb Museum of Anthropology	McL/19-47
148	4925	William S. Webb Museum of Anthropology	McL/19-96/1
148	4926	William S. Webb Museum of Anthropology	McL/19-94
148	4929	William S. Webb Museum of Anthropology	McL/19-120
148	4930	William S. Webb Museum of Anthropology	McL/19-152
148	4938	William S. Webb Museum of Anthropology	Ru/21-20/4
148	4946	William S. Webb Museum of Anthropology	15Ru25/92
148	4949	William S. Webb Museum of Anthropology	Cn-40
148	4951	William S. Webb Museum of Anthropology	Fa/14-126
148	4952	William S. Webb Museum of Anthropology	Fa/14-54
148	4954	William S. Webb Museum of Anthropology	Fa/14-6
148	4960	William S. Webb Museum of Anthropology	K2319
148	4964	William S. Webb Museum of Anthropology	K4272
148	4966	William S. Webb Museum of Anthropology	K2701
148	4967	William S. Webb Museum of Anthropology	K5297
148	4968	William S. Webb Museum of Anthropology	K4892
148	4969	William S. Webb Museum of Anthropology	K4868

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148	4975	William S. Webb Museum of Anthropology	K10810
148	4976	William S. Webb Museum of Anthropology	K10840
148	4978	William S. Webb Museum of Anthropology	15Ca47/2-1
148	4979	William S. Webb Museum of Anthropology	15Ca48/12
148	4981	William S. Webb Museum of Anthropology	15Ca48/22-3
148	4984	William S. Webb Museum of Anthropology	15Ca48/16-1
148	4985	William S. Webb Museum of Anthropology	15Ca48/15
148	4987	William S. Webb Museum of Anthropology	15Bu569/4-5
148	4992	William S. Webb Museum of Anthropology	Le-20
148	4999	William S. Webb Museum of Anthropology	Pl-5/3564
148	5001	William S. Webb Museum of Anthropology	Tr-2/5483
148	5002	William S. Webb Museum of Anthropology	Tr-2/5481
148	5003	William S. Webb Museum of Anthropology	Tr-1/6312
148	5004	William S. Webb Museum of Anthropology	Tr-1/6314
148	5012	William S. Webb Museum of Anthropology	Le-2
148	5015	William S. Webb Museum of Anthropology	Le-20
148	5016	William S. Webb Museum of Anthropology	Le-20
148	5017	William S. Webb Museum of Anthropology	Le-20
148	5018	William S. Webb Museum of Anthropology	Le-20
148	5019	William S. Webb Museum of Anthropology	Le-20
148	5020	William S. Webb Museum of Anthropology	Le-20
148	5022	William S. Webb Museum of Anthropology	Le-20
148	5027	William S. Webb Museum of Anthropology	2000-030/19
148	5029	William S. Webb Museum of Anthropology	2000-030/19
148	5030	William S. Webb Museum of Anthropology	2000-030/22
148	5031	William S. Webb Museum of Anthropology	2000-030/22
148	5032	William S. Webb Museum of Anthropology	2000-030/22
148	5033	William S. Webb Museum of Anthropology	2000-030/23
148	5034	William S. Webb Museum of Anthropology	2000-030/2
148	5035	William S. Webb Museum of Anthropology	Ch/11-94
148	5036	William S. Webb Museum of Anthropology	Ch/11-29
148	5038	William S. Webb Museum of Anthropology	Ch/15 12
148	5039	William S. Webb Museum of Anthropology	Ch/15 17
148	5041	William S. Webb Museum of Anthropology	Ch/12 57
148	5042	William S. Webb Museum of Anthropology	Ch/12 82
148	5044	William S. Webb Museum of Anthropology	Ch/12 115
148	5047	William S. Webb Museum of Anthropology	Ch/12 20
148	5048	William S. Webb Museum of Anthropology	Ch/12 161
148	5049	William S. Webb Museum of Anthropology	Ch/12 26
148	5050	William S. Webb Museum of Anthropology	Ch/16 14

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148	5051	William S. Webb Museum of Anthropology	Ch/16 8
148	5053	William S. Webb Museum of Anthropology	Ch/16 16
148	5056	William S. Webb Museum of Anthropology	15Hy51/99
148	5059	William S. Webb Museum of Anthropology	15Md440/1102
149	1872	University of Western Ontario	194
149	1873	University of Western Ontario	189
149	1874	University of Western Ontario	180
149	1875	University of Western Ontario	193
149	1876	University of Western Ontario	185
149	1877	University of Western Ontario	165
149	1879	University of Western Ontario	184
149	1880	University of Western Ontario	469
149	1881	University of Western Ontario	468
149	1882	University of Western Ontario	174
149	1886	University of Western Ontario	197
149	1887	University of Western Ontario	1
149	1888	University of Western Ontario	172
149	1889	University of Western Ontario	483
149	1891	University of Western Ontario	169
149	1893	University of Western Ontario	196
149	1894	University of Western Ontario	M C S-1295
149	1895	University of Western Ontario	192
149	1896	University of Western Ontario	183
149	1899	University of Western Ontario	173
149	1900	University of Western Ontario	162
149	1901	University of Western Ontario	178
149	1902	University of Western Ontario	97
149	1903	University of Western Ontario	188
149	1905	University of Western Ontario	168
149	1907	University of Western Ontario	
149	1909	University of Western Ontario	466
149	1913	University of Western Ontario	427
149	1915	University of Western Ontario	175
149	1916	University of Western Ontario	9
149	1918	University of Western Ontario	187
149	1920	University of Western Ontario	467
149	1925	University of Western Ontario	
149	1927	University of Western Ontario	ST-78
149	1928	University of Western Ontario	CXA-202
149	1929	University of Western Ontario	12

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149	1930	University of Western Ontario	293
149	1931	University of Western Ontario	22
149	1932	University of Western Ontario	4
159	2564	Indiana State University	87461/4
159	2565	Indiana State University	85240/12
159	2566	Indiana State University	85310/1
159	2567	Indiana State University	86110/1
159	2570	Indiana State University	8435/5
159	2571	Indiana State University	84411/5
159	2573	Indiana State University	85249/10
159	2577	Indiana State University	86156/1
159	2578	Indiana State University	85252/9
159	2579	Indiana State University	86108/1
159	2580	Indiana State University	87483/1
159	2581	Indiana State University	83367/1
159	2582	Indiana State University	83481/1
159	2584	Indiana State University	84558/7
159	2585	Indiana State University	86247/1
159	2586	Indiana State University	85252/11
159	2587	Indiana State University	8468/10
159	2589	Indiana State University	85240/16
159	2591	Indiana State University	85124/10
159	2592	Indiana State University	88209/1
159	2593	Indiana State University	85134/10
159	2594	Indiana State University	86273/3
159	2595	Indiana State University	85240/17
159	2597	Indiana State University	87105/2
159	2598	Indiana State University	84481/9
159	2599	Indiana State University	85244/21
159	2600	Indiana State University	84713/1
159	2601	Indiana State University	86245/1
159	2602	Indiana State University	87167/1
159	2604	Indiana State University	
159	2605	Indiana State University	84211/7
159	2606	Indiana State University	86201/1
159	2607	Indiana State University	88180/11
159	2608	Indiana State University	84592/2
159	2609	Indiana State University	85240/20
159	2610	Indiana State University	84216/12
159	2612	Indiana State University	8878/10

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159	2614	Indiana State University	85363/3
159	2615	Indiana State University	83462/1
159	2616	Indiana State University	84848/4
159	2617	Indiana State University	85406/12
159	2618	Indiana State University	86179/1
159	2620	Indiana State University	84268/5
159	2621	Indiana State University	85326/2
159	2624	Indiana State University	86211/3
159	2625	Indiana State University	83524/7
159	2626	Indiana State University	88164/1
159	2628	Indiana State University	87211/1
159	2629	Indiana State University	86119/22
159	2630	Indiana State University	87190/1
159	2632	Indiana State University	85120/3
159	2633	Indiana State University	85240/21
159	2634	Indiana State University	84487/16
159	2635	Indiana State University	38
159	2637	Indiana State University	23
159	2638	Indiana State University	16
159	2639	Indiana State University	
159	2640	Indiana State University	6
159	2642	Indiana State University	
159	2645	Indiana State University	
159	2647	Indiana State University	47
159	2648	Indiana State University	
159	2649	Indiana State University	
159	2650	Indiana State University	
159	2651	Indiana State University	
159	2652	Indiana State University	
159	2653	Indiana State University	
159	2654	Indiana State University	
161	3520	Grand Valley State University	26.1
161	3521	Grand Valley State University	26.2
161	3522	Grand Valley State University	26.3
161	3526	Grand Valley State University	
161	3530	Grand Valley State University	
161	3531	Grand Valley State University	
161	3533	Grand Valley State University	
161	3534	Grand Valley State University	26C
161	3536	Grand Valley State University	

Collection ID	Point ID	Institution/Collection	Accession/Catalog
161	3537	Grand Valley State University	26H
161	3540	Grand Valley State University	40.6
163	1123	Ohio Historical Society	10/162
163	1141	Ohio Historical Society	266/
163	1142	Ohio Historical Society	266/
163	1153	Ohio Historical Society	9111
163	1155	Ohio Historical Society	15/9.1
163	1156	Ohio Historical Society	128/35
163	1157	Ohio Historical Society	308/99
163	1161	Ohio Historical Society	1929/155
163	1167	Ohio Historical Society	206/13
163	1169	Ohio Historical Society	79/
163	1171	Ohio Historical Society	807/
163	1174	Ohio Historical Society	6/2
163	3556	Ohio Historical Society	147/30
163	3560	Ohio Historical Society	199/9
163	3580	Ohio Historical Society	967/2
163	3615	Ohio Historical Society	203/222
164	3828	Illinois State Museum-Springfield	Cn19/Sur.459
164	3830	Illinois State Museum-Springfield	Cn60 sur
164	3831	Illinois State Museum-Springfield	Sg 229
164	3837	Illinois State Museum-Springfield	x802/876b
164	3841	Illinois State Museum-Springfield	x803/624b
164	3842	Illinois State Museum-Springfield	x803/626
164	3850	Illinois State Museum-Springfield	11-RA-501-1961
164	3852	Illinois State Museum-Springfield	11Ra501 1276-1
164	3853	Illinois State Museum-Springfield	5561
164	3854	Illinois State Museum-Springfield	5550
164	3886	Illinois State Museum-Springfield	x801/721a
164	3887	Illinois State Museum-Springfield	801/530.2
164	3888	Illinois State Museum-Springfield	801/519
164	3889	Illinois State Museum-Springfield	801/447
164	3890	Illinois State Museum-Springfield	801/464
164	3892	Illinois State Museum-Springfield	801/499
164	3893	Illinois State Museum-Springfield	801/467
164	3895	Illinois State Museum-Springfield	801/444
164	3896	Illinois State Museum-Springfield	801/430
164	3898	Illinois State Museum-Springfield	801/450
164	3899	Illinois State Museum-Springfield	814/727
164	3903	Illinois State Museum-Springfield	814/730 "1334"

Collection ID	Point ID	Institution/Collection	Accession/Catalog
164	3907	Illinois State Museum-Springfield	814/730 "1330"
164	3910	Illinois State Museum-Springfield	814/728 "7"
164	3913	Illinois State Museum-Springfield	814/725 "774"
164	3917	Illinois State Museum-Springfield	814/746 "856"
164	3922	Illinois State Museum-Springfield	814/829 "2769"
164	3926	Illinois State Museum-Springfield	814/829 "2768"
164	3927	Illinois State Museum-Springfield	814/826 "671"
164	3931	Illinois State Museum-Springfield	814/730 "1344"
164	3933	Illinois State Museum-Springfield	814/836 "6159"
164	3934	Illinois State Museum-Springfield	814/836 "12"
164	3936	Illinois State Museum-Springfield	814/836 "4607"
164	3937	Illinois State Museum-Springfield	814/836 "4218"
164	3939	Illinois State Museum-Springfield	814/836 "1966"
164	3941	Illinois State Museum-Springfield	814/836 "52"
164	3946	Illinois State Museum-Springfield	814/836 "3249"
164	3948	Illinois State Museum-Springfield	814/836 "3393"
164	3949	Illinois State Museum-Springfield	814/836
164	3950	Illinois State Museum-Springfield	814/836 "6361"
164	3959	Illinois State Museum-Springfield	814/744 "30"
164	3963	Illinois State Museum-Springfield	814/829 "945"
164	3966	Illinois State Museum-Springfield	814/836 "5080"
164	3967	Illinois State Museum-Springfield	814/836 "3638"
164	3969	Illinois State Museum-Springfield	814/838 "6052"
164	3975	Illinois State Museum-Springfield	814/842
164	3977	Illinois State Museum-Springfield	814/842 "3523"
164	3980	Illinois State Museum-Springfield	x802/876c
164	3982	Illinois State Museum-Springfield	x802/877f
164	3984	Illinois State Museum-Springfield	x802/877ac
164	3986	Illinois State Museum-Springfield	x802/877b
164	3988	Illinois State Museum-Springfield	x802/877c
164	3989	Illinois State Museum-Springfield	x802/877e
164	3992	Illinois State Museum-Springfield	820/341c
164	3993	Illinois State Museum-Springfield	820/349b
164	3994	Illinois State Museum-Springfield	59.14/1
164	3995	Illinois State Museum-Springfield	58.21/26
164	3998	Illinois State Museum-Springfield	53.47/4
164	3999	Illinois State Museum-Springfield	56.14/14
164	4001	Illinois State Museum-Springfield	54.15/59
164	4003	Illinois State Museum-Springfield	58.90/2
164	4011	Illinois State Museum-Springfield	801/804e

Collection ID	Point ID	Institution/Collection	Accession/Catalog
164	4023	Illinois State Museum-Springfield	801/911ap
164	4025	Illinois State Museum-Springfield	x816/521h
164	4029	Illinois State Museum-Springfield	Cw324
164	4033	Illinois State Museum-Springfield	Cw344
164	4037	Illinois State Museum-Springfield	Cw362
164	4040	Illinois State Museum-Springfield	Cl225
164	4044	Illinois State Museum-Springfield	W83
164	4045	Illinois State Museum-Springfield	3490/40 Ri268
164	4050	Illinois State Museum-Springfield	"50 feet NW of Lw 183/184"
164	4051	Illinois State Museum-Springfield	"300 feet SE of Lw211"
164	4052	Illinois State Museum-Springfield	Lw206
164	4054	Illinois State Museum-Springfield	Lw263
164	4057	Illinois State Museum-Springfield	Lw231
164	4058	Illinois State Museum-Springfield	Lw231
164	4059	Illinois State Museum-Springfield	Lw232
164	4060	Illinois State Museum-Springfield	Lw274
164	4061	Illinois State Museum-Springfield	Lw265
164	4063	Illinois State Museum-Springfield	Lw222
164	4064	Illinois State Museum-Springfield	Lw212
164	4065	Illinois State Museum-Springfield	Lw 292
164	4435	Illinois State Museum-Springfield	1962-11
164	4437	Illinois State Museum-Springfield	1987-50 822/214
164	4441	Illinois State Museum-Springfield	1987-50 822/234
164	4442	Illinois State Museum-Springfield	1987-50 822/258
164	4443	Illinois State Museum-Springfield	1987-50 822/316
164	4447	Illinois State Museum-Springfield	1987-50 822/462
164	4451	Illinois State Museum-Springfield	1987-50 827/144B
164	4452	Illinois State Museum-Springfield	1987-50 827/143B
164	4455	Illinois State Museum-Springfield	1985-197 821/606b
164	4458	Illinois State Museum-Springfield	1985-197 821/606ac
164	4465	Illinois State Museum-Springfield	1985-197 821/602f
164	4466	Illinois State Museum-Springfield	1985-197 821/602e
164	4467	Illinois State Museum-Springfield	1985-197 821/602d
164	4468	Illinois State Museum-Springfield	1985-197 821602i
164	4471	Illinois State Museum-Springfield	1954-80 A.602
164	4472	Illinois State Museum-Springfield	1954-60
164	4476	Illinois State Museum-Springfield	1990-165F
164	4477	Illinois State Museum-Springfield	1990-165F
164	4480	Illinois State Museum-Springfield	1990-116F

Collection ID	Point ID	Institution/Collection	Accession/Catalog
164	4486	Illinois State Museum-Springfield	2005-521 "MM2"
164	4489	Illinois State Museum-Springfield	2005-521 "MM58"
164	4492	Illinois State Museum-Springfield	2005-521 "GP382"
164	4501	Illinois State Museum-Springfield	2005-521 "GP69"
164	4506	Illinois State Museum-Springfield	2005-521 "GP191"
164	4509	Illinois State Museum-Springfield	2005-521 "GP209"
164	4510	Illinois State Museum-Springfield	2005-521 "GP205"
164	4525	Illinois State Museum-Springfield	2005-521 "GP291"
164	5788	Illinois State Museum-Springfield	TWD-1-21
164	5796	Illinois State Museum-Springfield	34-243
164	5797	Illinois State Museum-Springfield	51-092
164	5798	Illinois State Museum-Springfield	53-337
164	5801	Illinois State Museum-Springfield	34-245
164	5802	Illinois State Museum-Springfield	74-127
164	5810	Illinois State Museum-Springfield	TWD-SQ.15-14-2-Art.2
164	5811	Illinois State Museum-Springfield	TWD-SQ.25-10NE-14-Art.12
164	5814	Illinois State Museum-Springfield	TWD-SQ-30-09NW-15-Art. 11
164	5815	Illinois State Museum-Springfield	TWD-SQ.32-07NE-3-Art.3
164	5816	Illinois State Museum-Springfield	TWD-SQ.4.21.1.Art.1
164	5818	Illinois State Museum-Springfield	TWD-SQ4-21-2.Art.2
164	5819	Illinois State Museum-Springfield	TWD-SQ.32-07NE-1-Art.1
164	5820	Illinois State Museum-Springfield	TWD-SQ.48-07SE-1-Art.1
164	5823	Illinois State Museum-Springfield	TWD-SQ.27-10NW-1-Art.1
164	5824	Illinois State Museum-Springfield	TWD-SQ.36-08NW-1-Art.1
164	5825	Illinois State Museum-Springfield	TWD-SQ.8-13-2-Art.2
164	5827	Illinois State Museum-Springfield	TWD-SQ.24-10NW-8.Art.5
164	5828	Illinois State Museum-Springfield	TWD-SQ.26-112-1
164	5829	Illinois State Museum-Springfield	TWD-SQ.50-08NW-3-Art.3
165	4068	Illinois State Museum-Dickson Mounds	822/753d
165	4069	Illinois State Museum-Dickson Mounds	822/753c
165	4079	Illinois State Museum-Dickson Mounds	822/764b
165	4080	Illinois State Museum-Dickson Mounds	822/764c
165	4082	Illinois State Museum-Dickson Mounds	822/766e
165	4086	Illinois State Museum-Dickson Mounds	822/722i
165	4087	Illinois State Museum-Dickson Mounds	822/722b

Collection ID	Point ID	Institution/Collection	Accession/Catalog
165	4088	Illinois State Museum-Dickson Mounds	822/722a
165	4089	Illinois State Museum-Dickson Mounds	822/753a
165	4090	Illinois State Museum-Dickson Mounds	822/753b
165	4091	Illinois State Museum-Dickson Mounds	822/722u
165	4092	Illinois State Museum-Dickson Mounds	822/722g
165	4093	Illinois State Museum-Dickson Mounds	822/722e
165	4094	Illinois State Museum-Dickson Mounds	822/722g
165	4095	Illinois State Museum-Dickson Mounds	822/722c
165	4096	Illinois State Museum-Dickson Mounds	822/722f
165	4097	Illinois State Museum-Dickson Mounds	822/722j
165	4099	Illinois State Museum-Dickson Mounds	822/722am
165	4100	Illinois State Museum-Dickson Mounds	822/722o
165	4101	Illinois State Museum-Dickson Mounds	822/722h
165	4103	Illinois State Museum-Dickson Mounds	822/867a
165	4111	Illinois State Museum-Dickson Mounds	824/974a
165	4115	Illinois State Museum-Dickson Mounds	824/992d
165	4117	Illinois State Museum-Dickson Mounds	824/978b
165	4118	Illinois State Museum-Dickson Mounds	824/986a
165	4119	Illinois State Museum-Dickson Mounds	824/995a
165	4120	Illinois State Museum-Dickson Mounds	824/946
165	4121	Illinois State Museum-Dickson Mounds	825/051
165	4124	Illinois State Museum-Dickson Mounds	825/095
165	4131	Illinois State Museum-Dickson Mounds	824/833d
165	4134	Illinois State Museum-Dickson Mounds	824/850a
165	4135	Illinois State Museum-Dickson Mounds	824/838g
165	4136	Illinois State Museum-Dickson Mounds	824/938a
165	4137	Illinois State Museum-Dickson Mounds	824/934c
165	4148	Illinois State Museum-Dickson Mounds	822/893b
165	4528	Illinois State Museum-Dickson Mounds	1991-113 825/173a "A156"
165	4529	Illinois State Museum-Dickson Mounds	1991-113 825/173c "A156"
165	4530	Illinois State Museum-Dickson Mounds	1991-113 825/1736 "A156"
165	4531	Illinois State Museum-Dickson Mounds	1991-113 825/163a "A155"
165	4532	Illinois State Museum-Dickson Mounds	1991-113 825/191 "A162"
165	4537	Illinois State Museum-Dickson Mounds	1991-113 825/031 "A103"
165	4538	Illinois State Museum-Dickson Mounds	1991-113 825/068a "A117"
165	4540	Illinois State Museum-Dickson Mounds	1991-113 825/037a "A106"

Collection ID	Point ID	Institution/Collection	Accession/Catalog
165	4541	Illinois State Museum-Dickson Mounds	1991-113 825/037b "A106"
165	4550	Illinois State Museum-Dickson Mounds	1991-113 825/230 "A183"
165	4551	Illinois State Museum-Dickson Mounds	1991-113 825/884 "A56"
165	4553	Illinois State Museum-Dickson Mounds	1991-113 825/859h "A51"
165	4554	Illinois State Museum-Dickson Mounds	1991-113 825/859c "A51"
165	4557	Illinois State Museum-Dickson Mounds	1991-113 825/860a "A51"
165	4558	Illinois State Museum-Dickson Mounds	1991-113 825/860b "A51"
165	4559	Illinois State Museum-Dickson Mounds	1991-113 825/892 "A58"
165	4560	Illinois State Museum-Dickson Mounds	1991-113 825/859i "A51"
165	4561	Illinois State Museum-Dickson Mounds	1991-113 825/270a "A203"
165	4563	Illinois State Museum-Dickson Mounds	1991-113 825/281b
165	4575	Illinois State Museum-Dickson Mounds	1991-113 825/429 "G34"
165	4579	Illinois State Museum-Dickson Mounds	1991-113 825/612b "M18"
165	4582	Illinois State Museum-Dickson Mounds	1991-113 825/565a "M12"
165	4584	Illinois State Museum-Dickson Mounds	1991-113 825/558a "M11"
165	4585	Illinois State Museum-Dickson Mounds	1991-113 825/625a "M20"
165	4589	Illinois State Museum-Dickson Mounds	1991-113 825/351g "G5"
165	4591	Illinois State Museum-Dickson Mounds	1991-113 825/352a "G5"
165	4593	Illinois State Museum-Dickson Mounds	1991-113 825/351j "G5"
165	4594	Illinois State Museum-Dickson Mounds	1991-113 825/356e "G5"
165	4595	Illinois State Museum-Dickson Mounds	1991-113 825/356b "G5"
165	4597	Illinois State Museum-Dickson Mounds	1991-113 825/651 "M30"
165	4600	Illinois State Museum-Dickson Mounds	1991-113 825/631a "M22"
165	4602	Illinois State Museum-Dickson Mounds	1991-113 825/411e "G20"
165	4605	Illinois State Museum-Dickson Mounds	1991-113 825/405b
165	4606	Illinois State Museum-Dickson Mounds	1991-113 825/414 "G23"
165	4608	Illinois State Museum-Dickson Mounds	1991-113 825/403a "G18"
165	4611	Illinois State Museum-Dickson Mounds	1991-113 825/415b "G24"
165	4613	Illinois State Museum-Dickson Mounds	1991-113 825/409c "G19"
165	4614	Illinois State Museum-Dickson Mounds	1991-113 825/379a "G12"

Collection ID	Point ID	Institution/Collection	Accession/Catalog
165	4615	Illinois State Museum-Dickson Mounds	1991-113 825/381b "G13"
165	4617	Illinois State Museum-Dickson Mounds	1991-113 825/377a "G12"
165	4620	Illinois State Museum-Dickson Mounds	1991-113 825/369 "G10"
165	4624	Illinois State Museum-Dickson Mounds	1991-113 825/705 "M68"
165	4625	Illinois State Museum-Dickson Mounds	1991-113 825/516o "M9"
165	4626	Illinois State Museum-Dickson Mounds	1991-113 825/477c "M1"
165	4629	Illinois State Museum-Dickson Mounds	1991-113 825/500b
165	4637	Illinois State Museum-Dickson Mounds	1988-60 822/677b
165	4638	Illinois State Museum-Dickson Mounds	1988-60 822/678f
165	4639	Illinois State Museum-Dickson Mounds	1988-60 822/678e
165	4640	Illinois State Museum-Dickson Mounds	1988-60 822/678c
165	4643	Illinois State Museum-Dickson Mounds	1988-60 822/676c
165	4644	Illinois State Museum-Dickson Mounds	1988-60 822/677c
165	4646	Illinois State Museum-Dickson Mounds	"Peoria, IL DMM"
165	4647	Illinois State Museum-Dickson Mounds	803/929
165	4649	Illinois State Museum-Dickson Mounds	803/949
165	4650	Illinois State Museum-Dickson Mounds	"Fv12987 Lot 1"
165	4652	Illinois State Museum-Dickson Mounds	x819/815
165	4653	Illinois State Museum-Dickson Mounds	806/054 (cast)
165	4658	Illinois State Museum-Dickson Mounds	818/170
165	4659	Illinois State Museum-Dickson Mounds	819/851b
165	4660	Illinois State Museum-Dickson Mounds	1959-25
165	4661	Illinois State Museum-Dickson Mounds	1984-62 820/792
165	4663	Illinois State Museum-Dickson Mounds	"Fv470-495 1963"
165	4664	Illinois State Museum-Dickson Mounds	1950-17 804/025
165	4665	Illinois State Museum-Dickson Mounds	1959-25 "Fv229 Wray"
165	4666	Illinois State Museum-Dickson Mounds	1950-17 803/920
165	4668	Illinois State Museum-Dickson Mounds	1950-17 803/804
165	4671	Illinois State Museum-Dickson Mounds	not_numbered_yet
165	4672	Illinois State Museum-Dickson Mounds	not_numbered_yet
165	4673	Illinois State Museum-Dickson Mounds	not_numbered_yet
165	4674	Illinois State Museum-Dickson Mounds	not_numbered_yet
165	4675	Illinois State Museum-Dickson Mounds	not_numbered_yet
165	4677	Illinois State Museum-Dickson Mounds	not_numbered_yet
165	4678	Illinois State Museum-Dickson Mounds	not_numbered_yet
165	4680	Illinois State Museum-Dickson Mounds	not_numbered_yet
165	4682	Illinois State Museum-Dickson Mounds	not_numbered_yet

Collection ID	Point ID	Institution/Collection	Accession/Catalog
165	4683	Illinois State Museum-Dickson Mounds	not_numbered_yet
165	4684	Illinois State Museum-Dickson Mounds	not_numbered_yet
165	4685	Illinois State Museum-Dickson Mounds	not_numbered_yet
165	4686	Illinois State Museum-Dickson Mounds	not_numbered_yet
165	4689	Illinois State Museum-Dickson Mounds	not_numbered_yet
165	4694	Illinois State Museum-Dickson Mounds	not_numbered_yet
166	1083	Field Museum of Natural History	1899.601.54231
166	4153	Field Museum of Natural History	1900.662.55078
166	4154	Field Museum of Natural History	1900.662.55488.4
166	4160	Field Museum of Natural History	1936.2132.57605
166	4163	Field Museum of Natural History	1936.2132.57629
166	4165	Field Museum of Natural History	1936.2132.57629
166	4166	Field Museum of Natural History	1936.2132.57632
166	4167	Field Museum of Natural History	1936.2132.57632
166	4172	Field Museum of Natural History	1936.2132.57641
166	4183	Field Museum of Natural History	1957.2581.166614
166	4184	Field Museum of Natural History	1957.2581.166614
166	4187	Field Museum of Natural History	1957.2581.166614
166	4192	Field Museum of Natural History	1906.998.104034
166	4193	Field Museum of Natural History	1906.998.104035
166	4195	Field Museum of Natural History	1906.998.104035/2
166	4197	Field Museum of Natural History	1906.998.104040
166	4198	Field Museum of Natural History	1906.998.104041/2
166	4199	Field Museum of Natural History	1906.998.104057
166	4201	Field Museum of Natural History	1906.998.104047/1
166	4203	Field Museum of Natural History	1906.998.104052/1
166	4204	Field Museum of Natural History	1906.998.104060
166	4205	Field Museum of Natural History	1906.998.104065/12
166	4209	Field Museum of Natural History	1906.998.104075
166	4213	Field Museum of Natural History	1906.998.104083/2
166	4215	Field Museum of Natural History	1906.998.104084
166	4216	Field Museum of Natural History	1906.998.104086
166	4221	Field Museum of Natural History	1906.998.104111
166	4228	Field Museum of Natural History	1917.1284.204740
166	4229	Field Museum of Natural History	1917.1284.204790
166	4231	Field Museum of Natural History	1917.1284.204763
166	4232	Field Museum of Natural History	1917.1284.204809
166	4233	Field Museum of Natural History	1917.1284.204828-1
166	4236	Field Museum of Natural History	1918.1301.205011
166	4237	Field Museum of Natural History	1918.1301.205037

Collection ID	Point ID	Institution/Collection	Accession/Catalog
166	4238	Field Museum of Natural History	1966.2932.239347
166	4239	Field Museum of Natural History	1966.2932.239349
166	4241	Field Museum of Natural History	1987.3707.270923
166	4242	Field Museum of Natural History	1987.3707.270931
166	4243	Field Museum of Natural History	1987.3707.270943
166	4248	Field Museum of Natural History	205258/2652
166	4249	Field Museum of Natural History	205258/2629
166	4251	Field Museum of Natural History	205258/2565
166	4256	Field Museum of Natural History	1900.662.55499/6
166	4260	Field Museum of Natural History	1900.662.55477/24
166	4261	Field Museum of Natural History	1900.662.55482/10
166	4263	Field Museum of Natural History	1900.662.55476/19
166	4265	Field Museum of Natural History	1900.662.55476/11
166	4267	Field Museum of Natural History	1900.662.55486/10
166	4269	Field Museum of Natural History	1900.662.55486/12
166	4270	Field Museum of Natural History	1900.662.55486/27
166	4271	Field Museum of Natural History	1900.662.55486/4
166	4273	Field Museum of Natural History	1900.662.55486/7
166	4275	Field Museum of Natural History	1900.662.55486/11
166	4276	Field Museum of Natural History	1900.662.55486/18
166	4277	Field Museum of Natural History	1900.662.55485/37
166	4278	Field Museum of Natural History	1900.662.55485/2
166	4280	Field Museum of Natural History	1900.662.55485/21
166	4284	Field Museum of Natural History	1900.662.55480/15
166	4285	Field Museum of Natural History	1900.662.55480/17
166	4286	Field Museum of Natural History	1900.662.55480/24
166	4287	Field Museum of Natural History	1900.662.55480/6
166	4289	Field Museum of Natural History	1900.662.55489/2
166	4291	Field Museum of Natural History	1900.662.55475/8
166	4292	Field Museum of Natural History	1900.662.55475/6
166	4293	Field Museum of Natural History	1900.662.55475/7
166	4294	Field Museum of Natural History	1900.662.55473/10
166	4295	Field Museum of Natural History	1894.146.51261/4
166	4297	Field Museum of Natural History	1894.146.51432.198
166	4299	Field Museum of Natural History	1905.970.205255/4
166	4302	Field Museum of Natural History	1905.970.205255 "2433"
166	4303	Field Museum of Natural History	1905.970.205255 "2437"
166	4307	Field Museum of Natural History	1905.970.205255 "2452"

Collection ID	Point ID	Institution/Collection	Accession/Catalog
166	4312	Field Museum of Natural History	1905.970.205255 "3834"
166	4315	Field Museum of Natural History	1905.970.205255 "2459"
166	4318	Field Museum of Natural History	1933.2030.205962
166	4319	Field Museum of Natural History	1933.2030.205938
166	4320	Field Museum of Natural History	1933.2030.205933
166	4321	Field Museum of Natural History	1933.2030.205939
166	4322	Field Museum of Natural History	1933.2030.205935
166	4323	Field Museum of Natural History	1933.2030.205957
166	4324	Field Museum of Natural History	1933.2030.205943
166	4327	Field Museum of Natural History	1931.1928.205395
166	4328	Field Museum of Natural History	1931.1928.205396
166	4331	Field Museum of Natural History	1894.146.51280/4
166	4334	Field Museum of Natural History	1894.146.51263/6
166	4335	Field Museum of Natural History	1894.146.51263/25
166	4336	Field Museum of Natural History	1894.146.51234/5
166	4337	Field Museum of Natural History	1894.146.51489/89
166	4341	Field Museum of Natural History	1894.146.51489/58
166	4342	Field Museum of Natural History	1894.146.51489/46
166	4343	Field Museum of Natural History	1894.146.51489/28
166	4345	Field Museum of Natural History	1894.146.51489/54
166	4347	Field Museum of Natural History	1894.146.51247/1
166	4349	Field Museum of Natural History	1966.2932.239381
166	4356	Field Museum of Natural History	1894.146.51478/197
166	4357	Field Museum of Natural History	1894.146.51478/110
166	4358	Field Museum of Natural History	1894.146.51478/67
166	4361	Field Museum of Natural History	1894.146.51478/25
166	4362	Field Museum of Natural History	1894.146.51478/21
166	4363	Field Museum of Natural History	1894.146.51500/51
166	4364	Field Museum of Natural History	1894.146.51500/65
166	4365	Field Museum of Natural History	1894.146.51500/16
166	4366	Field Museum of Natural History	1894.146.51500/39
166	4370	Field Museum of Natural History	1933.2036.205987
166	4371	Field Museum of Natural History	1932.1997.205748
166	4372	Field Museum of Natural History	1933.2036.205984
166	4373	Field Museum of Natural History	1933.2036.205981
166	4374	Field Museum of Natural History	1933.2036.205985
166	4376	Field Museum of Natural History	1933.2030.205974
166	4378	Field Museum of Natural History	1933.2030.205977
166	4379	Field Museum of Natural History	1933.2030.205972

Collection ID	Point ID	Institution/Collection	Accession/Catalog
166	4381	Field Museum of Natural History	1933.2036.205982
166	4384	Field Museum of Natural History	1933.2036.205978
166	4386	Field Museum of Natural History	1933.2030.205979
166	4387	Field Museum of Natural History	1933.2036.205989
166	4390	Field Museum of Natural History	1932.1971.15498
166	4391	Field Museum of Natural History	1894.146.51481/57
166	4394	Field Museum of Natural History	1894.146.51481/20
166	4397	Field Museum of Natural History	1959.2656.268214
166	4400	Field Museum of Natural History	1958.2635.268018
166	4402	Field Museum of Natural History	1932.1965.15497
166	4410	Field Museum of Natural History	1905.970.205254/4 "2494"
166	4411	Field Museum of Natural History	1905.970.205254 "2484"
166	4412	Field Museum of Natural History	1905.970.205252
166	4413	Field Museum of Natural History	1905.970.205252
166	4414	Field Museum of Natural History	1905.970.205252
166	4415	Field Museum of Natural History	1905.970.205252/7 "2703"
166	4416	Field Museum of Natural History	1905.970.205252 "2681"
166	4418	Field Museum of Natural History	1905.970.205251
166	4427	Field Museum of Natural History	1905.970.205254
167	4699	Polo Historical Society (Polo, IL)	"2629"
167	4700	Polo Historical Society (Polo, IL)	"2145"
167	4709	Polo Historical Society (Polo, IL)	"475"
167	4710	Polo Historical Society (Polo, IL)	"2149"
167	4712	Polo Historical Society (Polo, IL)	"1330"
167	4716	Polo Historical Society (Polo, IL)	"3325"
167	4717	Polo Historical Society (Polo, IL)	"395"
167	4724	Polo Historical Society (Polo, IL)	"1155"
167	4726	Polo Historical Society (Polo, IL)	"1280"
167	4728	Polo Historical Society (Polo, IL)	"607"
168	5258	Cleveland Museum of Natural History	1725A-045-02
168	5261	Cleveland Museum of Natural History	1725A-02-A3-00-01
168	5262	Cleveland Museum of Natural History	1725A-04-00-00-01
168	5266	Cleveland Museum of Natural History	1725A-02-C2-00-01
168	5279	Cleveland Museum of Natural History	1725A-042-099
168	5285	Cleveland Museum of Natural History	1725A-02-00-00-01
168	5295	Cleveland Museum of Natural History	1725A-06-19-34-04
168	5296	Cleveland Museum of Natural History	1725A-02-B1-00-01
168	5301	Cleveland Museum of Natural History	291-A-001

Collection ID	Point ID	Institution/Collection	Accession/Catalog
168	5303	Cleveland Museum of Natural History	292-A-001
168	5307	Cleveland Museum of Natural History	164-A-001
168	5309	Cleveland Museum of Natural History	142-A-001
168	5311	Cleveland Museum of Natural History	105-A-001
168	5314	Cleveland Museum of Natural History	6906
168	5315	Cleveland Museum of Natural History	6906
168	5316	Cleveland Museum of Natural History	6906
168	5317	Cleveland Museum of Natural History	6906
168	5318	Cleveland Museum of Natural History	6906
168	5321	Cleveland Museum of Natural History	6906
168	5322	Cleveland Museum of Natural History	6906
168	5325	Cleveland Museum of Natural History	6906
168	5328	Cleveland Museum of Natural History	6906
168	5329	Cleveland Museum of Natural History	6906
168	5331	Cleveland Museum of Natural History	6906
168	5333	Cleveland Museum of Natural History	6906
168	5334	Cleveland Museum of Natural History	6906
168	5335	Cleveland Museum of Natural History	6906
168	5341	Cleveland Museum of Natural History	2111
168	5344	Cleveland Museum of Natural History	2119
168	5345	Cleveland Museum of Natural History	2119
168	5349	Cleveland Museum of Natural History	1694
168	5350	Cleveland Museum of Natural History	1694
168	5361	Cleveland Museum of Natural History	340-A-3-570
168	5374	Cleveland Museum of Natural History	340-A-3-568
168	5376	Cleveland Museum of Natural History	340-A-3-178
168	5378	Cleveland Museum of Natural History	340-A-3-281
168	5382	Cleveland Museum of Natural History	340-A-3-44
168	5383	Cleveland Museum of Natural History	340-A-3-309
168	5384	Cleveland Museum of Natural History	340-A-3-495
168	5385	Cleveland Museum of Natural History	340-A-3-307
168	5387	Cleveland Museum of Natural History	340-A-3-641
168	5388	Cleveland Museum of Natural History	340-A-3-314
168	5389	Cleveland Museum of Natural History	340-A-3-435
168	5392	Cleveland Museum of Natural History	340-A-3-509
168	5396	Cleveland Museum of Natural History	340-A-3-39
168	5397	Cleveland Museum of Natural History	340-A-3-530
168	5399	Cleveland Museum of Natural History	340-A-3-467
168	5400	Cleveland Museum of Natural History	340-A-3-566
168	5401	Cleveland Museum of Natural History	340-A-3-365

Collection ID	Point ID	Institution/Collection	Accession/Catalog
168	5402	Cleveland Museum of Natural History	340-A-3-446
168	5403	Cleveland Museum of Natural History	340-A-3-59
168	5404	Cleveland Museum of Natural History	340-A-3-280
168	5408	Cleveland Museum of Natural History	340-A-3-87
168	5409	Cleveland Museum of Natural History	3273
168	5415	Cleveland Museum of Natural History	1610 1396
168	5416	Cleveland Museum of Natural History	1434 2162
168	5419	Cleveland Museum of Natural History	1410 2076
168	5420	Cleveland Museum of Natural History	1433 2147
168	5422	Cleveland Museum of Natural History	1408 2069
168	5424	Cleveland Museum of Natural History	1403 1909
168	5474	Cleveland Museum of Natural History	6905
168	5475	Cleveland Museum of Natural History	6905
168	5476	Cleveland Museum of Natural History	6905
168	5479	Cleveland Museum of Natural History	2162
168	5485	Cleveland Museum of Natural History	340-A-2-8
168	5486	Cleveland Museum of Natural History	340-A-2-6
168	5487	Cleveland Museum of Natural History	340-A-2-31
168	5488	Cleveland Museum of Natural History	340-A-2-33
168	5498	Cleveland Museum of Natural History	342-A-1-1
168	5499	Cleveland Museum of Natural History	6969
168	5501	Cleveland Museum of Natural History	342-A-1-94
168	5503	Cleveland Museum of Natural History	342-A-1-112
168	5506	Cleveland Museum of Natural History	1080-A-001
168	5507	Cleveland Museum of Natural History	1080-A-001
168	5508	Cleveland Museum of Natural History	1080-A-001
168	5509	Cleveland Museum of Natural History	1080-A-001
168	5511	Cleveland Museum of Natural History	7403
168	5517	Cleveland Museum of Natural History	7365
168	5518	Cleveland Museum of Natural History	7362
168	5520	Cleveland Museum of Natural History	2712A-001
168	5521	Cleveland Museum of Natural History	340-A-36-22
168	5523	Cleveland Museum of Natural History	340-A-36-33
168	5526	Cleveland Museum of Natural History	340-A-36-6
168	5527	Cleveland Museum of Natural History	340-A-36-4
168	5529	Cleveland Museum of Natural History	340-A-36-5
168	5530	Cleveland Museum of Natural History	7702
168	5531	Cleveland Museum of Natural History	7702
168	5547	Cleveland Museum of Natural History	7702
168	5551	Cleveland Museum of Natural History	3732

Collection ID	Point ID	Institution/Collection	Accession/Catalog
168	5552	Cleveland Museum of Natural History	3818
168	5553	Cleveland Museum of Natural History	3832
168	5554	Cleveland Museum of Natural History	3824
168	5555	Cleveland Museum of Natural History	3831
168	5558	Cleveland Museum of Natural History	340-A-3-461
168	5559	Cleveland Museum of Natural History	340-A-3-465
168	5560	Cleveland Museum of Natural History	340-A-3-379
168	5561	Cleveland Museum of Natural History	340-A-3-293
168	5563	Cleveland Museum of Natural History	340-A-3-634
168	5570	Cleveland Museum of Natural History	340-A-3-310
168	5578	Cleveland Museum of Natural History	40-A-003
168	5581	Cleveland Museum of Natural History	40-A-003
168	5583	Cleveland Museum of Natural History	40-A-003
168	5584	Cleveland Museum of Natural History	40-A-003
168	5585	Cleveland Museum of Natural History	40-A-003
168	5586	Cleveland Museum of Natural History	40-A-003
168	5589	Cleveland Museum of Natural History	40-A-003
168	5592	Cleveland Museum of Natural History	40-A-003
168	5593	Cleveland Museum of Natural History	40-A-003
168	5594	Cleveland Museum of Natural History	40-A-003
168	5596	Cleveland Museum of Natural History	40-A-003
168	5597	Cleveland Museum of Natural History	40-A-003
170	5615	Southern Illinois University Carbondale	59.149
170	5617	Southern Illinois University Carbondale	59.100/17
170	5619	Southern Illinois University Carbondale	56.036/4
170	5626	Southern Illinois University Carbondale	54.19/38
170	5627	Southern Illinois University Carbondale	57.47/5
170	5629	Southern Illinois University Carbondale	54.19/29
170	5630	Southern Illinois University Carbondale	57.47/6
170	5635	Southern Illinois University Carbondale	57.102/2
170	5636	Southern Illinois University Carbondale	58.49/3
170	5637	Southern Illinois University Carbondale	58.9/3
170	5638	Southern Illinois University Carbondale	56.40/1
170	5640	Southern Illinois University Carbondale	58.64/3
170	5643	Southern Illinois University Carbondale	55.20/1
170	5648	Southern Illinois University Carbondale	57.96/11
170	5650	Southern Illinois University Carbondale	57.96/31
170	5652	Southern Illinois University Carbondale	58.49/6
170	5653	Southern Illinois University Carbondale	60.16/2
170	5657	Southern Illinois University Carbondale	55.22/26

Collection ID	Point ID	Institution/Collection	Accession/Catalog
170	5658	Southern Illinois University Carbondale	57.8/4
170	5660	Southern Illinois University Carbondale	57.107/1
170	5661	Southern Illinois University Carbondale	59.108/2
170	5663	Southern Illinois University Carbondale	59.100/18
170	5665	Southern Illinois University Carbondale	59.35/5
170	5669	Southern Illinois University Carbondale	53.36/11
170	5670	Southern Illinois University Carbondale	59.30/99
170	5672	Southern Illinois University Carbondale	21 (Pulcher)
170	5676	Southern Illinois University Carbondale	71.9/8
170	5677	Southern Illinois University Carbondale	71.32/1
170	5678	Southern Illinois University Carbondale	70.246/11-c
170	5680	Southern Illinois University Carbondale	71.44/6
170	5684	Southern Illinois University Carbondale	72.57/175
170	5685	Southern Illinois University Carbondale	71.118
170	5687	Southern Illinois University Carbondale	72.150/4
170	5689	Southern Illinois University Carbondale	93.140/153
170	5691	Southern Illinois University Carbondale	87.1/24
170	5694	Southern Illinois University Carbondale	86.15/161-b
170	5695	Southern Illinois University Carbondale	86-13/137
170	5699	Southern Illinois University Carbondale	86.13/138
170	5702	Southern Illinois University Carbondale	86.15/163
170	5704	Southern Illinois University Carbondale	86.8/1.0006a
170	5705	Southern Illinois University Carbondale	86.8/1.0006-c
170	5709	Southern Illinois University Carbondale	90.9/400
170	5715	Southern Illinois University Carbondale	65.10/450
170	5717	Southern Illinois University Carbondale	88.211/3
170	5722	Southern Illinois University Carbondale	75.30
170	5723	Southern Illinois University Carbondale	61.2/a
170	5725	Southern Illinois University Carbondale	9x5/19 or 267
170	5727	Southern Illinois University Carbondale	9x5/219
170	5730	Southern Illinois University Carbondale	9x5/123
170	5732	Southern Illinois University Carbondale	9x5/35
170	5736	Southern Illinois University Carbondale	56.14/16
170	5740	Southern Illinois University Carbondale	75.152/13
170	5744	Southern Illinois University Carbondale	56.35/4
170	5745	Southern Illinois University Carbondale	57.17/1
170	5747	Southern Illinois University Carbondale	59.13/1
170	5749	Southern Illinois University Carbondale	59.12/263
170	5754	Southern Illinois University Carbondale	59.30/24
170	5756	Southern Illinois University Carbondale	59.30/188

Collection ID	Point ID	Institution/Collection	Accession/Catalog
170	5757	Southern Illinois University Carbondale	59.122/1
170	5758	Southern Illinois University Carbondale	59.150/1
170	5759	Southern Illinois University Carbondale	59.151/2
170	5762	Southern Illinois University Carbondale	9x5/22
170	5765	Southern Illinois University Carbondale	51.12/31

Appendix D

MORPHOMETRIC DATA DERIVED FROM PROJECTILE POINTS IN ARCHAEOLOGICAL DATASET

This appendix provides the morphometric data used in analysis. Points are ordered by identification number ("Point ID"). Metric variables A, B, C, E, F, G, H, I, and maximum thickness are as described in Chapter 7. All measurements are in millimeters.

Point ID	Group	A	B	C	E	F	G	H	I	Max. Thick.
10	EFP	23.1	-	-	-	9.6	-	-	-	5.1
15	EFP	25.8	-	-	-	7.6	-	-	-	-
83	EFP	20.5	26.3	26.7	0.4	5.7	7.5	-1.3	8.8	7.7
112	Hi-Lo	15.3	20.7	22.0	1.3	1.3	3.8	1.0	2.7	7.1
129	Hi-Lo	19.9	25.6	25.7	0.2	4.3	5.1	1.0	4.1	7.9
130	Hi-Lo	14.5	16.0	17.0	1.0	2.4	3.0	-0.4	3.4	6.7
143	Hi-Lo	16.5	23.3	23.3	0.0	1.9	3.4	0.0	3.4	8.4
149	Hi-Lo	15.4	20.8	22.1	1.3	3.0	4.3	-1.0	5.3	7.9
169	EFP	23.8	-	-	-	4.0	-	-	-	9.7
179	Hi-Lo	16.3	19.7	21.2	1.5	4.1	2.7	-1.0	3.7	6.9
190	Hi-Lo	20.0	22.7	25.4	2.7	6.6	4.4	-3.2	7.5	8.2
217	EFP	25.0	-	-	-	3.6	-	-	-	5.8
220	EFP	25.9	-	-	-	5.4	-	-	-	7.7
229	Hi-Lo	18.2	20.9	21.0	0.1	1.8	3.2	-0.5	3.7	9.4
234	EFP	18.6	-	-	-	3.7	-	-	-	8.5
238	Hi-Lo	16.5	19.4	20.1	0.7	2.4	1.6	-0.7	2.3	7.1
264	Hi-Lo	11.0	25.8	27.6	1.7	2.0	3.8	-0.1	3.9	7.3
265	Thebes	14.0	22.2	38.0	15.8	1.2	13.4	3.7	9.7	8.4
268	Thebes	12.5	17.5	21.9	4.5	0.1	7.3	3.3	4.0	7.9
274	Hi-Lo	17.5	20.5	22.4	1.9	2.2	4.0	-0.2	4.3	8.1

Point ID	Group	A	B	C	E	F	G	H	I	Max. Thick.
275	Hi-Lo	15.4	19.8	20.3	0.6	2.8	2.9	0.8	2.1	6.9
277	Hi-Lo	19.6	24.3	24.7	0.3	1.3	4.1	2.4	1.7	7.2
285	Hi-Lo	13.5	15.5	16.5	1.0	2.3	3.4	-0.3	3.7	4.2
286	Hi-Lo	12.2	15.6	16.7	1.1	1.9	3.7	0.6	3.1	-
288	Hi-Lo	14.3	18.4	20.7	2.3	2.0	4.3	0.1	4.2	6.5
289	Hi-Lo	14.9	18.8	19.9	1.1	1.4	3.9	0.9	3.0	6.6
298	EFP	20.5	-	-	-	5.2	-	-	-	7.7
299	EFP	19.1	-	-	-	4.9	-	-	-	7.5
301	EFP	16.6	-	-	-	4.0	-	-	-	6.6
303	Thebes	20.8	19.6	36.9	17.3	1.8	16.1	4.9	11.2	8.8
337	Hi-Lo	14.8	18.4	21.0	2.7	3.4	2.5	-1.4	3.9	8.0
339	Hi-Lo	18.0	20.0	21.9	1.9	2.6	3.5	-1.3	4.8	7.9
342	Hi-Lo	12.6	17.7	19.8	2.1	2.7	4.2	0.2	4.0	9.4
345	Hi-Lo	13.4	21.7	22.6	0.9	2.9	5.2	0.8	4.3	8.2
347	EFP	22.2	-	-	-	5.7	-	-	-	7.1
352	EFP	18.2	-	-	-	2.8	-	-	-	7.4
353	Dalton	13.7	15.0	18.7	3.7	2.9	5.5	-0.7	6.2	6.1
355	EFP	19.6	-	-	-	3.5	-	-	-	8.3
358	Dalton	23.4	-	30.2	-	4.5	-	-1.8	-	5.7
361	EFP	19.6	22.9	23.8	1.0	5.7	7.9	-4.2	12.1	7.6
362	EFP	20.9	24.2	24.7	0.5	4.2	3.4	-2.5	5.9	6.6
365	EFP	19.9	-	-	-	4.0	-	-	-	8.8
370	EFP	21.8	-	-	-	5.8	-	-	-	7.8
376	EFP	28.2	-	-	-	6.7	-	-	-	8.5
378	EFP	15.5	-	-	-	2.2	-	-	-	5.9
379	EFP	24.8	-	-	-	3.7	-	-	-	7.7
399	Dalton	19.4	22.3	25.0	2.7	2.8	5.1	-0.1	5.2	8.1
400	Hi-Lo	12.4	16.6	18.6	2.0	2.8	3.4	0.0	3.4	6.3
410	Hi-Lo	16.4	20.4	20.7	0.3	3.6	2.9	-1.2	4.1	8.0
413	Hi-Lo	11.6	19.3	20.4	1.1	0.9	4.0	1.8	2.2	8.7
414	Hi-Lo	14.2	19.9	21.0	1.1	1.9	5.9	2.2	3.7	8.5
454	Hi-Lo	10.9	15.2	15.9	0.7	2.7	1.8	-0.8	2.6	4.4
457	Hi-Lo	13.5	17.2	20.1	2.8	1.5	3.4	0.0	3.4	-
461	EFP	25.4	-	-	-	7.9	-	-	-	-
463	Hi-Lo	18.2	22.1	23.8	1.7	1.7	4.7	0.7	4.0	-
471	Hi-Lo	16.0	21.3	22.0	0.6	4.7	2.3	-2.3	4.6	-
473	Hi-Lo	15.6	21.0	21.7	0.7	2.4	4.7	2.0	2.7	-
477	Hi-Lo	15.8	20.2	23.9	3.7	1.8	4.6	0.7	3.9	-
480	EFP	23.7	-	-	-	4.1	-	-	-	-
482	Hi-Lo	18.7	21.1	21.4	0.2	3.8	2.1	0.0	2.0	-

Point ID	Group	A	B	C	E	F	G	H	I	Max. Thick.
489	Hi-Lo	16.8	20.7	21.1	0.3	3.3	3.5	0.7	2.8	-
502	Hi-Lo	15.8	-	-	-	2.1	-	-	-	-
527	Hi-Lo	15.4	-	-	-	3.6	-	-	-	-
533	Hi-Lo	15.8	19.1	19.9	0.8	4.3	1.4	-3.2	4.6	-
579	Hi-Lo	12.8	17.7	19.2	1.5	1.7	4.8	1.1	3.7	-
598	Hi-Lo	14.9	21.7	22.9	1.2	3.0	6.7	0.5	6.2	-
602	Hi-Lo	15.9	19.8	20.3	0.5	2.5	3.1	-0.8	4.0	-
613	Hi-Lo	18.8	24.5	25.2	0.6	2.3	3.1	0.0	3.0	8.1
631	Hi-Lo	15.3	18.5	18.8	0.3	1.5	4.0	1.2	2.8	7.5
637	Thebes	21.4	23.9	37.1	13.3	0.6	18.8	10.3	8.5	10.9
638	Thebes	-	19.7	35.0	15.3	-	16.7	5.4	11.3	8.9
640	Hi-Lo	21.2	24.3	26.7	2.4	4.6	3.3	-2.0	5.3	7.3
642	Hi-Lo	13.7	20.0	20.2	0.2	1.0	4.2	2.8	1.4	7.4
648	Hi-Lo	9.0	20.9	21.2	0.3	0.6	4.5	2.1	2.5	7.3
649	Hi-Lo	18.4	-	-	-	3.8	-	-	-	6.6
653	Hi-Lo	16.6	22.8	23.0	0.2	3.6	3.1	1.0	2.1	9.0
654	Hi-Lo	12.8	-	-	-	2.6	-	-	-	7.7
662	Hi-Lo	17.3	24.9	25.5	0.6	2.1	4.3	2.5	1.7	8.4
673	Hi-Lo	24.1	26.8	28.2	1.4	1.6	3.9	0.1	3.8	9.0
677	Thebes	-	24.6	42.3	17.7	-	18.9	8.6	10.3	10.1
679	Thebes	-	14.3	24.6	10.3	-	10.6	6.3	4.3	8.4
684	Thebes	9.7	19.0	27.3	8.3	0.8	15.4	9.1	6.3	10.9
686	Thebes	5.8	19.9	36.7	16.8	1.6	14.0	6.6	7.4	9.1
690	Kirk	-	13.5	23.2	9.7	-	8.5	2.2	6.4	6.4
742	Kirk	-	21.4	25.5	4.1	-	6.1	2.8	3.3	8.4
749	EFP	16.7	-	-	-	2.5	-	-	-	7.3
750	Hi-Lo	16.3	18.0	18.6	0.6	3.3	2.7	-1.8	4.5	8.6
751	EFP	24.1	-	-	-	4.9	-	-	-	8.6
753	Dalton	23.2	23.6	27.0	3.4	9.7	-0.3	-7.2	7.0	7.1
754	EFP	24.9	-	-	-	4.0	-	-	-	7.9
755	Hi-Lo	23.3	-	-	-	3.7	-	-	-	8.5
756	Hi-Lo	19.0	23.3	24.1	0.8	5.5	0.4	-2.3	2.7	7.9
768	Hi-Lo	20.2	22.7	23.8	1.1	3.1	2.9	-1.2	4.2	8.8
769	Hi-Lo	17.9	21.5	22.3	0.8	2.0	3.6	0.8	2.9	8.2
781	Hi-Lo	16.8	19.7	21.9	2.3	3.3	2.6	-1.5	4.1	7.4
788	EFP	22.7	-	-	-	4.4	-	-	-	5.8
791	EFP	16.3	-	-	-	2.9	-	-	-	5.6
792	Hi-Lo	20.6	24.3	24.7	0.5	4.0	0.8	-1.2	2.0	10.7
794	Hi-Lo	19.9	22.8	25.9	3.1	4.0	3.7	-1.1	4.8	7.5
795	Hi-Lo	16.5	20.0	20.7	0.6	3.0	1.6	-1.0	2.6	7.2

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796	Hi-Lo	20.2	23.5	24.8	1.2	2.0	3.8	0.0	3.8	8.7
799	EFP	20.1	-	-	-	3.7	-	-	-	10.0
801	Hi-Lo	22.4	-	-	-	5.6	-	-	-	10.1
808	Hi-Lo	21.2	-	-	-	4.0	-	-	-	6.3
811	EFP	13.8	-	-	-	1.3	-	-	-	5.1
812	EFP	22.3	-	-	-	2.5	-	-	-	6.0
813	EFP	20.4	23.4	23.9	0.5	2.5	5.6	1.4	4.2	9.3
814	EFP	15.6	-	-	-	4.0	-	-	-	6.2
815	EFP	20.6	-	-	-	2.6	-	-	-	7.1
817	EFP	21.8	26.3	27.1	0.8	4.5	3.0	-1.9	4.8	8.2
818	EFP	20.4	-	-	-	5.5	-	-	-	8.5
820	EFP	22.1	24.9	25.3	0.4	3.5	6.6	-1.9	8.5	8.6
823	EFP	22.3	24.7	25.7	1.0	3.1	3.8	-1.1	4.9	8.7
824	EFP	20.5	-	-	-	3.9	-	-	-	7.8
825	EFP	16.1	-	-	-	3.3	-	-	-	6.9
826	EFP	19.8	-	-	-	4.1	-	-	-	5.2
828	Dalton	14.0	16.8	18.9	2.1	2.5	2.1	-0.4	2.6	6.2
830	EFP	22.9	-	-	-	5.4	-	-	-	9.6
841	EFP	26.3	-	-	-	5.2	-	-	-	10.8
852	Hi-Lo	21.5	26.9	27.7	0.8	3.1	0.7	-1.2	1.9	9.2
860	Hi-Lo	14.2	17.2	17.9	0.7	2.1	2.4	0.6	1.9	8.2
904	Kirk	-	12.9	16.3	3.4	-	5.8	2.4	3.4	6.0
911	EFP	22.4	-	-	-	5.5	-	-	-	7.0
912	EFP	19.4	21.6	22.0	0.4	3.0	0.0	-1.8	1.8	8.0
913	EFP	21.6	-	-	-	3.5	-	-	-	8.0
914	EFP	21.8	-	-	-	5.2	-	-	-	8.0
915	EFP	18.4	-	-	-	4.7	-	-	-	6.0
923	EFP	21.7	-	-	-	5.7	-	-	-	10.0
926	EFP	21.3	-	-	-	4.7	-	-	-	-
927	EFP	19.5	20.9	22.0	1.1	5.2	7.9	-3.7	11.6	5.0
928	EFP	21.4	24.7	25.5	0.8	5.4	4.3	-3.1	7.4	-
931	EFP	22.2	25.5	25.9	0.4	5.5	-1.7	-3.4	1.7	8.0
934	EFP	26.2	-	-	-	7.1	-	-	-	7.0
935	EFP	19.5	22.7	22.9	0.2	3.7	4.4	0.5	3.9	7.0
946	EFP	23.7	27.1	27.5	0.3	5.0	-1.1	-3.8	2.7	10.0
948	EFP	19.6	-	-	-	4.1	-	-	-	7.0
949	EFP	20.5	-	-	-	4.7	-	-	-	10.0
950	EFP	18.1	-	-	-	2.2	-	-	-	7.0
951	EFP	27.3	-	-	-	6.9	-	-	-	9.0
954	EFP	17.2	22.3	22.9	0.6	3.3	7.9	4.5	3.3	7.0

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955	EFP	20.1	22.2	22.4	0.2	4.0	0.4	-1.6	2.0	6.0
956	EFP	21.9	24.8	25.1	0.3	5.1	-0.6	-3.2	2.6	6.0
960	EFP	25.3	-	-	-	3.8	-	-	-	8.0
961	EFP	16.6	-	-	-	3.3	-	-	-	8.0
963	EFP	23.6	-	-	-	6.0	-	-	-	-
964	EFP	15.4	-	-	-	1.8	-	-	-	8.0
966	EFP	21.9	-	-	-	4.9	-	-	-	7.0
968	EFP	24.9	-	-	-	4.8	-	-	-	-
969	EFP	21.0	-	-	-	4.7	-	-	-	7.0
972	EFP	15.8	-	-	-	2.1	-	-	-	7.0
976	EFP	20.1	-	-	-	3.3	-	-	-	9.0
977	EFP	9.8	-	-	-	1.1	-	-	-	4.0
978	EFP	21.0	-	-	-	5.5	-	-	-	6.0
982	EFP	17.5	-	-	-	4.5	-	-	-	6.0
985	EFP	20.6	21.3	23.5	2.2	2.7	12.8	-0.9	13.7	7.0
989	EFP	18.0	23.9	25.3	1.4	4.1	2.2	-1.4	3.5	8.0
991	EFP	17.7	-	-	-	3.3	-	-	-	5.0
993	EFP	18.1	-	-	-	1.8	-	-	-	7.0
994	EFP	27.5	26.8	29.6	2.8	5.2	14.7	-3.6	18.3	-
997	EFP	20.9	23.3	24.7	1.4	3.4	4.1	-1.5	5.6	-
1003	EFP	22.1	-	-	-	7.2	-	-	-	9.0
1011	EFP	18.2	-	25.7	-	4.8	-	-1.9	-	6.0
1012	EFP	22.5	24.4	26.0	1.7	4.9	4.9	-0.6	5.5	8.0
1020	EFP	23.2	-	-	-	8.3	-	-	-	8.0
1034	EFP	22.4	-	-	-	5.0	-	-	-	-
1037	EFP	26.3	-	-	-	6.3	-	-	-	6.0
1039	EFP	32.7	33.0	36.0	3.0	3.2	19.0	-0.8	19.8	-
1041	EFP	14.4	-	-	-	1.9	-	-	-	5.0
1042	EFP	14.6	16.9	18.0	1.1	2.2	6.3	-1.2	7.5	5.0
1043	EFP	25.2	-	-	-	4.5	-	-	-	7.0
1044	EFP	25.6	26.6	28.6	2.0	2.7	3.6	-1.3	5.0	-
1048	EFP	20.1	-	-	-	3.4	-	-	-	7.0
1055	EFP	20.6	24.1	25.2	1.1	4.2	1.8	-2.0	3.8	6.0
1057	EFP	21.6	-	-	-	5.9	-	-	-	6.0
1058	EFP	19.7	-	-	-	2.9	-	-	-	7.0
1061	EFP	20.2	-	-	-	4.6	-	-	-	8.0
1062	EFP	18.1	-	-	-	4.4	-	-	-	-
1063	EFP	24.2	-	-	-	5.2	-	-	-	-
1065	EFP	18.3	-	-	-	3.4	-	-	-	6.0
1069	EFP	20.6	22.1	22.6	0.6	4.7	3.0	-2.1	5.1	6.0

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1082	EFP	20.4	22.0	22.9	0.8	3.6	1.6	-1.9	3.5	7.0
1083	EFP	20.5	-	-	-	3.6	-	-	-	7.8
1086	EFP	21.0	-	-	-	5.0	-	-	-	-
1091	EFP	15.8	19.5	20.0	0.4	2.7	2.2	-0.4	2.6	7.0
1095	EFP	26.0	29.2	29.5	0.3	7.6	-0.2	-2.5	2.3	10.0
1097	EFP	22.3	-	-	-	7.2	-	-	-	9.0
1098	EFP	20.7	-	-	-	6.4	-	-	-	6.0
1099	EFP	20.2	-	-	-	6.8	-	-	-	9.0
1100	EFP	24.6	28.1	28.6	0.5	3.4	1.5	-1.4	2.9	7.0
1101	EFP	21.5	23.8	26.5	2.7	2.4	9.7	0.9	8.9	9.0
1104	EFP	19.6	-	-	-	4.8	-	-	-	8.0
1105	EFP	17.7	-	-	-	3.4	-	-	-	7.0
1106	EFP	20.2	-	-	-	3.2	-	-	-	6.0
1108	EFP	21.1	26.3	27.4	1.1	4.2	2.1	-2.6	4.7	8.0
1110	EFP	26.3	-	-	-	9.5	-	-	-	11.0
1112	EFP	15.4	-	-	-	4.1	-	-	-	7.0
1113	EFP	19.8	22.6	22.8	0.1	2.8	0.7	-1.1	1.8	7.0
1114	EFP	19.9	-	-	-	3.9	-	-	-	6.0
1116	EFP	21.5	25.8	26.4	0.6	5.2	1.4	-2.0	3.4	10.0
1118	EFP	22.7	-	-	-	5.3	-	-	-	9.0
1120	EFP	22.4	-	-	-	9.5	-	-	-	7.0
1123	EFP	25.0	28.4	30.1	1.7	2.6	6.5	-1.2	7.6	8.9
1126	EFP	24.8	-	-	-	5.9	-	-	-	8.0
1128	EFP	20.4	-	-	-	4.8	-	-	-	-
1134	EFP	16.3	17.7	18.1	0.4	2.8	-0.4	-1.4	1.0	6.0
1140	EFP	17.3	20.6	21.6	1.0	2.6	4.2	-1.0	5.2	6.0
1141	EFP	19.9	24.3	24.8	0.5	3.0	1.5	-1.1	2.7	8.2
1146	EFP	20.0	22.2	23.2	0.9	2.8	5.1	-0.2	5.3	7.0
1148	EFP	22.5	-	-	-	6.4	-	-	-	8.0
1150	EFP	17.7	-	-	-	3.6	-	-	-	6.0
1152	EFP	21.9	26.4	28.1	1.7	7.2	11.3	-2.8	14.1	9.0
1153	EFP	15.2	-	-	-	2.1	-	-	-	5.0
1154	EFP	18.9	-	-	-	1.7	-	-	-	8.0
1156	EFP	24.4	26.2	27.9	1.6	4.7	8.6	0.7	7.9	9.0
1157	EFP	20.5	-	-	-	3.9	-	-	-	5.8
1164	EFP	14.3	15.4	16.0	0.6	4.0	2.3	-2.2	4.5	4.0
1166	EFP	22.7	-	-	-	5.9	-	-	-	-
1167	EFP	23.4	-	-	-	2.4	-	-	-	9.0
1168	EFP	17.4	22.9	23.3	0.5	3.2	1.8	-0.9	2.7	5.0
1170	EFP	18.4	-	-	-	3.0	-	-	-	-

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1174	EFP	21.9	-	-	-	5.3	-	-	-	5.7
1177	EFP	22.7	-	-	-	5.1	-	-	-	6.0
1180	EFP	24.9	25.5	27.0	1.4	5.7	0.5	-4.6	5.1	6.0
1183	EFP	20.1	21.6	22.1	0.5	2.3	8.6	-1.2	9.8	-
1190	EFP	20.1	22.0	22.7	0.6	3.9	2.1	-2.3	4.4	7.0
1193	EFP	16.8	20.0	20.6	0.6	2.6	2.1	0.6	1.5	6.0
1200	EFP	21.8	-	-	-	3.5	-	-	-	-
1204	EFP	24.7	-	-	-	4.2	-	-	-	-
1209	EFP	22.1	-	-	-	5.7	-	-	-	-
1222	EFP	19.5	-	-	-	4.7	-	-	-	7.0
1228	EFP	15.4	-	-	-	7.0	-	-	-	-
1232	EFP	19.2	-	-	-	4.5	-	-	-	7.0
1233	EFP	19.0	23.4	23.7	0.2	4.1	0.5	-1.0	1.4	8.0
1234	EFP	15.8	-	-	-	3.2	-	-	-	6.0
1238	EFP	24.9	26.9	27.9	1.0	5.2	5.6	-3.9	9.5	8.0
1239	EFP	20.1	-	-	-	5.6	-	-	-	7.0
1241	EFP	22.2	-	-	-	5.1	-	-	-	6.0
1245	EFP	21.8	-	-	-	4.4	-	-	-	7.0
1246	EFP	21.6	-	-	-	5.8	-	-	-	7.0
1248	EFP	19.9	-	-	-	4.0	-	-	-	-
1249	EFP	17.1	19.7	19.9	0.3	3.2	0.7	-0.7	1.5	8.0
1250	EFP	19.3	22.6	22.9	0.2	4.3	-0.5	-1.8	1.3	7.0
1251	EFP	20.2	23.7	24.2	0.6	3.8	1.3	-1.1	2.4	8.0
1252	EFP	20.8	-	-	-	5.2	-	-	-	8.0
1254	EFP	22.3	-	-	-	4.8	-	-	-	7.0
1258	EFP	21.8	-	-	-	3.2	-	-	-	-
1262	EFP	17.2	17.9	18.6	0.7	3.0	5.1	-1.1	6.2	6.0
1263	EFP	20.4	-	-	-	4.5	-	-	-	7.0
1264	EFP	14.8	-	-	-	2.3	-	-	-	6.0
1273	EFP	24.0	31.4	32.4	1.0	6.4	4.0	0.4	3.6	8.0
1279	EFP	24.7	28.3	29.5	1.2	5.5	5.6	-2.6	8.2	-
1295	EFP	16.4	20.1	21.8	1.7	1.3	9.0	1.9	7.2	7.0
1301	EFP	21.7	-	-	-	5.8	-	-	-	10.0
1304	EFP	17.0	-	-	-	2.0	-	-	-	7.0
1308	EFP	22.3	26.3	26.9	0.6	1.8	3.9	1.5	2.3	8.0
1310	EFP	19.4	-	-	-	5.0	-	-	-	8.0
1311	EFP	25.8	-	-	-	7.0	-	-	-	6.0
1312	EFP	20.6	-	-	-	4.8	-	-	-	8.0
1313	EFP	23.4	26.7	27.5	0.7	7.7	4.2	-5.6	9.8	6.0
1315	EFP	21.2	-	-	-	4.6	-	-	-	9.0

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1316	EFP	18.9	-	-	-	3.6	-	-	-	9.0
1322	EFP	22.0	-	-	-	3.1	-	-	-	-
1323	EFP	20.6	23.4	24.2	0.8	4.2	2.9	-0.7	3.6	6.0
1324	EFP	20.1	-	-	-	4.8	-	-	-	9.0
1330	EFP	24.1	26.4	26.5	0.1	3.3	2.0	-1.7	3.6	7.0
1332	EFP	19.3	-	-	-	4.6	-	-	-	6.0
1333	EFP	21.3	-	-	-	6.2	-	-	-	7.0
1345	EFP	17.1	-	-	-	2.8	-	-	-	8.0
1346	EFP	23.8	25.2	27.5	2.3	6.2	2.8	-4.0	6.8	8.0
1348	EFP	17.1	-	-	-	3.6	-	-	-	-
1356	EFP	21.5	25.3	25.8	0.5	4.6	3.3	-1.2	4.5	9.0
1358	EFP	25.4	-	-	-	6.7	-	-	-	-
1359	EFP	22.9	-	-	-	5.7	-	-	-	10.0
1362	EFP	22.5	-	-	-	4.6	-	-	-	-
1366	EFP	17.1	21.1	22.1	1.0	3.9	4.1	-1.3	5.4	-
1367	EFP	17.9	20.2	20.5	0.3	2.5	0.5	-1.1	1.6	7.0
1371	EFP	18.2	-	-	-	3.9	-	-	-	-
1375	EFP	17.3	22.0	23.7	1.7	2.2	5.1	1.9	3.1	8.0
1376	EFP	15.9	-	-	-	2.0	-	-	-	6.0
1383	EFP	20.1	-	-	-	3.6	-	-	-	8.0
1384	EFP	21.7	-	-	-	5.0	-	-	-	-
1388	EFP	25.2	28.5	29.5	1.0	1.2	8.0	1.1	7.0	-
1405	EFP	19.0	19.3	20.8	1.5	1.3	9.7	0.3	9.4	6.0
1478	EFP	19.7	24.6	24.8	0.3	3.0	4.9	2.3	2.6	-
1492	EFP	15.9	-	-	-	4.5	-	-	-	7.0
1493	EFP	16.7	-	-	-	2.4	-	-	-	-
1494	EFP	15.3	-	-	-	4.4	-	-	-	-
1496	EFP	17.0	-	-	-	1.9	-	-	-	6.0
1497	EFP	21.9	23.3	25.1	1.9	3.2	8.6	-1.1	9.6	-
1498	EFP	21.2	-	-	-	4.3	-	-	-	5.0
1500	EFP	20.8	-	-	-	3.1	-	-	-	11.0
1502	EFP	19.5	-	-	-	4.8	-	-	-	8.0
1503	EFP	21.1	-	-	-	2.2	-	-	-	10.0
1504	EFP	20.8	-	-	-	2.7	-	-	-	8.0
1507	EFP	18.9	-	-	-	4.1	-	-	-	8.0
1508	EFP	17.8	21.3	22.5	1.2	2.9	4.8	0.5	4.4	7.0
1510	EFP	19.2	-	-	-	4.2	-	-	-	7.0
1511	EFP	16.6	19.0	19.7	0.7	2.8	2.2	-0.4	2.6	7.0
1513	EFP	23.8	25.5	26.4	0.9	3.3	6.4	-0.7	7.0	9.0
1514	EFP	19.4	-	-	-	2.1	-	-	-	6.0

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1520	EFP	20.4	-	-	-	4.8	-	-	-	7.0
1521	EFP	24.8	-	-	-	6.6	-	-	-	8.0
1522	EFP	17.3	-	-	-	2.4	-	-	-	7.0
1523	EFP	19.2	-	-	-	3.9	-	-	-	8.0
1524	EFP	20.3	-	-	-	4.5	-	-	-	8.0
1525	EFP	20.0	-	-	-	5.7	-	-	-	9.0
1527	EFP	14.4	-	-	-	2.7	-	-	-	5.0
1530	EFP	19.6	-	-	-	2.7	-	-	-	7.0
1532	EFP	20.0	23.5	24.5	1.0	3.8	5.3	-2.0	7.2	7.0
1533	EFP	15.2	-	-	-	3.8	-	-	-	6.0
1535	EFP	20.7	-	-	-	3.5	-	-	-	-
1536	EFP	18.1	-	-	-	4.1	-	-	-	-
1541	EFP	23.8	-	-	-	6.8	-	-	-	-
1543	EFP	15.6	-	-	-	3.5	-	-	-	7.0
1547	EFP	24.4	26.9	27.1	0.2	5.7	1.4	-2.9	4.3	9.0
1548	EFP	19.5	-	-	-	5.1	-	-	-	9.0
1551	EFP	22.4	24.4	26.0	1.6	5.3	5.2	-3.8	9.0	9.0
1557	EFP	22.2	22.7	24.5	1.8	3.8	6.2	-2.4	8.6	7.0
1558	EFP	21.9	-	-	-	4.7	-	-	-	7.0
1559	EFP	24.8	25.7	28.2	2.6	4.8	3.3	-3.1	6.4	8.0
1560	EFP	26.4	-	-	-	12.5	-	-	-	8.0
1562	EFP	22.1	25.3	26.2	0.9	4.8	4.1	-3.2	7.3	11.0
1563	EFP	21.1	-	-	-	5.6	-	-	-	8.0
1564	EFP	19.6	-	-	-	5.9	-	-	-	9.0
1567	EFP	23.7	-	-	-	6.1	-	-	-	8.0
1568	EFP	22.2	27.2	29.4	2.1	4.4	7.6	-1.0	8.7	9.0
1569	EFP	22.2	-	-	-	3.7	-	-	-	8.0
1570	EFP	20.6	-	-	-	4.9	-	-	-	8.0
1579	EFP	21.4	-	-	-	2.4	-	-	-	-
1581	EFP	15.7	-	-	-	2.6	-	-	-	7.0
1582	EFP	20.7	-	-	-	5.4	-	-	-	-
1584	EFP	21.9	-	-	-	5.5	-	-	-	8.0
1585	EFP	20.5	-	-	-	3.9	-	-	-	-
1588	EFP	21.6	-	-	-	4.0	-	-	-	8.0
1590	EFP	23.6	-	-	-	3.3	-	-	-	-
1592	EFP	19.7	-	-	-	4.0	-	-	-	-
1593	EFP	22.8	-	-	-	4.5	-	-	-	-
1595	EFP	18.0	20.4	21.6	1.3	3.2	6.2	-2.0	8.2	-
1597	Hi-Lo	19.2	25.0	26.6	1.6	4.3	5.0	-1.0	6.0	9.3
1598	Hi-Lo	15.8	19.0	20.4	1.4	3.4	2.7	-0.6	3.3	9.4

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1599	Hi-Lo	16.0	18.6	19.1	0.5	2.7	2.5	-0.6	3.1	8.4
1601	Hi-Lo	15.8	-	-	-	1.9	-	-	-	8.0
1602	Hi-Lo	23.6	26.5	26.9	0.4	5.2	-1.6	-3.0	1.4	8.8
1604	Hi-Lo	17.6	-	-	-	6.5	-	-	-	8.7
1606	Hi-Lo	14.9	24.6	24.6	0.0	3.1	2.8	1.1	1.6	8.8
1610	Hi-Lo	13.9	-	-	-	2.9	-	-	-	7.6
1612	Hi-Lo	18.4	24.4	25.3	0.9	4.0	1.2	-1.3	2.5	10.5
1622	Hi-Lo	12.3	17.0	17.5	0.5	2.3	2.8	-0.5	3.4	5.8
1625	Thebes	24.8	24.5	42.2	17.8	2.6	14.5	6.6	7.8	11.3
1626	Hi-Lo	15.0	20.4	21.0	0.5	3.7	2.3	-1.1	3.3	7.6
1627	Hi-Lo	9.7	15.1	17.0	1.9	1.7	4.1	0.2	3.8	7.2
1628	Hi-Lo	13.6	19.4	20.1	0.7	1.9	4.4	1.6	2.8	6.7
1629	Hi-Lo	18.8	22.8	23.2	0.4	3.3	1.8	-0.4	2.2	10.1
1630	Hi-Lo	13.6	17.6	18.5	0.8	1.8	4.1	0.8	3.3	8.0
1632	Hi-Lo	14.2	17.8	19.2	1.5	2.7	2.9	-0.7	3.6	5.7
1638	EFP	19.1	-	-	-	5.4	-	-	-	-
1642	Hi-Lo	18.5	24.1	24.5	0.3	3.8	3.9	2.5	1.4	9.6
1643	Hi-Lo	15.1	17.4	18.3	0.9	2.7	3.9	-1.3	5.2	7.4
1644	Hi-Lo	16.2	18.6	20.2	1.6	3.4	3.4	-1.7	5.1	7.1
1646	Hi-Lo	14.2	15.3	17.3	2.1	1.2	4.2	0.7	3.4	6.2
1647	Hi-Lo	13.8	16.4	17.4	1.0	1.3	4.4	1.8	2.7	8.1
1649	Hi-Lo	23.5	-	-	-	4.8	-	-	-	6.8
1650	Hi-Lo	12.8	15.0	16.4	1.5	1.9	3.0	0.1	2.9	6.2
1653	Hi-Lo	12.7	-	-	-	1.0	-	-	-	6.1
1654	Thebes	-	16.7	27.6	11.0	-	12.9	4.1	8.9	9.1
1655	Thebes	-	16.8	31.4	14.6	-	13.4	6.6	6.8	8.5
1656	Hi-Lo	15.0	19.5	19.9	0.3	2.8	2.9	-0.7	3.5	7.6
1666	Thebes	-	18.4	33.8	15.4	-	17.6	6.8	10.8	9.3
1667	Kirk	26.1	21.1	29.8	8.8	2.2	6.9	0.1	6.9	7.6
1668	Hi-Lo	11.4	15.6	16.8	1.2	1.5	3.9	0.7	3.2	8.0
1670	Hi-Lo	20.5	-	-	-	3.8	-	-	-	10.4
1671	Hi-Lo	21.4	25.8	26.0	0.3	3.1	1.9	0.7	1.2	8.6
1673	Hi-Lo	20.1	26.6	27.1	0.5	2.7	2.7	0.7	2.0	8.1
1674	Hi-Lo	19.9	24.6	26.4	1.8	2.8	4.2	-0.3	4.5	10.4
1675	Hi-Lo	14.8	19.9	20.4	0.6	2.1	3.0	0.0	2.9	9.1
1676	Hi-Lo	18.7	21.2	22.7	1.5	2.8	1.7	-1.6	3.3	8.9
1678	Thebes	14.4	14.0	25.2	11.3	1.1	12.8	2.1	10.7	-
1683	Hi-Lo	11.6	18.9	19.2	0.3	1.6	3.3	1.6	1.7	6.2
1684	Hi-Lo	17.6	-	-	-	3.1	-	-	-	9.2
1686	Hi-Lo	14.4	-	-	-	2.0	-	-	-	11.2

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1688	Hi-Lo	11.9	18.6	19.5	0.9	2.3	3.8	1.6	2.2	8.0
1690	Hi-Lo	9.7	17.8	18.5	0.7	1.7	4.3	1.1	3.3	8.3
1692	Hi-Lo	21.0	25.1	27.1	2.0	3.6	4.8	-0.2	4.9	7.8
1693	Thebes	-	17.0	26.0	9.0	-	13.0	8.2	4.8	10.8
1694	Thebes	-	21.2	39.0	17.8	-	16.2	6.8	9.4	9.1
1695	Thebes	4.2	14.0	21.5	7.5	0.9	9.7	6.6	3.1	9.8
1696	Thebes	-	21.4	39.3	17.9	-	17.2	9.0	8.2	-
1697	Hi-Lo	15.6	22.4	24.9	2.5	2.5	8.7	1.7	7.1	10.2
1717	EFP	22.8	-	-	-	8.4	-	-	-	8.0
1722	EFP	22.2	-	-	-	5.0	-	-	-	8.3
1776	Dalton	22.3	24.7	27.6	2.9	4.2	2.3	-2.2	4.5	7.3
1778	EFP	20.1	22.8	23.2	0.4	4.3	2.5	-2.9	5.4	8.5
1780	Kirk	-	15.2	19.8	4.6	-	6.6	2.7	3.9	-
1783	Dalton	17.4	21.4	23.5	2.1	4.2	3.0	-1.9	4.9	6.6
1786	Dalton	23.9	25.3	31.1	5.8	2.6	8.3	2.2	6.1	7.1
1787	Dalton	22.0	23.6	27.9	4.2	2.6	4.4	0.2	4.2	8.9
1788	Dalton	17.8	23.5	26.0	2.5	2.6	8.5	0.8	7.6	7.5
1789	Dalton	20.8	26.2	28.6	2.4	4.5	5.8	0.2	5.6	7.9
1790	Dalton	27.5	25.1	31.6	6.5	4.1	7.6	-0.9	8.5	8.9
1791	Dalton	15.1	21.6	23.4	1.9	4.1	3.5	-2.5	5.9	6.9
1792	Dalton	23.6	32.7	36.9	4.2	2.4	7.7	0.0	7.6	8.2
1794	Dalton	26.0	28.9	31.7	2.8	4.4	4.9	-2.2	7.2	6.8
1795	Dalton	21.7	26.6	28.5	1.9	5.1	3.5	-2.3	5.8	7.9
1796	Dalton	-	28.2	-	-	-	4.0	-	-	8.1
1797	Dalton	18.2	27.8	30.9	3.1	2.6	5.9	1.0	5.0	8.7
1798	Dalton	18.2	23.9	26.1	2.2	2.4	8.9	2.8	6.1	7.3
1799	Dalton	19.8	29.3	30.5	1.2	3.7	6.7	1.2	5.4	6.8
1800	Dalton	21.9	23.0	27.5	4.5	2.9	6.4	0.9	5.6	6.5
1801	Dalton	-	29.3	-	-	-	-	-	-	7.8
1802	Dalton	19.5	22.6	24.6	2.0	5.0	6.2	-4.0	10.1	6.2
1803	Dalton	17.4	16.5	23.0	6.4	3.9	6.9	-1.2	8.1	4.2
1805	EFP	20.4	-	-	-	2.1	-	-	-	6.6
1806	Dalton	23.9	25.7	28.3	2.6	6.6	6.9	-4.3	11.2	6.5
1807	Dalton	20.7	25.8	26.1	0.4	3.3	2.2	-1.6	3.8	7.4
1809	Dalton	24.1	23.2	26.7	3.5	4.8	12.1	-3.0	15.1	6.2
1810	Dalton	18.9	21.9	25.4	3.5	4.3	8.9	-2.7	11.5	5.5
1811	Dalton	20.5	19.8	26.2	6.4	7.8	9.2	-6.3	15.5	6.4
1812	Dalton	14.0	19.0	21.4	2.4	2.8	4.4	-0.5	4.9	8.3
1813	Dalton	-	22.2	-	-	-	6.6	-	-	8.2
1820	Dalton	23.9	-	30.8	-	3.2	-	-0.1	-	7.9

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1821	Dalton	21.2	26.6	29.5	2.9	5.0	5.1	-0.5	5.6	7.1
1823	Dalton	22.2	24.6	27.5	2.9	4.8	5.0	-2.7	7.7	6.5
1824	Dalton	17.6	18.5	21.1	2.6	3.8	6.8	-2.2	9.0	5.2
1827	Kirk	16.2	17.9	24.7	6.8	1.5	7.4	1.2	6.2	6.7
1833	Dalton	20.2	19.8	27.1	7.3	3.4	4.1	-1.7	5.8	8.6
1835	Thebes	6.9	18.7	29.8	11.2	0.7	10.8	5.0	5.8	9.5
1836	Thebes	5.9	17.3	27.6	10.3	1.5	10.3	5.4	4.9	10.7
1837	Thebes	-	17.5	28.9	11.4	-	12.7	6.9	5.8	9.8
1838	Kirk	15.4	16.3	24.1	7.8	0.9	6.5	1.8	4.7	6.2
1839	Kirk	19.7	16.2	24.7	8.5	0.8	7.2	1.4	5.9	7.3
1840	Kirk	18.0	16.4	22.7	6.3	0.7	6.0	0.2	5.8	6.7
1841	Kirk	16.8	15.7	20.2	4.6	0.8	5.6	0.5	5.1	6.3
1842	Kirk	-	17.5	24.9	7.5	-	8.3	3.7	4.6	7.1
1843	Kirk	25.9	21.5	30.3	8.8	1.3	8.0	0.9	7.1	7.2
1844	Kirk	-	19.5	25.1	5.6	-	8.0	2.4	5.6	6.8
1847	Kirk	18.3	16.0	22.4	6.4	1.2	6.5	0.5	6.0	6.1
1848	Kirk	20.2	16.4	23.9	7.5	2.1	6.3	0.3	6.0	-
1849	Kirk	-	15.6	25.5	9.9	-	7.9	1.5	6.5	6.9
1850	Kirk	16.7	13.4	21.1	7.7	0.6	6.4	2.0	4.4	5.5
1851	Kirk	13.9	14.4	20.0	5.7	0.4	7.3	1.7	5.6	6.2
1854	Kirk	-	10.4	20.1	9.7	-	7.7	1.1	6.6	6.8
1856	Thebes	17.4	20.4	29.2	8.8	0.6	11.4	6.7	4.7	6.5
1866	Thebes	16.0	22.3	35.6	13.3	1.3	11.0	2.7	8.3	10.0
1869	Kirk	-	17.4	24.0	6.6	-	8.5	2.3	6.1	8.0
1870	Dalton	24.2	24.6	30.9	6.2	3.8	7.5	-0.2	7.7	8.4
1872	Hi-Lo	14.6	19.4	21.3	1.9	2.0	5.5	1.8	3.7	7.9
1873	Hi-Lo	14.1	17.8	18.8	1.0	2.4	3.5	1.1	2.5	8.3
1874	Hi-Lo	12.3	16.6	17.3	0.8	2.0	3.2	0.5	2.7	9.0
1875	Hi-Lo	13.5	21.4	22.3	0.9	1.9	5.3	1.5	3.8	8.6
1876	Hi-Lo	11.4	14.9	16.3	1.4	2.5	3.1	-0.6	3.7	8.5
1877	Hi-Lo	15.5	17.9	18.3	0.4	3.7	-0.4	-2.3	2.0	7.7
1879	Hi-Lo	9.9	15.4	16.2	0.8	1.5	3.5	1.5	2.1	7.9
1880	Hi-Lo	14.3	20.4	20.6	0.2	3.2	4.6	3.2	1.4	8.6
1881	Hi-Lo	14.6	17.5	18.9	1.5	2.7	2.6	-0.9	3.5	5.7
1882	Hi-Lo	14.3	17.6	19.1	1.5	1.7	2.3	-0.2	2.6	9.6
1886	Hi-Lo	13.6	-	-	-	2.5	-	-	-	8.7
1887	Hi-Lo	12.4	19.9	20.8	0.8	3.0	2.0	0.0	2.0	7.6
1888	Hi-Lo	16.9	20.9	21.4	0.5	2.8	2.2	-0.3	2.6	7.6
1889	Hi-Lo	17.4	21.0	23.1	2.1	2.2	4.4	1.4	3.0	8.0
1891	Hi-Lo	13.2	19.0	19.9	0.9	2.5	2.0	-0.2	2.3	8.0

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1893	Hi-Lo	18.3	-	-	-	2.7	-	-	-	10.6
1894	Hi-Lo	16.8	21.1	23.7	2.6	3.0	3.1	-0.6	3.7	9.6
1895	Hi-Lo	16.2	19.9	20.7	0.7	2.8	4.5	-0.1	4.5	9.7
1896	Hi-Lo	12.8	18.3	18.5	0.2	2.5	1.6	-0.3	1.8	6.4
1899	Hi-Lo	18.0	19.8	20.9	1.2	1.6	3.3	-0.1	3.4	8.4
1900	Hi-Lo	14.2	21.0	21.5	0.4	2.4	5.1	1.0	4.1	7.8
1901	Hi-Lo	13.9	20.9	22.3	1.4	2.7	4.2	-0.3	4.5	8.9
1902	Hi-Lo	11.7	19.3	20.2	0.9	3.3	3.8	1.1	2.7	7.0
1903	Hi-Lo	16.7	21.0	22.2	1.2	2.3	5.3	1.7	3.7	8.4
1905	Hi-Lo	15.9	19.2	21.0	1.8	2.3	4.0	0.4	3.5	8.1
1907	Hi-Lo	9.9	14.4	17.3	2.9	1.6	4.4	1.0	3.4	7.0
1909	Hi-Lo	16.1	17.3	18.1	0.7	2.9	0.5	-1.1	1.6	6.0
1913	Hi-Lo	9.4	10.9	12.4	1.5	2.5	2.5	-0.4	2.9	6.1
1915	Hi-Lo	10.6	14.3	14.6	0.2	2.1	1.2	-0.3	1.5	8.0
1916	Hi-Lo	15.0	18.8	19.8	1.0	2.3	4.5	0.4	4.1	8.0
1918	Hi-Lo	17.4	21.6	22.8	1.3	4.2	2.6	-1.7	4.2	-
1925	Hi-Lo	15.0	19.8	21.2	1.3	3.5	2.4	-1.4	3.8	8.6
1927	Hi-Lo	19.2	21.5	22.4	0.9	2.3	4.7	0.6	4.1	8.8
1928	Hi-Lo	14.8	20.2	21.0	0.8	2.9	4.3	1.3	2.9	7.9
1929	Hi-Lo	19.6	21.4	23.1	1.8	2.1	4.4	-0.1	4.5	8.4
1930	Hi-Lo	11.9	21.7	22.4	0.7	1.5	5.4	2.7	2.7	6.7
1931	Hi-Lo	14.8	21.5	23.0	1.5	4.1	4.9	1.4	3.6	9.1
1932	Hi-Lo	16.6	20.1	22.6	2.5	1.8	6.1	1.1	5.0	7.6
1971	Hi-Lo	19.9	22.9	23.8	0.9	6.2	3.1	-3.1	6.1	7.6
1972	Hi-Lo	10.7	17.9	18.8	0.9	1.1	4.7	1.1	3.6	7.5
1973	Hi-Lo	12.8	15.7	16.3	0.6	1.5	2.9	0.5	2.4	7.1
1974	Kirk	14.2	15.2	21.1	5.9	0.4	5.6	1.7	3.9	6.2
1979	Thebes	-	17.1	28.9	11.7	-	14.1	5.5	8.6	-
1980	Kirk	19.2	17.3	25.2	7.9	1.2	5.3	1.1	4.2	5.7
1981	Kirk	17.6	20.0	25.9	5.8	1.2	6.2	1.5	4.6	7.7
1987	Hi-Lo	15.5	22.8	23.6	0.7	3.4	2.8	0.1	2.7	8.5
1988	Hi-Lo	19.4	25.7	27.1	1.3	5.1	2.4	-1.2	3.6	10.2
1989	Hi-Lo	16.4	21.8	22.6	0.7	1.4	4.2	1.1	3.2	8.1
1991	Hi-Lo	13.3	-	-	-	1.7	-	-	-	6.6
1992	Hi-Lo	13.6	15.7	17.4	1.6	2.4	3.8	-0.3	4.1	6.4
1993	Thebes	3.8	18.9	32.1	13.1	0.7	16.5	7.3	9.2	-
1994	Hi-Lo	19.6	25.4	25.6	0.2	5.2	1.4	-1.2	2.6	-
1995	Hi-Lo	19.1	20.7	21.8	1.0	2.1	3.5	-0.2	3.7	7.5
1996	Hi-Lo	18.6	23.4	25.2	1.8	3.9	4.2	-1.9	6.2	8.6
1999	Hi-Lo	18.6	22.3	22.4	0.1	2.5	1.3	-0.2	1.5	8.9

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2001	Hi-Lo	18.3	20.2	21.8	1.7	4.2	2.6	-1.7	4.3	7.7
2003	Hi-Lo	21.6	25.4	25.8	0.5	3.3	3.1	-0.4	3.4	7.7
2004	Hi-Lo	22.2	26.1	27.5	1.4	3.6	4.0	-0.5	4.5	10.3
2017	EFP	18.4	-	21.2	-	1.4	-	-0.2	-	-
2019	Dalton	14.1	16.9	19.6	2.7	1.9	4.3	0.1	4.2	-
2022	Dalton	20.6	22.5	26.6	4.1	7.1	6.7	-3.8	10.5	-
2025	EFP	22.5	-	26.1	-	5.3	-	-3.1	-	-
2028	Thebes	6.2	14.3	27.2	13.0	0.3	12.1	4.3	7.8	9.9
2029	Thebes	14.6	16.3	20.6	4.4	1.1	6.5	0.8	5.7	8.1
2031	Thebes	17.6	22.4	28.9	6.5	0.7	9.6	1.6	8.0	8.1
2032	Thebes	10.1	15.7	25.6	9.9	0.8	11.7	6.3	5.5	10.1
2036	Thebes	-	18.1	28.4	10.3	-	12.4	5.9	6.5	9.8
2037	Kirk	9.1	15.4	20.7	5.2	1.0	8.1	2.1	6.0	7.0
2038	Kirk	14.2	19.5	24.4	4.8	0.4	6.4	2.5	3.9	4.9
2040	Thebes	-	14.1	21.4	7.3	-	10.2	6.6	3.5	9.2
2047	Kirk	16.0	18.2	23.8	5.6	0.3	6.6	1.2	5.4	5.6
2056	Kirk	-	13.2	19.0	5.8	-	6.5	1.5	5.0	6.9
2057	Hi-Lo	16.7	18.5	21.1	2.6	1.6	4.8	-0.1	4.9	7.4
2058	Thebes	-	14.7	26.0	11.2	-	11.5	7.5	4.0	9.0
2059	Thebes	17.3	22.4	36.6	14.2	1.3	13.5	7.9	5.6	10.1
2060	Thebes	-	14.3	25.6	11.3	-	12.0	6.0	6.0	8.9
2062	Thebes	8.8	14.7	23.6	8.9	0.2	10.0	5.6	4.4	9.5
2066	Kirk	15.9	14.2	20.6	6.4	1.1	6.8	0.8	6.0	6.9
2069	Kirk	7.9	13.5	17.6	4.2	0.6	5.1	0.9	4.2	5.7
2071	EFP	21.3	-	-	-	5.1	-	-	-	7.7
2072	Kirk	17.3	16.6	22.4	5.7	0.8	6.2	0.4	5.8	7.1
2073	Thebes	9.8	20.4	30.4	9.9	1.8	11.4	5.3	6.1	8.2
2075	Thebes	-	14.3	21.0	6.6	-	9.8	6.1	3.6	9.7
2079	Kirk	15.7	16.7	21.0	4.2	1.6	5.1	-0.2	5.3	7.3
2080	Kirk	-	14.9	20.0	5.2	-	6.6	2.4	4.2	6.0
2081	Kirk	19.0	16.8	22.2	5.4	1.6	5.5	-0.3	5.8	6.5
2082	Thebes	22.2	19.2	34.7	15.6	3.3	11.0	4.8	6.2	-
2084	Kirk	-	16.6	20.9	4.3	-	7.3	1.7	5.7	6.8
2085	Hi-Lo	15.2	19.3	21.1	1.8	1.1	4.4	1.6	2.7	8.1
2086	Thebes	-	13.2	22.7	9.5	-	11.2	7.2	4.0	9.8
2087	Kirk	10.6	17.1	20.7	3.6	1.4	5.2	1.6	3.6	6.6
2088	Kirk	18.1	16.1	23.8	7.6	0.8	9.1	1.5	7.6	6.6
2089	Hi-Lo	13.4	17.9	20.3	2.4	2.4	5.4	1.3	4.1	8.3
2097	Kirk	15.3	15.3	18.8	3.5	0.6	5.5	0.7	4.8	5.7
2099	Thebes	13.2	20.5	27.1	6.6	1.4	8.5	2.0	6.5	9.8

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2101	Kirk	20.4	18.8	27.0	8.3	0.7	7.6	2.9	4.8	6.1
2103	Kirk	-	13.8	23.3	9.5	-	7.7	3.9	3.8	5.5
2106	Kirk	-	14.9	23.2	8.3	-	-	-	5.5	5.1
2108	Thebes	7.8	14.8	22.6	7.8	2.0	8.3	4.2	4.1	9.2
2110	Kirk	7.8	16.0	22.9	6.9	0.3	8.0	2.6	5.4	5.8
2111	Dalton	-	22.0	-	-	-	10.2	-	-	7.8
2112	Kirk	17.1	22.4	28.0	5.7	1.7	8.3	2.1	6.2	7.6
2113	Kirk	20.7	19.3	26.3	7.1	0.2	9.7	1.5	8.1	9.9
2114	Kirk	16.5	16.5	23.9	7.4	0.6	6.8	2.0	4.8	5.9
2117	Kirk	9.2	15.6	20.9	5.3	0.2	6.6	2.4	4.2	7.3
2118	Kirk	11.2	14.0	18.7	4.7	0.4	5.7	1.7	4.0	6.1
2120	Kirk	20.1	17.5	25.1	7.5	1.2	6.3	1.5	4.8	8.2
2125	Thebes	9.8	16.7	29.6	12.9	0.2	12.9	6.7	6.2	6.9
2129	Thebes	13.8	18.0	28.1	10.2	1.8	11.6	4.6	7.0	9.4
2131	Thebes	6.4	14.0	23.2	9.1	0.2	9.1	5.4	3.7	8.4
2132	Dalton	-	26.6	-	-	-	5.6	-	-	9.0
2134	Thebes	-	22.3	33.9	11.7	-	12.8	8.1	4.7	9.1
2135	Kirk	22.1	21.4	24.9	3.4	1.8	4.3	-0.2	4.5	5.9
2136	Thebes	20.3	16.1	28.2	12.0	1.6	12.7	1.8	10.9	8.8
2137	Thebes	5.9	13.5	25.6	12.1	0.1	12.4	6.6	5.8	7.2
2138	Thebes	11.3	17.2	30.3	13.1	1.4	15.3	5.7	9.7	10.0
2143	Thebes	7.9	13.9	21.2	7.3	0.3	9.6	5.6	4.0	10.0
2146	Thebes	3.7	15.1	23.2	8.1	0.9	9.9	6.3	3.6	8.6
2147	Thebes	10.7	13.7	26.3	12.6	0.2	15.1	6.4	8.7	9.3
2151	Kirk	-	14.4	22.1	7.7	-	7.3	3.0	4.4	6.3
2152	Kirk	16.3	14.3	22.0	7.7	0.9	9.0	1.6	7.4	7.5
2156	Thebes	-	12.7	18.1	5.4	-	8.2	3.8	4.3	7.8
2159	Kirk	23.0	14.7	26.8	12.1	1.9	6.8	1.4	5.3	6.0
2162	Kirk	25.8	20.1	32.8	12.7	0.8	10.6	1.2	9.4	7.4
2164	Thebes	17.8	14.6	27.5	12.9	1.7	9.1	4.2	4.9	9.5
2167	Kirk	18.6	16.3	22.2	5.9	1.4	5.8	0.3	5.5	8.8
2171	Kirk	-	13.3	21.1	7.8	-	8.4	3.2	5.2	6.7
2173	Kirk	-	16.1	23.4	7.3	-	9.5	2.4	7.1	5.8
2175	Thebes	19.9	18.8	33.0	14.2	1.2	13.7	6.3	7.4	9.0
2178	Thebes	-	13.6	24.8	11.2	-	11.3	6.0	5.3	7.3
2180	Kirk	-	12.8	19.9	7.1	-	7.0	2.6	4.4	6.3
2183	Thebes	10.6	15.7	26.7	11.0	0.8	10.0	4.0	6.0	9.4
2184	Thebes	-	22.1	31.4	9.4	-	14.6	8.4	6.2	7.6
2185	Kirk	14.0	16.7	23.2	6.5	0.4	8.9	1.0	7.9	7.7
2186	Kirk	-	14.4	21.0	6.5	-	7.8	3.0	4.8	6.9

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2187	Thebes	11.3	17.5	32.7	15.2	0.5	13.4	4.3	9.1	9.6
2191	Kirk	-	13.2	16.5	3.3	-	4.7	1.7	3.0	4.9
2192	Kirk	-	18.8	26.6	7.8	-	-	-	7.8	9.4
2193	Kirk	13.6	15.6	20.7	5.2	0.2	7.8	1.9	5.9	6.4
2194	Kirk	15.9	14.5	22.2	7.6	0.2	7.2	2.0	5.3	5.0
2195	Kirk	16.5	15.1	22.1	7.0	1.0	6.6	0.1	6.5	8.1
2197	Kirk	11.1	18.1	22.6	4.5	0.7	6.9	0.9	6.0	7.2
2199	Kirk	8.9	12.2	19.1	6.9	0.6	7.3	1.7	5.6	6.8
2202	Kirk	17.7	18.4	24.2	5.8	0.2	5.8	1.9	3.9	6.0
2204	Kirk	13.6	16.3	22.0	5.7	0.5	7.1	2.2	4.9	6.3
2211	Kirk	-	17.5	21.6	4.1	-	6.4	1.9	4.5	5.0
2212	Kirk	-	15.6	23.2	7.5	-	7.8	1.6	6.3	6.2
2219	Thebes	14.8	14.1	25.3	11.3	3.0	7.3	3.1	4.2	-
2221	Kirk	-	13.2	17.6	4.4	-	8.6	2.2	6.4	6.6
2222	EFP	20.6	22.5	23.9	1.4	3.1	4.9	-2.2	7.1	-
2223	Thebes	11.9	19.5	27.6	8.0	1.6	8.9	1.4	7.5	9.9
2227	Kirk	5.9	14.2	16.7	2.5	0.5	5.6	1.7	3.9	4.6
2228	Thebes	8.7	21.7	31.3	9.6	2.0	11.2	5.3	5.8	9.6
2230	Kirk	22.9	18.0	27.1	9.1	2.0	10.5	-0.5	11.1	8.9
2233	EFP	17.1	-	-	-	4.2	-	-	-	8.2
2250	Thebes	15.4	16.2	28.9	12.7	0.9	9.6	3.4	6.2	7.3
2253	Thebes	9.8	19.6	31.5	11.9	1.8	9.1	3.6	5.5	9.9
2262	Kirk	-	11.1	14.1	3.0	-	6.3	2.8	3.4	5.8
2264	Thebes	-	21.2	31.9	10.8	-	13.6	9.1	4.5	9.6
2266	Thebes	9.5	20.7	29.1	8.4	0.2	10.9	5.9	5.1	9.4
2267	Thebes	13.1	16.4	23.2	6.9	0.4	8.9	4.5	4.4	8.9
2271	Kirk	-	14.6	20.8	6.1	-	6.5	2.0	4.5	6.1
2273	Hi-Lo	12.9	18.2	18.8	0.6	3.0	1.9	-1.0	2.9	9.7
2274	Thebes	-	17.8	26.3	8.6	-	11.8	6.8	5.0	7.9
2276	Thebes	22.6	19.6	43.5	23.8	6.3	16.1	1.2	14.9	9.6
2277	Thebes	10.5	14.2	25.0	10.8	0.4	11.0	3.3	7.7	8.2
2302	Kirk	22.2	23.5	28.2	4.7	1.0	4.5	0.3	4.2	10.1
2303	Kirk	15.8	14.8	21.5	6.7	0.6	6.4	0.9	5.6	5.4
2314	Thebes	-	13.0	20.6	7.6	-	9.4	5.2	4.2	9.8
2316	Kirk	19.9	16.4	22.1	5.7	0.8	6.0	0.1	5.8	6.5
2322	Thebes	9.5	19.1	23.3	4.2	0.5	9.2	4.4	4.8	7.1
2337	Thebes	14.4	11.8	24.1	12.3	-	-	-	4.9	7.6
2338	Kirk	15.9	16.3	20.6	4.3	1.5	4.9	0.2	4.7	6.8
2341	Thebes	6.6	19.7	35.9	16.1	0.3	14.1	10.5	3.6	8.0
2342	Thebes	21.3	16.3	32.4	16.1	3.4	15.6	2.5	13.1	8.9

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2344	Kirk	-	16.0	19.9	3.9	-	7.6	3.6	4.0	7.4
2350	Kirk	18.6	17.2	23.3	6.1	2.7	5.1	-1.2	6.3	5.8
2353	Thebes	14.7	19.0	33.9	14.9	0.3	16.2	5.2	11.0	9.2
2354	Kirk	-	21.0	27.6	6.6	-	8.2	3.5	4.7	6.4
2360	Kirk	24.9	24.7	31.4	6.6	2.9	7.5	0.5	7.0	8.0
2365	Kirk	16.6	16.4	23.1	6.7	0.6	6.7	1.0	5.7	8.3
2370	EFP	21.8	-	-	-	3.2	-	-	-	7.7
2385	EFP	19.1	21.4	21.7	0.3	4.6	-2.1	-3.4	1.3	6.9
2388	EFP	11.7	-	-	-	1.7	-	-	-	6.6
2392	EFP	22.4	-	-	-	3.8	-	-	-	9.4
2396	EFP	20.3	-	-	-	4.1	-	-	-	7.9
2398	Dalton	21.0	21.3	23.6	2.4	3.1	5.9	-1.5	7.4	7.1
2400	EFP	22.1	23.7	24.7	1.0	2.3	4.8	-1.0	5.9	8.0
2407	Hi-Lo	17.6	21.0	22.0	0.9	2.5	1.9	-0.5	2.4	9.6
2414	Hi-Lo	13.3	19.6	20.1	0.5	1.3	2.8	0.7	2.0	8.1
2421	Thebes	-	18.2	34.4	16.2	-	17.2	5.5	11.8	9.6
2422	Kirk	9.5	13.8	19.8	6.0	1.4	4.6	0.4	4.3	6.7
2428	Kirk	-	17.1	23.2	6.2	-	8.3	3.5	4.8	6.3
2429	Kirk	11.1	11.7	15.1	3.4	0.9	4.4	0.6	3.8	5.4
2437	Kirk	14.1	13.5	20.5	7.0	1.0	5.8	0.0	5.7	6.2
2438	Thebes	21.0	22.7	39.1	16.4	2.4	15.5	7.7	7.8	9.6
2439	Thebes	-	15.5	29.2	13.7	-	14.0	4.7	9.2	7.8
2440	Thebes	-	23.2	41.2	18.1	-	21.4	8.8	12.7	9.4
2441	Hi-Lo	22.2	25.1	25.9	0.8	5.4	1.6	-2.9	4.5	8.4
2442	EFP	22.2	-	-	-	3.8	-	-	-	8.7
2443	Thebes	-	16.7	33.8	17.1	-	18.0	7.8	10.3	8.4
2444	Thebes	-	20.7	32.8	12.2	-	19.0	10.6	8.4	9.6
2446	Thebes	-	16.9	26.3	9.4	-	12.5	7.6	4.9	7.2
2450	Thebes	8.1	16.3	29.2	12.9	0.9	13.0	5.2	7.9	7.8
2451	Kirk	-	13.4	17.3	3.8	-	7.4	3.2	4.2	6.8
2452	Kirk	22.3	20.4	32.8	12.4	-	-	-	8.5	7.0
2454	Kirk	-	17.5	23.3	5.8	-	5.8	1.2	4.7	7.0
2455	Kirk	10.9	12.0	15.0	2.9	0.8	4.1	0.9	3.1	5.5
2470	Kirk	23.5	20.7	28.5	7.8	2.7	7.3	0.4	6.8	8.8
2474	Kirk	-	16.7	24.8	8.1	-	9.0	3.7	5.3	6.8
2477	EFP	18.3	-	-	-	2.6	-	-	-	8.1
2482	Thebes	-	14.7	22.5	7.8	-	9.6	5.9	3.8	8.2
2483	Thebes	-	16.2	33.8	17.6	-	15.7	6.1	9.6	9.3
2484	Kirk	8.3	14.7	16.4	1.7	0.3	4.9	2.6	2.2	6.6
2485	Thebes	7.0	19.8	33.0	13.2	0.4	16.6	7.3	9.3	9.0

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2486	Thebes	25.0	22.0	42.3	20.4	3.0	14.6	3.7	10.9	9.1
2487	Thebes	-	16.1	30.2	14.1	-	11.0	6.2	4.8	7.0
2489	Thebes	15.6	21.6	34.6	13.0	0.8	15.2	5.1	10.1	13.9
2491	Kirk	21.5	20.7	27.4	6.7	1.6	9.0	1.1	7.9	8.6
2498	Kirk	13.7	14.7	21.5	6.8	0.7	6.6	1.7	4.9	6.1
2502	Kirk	16.3	16.8	22.3	5.5	0.5	6.8	1.8	5.0	5.9
2510	Thebes	4.0	12.8	22.6	9.8	0.2	11.0	5.9	5.2	8.4
2512	Thebes	-	18.7	28.9	10.2	-	11.3	4.7	6.6	8.9
2516	Kirk	15.6	17.8	21.8	4.0	2.3	5.0	0.2	4.9	5.4
2517	Kirk	-	22.3	28.7	6.4	-	8.5	3.0	5.6	6.6
2518	Thebes	-	19.6	35.3	15.7	-	13.6	6.4	7.2	7.8
2519	Thebes	17.7	15.8	29.6	13.8	0.1	14.4	4.7	9.7	7.9
2520	Thebes	14.8	17.5	31.8	14.3	1.8	12.1	5.0	7.1	9.7
2521	Hi-Lo	12.9	17.1	17.9	0.9	1.7	3.4	1.0	2.4	9.5
2522	Kirk	11.0	15.5	19.6	4.1	0.6	7.7	3.3	4.4	8.0
2527	Thebes	-	18.5	30.1	11.6	-	12.4	7.1	5.3	9.5
2528	Thebes	-	16.8	31.4	14.6	-	11.6	7.2	4.4	6.8
2529	Thebes	-	17.1	32.6	15.5	-	17.2	8.7	8.5	9.0
2532	Thebes	-	15.8	27.4	11.5	-	14.4	7.2	7.2	7.9
2534	Kirk	19.8	17.5	23.9	6.4	0.7	7.4	1.6	5.8	7.7
2540	Kirk	-	21.1	35.9	14.8	-	11.6	5.3	6.3	8.5
2541	Kirk	17.2	17.9	27.4	9.5	0.8	9.8	4.2	5.6	6.7
2544	Kirk	13.8	16.6	19.1	2.5	0.7	4.7	1.2	3.4	7.2
2545	Thebes	-	18.4	30.4	12.0	-	12.8	8.5	4.3	8.2
2546	Thebes	-	19.2	35.5	16.3	-	17.0	7.1	9.9	10.9
2547	Thebes	-	16.2	27.7	11.5	-	14.1	4.3	9.8	8.0
2550	Thebes	17.7	15.9	27.3	11.4	1.4	10.8	1.1	9.7	7.3
2555	Thebes	10.6	17.8	22.3	4.5	2.0	7.2	3.0	4.2	10.3
2556	Thebes	7.4	18.6	28.0	9.4	1.3	10.0	4.1	5.8	10.8
2564	Thebes	-	15.3	23.8	8.5	-	11.1	6.7	4.3	10.1
2566	Thebes	10.3	18.6	24.8	6.3	0.7	8.2	2.8	5.4	8.9
2567	Thebes	-	14.5	24.1	9.6	-	10.8	7.0	3.8	10.3
2570	Thebes	4.0	14.6	-	-	0.5	8.2	-	-	9.9
2571	Thebes	19.7	19.1	40.1	21.0	0.8	14.1	5.0	9.1	7.6
2577	Thebes	-	14.4	25.1	10.7	-	12.1	7.2	4.9	9.6
2578	Thebes	5.8	13.7	22.1	8.4	0.6	12.1	6.3	5.8	9.5
2579	Thebes	10.9	15.9	22.6	6.6	0.8	8.6	4.1	4.6	9.0
2580	Thebes	10.4	17.9	23.8	5.9	1.2	10.3	5.7	4.6	9.8
2581	Kirk	-	13.6	17.4	3.8	-	5.8	3.4	2.5	5.0
2582	Kirk	8.3	15.3	19.2	3.9	0.5	5.8	1.6	4.2	6.7

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2584	Kirk	-	17.0	25.7	8.7	-	9.2	2.3	6.9	5.7
2585	Kirk	14.8	23.1	25.6	2.6	1.9	6.4	1.6	4.8	6.9
2586	Kirk	8.1	15.3	19.1	3.8	0.5	5.8	1.5	4.3	6.1
2587	Kirk	-	16.1	22.4	6.4	-	9.2	2.6	6.7	7.2
2589	Kirk	-	14.3	18.6	4.3	-	6.4	4.1	2.3	5.6
2591	Kirk	-	14.2	21.0	6.8	-	-	-	3.9	5.9
2592	Kirk	8.6	17.3	21.4	4.1	0.7	5.1	1.9	3.2	4.5
2593	Kirk	10.3	19.2	25.7	6.5	0.2	7.6	2.7	4.9	8.1
2594	Kirk	-	18.6	25.8	7.2	-	8.1	3.2	4.9	6.3
2595	Kirk	-	12.6	16.4	3.8	-	5.2	2.5	2.6	-
2597	Kirk	19.9	16.1	23.1	6.9	1.3	6.0	0.1	5.8	4.9
2598	Kirk	18.9	23.7	30.0	6.3	0.9	7.8	2.6	5.2	7.9
2599	Kirk	12.1	15.5	20.2	4.8	0.5	5.9	1.4	4.5	7.4
2600	Kirk	11.6	13.8	18.4	4.6	0.6	5.0	0.4	4.6	7.0
2601	Kirk	-	18.2	24.0	5.9	-	6.4	1.9	4.6	6.1
2602	Kirk	-	19.2	26.2	7.0	-	7.0	3.4	3.6	5.6
2605	Kirk	10.5	17.7	21.1	3.5	0.4	6.1	1.3	4.8	6.5
2608	Kirk	10.2	17.3	24.7	7.4	0.8	8.3	3.0	5.3	8.2
2609	Kirk	-	17.9	23.0	5.2	-	7.7	4.3	3.4	5.3
2610	Kirk	12.8	16.6	20.2	3.7	2.5	4.3	0.2	4.0	8.1
2612	Kirk	-	16.8	20.9	4.2	-	6.9	3.1	3.8	6.4
2614	Kirk	-	15.7	20.3	4.6	-	4.9	1.3	3.7	6.4
2615	Kirk	19.3	17.5	26.8	9.4	0.2	9.0	2.2	6.8	6.1
2616	Kirk	9.0	16.5	23.4	6.9	0.2	10.0	2.4	7.6	7.3
2618	Kirk	-	12.6	17.4	4.8	-	7.5	3.7	3.8	6.4
2620	Kirk	-	15.4	20.4	5.0	-	7.2	1.1	6.1	6.3
2621	Kirk	-	13.5	20.9	7.4	-	6.4	3.1	3.3	4.7
2624	Kirk	-	14.1	18.8	4.7	-	6.2	2.9	3.3	5.4
2625	Kirk	24.0	23.1	34.6	11.5	0.2	11.6	3.2	8.4	7.2
2626	Kirk	-	14.9	21.4	6.5	-	8.7	4.2	4.5	6.5
2628	Kirk	8.0	15.0	23.3	8.3	0.3	8.9	4.5	4.4	6.0
2629	Thebes	19.0	20.1	31.7	11.7	0.5	11.4	5.6	5.9	-
2630	Thebes	-	16.5	26.4	9.9	-	12.8	7.6	5.2	5.7
2632	Kirk	15.0	17.2	24.8	7.7	0.8	8.1	1.7	6.4	6.9
2634	Kirk	-	13.6	18.5	4.9	-	6.3	3.4	2.9	4.7
2635	Thebes	23.6	23.3	41.3	18.0	1.7	13.1	6.0	7.1	10.6
2637	Kirk	16.6	16.0	24.1	8.2	1.3	7.2	1.4	5.8	6.3
2638	Kirk	12.5	14.3	20.9	6.7	0.4	7.1	1.9	5.2	6.6
2639	Thebes	-	12.4	18.3	5.9	-	9.4	5.2	4.2	8.1
2640	Kirk	10.3	17.3	20.9	3.6	1.5	4.8	1.2	3.5	6.2

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2645	Kirk	-	16.2	24.3	8.1	-	9.8	3.1	6.7	6.8
2647	Thebes	19.4	20.0	39.2	19.1	0.9	15.1	7.4	7.7	7.3
2648	Thebes	7.8	19.5	31.1	11.6	1.3	11.0	3.3	7.7	9.3
2649	Kirk	10.4	16.7	20.4	3.7	0.4	4.9	2.4	2.4	6.2
2650	Thebes	13.7	19.8	28.4	8.5	0.7	9.8	5.1	4.7	7.1
2651	Thebes	12.3	19.2	21.8	2.6	0.8	7.4	2.4	4.9	7.9
2652	Kirk	-	17.4	23.0	5.6	-	7.0	3.1	3.9	7.0
2653	Kirk	13.4	16.5	20.3	3.7	0.5	5.3	1.7	3.6	6.1
2654	Kirk	13.1	14.9	19.6	4.8	1.1	5.4	2.0	3.5	6.4
2655	EFP	24.2	-	-	-	5.6	-	-	-	-
2657	EFP	16.2	-	-	-	2.8	-	-	-	-
2662	EFP	22.5	-	-	-	5.7	-	-	-	-
2664	EFP	23.6	-	28.5	-	8.8	-	-4.4	-	-
2665	EFP	27.8	-	31.6	-	9.1	-	-6.7	-	-
2666	EFP	28.8	-	31.8	-	7.0	-	-3.6	-	-
2677	Dalton	22.1	24.9	27.6	2.7	5.5	6.6	-3.3	9.8	-
2678	Dalton	22.2	21.7	24.4	2.7	3.5	5.0	-2.2	7.2	-
2683	EFP	23.1	-	-	-	5.6	-	-	-	-
2686	EFP	20.8	-	-	-	3.5	-	-	-	-
2702	Hi-Lo	20.5	22.4	24.7	2.4	1.9	4.0	-0.1	4.0	-
2703	Hi-Lo	12.8	17.8	18.5	0.7	2.5	2.0	0.1	1.9	-
2708	Hi-Lo	13.5	20.3	21.4	1.2	1.9	4.9	0.0	4.9	-
2711	Hi-Lo	15.7	21.9	23.1	1.2	3.7	5.4	0.3	5.1	-
2712	Hi-Lo	18.2	23.5	25.7	2.2	2.0	6.5	2.4	4.1	-
2715	Hi-Lo	14.8	18.0	18.7	0.7	2.0	3.6	2.0	1.6	-
2716	Hi-Lo	13.6	16.0	17.8	1.9	2.0	4.1	0.0	4.1	-
2718	Hi-Lo	17.4	20.2	21.8	1.5	3.5	2.4	-1.2	3.6	-
2722	Hi-Lo	17.2	19.9	21.4	1.5	2.7	3.1	-1.5	4.6	-
2735	Kirk	10.3	14.0	18.1	4.1	0.6	7.2	2.5	4.6	-
2736	Kirk	-	13.0	14.5	1.5	-	6.4	4.4	2.0	-
2737	Kirk	-	13.8	16.1	2.4	-	7.1	2.8	4.3	-
2742	Kirk	6.4	15.8	18.5	2.7	0.5	6.3	2.3	4.0	-
2743	Kirk	-	14.5	17.2	2.7	-	6.6	2.1	4.5	-
2744	Kirk	-	17.7	21.2	3.5	-	7.0	2.9	4.0	-
2745	Kirk	15.2	15.4	22.7	7.3	1.9	5.0	0.6	4.4	-
2746	Kirk	11.0	17.7	23.5	5.7	0.3	7.4	2.4	5.0	-
2747	Kirk	7.4	18.7	27.7	8.9	0.4	9.5	4.1	5.3	-
2750	Kirk	18.6	18.1	23.6	5.6	0.7	6.0	1.0	5.0	-
2752	Kirk	18.7	20.9	25.1	4.2	0.8	4.1	0.6	3.5	-
2753	Kirk	6.6	19.8	27.2	7.4	0.7	9.4	3.6	5.8	-

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2826	Thebes	15.6	20.3	30.6	10.3	0.5	11.2	6.3	4.8	-
2827	Thebes	23.8	22.5	41.0	18.6	1.8	18.6	8.4	10.2	-
2829	Thebes	-	28.0	53.2	25.2	-	18.2	7.7	10.6	-
2830	Thebes	-	13.7	27.4	13.7	-	15.2	2.1	13.1	-
2837	Kirk	-	12.9	19.5	6.6	-	7.4	2.5	4.9	6.4
2838	Kirk	-	14.5	21.9	7.4	-	9.5	4.6	4.9	7.0
2848	Kirk	-	19.5	21.7	2.3	-	6.6	3.1	3.5	6.6
2852	Kirk	-	12.6	15.4	2.8	-	-	-	2.9	6.1
2861	Thebes	7.4	21.0	31.5	10.5	-	-	-	5.1	8.2
2866	Thebes	-	21.3	30.2	8.9	-	12.8	8.2	4.6	8.1
2867	Kirk	13.0	17.5	21.6	4.0	1.2	6.0	1.7	4.4	6.0
2874	Kirk	9.8	18.7	23.5	4.8	1.4	4.8	0.8	3.9	6.2
2895	Kirk	-	13.2	19.1	5.9	-	7.3	2.1	5.2	6.8
2907	Kirk	30.2	27.1	32.8	5.7	1.9	7.8	1.4	6.4	8.3
2915	Thebes	-	17.1	28.8	11.8	-	12.6	3.4	9.2	8.7
2920	Kirk	8.5	15.7	21.5	5.8	0.2	7.3	2.6	4.7	7.1
2928	Kirk	8.8	15.1	20.4	5.2	0.6	6.5	2.1	4.4	5.7
2929	Kirk	10.9	17.0	19.5	2.5	0.6	4.7	1.7	3.1	5.8
2930	Thebes	-	18.6	33.6	14.9	-	14.3	7.0	7.3	10.5
2934	Kirk	13.0	17.2	22.3	5.1	1.4	5.5	0.7	4.7	6.5
2936	Kirk	16.4	15.7	20.8	5.1	2.5	4.3	-0.9	5.2	5.9
2939	Thebes	-	18.6	24.7	6.1	-	11.8	3.0	8.8	8.2
2942	Kirk	-	15.2	19.3	4.1	-	5.6	1.9	3.7	7.3
2943	Kirk	19.9	22.3	28.0	5.7	2.8	6.2	-0.7	6.9	8.1
2945	Kirk	18.7	17.8	26.1	8.4	0.8	8.6	3.7	4.9	6.2
2946	Thebes	12.5	12.4	23.5	11.2	0.6	10.1	1.9	8.1	7.8
2947	Kirk	11.6	16.1	20.0	3.9	0.5	4.8	1.5	3.3	5.1
2959	Kirk	-	9.7	16.5	6.7	-	6.4	1.8	4.6	5.1
2961	Thebes	4.7	18.9	26.8	7.9	0.1	10.5	6.9	3.5	10.2
2962	Thebes	-	14.7	20.2	5.5	-	8.3	5.0	3.3	8.3
2964	Thebes	17.1	15.7	25.3	9.5	0.4	8.9	2.3	6.6	8.1
2967	Thebes	-	17.4	34.3	16.9	-	18.1	5.7	12.4	9.3
2969	Kirk	9.3	14.6	19.5	4.9	0.8	6.2	2.8	3.4	6.6
2970	Thebes	10.2	17.6	30.7	13.1	1.6	12.9	5.0	7.9	7.9
2971	Thebes	-	11.1	18.7	7.6	-	9.4	5.1	4.2	7.8
2972	Kirk	17.5	19.2	24.2	5.0	1.8	7.0	2.1	4.9	7.1
2978	Kirk	-	16.1	23.5	7.4	-	9.2	2.8	6.4	5.8
2979	Kirk	-	13.9	19.6	5.7	-	5.6	2.2	3.5	6.6
2986	Thebes	-	14.7	20.7	6.1	-	9.0	4.7	4.3	8.9
2987	Kirk	-	17.3	26.1	8.8	-	8.7	3.0	5.7	6.8

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2990	Kirk	6.0	18.4	23.2	4.8	1.1	5.2	1.0	4.2	7.8
2993	Kirk	9.9	13.5	18.9	5.4	0.6	7.2	1.4	5.8	5.5
3000	Thebes	-	16.7	31.6	14.9	-	12.1	6.2	5.9	7.8
3002	Kirk	-	16.8	22.3	5.5	-	6.8	3.7	3.1	6.0
3003	Kirk	22.7	26.6	31.0	4.4	0.6	6.5	3.2	3.2	9.0
3006	Kirk	13.5	13.8	19.9	6.1	0.1	6.7	1.8	5.0	6.0
3007	Kirk	21.2	19.1	27.8	8.7	2.4	7.4	1.0	6.4	6.4
3008	Kirk	10.7	14.1	18.6	4.5	1.1	6.5	3.0	3.5	5.5
3009	Kirk	9.4	14.9	18.0	3.1	0.4	7.2	3.3	3.9	6.3
3011	Kirk	-	14.6	24.7	10.1	-	10.7	3.2	7.5	7.0
3014	Thebes	10.6	18.0	28.0	10.0	0.7	10.4	3.9	6.4	8.5
3016	Kirk	20.4	17.3	24.5	7.2	0.7	5.2	-0.1	5.3	6.2
3017	Kirk	-	18.0	27.4	9.4	-	8.5	3.2	5.3	5.7
3018	Kirk	10.5	14.2	19.1	4.9	0.5	6.4	1.3	5.1	5.2
3020	Thebes	6.3	13.7	24.2	10.5	0.3	11.7	4.6	7.1	7.3
3022	Thebes	15.9	21.3	24.8	3.5	0.8	12.5	1.1	11.4	8.7
3025	Kirk	22.1	19.2	26.7	7.5	1.7	7.1	0.7	6.5	7.3
3026	Kirk	-	16.0	23.5	7.5	-	7.9	3.0	4.9	6.2
3027	Thebes	20.6	22.2	38.6	16.4	1.1	12.0	6.8	5.3	8.3
3029	Kirk	12.8	17.2	21.0	3.8	0.5	8.3	3.5	4.8	7.3
3030	Kirk	-	19.7	27.4	7.7	-	10.8	4.7	6.0	7.3
3035	Thebes	-	17.2	29.9	12.7	-	13.5	7.0	6.5	10.4
3038	Kirk	-	11.6	16.8	5.1	-	6.8	3.0	3.9	6.3
3039	Thebes	10.0	14.9	22.6	7.7	1.5	9.5	5.0	4.6	9.4
3043	Kirk	19.4	19.9	22.2	2.4	1.7	5.1	0.5	4.6	7.3
3046	Kirk	15.7	14.3	19.7	5.4	1.4	5.1	1.7	3.5	5.8
3047	Kirk	14.9	14.9	19.3	4.4	1.1	4.8	1.3	3.5	5.6
3048	Kirk	-	13.9	20.2	6.4	-	7.6	2.8	4.8	6.3
3049	Thebes	4.5	23.2	43.4	20.2	0.3	21.3	10.8	10.5	11.3
3053	Kirk	4.1	15.8	19.8	4.0	0.7	5.4	2.6	2.9	6.3
3057	Kirk	11.0	14.7	20.3	5.6	0.5	6.5	3.1	3.4	7.1
3059	Thebes	14.2	17.7	31.7	14.0	0.4	13.7	2.8	10.9	9.4
3068	Kirk	13.5	17.2	20.9	3.7	0.5	5.6	1.7	3.9	7.4
3070	Thebes	-	14.8	25.3	10.5	-	11.9	7.5	4.4	8.8
3074	Thebes	5.8	16.4	26.4	10.0	0.5	10.6	3.8	6.8	8.1
3075	Thebes	11.9	20.9	27.7	6.8	0.5	9.3	4.9	4.3	8.1
3076	Kirk	-	17.9	27.0	9.1	-	10.3	2.9	7.4	7.0
3079	Kirk	-	14.0	23.4	9.3	-	8.6	2.6	6.0	7.0
3080	Kirk	-	17.8	21.6	3.8	-	6.8	1.9	4.9	7.7
3083	Kirk	8.1	14.5	19.0	4.5	0.3	6.1	2.6	3.6	6.6

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3089	Kirk	18.3	19.8	25.4	5.6	1.2	5.6	0.9	4.7	6.3
3091	Kirk	15.0	14.4	21.4	7.1	0.5	7.6	2.6	5.0	6.3
3096	Kirk	-	13.7	19.1	5.4	-	6.3	1.8	4.5	6.1
3098	Kirk	15.0	17.5	26.8	9.3	1.1	7.8	1.2	6.6	6.6
3099	Kirk	14.8	19.2	23.6	4.4	2.3	5.0	1.2	3.8	6.0
3101	Kirk	-	17.7	23.7	6.0	-	6.7	3.4	3.3	5.9
3102	Kirk	12.6	18.1	21.0	2.9	2.0	4.5	1.3	3.2	5.9
3104	Thebes	-	17.1	29.7	12.6	-	16.2	7.8	8.4	9.2
3108	Kirk	4.5	16.4	23.0	6.7	0.5	7.1	3.6	3.5	6.1
3110	Kirk	18.9	17.1	23.1	6.0	0.4	6.7	1.7	4.9	6.2
3112	Thebes	-	15.7	22.6	6.9	-	9.9	5.6	4.3	-
3119	Kirk	-	18.6	25.4	6.7	-	8.5	3.7	4.8	7.0
3123	Kirk	16.5	23.1	27.4	4.2	0.9	8.2	3.2	4.9	8.1
3125	Kirk	16.2	15.2	20.8	5.6	0.6	5.1	0.5	4.6	6.5
3126	Kirk	21.3	19.5	24.0	4.6	1.4	3.4	0.0	3.5	5.9
3127	Kirk	20.1	18.5	22.4	3.9	1.3	3.7	-0.3	4.0	7.1
3128	Kirk	12.8	17.8	22.3	4.5	0.9	5.6	1.8	3.8	6.8
3129	Kirk	22.0	18.0	27.3	9.2	1.6	7.1	2.2	4.9	6.3
3131	Kirk	20.1	17.6	24.7	7.0	2.5	5.6	-0.3	5.9	6.6
3132	Kirk	19.9	17.9	25.9	8.0	1.4	8.7	1.2	7.4	5.7
3133	Kirk	-	16.0	21.0	5.0	-	7.3	2.9	4.3	6.4
3134	Kirk	-	18.3	23.4	5.1	-	6.4	3.4	3.1	5.8
3142	Kirk	-	18.6	25.6	6.9	-	8.7	3.8	4.9	6.1
3143	Kirk	19.3	16.3	23.4	7.1	0.9	6.8	1.6	5.2	6.0
3145	Kirk	8.7	13.4	19.5	6.0	0.5	6.4	3.0	3.3	6.8
3153	Kirk	-	14.7	22.1	7.5	-	6.6	2.7	3.9	5.1
3178	Kirk	-	18.9	23.4	4.4	-	7.2	2.1	5.2	6.5
3179	Kirk	-	18.3	25.1	6.8	-	8.6	3.4	5.2	7.7
3181	Kirk	-	19.2	23.8	4.6	-	-	-	4.2	6.1
3182	Kirk	12.9	14.7	20.2	5.6	0.9	5.3	0.3	5.0	6.0
3185	Kirk	15.4	15.2	21.6	6.5	0.6	6.0	1.6	4.4	6.7
3186	Kirk	19.0	17.4	27.2	9.8	0.5	10.2	3.2	6.9	7.0
3187	Kirk	20.3	16.0	24.7	8.7	1.4	8.1	2.4	5.7	6.8
3190	Kirk	19.5	18.1	26.3	8.2	0.7	7.9	2.2	5.6	6.5
3191	Thebes	22.0	19.4	28.2	8.8	1.9	9.8	3.3	6.5	7.2
3192	Thebes	8.6	14.5	22.6	8.1	0.3	9.2	5.4	3.9	9.0
3194	Kirk	-	17.4	22.0	4.6	-	-	-	4.3	6.5
3198	Kirk	-	17.4	21.8	4.4	-	7.3	3.5	3.8	6.5
3200	Kirk	-	13.9	20.0	6.2	-	6.7	3.3	3.5	-
3201	Kirk	-	16.8	22.7	5.9	-	7.2	2.6	4.6	6.5

Point ID	Group	A	B	C	E	F	G	H	I	Max. Thick.
3202	Kirk	-	17.6	23.7	6.1	-	7.6	2.5	5.1	7.3
3203	Kirk	6.7	13.4	19.0	5.6	0.8	6.4	0.7	5.6	7.4
3204	Thebes	10.0	16.8	27.0	10.2	2.2	8.6	1.1	7.5	9.0
3205	Thebes	16.1	20.6	38.6	18.1	1.2	14.0	5.6	8.4	8.9
3206	Kirk	15.9	17.9	25.8	7.9	0.7	7.4	2.6	4.8	7.6
3208	Thebes	-	13.5	20.8	7.3	-	10.5	6.8	3.7	9.8
3210	Kirk	-	19.3	26.4	7.1	-	8.7	3.9	4.8	7.5
3216	Thebes	17.3	18.2	28.7	10.6	0.6	10.6	5.4	5.2	8.4
3218	Kirk	17.4	18.8	25.0	6.1	1.1	6.2	0.9	5.3	7.2
3222	Kirk	6.7	19.0	26.0	7.0	1.3	6.2	1.5	4.7	5.5
3223	Dalton	24.9	27.1	31.2	4.1	3.9	6.5	-0.6	7.1	9.1
3225	Kirk	13.0	16.6	21.4	4.8	0.6	8.1	2.7	5.4	6.2
3226	Kirk	7.6	19.0	23.1	4.1	1.9	5.3	1.9	3.4	5.1
3228	Kirk	-	12.3	18.7	6.4	-	8.1	3.1	5.0	6.3
3235	Kirk	14.8	15.3	22.6	7.3	1.2	6.7	1.1	5.7	6.5
3236	Kirk	23.6	18.8	31.7	12.9	1.5	10.7	2.5	8.2	5.5
3238	Kirk	-	13.5	20.9	7.4	-	6.5	3.2	3.3	6.1
3240	Thebes	-	21.2	27.4	6.2	-	11.5	4.6	6.8	8.4
3241	Kirk	15.4	15.5	19.9	4.4	1.5	4.4	0.6	3.8	4.6
3246	Thebes	6.0	10.1	18.5	8.5	0.4	7.2	3.9	3.2	7.5
3249	Kirk	18.6	18.1	23.3	5.2	1.0	6.5	2.2	4.4	6.3
3250	Kirk	-	14.2	21.6	7.4	-	7.0	2.2	4.8	5.8
3251	Thebes	16.1	15.6	26.1	10.5	1.0	13.5	2.4	11.0	8.4
3253	Kirk	-	18.2	25.7	7.5	-	8.2	2.4	5.9	8.0
3254	Kirk	6.7	17.2	24.8	7.6	0.3	9.3	2.0	7.3	6.9
3255	Kirk	-	16.1	22.0	5.9	-	7.7	1.5	6.2	8.4
3256	Kirk	-	17.2	23.2	6.0	-	8.8	2.6	6.1	5.4
3257	Kirk	13.3	19.1	24.5	5.4	0.3	7.4	1.4	6.0	8.6
3258	Kirk	-	16.7	22.9	6.2	-	7.7	3.1	4.6	7.3
3259	Kirk	-	13.5	17.4	3.9	-	-	-	2.8	7.1
3260	Kirk	-	16.2	22.4	6.2	-	9.3	3.3	6.0	7.5
3261	Kirk	-	14.0	21.1	7.1	-	7.2	3.1	4.1	6.1
3263	Kirk	-	14.0	19.7	5.7	-	7.2	2.4	4.8	7.2
3264	Kirk	-	20.7	27.6	6.8	-	10.1	3.5	6.6	7.2
3266	Kirk	-	14.1	19.0	4.9	-	6.5	2.2	4.4	6.0
3267	Kirk	-	17.1	24.1	7.0	-	8.3	4.4	3.8	6.5
3268	Kirk	-	17.0	22.0	5.0	-	7.7	2.9	4.8	7.9
3269	Thebes	27.0	21.6	42.3	20.7	-	-	-	8.9	9.3
3270	Thebes	-	14.6	23.4	8.8	-	10.8	6.0	4.8	7.7
3271	Thebes	6.3	16.7	25.4	8.7	1.0	8.9	4.5	4.4	9.7

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3274	Thebes	-	21.2	27.3	6.1	-	10.4	3.1	7.3	8.0
3276	Thebes	-	26.0	34.1	8.1	-	14.8	4.3	10.4	9.5
3277	Thebes	-	24.0	30.9	6.9	-	9.7	3.5	6.2	8.5
3278	Thebes	-	17.6	25.0	7.4	-	10.9	3.6	7.3	7.6
3279	Thebes	-	17.8	38.0	20.2	-	13.7	5.7	8.0	10.8
3280	Thebes	25.3	20.7	33.8	13.1	4.1	9.2	3.4	5.8	8.5
3281	Thebes	16.6	19.2	31.3	12.1	2.4	9.9	3.8	6.0	7.6
3282	Thebes	18.3	23.2	27.8	4.6	1.9	8.3	1.5	6.7	8.1
3283	Thebes	13.7	21.9	28.9	7.0	0.2	9.3	3.2	6.1	8.7
3284	Kirk	-	20.7	26.2	5.4	-	7.6	2.5	5.1	7.5
3285	Kirk	-	19.7	28.5	8.8	-	9.9	2.6	7.2	7.5
3288	Kirk	9.8	14.7	23.9	9.2	0.3	7.4	1.7	5.7	7.3
3297	Thebes	-	22.6	34.5	11.9	-	11.4	7.6	3.9	8.2
3300	Thebes	3.2	14.2	23.0	8.8	0.4	8.7	4.2	4.5	8.3
3302	Thebes	10.1	16.4	23.9	7.5	1.6	7.4	3.3	4.1	9.9
3305	Kirk	-	14.9	21.2	6.3	-	8.5	3.9	4.6	6.9
3306	Kirk	-	14.0	17.4	3.4	-	7.4	3.5	3.9	7.5
3307	Kirk	-	18.0	22.0	4.0	-	8.2	4.6	3.6	8.2
3308	Kirk	-	12.3	15.1	2.8	-	5.8	2.9	3.0	4.8
3309	Kirk	-	13.2	17.6	4.4	-	7.5	1.8	5.7	7.6
3310	Kirk	-	15.0	20.3	5.3	-	6.7	2.2	4.5	5.5
3315	Thebes	-	13.6	25.5	11.9	-	15.6	6.2	9.4	7.4
3316	Thebes	21.7	16.5	35.4	18.9	0.7	12.5	5.5	7.1	8.4
3320	Dalton	17.2	26.1	26.9	0.9	6.1	-0.9	-2.9	2.0	7.5
3326	Thebes	-	19.8	27.0	7.2	-	-	-	5.4	7.3
3328	Kirk	-	13.0	17.0	4.0	-	6.5	1.8	4.7	5.6
3329	Kirk	-	12.5	18.5	6.0	-	6.7	2.6	4.1	5.6
3330	Thebes	16.8	17.9	24.6	6.7	1.0	9.7	1.5	8.2	6.9
3331	Kirk	13.3	14.5	18.7	4.2	1.1	4.6	1.7	2.9	5.1
3332	Kirk	-	18.7	24.5	5.8	-	8.9	1.9	7.1	5.5
3334	Kirk	18.7	20.6	27.1	6.5	1.2	9.4	2.4	7.0	8.1
3335	Kirk	-	17.1	22.3	5.2	-	7.3	1.4	5.8	5.7
3336	Kirk	-	18.4	23.9	5.6	-	7.3	2.2	5.1	7.0
3337	Kirk	14.6	17.8	24.6	6.7	0.5	7.6	2.4	5.2	6.5
3338	Kirk	-	18.9	26.2	7.3	-	10.1	4.0	6.1	6.2
3339	Kirk	14.7	17.2	23.0	5.8	0.4	8.5	2.2	6.2	6.2
3340	Kirk	17.9	14.7	22.4	7.8	0.8	6.4	1.6	4.8	5.5
3341	Kirk	-	21.9	30.3	8.4	-	9.1	1.4	7.6	7.7
3342	Kirk	17.9	18.3	22.2	3.9	0.8	6.9	1.6	5.4	6.8
3343	Kirk	-	15.9	23.1	7.2	-	7.7	2.0	5.8	7.8

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3344	Kirk	-	20.0	24.6	4.6	-	7.9	2.5	5.4	9.5
3346	Kirk	-	16.2	22.0	5.8	-	8.7	3.0	5.7	6.6
3347	Kirk	-	17.4	21.1	3.7	-	6.6	1.7	4.9	6.3
3348	Kirk	-	18.3	23.8	5.5	-	7.1	1.4	5.7	5.8
3352	Kirk	10.1	13.6	15.1	1.5	0.8	4.1	1.4	2.8	5.1
3355	Hi-Lo	14.8	16.9	19.6	2.7	1.4	4.4	0.2	4.2	6.0
3366	Kirk	18.7	21.0	24.3	3.3	1.8	5.8	1.7	4.1	7.6
3367	Kirk	17.9	16.5	25.5	9.1	0.5	8.5	1.9	6.6	6.8
3368	Kirk	6.6	16.8	25.5	8.6	1.0	6.1	2.2	3.9	6.9
3371	Thebes	-	19.4	27.2	7.9	-	13.3	8.2	5.2	9.7
3372	Thebes	-	18.6	27.7	9.0	-	11.1	6.1	5.0	10.3
3373	Thebes	15.8	19.1	27.5	8.4	2.0	9.1	4.5	4.6	10.2
3376	Kirk	13.6	13.1	19.5	6.4	1.9	5.5	0.8	4.7	5.4
3377	Dalton	-	18.5	-	-	-	6.3	-	-	7.5
3380	Hi-Lo	15.7	17.2	18.8	1.7	1.5	3.3	0.1	3.1	8.1
3385	Kirk	14.1	15.2	18.9	3.7	2.0	3.8	0.6	3.3	6.0
3386	Kirk	12.0	12.2	15.6	3.4	1.1	4.6	0.4	4.2	6.1
3387	Thebes	-	18.9	25.5	6.6	-	10.5	4.4	6.1	9.8
3395	Kirk	11.5	19.1	23.1	4.0	0.4	6.7	1.3	5.4	6.9
3396	Kirk	26.7	24.1	31.4	7.3	1.6	10.8	0.7	10.1	8.8
3397	Thebes	-	18.3	26.0	7.7	-	12.3	8.2	4.0	11.6
3399	Kirk	16.2	16.2	21.2	5.0	1.5	5.5	-0.2	5.7	5.4
3402	Thebes	14.9	19.5	32.6	13.1	0.5	13.3	4.3	9.0	7.7
3403	Thebes	7.9	14.6	21.4	6.8	0.2	9.3	4.8	4.5	8.6
3405	Thebes	-	17.3	32.9	15.6	-	15.5	6.8	8.7	10.1
3407	Thebes	12.6	15.1	24.3	9.2	1.3	8.3	2.3	6.0	8.3
3411	Kirk	14.1	15.1	22.3	7.2	0.5	5.8	1.3	4.5	6.2
3413	Kirk	16.2	17.7	22.1	4.3	1.1	4.9	1.0	4.0	5.3
3415	Thebes	-	20.8	33.4	12.6	-	12.7	8.0	4.7	8.9
3428	Kirk	11.9	13.6	19.0	5.4	0.4	5.6	1.4	4.2	6.7
3430	Kirk	11.2	13.4	18.3	4.9	0.5	5.6	2.1	3.6	6.4
3433	Kirk	10.9	17.9	22.2	4.3	0.6	5.5	1.4	4.1	7.0
3436	Kirk	14.3	14.0	19.5	5.5	1.7	5.7	1.3	4.4	7.4
3438	Kirk	15.0	14.4	20.6	6.1	1.0	6.3	0.7	5.6	6.4
3441	Kirk	14.9	13.9	21.0	7.0	1.0	6.5	1.8	4.8	7.8
3442	Kirk	13.7	15.4	21.1	5.7	1.3	5.2	1.4	3.8	5.9
3446	Kirk	13.4	15.4	21.5	6.1	1.1	5.0	1.2	3.9	5.5
3448	Kirk	9.1	14.2	17.0	2.8	0.2	4.2	1.1	3.1	8.0
3449	Kirk	3.7	15.0	-	-	0.2	7.3	-	-	6.5
3450	Kirk	15.1	16.6	20.7	4.1	0.6	6.6	1.6	5.0	6.5

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3452	Kirk	-	17.8	21.8	4.0	-	7.4	3.0	4.3	6.4
3460	Kirk	13.1	12.1	17.8	5.7	0.9	5.3	1.0	4.3	6.2
3461	Kirk	12.0	22.1	25.8	3.7	1.3	8.0	2.0	6.0	7.1
3463	Thebes	-	22.0	36.8	14.8	-	15.2	8.6	6.6	10.6
3464	Thebes	-	19.8	29.2	9.4	-	13.6	6.4	7.3	8.4
3466	Thebes	-	21.0	34.9	14.0	-	17.1	8.9	8.2	10.9
3467	Thebes	15.0	19.6	31.9	12.3	0.5	13.7	4.6	9.2	10.5
3468	EFP	19.1	-	-	-	3.3	-	-	-	7.5
3470	Kirk	8.7	20.1	25.2	5.2	0.6	6.9	1.7	5.1	7.1
3473	Thebes	-	22.8	43.8	21.0	-	15.0	9.5	5.5	7.4
3474	Thebes	11.6	19.2	31.8	12.6	1.2	10.4	2.3	8.1	9.0
3475	Thebes	-	14.3	24.1	9.8	-	12.1	3.7	8.4	8.4
3476	Thebes	16.5	19.3	31.7	12.4	1.2	11.3	1.9	9.4	7.5
3477	Thebes	10.5	20.5	32.6	12.1	1.3	11.2	2.8	8.3	10.4
3478	Thebes	-	15.9	30.4	14.5	-	13.0	5.2	7.8	8.2
3479	Thebes	-	17.3	28.6	11.4	-	13.4	5.6	7.9	9.6
3480	Thebes	-	16.3	29.3	12.9	-	15.8	7.2	8.5	8.8
3481	Thebes	-	21.1	33.6	12.5	-	15.1	7.7	7.4	10.9
3482	Thebes	14.9	18.8	35.2	16.3	0.7	15.0	5.6	9.4	7.7
3483	Thebes	-	14.6	26.3	11.7	-	12.5	4.4	8.1	8.2
3484	Thebes	15.1	17.6	32.6	15.0	0.9	15.9	4.4	11.5	8.4
3485	Thebes	10.6	15.2	25.4	10.2	0.7	12.9	4.6	8.2	8.6
3486	Thebes	10.6	16.5	28.0	11.5	0.2	12.8	3.8	9.1	7.5
3487	Thebes	-	16.9	30.9	14.0	-	12.5	4.1	8.3	10.5
3488	Thebes	17.2	16.2	27.2	11.1	2.0	9.5	2.8	6.7	9.9
3489	Thebes	-	19.6	33.6	14.0	-	15.7	7.6	8.1	9.1
3490	Thebes	-	17.9	29.3	11.4	-	16.5	9.1	7.4	10.0
3491	Thebes	-	16.6	31.4	14.9	-	19.4	5.8	13.6	11.3
3492	Thebes	12.1	20.3	34.6	14.3	0.3	15.9	7.7	8.1	10.0
3493	Kirk	-	17.7	20.3	2.6	-	6.5	2.3	4.1	7.4
3494	Thebes	-	19.1	31.0	11.9	-	14.2	10.2	4.0	9.5
3495	Kirk	25.4	24.2	30.9	6.7	1.6	9.1	1.9	7.2	7.0
3496	Kirk	21.0	25.8	30.0	4.3	1.2	10.3	2.0	8.3	8.9
3497	Kirk	13.4	17.9	22.2	4.3	0.8	4.0	0.3	3.7	5.5
3515	Hi-Lo	15.8	21.3	21.7	0.4	2.3	2.5	1.4	1.1	7.6
3520	Hi-Lo	12.5	25.0	27.7	2.8	3.6	3.8	-1.0	4.8	8.2
3521	Hi-Lo	17.2	-	-	-	3.1	-	-	-	8.1
3522	Hi-Lo	16.1	22.2	22.4	0.1	5.1	-1.6	-3.0	1.4	7.2
3530	Hi-Lo	22.0	29.2	29.8	0.6	3.5	2.1	-0.7	2.8	7.9
3531	Hi-Lo	24.0	26.5	27.5	0.9	4.2	0.1	-2.8	2.9	7.9

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3533	Hi-Lo	23.4	28.2	28.8	0.6	3.3	2.1	-0.8	2.9	-
3534	Hi-Lo	21.5	28.3	28.9	0.6	4.1	2.5	-1.0	3.5	6.7
3537	Hi-Lo	16.7	22.7	23.9	1.1	1.4	6.1	1.8	4.3	6.7
3540	Hi-Lo	15.6	-	-	-	3.3	-	-	-	8.5
3556	EFP	17.0	-	-	-	3.5	-	-	-	6.7
3560	EFP	25.7	28.7	30.9	2.2	5.2	7.0	-3.0	10.0	5.5
3828	Thebes	-	17.1	28.5	11.4	-	13.8	8.0	5.8	8.6
3830	Thebes	9.1	14.4	24.1	9.7	0.5	10.3	5.0	5.3	7.9
3831	Thebes	-	15.6	25.1	9.6	-	10.7	5.5	5.2	8.1
3837	Dalton	19.8	22.3	23.6	1.3	7.4	1.0	-5.9	6.9	7.2
3841	EFP	19.7	-	-	-	2.8	-	-	-	7.1
3850	Kirk	19.2	19.7	29.9	10.3	0.9	9.3	1.2	8.1	-
3852	Kirk	23.1	20.8	28.9	8.1	3.1	6.1	0.3	5.8	-
3853	Dalton	16.9	18.3	19.9	1.6	5.2	3.4	-3.8	7.2	6.1
3854	Thebes	11.3	20.2	26.2	5.9	0.8	10.8	4.5	6.3	10.1
3886	Thebes	21.2	19.7	32.8	13.1	2.2	9.3	2.7	6.6	9.0
3887	Dalton	20.8	24.3	25.3	1.1	3.8	4.8	-1.6	6.4	6.7
3888	Dalton	20.6	24.6	25.2	0.6	4.5	5.2	-0.9	6.1	7.4
3889	Dalton	19.9	23.6	24.2	0.6	7.3	1.9	-4.2	6.1	6.5
3890	Thebes	-	18.5	25.6	7.1	-	11.3	5.8	5.5	8.9
3892	Thebes	10.1	23.9	44.8	20.9	0.1	17.4	8.5	8.8	9.5
3893	Kirk	-	15.7	22.7	7.0	-	6.9	3.1	3.7	6.7
3895	Kirk	-	17.8	24.5	6.7	-	8.4	3.8	4.6	7.4
3896	Kirk	12.8	14.4	19.9	5.5	0.8	5.1	1.8	3.3	4.9
3898	Thebes	13.4	13.3	22.5	9.2	0.7	11.2	4.7	6.4	6.5
3899	Thebes	24.7	23.2	43.1	19.9	0.8	15.3	6.6	8.7	8.7
3903	EFP	21.8	-	-	-	5.1	-	-	-	-
3907	Kirk	-	11.7	17.3	5.6	-	6.1	2.0	4.1	5.7
3910	Thebes	-	20.4	28.1	7.6	-	13.7	9.1	4.6	10.9
3913	Kirk	18.3	19.0	25.2	6.2	1.2	5.0	0.1	4.9	7.1
3917	Thebes	-	19.8	28.8	9.0	-	14.3	7.3	7.0	9.5
3922	Kirk	12.9	13.8	19.8	6.0	0.8	6.0	1.5	4.6	6.6
3926	Kirk	-	16.3	21.5	5.2	-	6.8	2.6	4.2	8.9
3927	Kirk	12.2	15.3	20.7	5.4	1.1	5.3	1.1	4.2	6.8
3931	Thebes	-	18.3	27.0	8.7	-	10.8	7.1	3.7	7.0
3934	Thebes	22.7	32.5	39.0	6.5	1.7	9.4	1.6	7.8	9.5
3936	Thebes	-	22.3	36.5	14.1	-	16.5	6.5	9.9	9.6
3937	Kirk	-	13.0	16.7	3.7	-	6.0	2.2	3.8	6.6
3939	Kirk	16.8	18.2	22.6	4.4	0.8	6.6	1.6	5.0	6.7
3941	Kirk	12.9	14.5	18.9	4.3	0.8	5.1	1.2	3.9	6.8

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3946	Kirk	11.4	10.0	15.2	5.2	0.3	5.5	1.8	3.7	7.1
3948	Kirk	-	20.2	28.2	8.0	-	8.5	4.1	4.4	6.6
3949	Kirk	-	16.0	21.9	5.9	-	7.2	2.7	4.5	6.8
3950	Thebes	16.3	15.0	26.4	11.3	1.4	9.3	3.1	6.2	8.2
3959	Hi-Lo	12.6	17.5	20.1	2.6	1.9	4.8	0.8	4.0	8.0
3963	Thebes	4.5	14.4	23.9	9.5	0.2	10.4	6.6	3.8	9.7
3966	Kirk	-	13.7	20.8	7.0	-	8.8	4.4	4.4	6.4
3967	Thebes	18.7	26.0	49.5	23.5	0.4	17.8	7.6	10.2	9.6
3969	Kirk	-	16.1	24.5	8.4	-	8.5	2.4	6.2	8.9
3975	Kirk	12.7	14.4	18.8	4.4	0.6	4.8	1.8	3.0	5.2
3977	Kirk	-	14.7	18.9	4.2	-	5.4	2.0	3.5	5.6
3980	Dalton	22.0	24.6	27.3	2.7	5.7	6.8	-2.7	9.6	7.0
3982	Thebes	-	21.8	37.0	15.2	-	16.5	7.5	9.0	8.5
3984	Kirk	-	15.2	21.2	6.0	-	6.7	2.3	4.5	6.3
3986	Thebes	-	19.9	30.2	10.3	-	10.4	3.6	6.8	8.6
3988	Thebes	-	20.4	32.9	12.5	-	13.5	6.6	6.9	9.2
3989	Thebes	-	25.1	39.9	14.8	-	18.9	5.2	13.7	8.5
3992	Kirk	-	16.6	23.4	6.7	-	6.0	3.8	2.2	6.1
3993	Thebes	-	16.6	24.9	8.3	-	12.8	5.3	7.5	7.2
3994	Thebes	-	22.3	27.9	5.6	-	13.8	9.9	3.9	9.1
3998	Thebes	21.1	19.2	37.5	18.4	2.3	14.1	5.6	8.4	8.6
3999	Kirk	18.5	19.2	27.4	8.2	0.4	8.8	0.9	7.9	7.9
4003	Thebes	-	14.8	22.1	7.3	-	11.3	6.6	4.6	9.4
4011	Kirk	-	17.6	22.5	4.9	-	6.2	1.5	4.7	5.8
4023	Kirk	20.2	25.1	30.4	5.3	0.7	7.0	1.6	5.3	6.8
4025	Kirk	12.7	15.7	24.5	8.8	0.9	6.6	2.7	3.9	7.3
4029	Kirk	15.1	12.4	18.5	6.1	1.0	6.6	0.3	6.3	7.1
4033	Kirk	-	14.4	19.8	5.4	-	6.4	2.2	4.2	5.6
4037	Kirk	7.0	16.4	20.8	4.4	0.7	7.3	2.7	4.6	5.7
4040	Kirk	-	18.5	27.0	8.6	-	9.2	4.2	5.0	6.6
4044	Dalton	18.4	-	23.9	-	2.7	-	-0.9	-	5.4
4045	Kirk	16.2	21.4	26.3	4.9	1.0	5.7	1.9	3.8	5.4
4051	Thebes	-	14.8	20.4	5.5	-	8.8	4.1	4.7	9.4
4057	Kirk	-	15.4	22.0	6.6	-	8.0	3.9	4.2	6.5
4058	Kirk	14.7	16.6	21.1	4.5	0.7	6.3	2.1	4.1	5.6
4059	Kirk	17.9	21.1	25.7	4.5	1.3	5.2	1.6	3.6	7.3
4060	Thebes	19.9	21.3	34.5	13.3	1.3	13.6	8.6	5.0	8.8
4061	Kirk	-	11.9	21.1	9.2	-	7.8	3.1	4.7	6.4
4063	Kirk	20.2	15.8	23.0	7.2	0.9	6.5	1.3	5.1	6.6
4064	Kirk	21.5	18.0	25.2	7.2	1.7	5.9	0.6	5.3	5.7

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4065	Kirk	-	14.4	19.0	4.6	-	7.2	3.3	3.9	5.8
4068	Thebes	-	14.5	26.7	12.2	-	14.6	9.6	5.1	8.7
4079	Thebes	-	17.9	22.2	4.4	-	10.5	6.4	4.1	9.3
4080	Thebes	13.9	24.5	29.7	5.1	1.2	8.5	2.5	6.0	8.3
4082	Thebes	12.9	19.9	26.6	6.7	0.2	11.2	1.9	9.3	7.3
4086	Thebes	6.0	16.6	25.2	8.6	1.5	11.3	6.6	4.7	8.8
4087	Thebes	24.9	26.6	44.2	17.6	2.6	16.6	4.3	12.3	9.8
4088	Thebes	22.7	24.8	45.4	20.6	0.9	17.0	6.4	10.5	11.0
4089	Thebes	-	23.9	45.9	21.9	-	20.2	7.9	12.3	10.5
4090	Thebes	-	25.0	48.9	23.9	-	20.3	7.0	13.3	8.6
4091	Thebes	-	21.7	28.9	7.2	-	9.2	3.6	5.6	9.9
4092	Thebes	-	21.0	31.4	10.4	-	11.7	4.0	7.7	8.4
4093	Thebes	-	14.2	23.5	9.3	-	11.3	6.7	4.5	9.1
4094	Thebes	-	16.9	30.1	13.2	-	16.0	8.0	8.0	9.8
4095	Thebes	11.7	15.3	25.4	10.0	0.2	10.6	6.5	4.0	8.3
4096	Thebes	-	17.7	27.7	10.1	-	11.5	5.8	5.7	8.8
4097	Thebes	-	13.5	20.7	7.2	-	10.9	7.4	3.5	8.0
4099	Thebes	-	21.4	41.9	20.5	-	17.6	6.9	10.7	9.9
4100	Kirk	20.1	19.2	22.4	3.2	2.1	3.6	-1.0	4.6	5.7
4103	Kirk	-	18.8	22.6	3.8	-	6.9	2.9	4.0	8.0
4111	Thebes	19.6	20.8	34.6	13.8	0.6	14.6	5.5	9.1	8.7
4115	Thebes	21.7	27.7	51.2	23.6	0.8	18.8	8.1	10.8	8.8
4117	Thebes	11.3	21.8	31.1	9.3	0.4	11.0	2.5	8.5	9.0
4118	Thebes	36.1	23.7	52.4	28.6	3.9	16.4	7.3	9.1	10.8
4119	Thebes	-	15.6	23.6	8.0	-	12.5	6.2	6.3	7.3
4120	Thebes	29.4	24.0	45.8	21.8	3.1	15.8	2.5	13.3	9.9
4121	EFP	19.2	-	-	-	4.6	-	-	-	8.9
4124	Kirk	25.2	22.2	27.2	4.9	1.0	4.2	-0.2	4.4	6.6
4131	Thebes	22.1	21.3	34.0	12.7	1.0	13.8	6.8	7.0	8.9
4134	Kirk	-	18.5	21.2	2.7	-	6.1	2.6	3.5	7.2
4135	Kirk	21.2	23.0	29.0	6.0	1.4	5.2	0.2	5.0	7.2
4136	Thebes	-	16.5	23.0	6.5	-	10.1	5.5	4.6	7.1
4137	Kirk	11.6	12.4	16.0	3.6	0.9	5.3	0.9	4.3	7.5
4148	Thebes	-	22.5	41.1	18.7	-	21.0	12.8	8.2	9.2
4153	Dalton	31.6	29.8	35.4	5.6	6.0	7.3	-4.7	12.0	9.0
4154	Dalton	23.4	25.4	29.3	3.9	4.3	3.9	-3.1	6.9	6.2
4160	Kirk	-	23.2	28.4	5.2	-	9.5	4.6	4.9	6.7
4163	Kirk	11.8	14.4	18.5	4.1	1.3	4.4	0.9	3.5	6.3
4165	Kirk	10.9	14.5	19.0	4.5	1.1	5.4	2.1	3.3	6.2
4166	Kirk	16.6	15.6	22.9	7.3	2.5	4.6	1.5	3.2	5.3

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4167	Kirk	-	15.9	21.6	5.7	-	7.2	2.9	4.3	6.5
4172	Kirk	12.8	15.0	20.2	5.3	1.1	5.9	1.3	4.6	6.3
4183	Kirk	-	13.0	19.8	6.8	-	7.5	2.8	4.7	6.1
4184	Kirk	13.0	12.1	17.3	5.2	1.4	5.0	0.4	4.6	6.3
4187	Hi-Lo	13.8	16.7	17.8	1.1	1.1	3.0	1.1	1.9	7.4
4192	Thebes	18.1	18.4	28.4	10.0	1.9	9.0	4.2	4.8	7.0
4193	Kirk	17.1	18.3	21.7	3.4	0.6	5.7	0.9	4.7	6.2
4195	Kirk	-	17.3	20.9	3.7	-	5.7	3.0	2.7	6.1
4197	Kirk	20.3	22.5	31.8	9.3	0.5	10.8	4.2	6.6	8.2
4199	Thebes	-	21.2	39.5	18.4	-	17.1	7.5	9.6	9.6
4201	Kirk	-	26.8	31.5	4.8	-	6.8	1.3	5.5	7.7
4203	Thebes	-	20.1	29.1	8.9	-	12.6	8.3	4.2	-
4204	Dalton	-	24.1	-	-	-	5.1	-	-	5.5
4209	Thebes	-	13.6	20.4	6.8	-	9.8	5.9	4.0	8.7
4213	Thebes	4.2	12.6	19.0	6.5	0.4	9.3	5.5	3.8	8.8
4215	Kirk	10.4	17.2	20.5	3.3	1.7	6.3	0.3	6.0	7.7
4216	Thebes	22.1	19.0	45.3	26.3	0.9	15.3	4.6	10.6	8.5
4221	Dalton	15.7	19.7	22.3	2.5	2.1	4.7	1.0	3.7	6.7
4228	Dalton	22.4	-	33.2	-	4.8	-	-1.4	-	6.4
4229	Thebes	6.2	17.3	23.0	5.7	1.5	8.3	3.6	4.7	9.1
4231	Thebes	-	20.6	31.3	10.7	-	13.3	8.5	4.8	8.3
4232	Dalton	14.7	16.4	18.9	2.5	0.7	6.9	1.0	5.9	7.5
4233	Thebes	8.8	18.2	24.8	6.6	0.5	11.9	3.7	8.2	7.9
4237	Thebes	-	21.1	30.0	8.9	-	12.4	3.9	8.5	9.8
4239	Thebes	15.0	17.7	24.2	6.6	2.2	8.7	3.3	5.4	7.7
4241	Thebes	-	14.8	28.1	13.3	-	-	-	11.0	8.6
4242	Kirk	17.0	16.8	23.1	6.3	1.6	5.7	2.0	3.7	6.3
4243	Thebes	-	17.8	26.4	8.7	-	13.6	8.0	5.6	8.8
4248	Kirk	-	15.9	25.6	9.7	-	8.4	3.4	5.1	6.6
4249	Kirk	13.7	17.5	22.0	4.5	0.9	6.9	1.8	5.1	6.9
4251	Kirk	14.8	13.6	17.3	3.7	0.9	5.0	0.7	4.4	6.1
4256	Thebes	13.8	15.0	26.8	11.8	1.3	11.7	4.5	7.2	8.3
4260	Thebes	17.7	22.2	28.2	6.0	2.1	7.5	2.5	5.0	7.6
4261	Kirk	13.8	17.5	22.4	4.8	1.6	4.5	1.4	3.1	6.7
4263	Thebes	-	20.4	28.1	7.7	-	12.5	3.9	8.5	9.3
4265	Thebes	11.2	15.8	27.5	11.7	0.7	13.0	7.0	6.0	8.0
4267	Dalton	18.3	19.8	21.2	1.4	4.1	3.4	-2.6	6.0	7.0
4269	Dalton	20.3	25.0	26.8	1.8	4.0	9.3	-1.2	10.6	6.6
4270	Dalton	20.0	23.5	23.7	0.2	7.5	3.4	-4.8	8.1	6.8
4271	Dalton	15.5	21.9	23.4	1.5	3.3	3.1	-0.4	3.5	8.4

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4273	Dalton	-	25.2	-	-	-	1.1	-	-	6.8
4275	Dalton	19.7	22.4	23.2	0.8	4.7	2.0	-3.1	5.1	7.3
4276	Dalton	-	21.0	-	-	-	3.3	-	-	6.4
4278	Thebes	16.1	18.2	32.7	14.5	0.5	13.5	4.1	9.4	8.2
4280	Thebes	-	22.1	28.4	6.2	-	12.2	1.7	10.5	9.9
4284	Thebes	20.4	16.4	30.7	14.3	1.2	12.2	4.4	7.8	9.1
4285	Kirk	-	17.0	21.8	4.7	-	10.3	2.8	7.4	6.3
4286	Kirk	-	16.7	21.1	4.4	-	7.8	1.0	6.8	6.5
4287	Thebes	-	23.4	43.7	20.3	-	17.3	8.7	8.6	8.9
4289	Dalton	28.5	30.2	32.9	2.7	7.3	2.8	-5.4	8.3	8.0
4291	Kirk	13.5	24.8	29.6	4.8	0.8	9.5	3.6	5.9	6.4
4292	Thebes	18.4	20.9	33.6	12.7	0.7	12.0	5.2	6.8	8.0
4293	Kirk	-	23.9	30.0	6.0	-	11.2	4.7	6.5	9.2
4294	Kirk	13.4	15.1	22.6	7.5	1.1	6.2	2.0	4.2	6.1
4295	Thebes	5.5	15.3	24.0	8.8	0.4	11.9	8.1	3.8	10.1
4299	Kirk	14.3	15.1	19.2	4.1	0.7	5.7	0.6	5.1	6.6
4303	Kirk	16.2	17.4	21.6	4.3	2.2	4.9	0.3	4.6	6.0
4307	Kirk	17.6	18.3	22.2	3.9	0.9	5.8	0.7	5.1	6.9
4312	Thebes	28.9	22.5	39.2	16.7	3.8	14.3	4.1	10.2	9.7
4318	Thebes	18.3	21.7	32.1	10.5	3.1	10.8	4.0	6.7	11.2
4319	Thebes	-	16.6	28.0	11.4	-	16.0	8.2	7.8	8.8
4320	Kirk	11.4	15.9	22.5	6.6	2.0	5.1	1.1	4.0	6.0
4322	Thebes	-	14.8	22.4	7.6	-	9.7	5.8	3.9	6.4
4324	Hi-Lo	23.0	-	-	-	4.1	-	-	-	9.4
4327	Thebes	-	16.4	28.2	11.7	-	14.6	5.5	9.0	7.7
4331	Kirk	19.0	21.5	26.8	5.2	0.7	9.5	1.5	7.9	6.5
4334	Thebes	14.1	22.6	33.5	10.9	0.7	9.8	5.7	4.1	9.5
4335	Thebes	-	20.4	36.4	16.0	-	15.5	7.6	7.9	10.4
4336	Kirk	16.7	15.6	21.8	6.2	0.5	4.1	0.6	3.5	5.8
4337	Thebes	-	18.8	32.7	13.9	-	11.5	5.9	5.7	7.8
4341	Kirk	16.6	14.6	21.9	7.4	0.7	6.5	2.3	4.2	6.3
4342	Kirk	16.1	16.3	23.2	6.9	2.0	5.3	0.7	4.6	6.4
4343	Kirk	-	13.3	20.1	6.7	-	9.4	2.9	6.5	6.4
4345	Kirk	15.8	13.9	20.2	6.3	0.7	6.8	2.1	4.7	5.5
4347	Thebes	17.8	13.7	27.9	14.2	1.4	9.8	4.1	5.8	10.0
4349	Thebes	-	18.5	26.2	7.7	-	12.5	7.8	4.8	8.9
4356	Thebes	6.0	17.3	22.5	5.2	0.6	8.9	4.8	4.2	10.1
4357	Kirk	-	12.3	18.9	6.6	-	6.2	1.9	4.3	5.6
4358	Kirk	15.2	11.7	19.7	8.0	0.8	7.2	2.5	4.8	4.9
4361	Kirk	15.0	12.2	18.1	5.9	0.9	5.8	0.4	5.4	5.7

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4362	Kirk	14.7	13.2	19.3	6.1	0.3	6.7	1.5	5.1	6.0
4363	Thebes	-	17.6	33.4	15.8	-	13.5	6.0	7.5	9.4
4364	Thebes	17.5	15.1	27.6	12.5	2.7	8.2	1.8	6.4	7.7
4365	Kirk	11.5	12.7	17.2	4.5	0.2	4.2	1.2	3.0	5.9
4366	Kirk	15.5	18.7	23.4	4.7	0.5	6.4	1.3	5.1	6.8
4370	EFP	19.8	-	-	-	4.1	-	-	-	9.6
4371	EFP	23.3	-	-	-	6.0	-	-	-	7.9
4373	EFP	22.4	-	-	-	5.6	-	-	-	8.4
4374	EFP	20.7	23.8	24.0	0.2	3.2	2.2	-0.9	3.1	8.1
4376	EFP	21.2	-	-	-	4.0	-	-	-	7.5
4381	EFP	17.0	-	-	-	3.0	-	-	-	-
4384	EFP	21.1	-	-	-	5.9	-	-	-	10.9
4386	EFP	24.8	26.5	26.6	0.1	5.2	-0.2	-3.0	2.8	9.0
4387	EFP	19.6	-	-	-	4.2	-	-	-	9.1
4390	EFP	23.6	28.4	29.2	0.8	-	-	-	3.1	8.3
4391	Thebes	-	17.2	30.5	13.4	-	11.3	7.3	4.0	7.6
4394	Kirk	14.2	12.3	19.9	7.6	0.7	6.9	1.1	5.8	7.5
4397	Thebes	-	18.6	23.6	5.1	-	11.8	3.8	8.1	7.3
4400	Hi-Lo	19.8	24.3	25.0	0.8	6.3	4.6	-3.3	7.9	9.2
4410	Kirk	7.1	17.0	20.5	3.4	0.6	6.2	1.7	4.5	5.4
4411	Kirk	10.7	16.2	18.4	2.2	1.3	3.6	0.1	3.5	5.2
4412	Thebes	-	13.6	22.6	9.0	-	9.9	5.8	4.1	7.1
4413	Thebes	15.2	18.0	29.4	11.3	1.1	9.5	2.8	6.7	7.4
4414	Kirk	11.3	20.5	26.7	6.2	0.3	7.5	2.3	5.3	8.1
4415	Thebes	-	15.6	24.3	8.7	-	10.8	6.4	4.5	7.3
4416	Thebes	-	20.0	30.3	10.3	-	13.1	6.5	6.6	9.6
4418	Thebes	-	13.6	21.4	7.8	-	9.6	4.9	4.7	8.9
4427	Kirk	14.1	14.7	20.4	5.7	1.7	5.4	0.4	5.0	4.9
4435	EFP	19.7	22.4	22.7	0.3	3.3	1.0	-1.5	2.5	-
4437	Kirk	-	14.6	23.1	8.4	-	8.2	1.8	6.4	6.0
4441	Kirk	13.5	17.1	20.7	3.6	1.2	6.3	1.3	5.0	6.7
4443	Kirk	17.7	24.3	27.2	2.9	0.8	6.1	0.6	5.5	6.5
4447	Kirk	11.3	11.6	16.1	4.5	1.2	4.8	1.0	3.8	6.1
4451	Kirk	-	15.9	20.0	4.2	-	6.3	2.0	4.3	6.3
4452	Thebes	-	17.6	28.3	10.7	-	13.0	4.9	8.1	8.8
4455	Thebes	-	19.6	28.1	8.4	-	13.5	8.8	4.8	9.6
4465	Dalton	19.9	24.0	24.8	0.8	2.3	4.9	0.7	4.2	8.2
4466	Dalton	18.2	-	-	-	5.6	-	-	-	7.1
4467	Dalton	-	30.3	-	-	-	2.9	-	-	6.2
4468	Dalton	-	28.2	31.4	3.2	-	6.9	0.1	6.8	7.8

Point ID	Group	A	B	C	E	F	G	H	I	Max. Thick.
4471	Thebes	14.2	19.2	36.2	17.0	0.6	16.5	3.0	13.5	11.2
4472	Kirk	-	17.1	24.7	7.6	-	10.4	3.0	7.4	6.2
4476	Kirk	25.0	20.7	29.0	8.3	2.5	7.9	0.1	7.8	6.4
4480	Thebes	6.2	18.7	27.0	8.3	1.1	10.0	5.0	5.0	11.4
4486	Kirk	14.5	14.8	20.2	5.3	2.4	4.6	0.7	3.9	6.1
4489	Kirk	13.6	16.8	23.2	6.4	2.3	5.3	-0.1	5.3	6.4
4492	Kirk	-	14.5	20.6	6.1	-	8.0	3.0	5.0	5.9
4506	Kirk	21.5	21.3	26.1	4.8	1.2	4.6	0.0	4.6	5.6
4509	Thebes	13.7	15.7	28.0	12.2	1.6	10.9	3.5	7.4	9.8
4510	Kirk	13.3	13.7	17.9	4.2	1.5	3.8	0.2	3.6	6.6
4525	Thebes	18.1	19.5	33.7	14.2	1.0	15.6	7.1	8.5	8.0
4529	Kirk	-	21.3	27.8	6.6	-	7.7	1.8	5.9	7.1
4530	Kirk	16.9	17.3	20.8	3.5	0.3	4.3	1.1	3.2	5.6
4531	Thebes	17.7	19.4	34.9	15.5	0.3	14.0	5.5	8.5	9.1
4532	Thebes	17.2	24.2	38.0	13.8	0.4	16.0	7.8	8.2	12.2
4537	Kirk	9.2	18.1	22.0	3.9	0.5	6.2	2.5	3.7	5.5
4540	Kirk	-	19.9	25.8	5.9	-	7.1	2.9	4.3	7.7
4541	Kirk	18.0	15.9	22.4	6.5	0.9	6.1	0.7	5.3	8.4
4550	Kirk	-	16.9	21.2	4.3	-	-	-	4.2	6.3
4551	Thebes	-	17.6	27.1	9.4	-	13.2	8.3	4.9	9.5
4553	Kirk	20.0	20.9	24.2	3.3	1.0	2.5	-0.4	2.9	8.7
4554	Kirk	23.8	25.6	30.8	5.2	1.3	9.6	1.7	7.9	9.5
4557	Thebes	-	20.3	32.8	12.5	-	13.0	5.4	7.6	8.1
4558	Thebes	25.7	21.9	41.6	19.7	1.1	14.9	6.0	8.9	8.9
4559	Thebes	-	17.4	23.6	6.2	-	11.4	7.4	4.0	8.7
4560	Thebes	-	16.4	30.0	13.6	-	14.7	10.1	4.6	9.6
4561	Kirk	25.7	23.4	-	-	3.2	4.2	-	-	7.8
4563	EFP	23.9	-	-	-	8.4	-	-	-	7.6
4575	Kirk	23.1	22.9	25.9	3.0	2.2	2.7	-0.8	3.5	6.9
4579	Thebes	19.8	22.9	39.0	16.1	1.0	15.1	6.6	8.6	9.0
4582	Kirk	24.7	22.6	31.2	8.7	1.3	10.7	0.8	9.9	9.3
4584	Thebes	14.1	23.0	38.7	15.7	0.3	15.4	10.6	4.8	10.9
4585	Thebes	9.7	20.5	35.2	14.7	0.3	12.8	8.3	4.5	8.3
4589	Kirk	-	23.7	29.9	6.2	-	8.0	2.7	5.3	5.8
4591	Dalton	-	30.8	-	-	-	2.6	-	-	6.9
4593	Thebes	-	11.9	22.1	10.2	-	10.9	6.5	4.4	7.6
4594	Thebes	24.5	17.3	32.0	14.8	3.2	9.9	1.1	8.8	6.7
4595	Thebes	24.2	27.3	50.2	22.9	1.3	16.4	7.9	8.5	-
4597	Thebes	-	22.7	28.5	5.8	-	10.6	6.9	3.8	9.6
4600	Dalton	24.6	28.7	30.7	2.0	5.6	1.2	-2.9	4.1	6.8

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4602	Thebes	-	15.7	26.8	11.1	-	13.5	7.5	6.0	9.2
4605	Kirk	16.3	19.1	22.8	3.7	1.8	6.0	0.3	5.7	7.1
4606	Thebes	17.5	17.9	28.8	10.9	2.6	9.2	2.9	6.4	8.3
4608	Dalton	-	-	-	-	-	-	-	-	7.3
4611	Thebes	-	20.6	32.0	11.4	-	11.8	4.8	7.0	7.9
4613	Thebes	-	20.9	31.2	10.3	-	14.7	9.4	5.3	10.9
4614	Thebes	10.2	26.4	40.4	14.0	0.3	17.6	10.0	7.6	9.1
4615	Thebes	-	20.0	28.7	8.7	-	12.5	7.1	5.4	8.9
4617	Kirk	21.2	23.8	25.3	1.5	1.1	2.6	-0.1	2.7	8.7
4620	Dalton	-	-	-	-	-	-	-	-	7.5
4624	Thebes	18.3	23.0	35.3	12.4	1.2	10.5	4.8	5.8	8.2
4625	Kirk	15.2	20.3	24.2	3.9	0.3	4.3	1.9	2.4	6.6
4626	Thebes	-	21.7	36.7	15.1	-	15.8	7.3	8.5	9.9
4629	Kirk	13.3	20.1	23.7	3.6	0.1	5.2	1.7	3.5	7.0
4637	Thebes	-	20.2	34.6	14.5	-	14.9	8.3	6.6	9.8
4638	Kirk	-	15.7	20.3	4.5	-	3.8	-0.1	4.0	6.6
4639	Kirk	12.9	24.6	30.5	5.9	0.4	8.1	2.1	6.0	5.4
4640	Kirk	19.4	21.4	25.1	3.7	0.9	5.4	1.3	4.1	7.4
4643	Dalton	-	28.0	-	-	-	-	-	-	7.7
4644	Thebes	19.0	22.9	39.9	17.0	1.0	15.7	8.2	7.6	11.7
4646	Thebes	-	18.1	26.6	8.6	-	12.1	6.9	5.2	9.3
4647	Kirk	11.3	20.9	24.4	3.5	2.2	2.8	-0.6	3.4	7.3
4649	Thebes	23.8	21.3	32.7	11.5	2.8	10.9	1.8	9.1	8.9
4650	Thebes	-	21.1	33.5	12.4	-	15.6	3.4	12.1	8.9
4652	Dalton	25.5	-	28.0	-	5.2	-	-3.0	-	8.2
4653	EFP	20.7	25.7	26.3	0.7	6.3	0.0	-3.6	3.6	8.6
4658	Thebes	19.4	21.0	32.1	11.1	2.2	11.1	4.5	6.6	7.8
4659	Thebes	-	22.0	34.9	12.9	-	14.5	9.1	5.5	10.6
4660	Thebes	9.4	18.7	27.5	8.7	0.7	12.3	5.9	6.3	9.0
4661	Thebes	15.8	20.9	33.8	12.9	0.9	12.6	5.3	7.3	9.0
4663	Kirk	11.5	16.0	19.4	3.4	2.2	4.8	0.0	4.8	5.1
4664	Kirk	-	21.7	28.4	6.7	-	9.2	3.1	6.1	6.8
4665	Kirk	-	20.5	24.1	3.5	-	7.1	3.3	3.8	8.3
4666	Kirk	-	16.7	20.0	3.3	-	6.9	1.9	4.9	6.1
4668	Kirk	19.5	21.5	25.9	4.4	1.9	7.6	0.7	6.8	7.3
4671	Thebes	-	20.1	28.7	8.6	-	13.3	7.4	5.9	8.6
4672	Thebes	-	28.5	41.9	13.3	-	18.5	9.3	9.3	10.4
4673	Kirk	25.4	25.4	30.3	4.9	2.9	6.3	0.8	5.5	7.0
4674	Kirk	16.9	18.2	22.5	4.3	0.7	5.6	1.7	3.9	6.4
4675	Kirk	12.7	18.6	23.5	4.9	1.2	6.6	2.4	4.2	5.7

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4677	Kirk	23.0	20.6	26.1	5.5	1.8	5.9	-0.7	6.6	6.2
4678	Kirk	23.0	19.4	29.9	10.5	1.5	7.7	0.6	7.1	7.5
4680	Kirk	13.6	14.2	17.8	3.6	1.2	4.4	-0.1	4.5	5.1
4682	Kirk	-	16.9	20.8	3.9	-	-	-	4.4	5.9
4683	Thebes	8.3	17.6	27.5	9.8	0.6	9.7	4.7	5.0	7.4
4684	Kirk	16.4	18.2	22.9	4.6	1.8	6.1	0.1	6.1	7.6
4685	Kirk	13.9	14.4	19.1	4.7	1.3	4.6	0.6	4.0	5.7
4686	Kirk	24.2	20.9	26.4	5.6	1.8	6.6	-0.6	7.2	6.8
4689	Kirk	-	26.7	32.1	5.4	-	9.3	6.2	3.1	7.8
4694	Thebes	16.2	21.8	33.0	11.2	0.6	12.0	2.7	9.3	9.0
4699	Kirk	-	12.2	14.4	2.2	-	-	-	3.8	4.7
4700	Thebes	-	25.2	43.6	18.5	-	18.0	7.9	10.1	9.7
4709	Thebes	-	21.6	29.4	7.8	-	12.7	4.3	8.3	7.4
4710	Kirk	20.8	25.2	30.6	5.4	0.8	9.5	1.6	7.8	9.4
4712	Thebes	-	19.8	29.4	9.6	-	13.0	8.1	4.9	8.7
4716	Thebes	-	17.7	24.2	6.4	-	10.9	6.7	4.2	10.1
4717	Thebes	-	16.8	26.6	9.8	-	10.4	3.3	7.1	10.2
4724	Kirk	11.2	15.3	20.7	5.4	0.3	6.3	2.8	3.5	7.9
4726	Kirk	12.5	18.8	26.1	7.3	0.5	8.4	2.0	6.4	6.7
4728	Kirk	18.9	22.3	25.4	3.1	1.3	6.3	1.0	5.2	8.8
4744	Kirk	10.8	14.2	19.4	5.2	0.7	5.8	1.1	4.7	7.9
4746	Kirk	13.0	17.0	20.7	3.6	1.1	5.7	1.1	4.6	6.5
4747	Kirk	11.0	13.5	18.8	5.3	1.2	5.3	0.9	4.4	5.5
4751	Kirk	-	15.5	23.5	7.9	-	-	-	6.0	7.4
4755	Kirk	15.0	15.7	20.3	4.5	0.5	3.6	0.7	3.0	5.3
4756	Thebes	-	15.2	29.5	14.3	-	14.8	3.8	11.1	8.2
4757	Thebes	13.9	13.9	24.4	10.5	0.6	11.0	2.7	8.3	8.8
4758	Thebes	-	13.8	21.5	7.7	-	10.5	6.9	3.6	8.5
4759	Thebes	10.7	14.6	23.4	8.7	0.7	10.7	5.3	5.4	8.4
4764	Thebes	-	19.4	35.6	16.2	-	16.9	5.1	11.8	-
4772	Kirk	18.3	18.9	23.7	4.8	1.6	5.6	-0.1	5.8	6.5
4773	Kirk	15.3	16.7	23.7	7.0	0.5	8.1	1.3	6.8	6.2
4775	Kirk	23.6	21.7	29.2	7.4	1.9	9.4	-0.1	9.5	7.6
4783	Kirk	11.5	15.2	18.3	3.1	0.9	3.7	-0.2	3.9	7.2
4784	Kirk	-	15.4	21.3	5.9	-	8.4	2.4	6.0	6.3
4787	Kirk	-	17.8	21.0	3.1	-	7.1	4.1	3.0	6.6
4792	Thebes	4.4	15.6	22.8	7.2	0.2	12.2	6.6	5.6	10.1
4797	Kirk	18.8	16.4	25.8	9.4	0.9	9.5	2.7	6.8	5.7
4798	Kirk	10.7	14.9	18.2	3.3	1.1	4.7	1.0	3.6	6.9
4801	Kirk	16.1	17.1	19.5	2.4	1.5	3.0	0.2	2.8	7.2

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4804	Thebes	-	16.5	26.1	9.6	-	10.4	6.2	4.2	9.4
4805	Kirk	17.1	16.3	21.9	5.6	1.2	5.9	1.3	4.6	-
4806	Kirk	13.8	18.8	24.7	5.9	1.0	5.1	2.2	2.9	5.6
4808	EFP	28.0	27.8	31.7	4.0	5.1	12.0	-3.4	15.4	7.1
4809	EFP	21.7	-	-	-	5.9	-	-	-	8.7
4810	Thebes	-	13.8	22.5	8.7	-	11.9	8.6	3.3	10.3
4814	Kirk	-	19.6	22.3	2.7	-	-	-	3.7	6.3
4816	Kirk	18.1	13.5	21.2	7.7	0.8	6.7	1.0	5.7	6.2
4817	Thebes	10.2	19.0	28.1	9.1	1.7	8.9	3.0	6.0	8.3
4819	EFP	20.2	24.6	24.7	0.1	4.2	3.2	1.4	1.8	6.3
4821	Kirk	-	15.5	18.9	3.4	-	-	-	2.7	5.4
4824	Kirk	11.9	12.6	16.2	3.6	0.8	3.1	0.4	2.7	5.0
4826	Kirk	13.4	12.8	18.4	5.6	0.9	6.1	1.4	4.7	7.3
4829	Dalton	-	24.0	-	-	-	4.3	-	-	8.3
4831	Thebes	-	19.7	25.6	5.9	-	9.8	6.0	3.8	-
4839	Dalton	19.8	23.1	30.5	7.4	2.9	6.2	1.6	4.6	8.6
4841	Kirk	-	15.7	19.5	3.7	-	7.5	3.1	4.5	5.6
4842	Kirk	-	17.6	24.4	6.8	-	9.5	2.5	7.0	7.4
4845	Kirk	-	14.4	19.7	5.3	-	8.3	2.5	5.9	6.3
4850	Kirk	14.4	11.6	17.3	5.7	1.0	4.7	1.1	3.6	5.2
4851	Kirk	24.4	19.4	28.9	9.5	2.7	8.0	-1.1	9.1	6.5
4852	Dalton	16.5	20.3	-	-	3.7	4.0	-	-	8.4
4854	Kirk	25.9	23.4	30.9	7.5	1.0	7.8	0.9	6.9	7.4
4863	Kirk	-	16.7	24.0	7.3	-	9.4	3.6	5.8	6.5
4864	Kirk	17.6	16.9	21.1	4.2	2.1	4.7	0.0	4.7	5.6
4865	Kirk	18.4	15.6	24.5	8.9	1.1	7.8	1.1	6.7	8.0
4866	Kirk	13.2	19.5	-	-	0.5	7.4	-	-	7.4
4869	Kirk	14.4	13.6	19.6	6.1	0.8	7.6	1.8	5.8	7.2
4872	Kirk	14.8	13.8	20.4	6.6	1.1	7.1	1.8	5.3	6.0
4873	Kirk	7.4	12.7	17.0	4.3	0.5	6.1	1.3	4.7	4.9
4876	Kirk	-	14.5	20.7	6.2	-	5.9	2.2	3.7	7.6
4877	Thebes	15.6	19.4	27.5	8.1	1.3	9.7	1.3	8.4	8.6
4880	Kirk	-	12.2	14.7	2.6	-	5.1	1.7	3.4	6.5
4881	Kirk	7.0	11.2	16.3	5.1	0.3	5.8	2.0	3.9	5.3
4885	Kirk	-	14.5	20.6	6.1	-	8.6	3.8	4.8	7.3
4893	Kirk	-	15.8	21.7	5.9	-	-	-	4.9	7.7
4896	Thebes	13.5	18.2	29.5	11.3	1.4	10.0	3.4	6.6	8.6
4901	Kirk	19.9	22.9	27.5	4.6	1.1	7.2	0.9	6.3	7.1
4903	Kirk	12.6	15.4	21.9	6.6	0.5	6.5	1.7	4.8	5.6
4905	Kirk	18.0	16.0	22.7	6.8	1.2	6.9	0.1	6.8	7.4

Point ID	Group	A	B	C	E	F	G	H	I	Max. Thick.
4908	Thebes	10.1	15.6	31.9	16.3	0.8	12.4	7.4	5.0	8.4
4910	Kirk	-	13.8	19.0	5.2	-	7.0	2.1	4.9	7.0
4911	Thebes	-	14.5	22.3	7.8	-	10.7	6.8	3.9	8.2
4916	Kirk	14.7	12.3	19.1	6.9	1.1	6.1	0.2	5.9	6.0
4918	Kirk	17.9	19.7	25.9	6.2	2.3	6.6	0.0	6.6	7.6
4919	Kirk	17.8	16.7	21.9	5.2	0.8	6.1	0.4	5.7	6.7
4922	Kirk	17.1	16.1	26.0	9.9	1.0	10.0	2.2	7.7	5.7
4923	Kirk	-	19.4	30.6	11.3	-	12.3	5.1	7.2	5.3
4926	Kirk	14.1	16.8	23.4	6.6	1.3	5.9	0.8	5.2	6.0
4929	Kirk	-	19.0	30.6	11.6	-	10.0	3.3	6.7	5.5
4930	Kirk	-	17.4	23.6	6.3	-	7.1	2.3	4.8	7.8
4938	Kirk	15.3	16.4	20.9	4.5	0.9	5.4	0.0	5.4	6.2
4946	Kirk	11.7	12.3	14.0	1.7	1.5	1.7	-0.8	2.4	4.8
4949	Dalton	20.3	20.8	24.1	3.2	5.0	7.4	-3.6	11.0	6.9
4951	Kirk	16.8	16.7	23.0	6.3	1.3	7.1	1.4	5.7	6.3
4952	Kirk	11.2	12.3	17.4	5.1	0.6	5.0	1.3	3.7	4.5
4954	Thebes	7.6	18.6	24.7	6.1	0.3	11.2	2.4	8.9	8.3
4964	Kirk	20.7	17.3	-	-	1.3	5.8	-	-	6.1
4966	Kirk	13.2	15.6	-	-	0.5	4.8	-	-	5.9
4967	Kirk	18.0	16.3	22.3	6.0	2.3	4.8	-0.5	5.3	6.2
4968	Kirk	-	13.3	-	-	-	6.9	-	-	6.6
4969	Kirk	16.5	17.4	23.4	6.0	1.2	4.9	0.9	3.9	5.7
4976	Kirk	-	20.7	25.2	4.5	-	8.1	2.9	5.2	7.2
4978	Kirk	-	14.7	18.7	4.0	-	6.6	1.9	4.6	5.9
4979	Dalton	19.3	20.6	24.3	3.8	4.1	5.3	-1.8	7.1	4.5
4984	Kirk	11.9	14.7	17.7	3.0	1.3	3.6	1.0	2.6	6.8
4985	Kirk	12.1	14.5	20.6	6.1	0.5	6.8	2.4	4.4	5.3
4987	Kirk	14.0	14.1	23.7	9.6	0.4	9.1	2.0	7.1	6.4
4992	Kirk	-	19.1	24.7	5.6	-	8.2	3.3	4.9	7.2
4999	Dalton	-	23.4	-	-	-	6.8	-	-	7.5
5001	Kirk	-	15.7	20.2	4.5	-	6.2	2.0	4.2	6.3
5002	Kirk	-	12.6	20.1	7.5	-	9.7	1.7	8.0	6.0
5003	Kirk	12.1	17.9	22.9	5.0	0.6	6.7	1.2	5.5	6.0
5004	Kirk	5.8	13.5	17.8	4.3	0.7	5.8	0.8	5.0	4.6
5012	Kirk	-	15.2	23.6	8.4	-	8.2	3.3	4.9	6.8
5015	Kirk	-	15.2	21.6	6.4	-	8.2	1.4	6.8	6.4
5016	Kirk	-	17.3	24.0	6.8	-	8.5	3.4	5.1	6.9
5017	Kirk	-	18.0	22.1	4.1	-	7.2	2.6	4.6	7.7
5018	Kirk	-	19.6	25.3	5.8	-	8.2	3.8	4.4	8.0
5019	Kirk	12.7	13.9	21.6	7.8	1.6	5.9	1.6	4.3	5.4

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5020	Kirk	14.1	15.3	23.4	8.1	0.3	8.1	2.2	5.8	6.6
5022	Kirk	-	12.9	19.1	6.2	-	7.9	1.8	6.1	-
5027	Kirk	12.4	15.9	-	-	0.3	4.1	-	-	7.0
5029	Kirk	19.4	15.8	23.7	7.9	0.6	7.0	0.3	6.7	5.8
5030	Kirk	20.7	16.6	25.0	8.4	1.9	8.2	0.9	7.4	7.2
5031	Kirk	-	19.5	28.2	8.7	-	8.6	4.3	4.3	8.1
5032	Kirk	24.2	20.3	31.4	11.1	1.8	11.1	2.8	8.3	5.8
5033	Kirk	16.5	15.6	-	-	1.7	5.8	-	-	5.4
5034	Dalton	16.3	16.2	23.1	6.9	2.6	8.5	-0.3	8.9	6.4
5035	Kirk	-	17.5	24.8	7.3	-	7.9	3.4	4.6	6.3
5036	Kirk	16.7	14.5	20.7	6.2	1.9	7.6	0.7	6.9	6.5
5038	Kirk	-	20.5	27.4	6.9	-	9.0	3.6	5.4	7.1
5039	Kirk	17.4	22.1	28.2	6.1	0.4	8.6	1.6	6.9	7.8
5041	Dalton	21.4	29.4	33.5	4.1	1.4	10.9	2.6	8.3	7.6
5042	Thebes	-	18.7	29.3	10.5	-	12.1	4.4	7.7	11.6
5044	Thebes	16.3	22.9	27.4	4.5	1.6	7.7	2.0	5.7	9.2
5047	Kirk	-	15.5	23.1	7.6	-	8.8	2.6	6.2	6.9
5048	Kirk	-	16.5	23.9	7.5	-	7.5	2.4	5.1	5.3
5049	Kirk	21.5	18.5	25.4	6.9	1.5	5.6	0.8	4.8	6.0
5050	Kirk	17.4	13.3	20.7	7.5	1.0	6.6	1.2	5.3	5.9
5051	Kirk	-	15.2	25.2	10.0	-	10.6	2.5	8.0	6.0
5053	Kirk	16.7	15.0	23.2	8.3	0.6	6.2	0.7	5.4	5.5
5056	Kirk	18.4	18.5	25.2	6.7	0.4	6.2	0.4	5.8	-
5059	Thebes	12.4	15.4	19.4	4.0	1.1	7.6	2.7	4.9	8.2
5082	EFP	23.7	27.3	27.6	0.3	7.6	3.2	-2.6	5.9	8.0
5086	EFP	21.3	23.5	23.7	0.2	7.8	-2.5	-6.4	3.9	6.0
5095	EFP	22.9	25.9	26.4	0.5	4.8	0.8	-2.1	3.0	10.0
5096	EFP	19.7	24.1	24.2	0.1	3.9	-0.3	-2.4	2.0	6.0
5097	EFP	22.1	25.1	26.0	0.9	5.2	1.1	-3.2	4.3	8.0
5099	EFP	15.6	-	-	-	2.9	-	-	-	5.0
5105	EFP	22.4	24.8	25.6	0.8	4.4	4.8	-1.9	6.6	7.0
5106	EFP	21.3	-	-	-	4.1	-	-	-	6.0
5121	EFP	23.3	-	-	-	4.3	-	-	-	8.0
5125	Dalton	24.1	25.0	29.6	4.6	8.4	3.1	-6.4	9.5	8.0
5128	EFP	24.5	-	-	-	6.4	-	-	-	-
5130	EFP	25.3	26.1	27.6	1.5	6.0	6.0	-0.5	6.6	-
5131	EFP	32.5	-	-	-	6.6	-	-	-	-
5132	EFP	23.1	26.9	28.6	1.7	5.9	2.7	-2.9	5.6	8.0
5133	EFP	22.4	-	-	-	8.2	-	-	-	9.0
5139	EFP	19.7	21.8	22.5	0.8	2.7	0.7	-1.6	2.3	6.0

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5145	EFP	20.0	-	-	-	3.3	-	-	-	6.0
5146	EFP	24.5	27.4	27.8	0.3	5.0	3.5	-1.9	5.3	6.0
5147	EFP	22.9	-	26.4	-	4.2	-	0.3	-	6.0
5150	EFP	17.8	-	-	-	1.2	-	-	-	6.0
5152	EFP	22.7	25.2	26.4	1.2	2.8	5.2	-1.0	6.2	6.0
5154	EFP	17.1	-	-	-	3.3	-	-	-	5.0
5158	EFP	22.4	25.5	26.6	1.1	3.2	2.9	-1.3	4.2	8.0
5160	EFP	21.3	-	-	-	7.0	-	-	-	7.0
5161	EFP	23.4	24.6	25.3	0.7	3.9	-0.4	-3.1	2.7	6.0
5162	EFP	18.3	22.3	22.5	0.2	2.1	4.0	0.1	3.9	6.0
5168	EFP	22.4	27.7	28.0	0.3	2.8	4.7	0.0	4.7	7.0
5170	EFP	22.5	25.1	25.3	0.3	4.1	2.3	-0.9	3.2	8.0
5173	EFP	27.5	30.0	31.4	1.4	5.5	8.8	-3.6	12.4	10.0
5184	EFP	18.9	19.9	20.7	0.8	2.9	2.1	-2.1	4.2	-
5189	EFP	31.3	-	-	-	4.5	-	-	-	7.0
5191	EFP	18.5	24.2	25.5	1.3	3.9	1.8	-2.1	3.9	6.0
5208	EFP	23.2	-	-	-	9.0	-	-	-	8.0
5210	EFP	23.0	-	-	-	5.8	-	-	-	9.0
5215	EFP	22.3	-	-	-	3.7	-	-	-	8.0
5216	EFP	23.2	26.8	28.0	1.3	4.1	6.3	-2.1	8.4	9.0
5219	EFP	20.2	-	-	-	3.8	-	-	-	6.0
5229	EFP	20.1	25.2	25.5	0.3	5.0	3.4	-1.7	5.1	8.0
5232	EFP	23.6	26.1	27.5	1.4	3.9	10.5	-2.0	12.5	7.0
5241	EFP	25.8	-	-	-	7.4	-	-	-	5.0
5261	EFP	14.2	-	-	-	1.2	-	-	-	6.7
5262	EFP	18.5	22.3	22.3	0.1	2.0	2.6	-0.2	2.8	6.6
5266	EFP	19.7	-	-	-	4.7	-	-	-	-
5295	Kirk	-	17.0	21.2	4.1	-	6.8	2.8	4.0	6.0
5301	Thebes	15.4	16.6	33.0	16.4	0.6	18.6	7.9	10.7	10.1
5303	Kirk	-	16.9	20.6	3.7	-	7.1	3.3	3.7	5.8
5309	Kirk	21.2	19.0	29.2	10.2	1.1	9.6	3.1	6.5	6.8
5311	Kirk	13.4	12.4	17.1	4.7	1.0	5.2	1.7	3.5	6.3
5314	Thebes	17.7	16.2	29.1	12.9	1.1	13.9	3.1	10.7	10.2
5315	Kirk	15.0	18.0	21.7	3.7	0.9	5.3	1.5	3.8	7.3
5316	Thebes	16.6	18.3	33.5	15.2	1.2	14.0	3.5	10.5	7.5
5317	Thebes	-	13.7	27.2	13.6	-	14.4	4.9	9.5	7.6
5318	Thebes	20.5	17.8	27.8	10.0	2.8	6.0	0.8	5.2	7.8
5321	Hi-Lo	15.9	20.4	20.9	0.6	2.8	2.1	-0.2	2.2	9.3
5322	Kirk	-	15.2	21.3	6.0	-	8.0	2.4	5.5	6.9
5325	Kirk	11.7	13.0	19.8	6.8	0.5	6.2	1.6	4.6	-

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5328	Kirk	-	15.6	24.4	8.7	-	8.5	4.1	4.5	6.3
5329	Kirk	11.9	11.3	19.7	8.3	1.2	5.7	0.5	5.2	6.9
5331	Thebes	-	15.7	20.6	4.9	-	9.2	5.9	3.2	8.0
5333	Kirk	12.3	15.1	20.4	5.3	0.9	5.8	1.5	4.3	6.9
5335	Thebes	-	12.3	19.8	7.6	-	8.9	2.6	6.3	9.1
5341	Kirk	8.3	13.6	21.4	7.8	0.4	7.5	2.1	5.4	6.8
5345	Thebes	15.3	18.6	33.8	15.2	1.0	10.9	5.4	5.5	9.6
5350	Thebes	8.1	15.1	30.0	14.8	0.2	17.4	7.1	10.3	9.5
5361	Kirk	20.4	19.3	24.2	5.0	2.2	4.9	-0.1	5.0	5.6
5374	Hi-Lo	11.9	16.3	17.2	0.9	1.8	3.3	0.3	3.1	7.7
5376	Kirk	-	14.1	17.8	3.7	-	5.4	2.1	3.3	5.9
5378	Thebes	-	14.6	22.8	8.3	-	11.2	3.2	8.1	6.9
5382	Thebes	8.1	16.4	28.2	11.8	0.4	14.0	6.7	7.3	10.2
5383	Thebes	-	16.9	33.3	16.4	-	15.3	5.3	10.1	9.6
5384	Thebes	16.9	22.1	32.8	10.7	2.5	9.0	1.1	7.9	9.1
5385	Thebes	12.9	18.3	27.9	9.6	0.5	12.2	1.9	10.3	9.4
5388	Thebes	-	19.0	36.8	17.8	-	16.3	5.2	11.1	9.4
5389	Kirk	-	15.9	21.8	5.9	-	8.4	4.3	4.1	6.6
5392	Thebes	13.9	17.4	29.9	12.4	0.5	18.4	9.2	9.2	9.6
5396	Thebes	13.0	15.9	28.0	12.1	0.6	15.7	7.2	8.5	9.3
5397	Kirk	16.8	14.2	22.2	8.0	1.2	6.9	1.9	5.1	6.3
5400	Kirk	-	16.0	19.4	3.5	-	6.1	2.6	3.5	6.4
5401	Kirk	-	18.5	25.5	7.1	-	10.0	4.6	5.4	5.9
5402	Kirk	-	14.5	18.4	3.9	-	6.2	2.4	3.7	5.3
5403	Kirk	5.6	14.8	17.8	3.0	0.7	4.9	2.4	2.5	7.0
5404	Kirk	9.5	16.7	23.5	6.8	0.4	7.6	1.9	5.7	7.0
5408	Kirk	-	17.7	22.9	5.1	-	7.5	4.0	3.5	7.5
5415	Kirk	-	17.3	23.8	6.5	-	7.7	3.2	4.5	6.8
5416	Thebes	-	19.1	33.7	14.6	-	15.6	11.1	4.5	10.9
5420	Thebes	14.7	14.4	28.6	14.3	2.7	14.6	2.5	12.1	8.2
5422	Thebes	-	17.9	32.9	15.0	-	14.3	4.7	9.7	7.5
5424	Kirk	23.1	22.4	31.9	9.5	2.8	9.0	-1.1	10.0	8.3
5425	EFP	22.9	24.8	25.1	0.3	5.1	-0.4	-3.0	2.6	9.3
5427	EFP	26.3	-	-	-	10.3	-	-	-	7.8
5430	Dalton	23.3	23.3	28.2	4.8	5.4	4.6	-3.4	8.0	6.7
5431	Dalton	22.3	22.1	26.4	4.3	4.8	6.8	-3.2	9.9	-
5434	Dalton	20.8	25.7	27.1	1.4	2.1	4.1	1.3	2.8	7.4
5437	Dalton	15.1	19.2	24.1	4.9	2.6	5.4	-0.2	5.6	5.4
5443	Dalton	22.4	-	30.2	-	1.4	-	0.9	-	6.6
5445	Dalton	23.9	27.5	30.3	2.9	-	-	-	7.5	6.1

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5446	Dalton	28.4	33.9	38.4	4.5	5.5	10.9	-1.3	12.2	7.7
5448	Dalton	22.4	22.5	27.1	4.6	4.4	10.3	-1.1	11.3	-
5449	Dalton	18.8	17.0	23.1	6.1	3.0	9.4	-1.7	11.1	-
5451	EFP	16.9	-	-	-	3.1	-	-	-	-
5453	EFP	22.0	-	28.3	-	7.3	-	-5.0	-	6.7
5456	Dalton	15.1	16.6	18.6	2.0	2.0	2.4	-0.7	3.0	3.9
5457	Dalton	16.5	22.3	28.0	5.7	0.9	9.3	4.4	4.9	8.3
5459	EFP	22.3	-	-	-	4.3	-	-	-	-
5461	Dalton	19.6	20.0	25.2	5.2	6.0	6.9	-4.0	11.0	6.5
5462	Dalton	27.9	-	34.5	-	9.4	-	-6.5	-	-
5463	Dalton	24.6	-	29.8	-	5.9	-	-3.0	-	-
5465	Dalton	13.7	24.0	26.8	2.8	2.8	3.8	1.7	2.1	5.1
5469	Dalton	10.6	19.7	26.3	6.7	0.6	8.5	3.3	5.2	6.7
5474	Kirk	16.6	15.1	22.6	7.5	1.0	6.3	1.3	4.9	7.1
5475	Kirk	-	12.4	18.0	5.7	-	-	-	4.5	5.4
5479	Thebes	18.8	15.0	25.3	10.3	3.6	9.2	1.1	8.1	10.0
5485	Kirk	24.1	25.1	30.3	5.2	1.4	5.9	1.2	4.7	8.3
5487	Thebes	-	15.8	24.6	8.8	-	12.1	7.4	4.7	10.7
5488	Kirk	12.1	17.4	23.2	5.8	0.3	6.6	1.5	5.1	7.2
5498	Kirk	24.4	21.8	29.3	7.5	2.9	9.0	-1.1	10.2	7.1
5503	Kirk	-	13.9	19.2	5.3	-	5.4	1.4	4.0	6.4
5506	Thebes	-	18.4	29.2	10.8	-	13.7	9.4	4.3	9.3
5507	Thebes	-	16.2	23.1	6.9	-	10.0	6.1	3.9	9.8
5508	Kirk	23.5	23.3	31.3	8.1	1.5	5.6	0.5	5.1	7.7
5509	Thebes	13.7	17.7	32.2	14.4	1.8	10.1	3.7	6.4	9.3
5517	Thebes	17.4	18.2	35.3	17.1	1.0	18.7	6.4	12.3	8.6
5518	Kirk	13.4	16.3	20.6	4.3	0.8	6.2	1.6	4.6	6.4
5520	Thebes	-	18.0	26.3	8.3	-	8.8	5.9	3.0	9.6
5521	Thebes	-	14.7	23.2	8.5	-	11.3	8.1	3.2	9.1
5523	Thebes	-	14.8	24.7	9.9	-	11.5	7.0	4.5	8.9
5526	Thebes	-	18.1	26.2	8.1	-	12.5	8.2	4.3	9.4
5527	Thebes	-	14.8	21.4	6.6	-	9.5	5.3	4.2	8.2
5529	Kirk	16.4	16.0	17.6	1.6	1.8	1.2	-1.3	2.5	7.3
5530	Thebes	-	15.0	26.6	11.7	-	15.0	5.7	9.3	10.5
5531	Thebes	12.3	16.0	27.0	11.0	0.5	10.6	4.3	6.3	8.7
5547	Thebes	11.2	17.2	33.3	16.1	0.5	17.6	7.3	10.3	9.2
5551	Thebes	25.1	19.2	36.9	17.7	1.8	13.4	6.2	7.2	10.7
5552	Thebes	19.6	16.6	32.0	15.4	1.1	8.8	2.7	6.1	7.3
5553	Thebes	-	16.6	30.1	13.5	-	13.4	7.4	6.0	8.5
5554	Thebes	-	16.3	23.2	6.9	-	9.6	5.3	4.3	8.5

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5555	Thebes	-	17.8	25.0	7.2	-	10.6	6.5	4.2	11.2
5558	Thebes	-	20.7	34.5	13.8	-	17.7	9.1	8.5	10.9
5559	Thebes	22.7	20.6	40.1	19.5	1.4	13.3	7.8	5.5	8.4
5560	Thebes	-	19.2	39.1	19.9	-	19.4	6.3	13.1	10.3
5561	Thebes	10.2	16.3	27.4	11.1	0.5	14.3	2.9	11.4	9.8
5563	EFP	21.6	-	-	-	4.6	-	-	-	7.7
5570	Thebes	-	18.2	33.0	14.8	-	13.7	5.9	7.8	8.9
5578	Kirk	14.6	17.7	19.6	1.9	0.8	3.4	0.2	3.1	8.4
5581	Thebes	-	19.0	28.7	9.7	-	13.6	3.9	9.6	8.7
5583	Kirk	15.1	15.1	20.8	5.6	1.1	6.2	1.7	4.5	5.1
5584	Thebes	10.8	15.2	31.6	16.4	0.4	11.4	5.4	6.0	7.2
5585	Kirk	-	19.9	25.8	5.8	-	8.9	1.6	7.3	8.6
5586	Kirk	12.4	15.6	19.8	4.2	1.0	6.4	2.2	4.1	6.4
5589	Kirk	-	14.2	25.0	10.8	-	8.4	2.9	5.4	6.2
5592	Kirk	11.9	17.3	24.6	7.3	0.4	8.1	2.3	5.8	6.5
5593	Thebes	-	17.3	34.6	17.3	-	12.6	5.8	6.9	7.7
5594	Thebes	4.8	14.2	25.4	11.2	0.4	15.7	7.5	8.2	7.8
5596	Kirk	16.5	16.8	19.7	3.0	0.7	3.4	-0.1	3.5	7.2
5597	Thebes	4.0	15.0	26.5	11.5	0.2	12.1	5.8	6.4	8.1
5601	Hi-Lo	9.2	13.9	15.9	2.0	1.0	3.8	1.0	2.8	6.6
5602	Hi-Lo	11.0	16.6	17.8	1.1	3.0	2.3	0.5	1.8	7.8
5604	Thebes	-	18.4	22.9	4.5	-	22.1	18.3	3.8	7.2
5605	Kirk	25.4	18.7	30.5	11.8	1.8	9.0	1.4	7.6	7.2
5615	Dalton	18.9	17.9	19.9	2.0	11.0	1.1	-10.3	11.3	-
5617	Dalton	18.8	18.4	22.1	3.7	1.8	6.9	-0.5	7.5	5.5
5619	Dalton	25.9	28.2	30.5	2.3	5.9	3.1	-4.1	7.2	7.7
5626	Dalton	17.3	-	-	-	3.4	-	-	-	6.8
5627	Dalton	22.1	21.5	24.1	2.5	6.7	10.0	-5.0	15.0	7.3
5630	Dalton	17.7	19.5	23.6	4.2	3.6	6.2	-2.2	8.3	6.4
5635	Dalton	20.9	20.2	25.5	5.3	4.8	5.1	-2.4	7.5	-
5637	Dalton	25.0	29.1	30.2	1.0	6.4	-1.2	-4.4	3.2	6.6
5638	Dalton	17.7	18.3	21.0	2.8	4.9	1.2	-3.7	4.9	6.3
5643	Dalton	18.1	19.7	21.0	1.2	7.0	4.1	-5.6	9.8	6.5
5648	Dalton	19.6	22.3	26.5	4.1	5.4	3.3	-2.7	6.0	6.9
5650	Dalton	22.3	-	25.9	-	4.3	-	-2.6	-	6.8
5652	Dalton	18.3	22.1	25.1	2.9	6.2	8.6	-3.3	12.0	7.8
5653	Dalton	16.9	-	19.2	-	5.4	-	-4.3	-	5.9
5658	Dalton	23.4	24.7	30.1	5.4	6.5	4.8	-4.5	9.3	6.6
5660	Dalton	21.1	-	22.8	-	4.5	-	-2.6	-	5.8
5661	Dalton	19.6	20.7	21.8	1.0	2.9	9.1	-2.1	11.2	7.1

Point ID	Group	A	B	C	E	F	G	H	I	Max. Thick.
5663	EFP	13.5	-	-	-	2.0	-	-	-	6.1
5665	EFP	19.6	22.2	22.7	0.6	4.5	3.0	-1.1	4.1	6.8
5669	Dalton	18.8	-	22.5	-	5.2	-	-2.9	-	6.5
5670	Dalton	17.2	18.1	21.1	2.9	4.3	3.0	-3.0	5.9	7.9
5672	Dalton	22.8	22.9	25.6	2.7	5.0	3.5	-3.4	6.9	7.0
5676	Dalton	27.0	27.6	29.8	2.2	4.6	7.4	-2.3	9.7	9.1
5677	Dalton	21.9	-	24.0	-	8.7	-	-6.4	-	6.5
5678	Dalton	14.5	18.7	18.9	0.3	5.1	1.8	-0.1	1.9	7.1
5685	Dalton	19.6	18.7	22.8	4.0	2.7	3.9	-1.0	4.9	8.2
5687	Dalton	25.1	29.2	30.9	1.7	5.2	3.9	-3.2	7.1	6.9
5689	Dalton	19.8	-	26.3	-	2.5	-	0.5	-	8.2
5691	Dalton	21.9	22.7	23.7	1.0	5.8	4.3	-4.7	9.0	5.4
5694	Dalton	19.1	18.3	20.5	2.2	8.1	2.8	-6.5	9.3	6.2
5695	Dalton	15.2	20.9	21.0	0.1	5.8	0.0	-3.4	3.4	5.8
5699	Dalton	18.3	21.0	21.2	0.2	6.7	-2.7	-5.1	2.4	6.1
5709	Dalton	20.0	22.5	23.2	0.7	7.1	-2.2	-6.0	3.8	5.9
5715	Dalton	22.0	-	-	-	7.4	-	-	-	5.8
5717	Dalton	19.2	17.6	22.3	4.6	6.0	2.7	-5.0	7.8	7.0
5722	Dalton	18.6	19.5	22.4	2.9	3.7	7.9	-1.3	9.2	6.7
5725	Dalton	21.6	24.1	29.3	5.2	4.0	8.3	-0.9	9.2	7.9
5727	Dalton	19.8	21.6	23.3	1.7	7.2	-0.3	-6.0	5.7	5.3
5730	Dalton	19.4	22.8	26.9	4.0	3.3	7.7	-1.4	9.1	8.8
5732	Dalton	21.8	24.9	26.9	2.0	7.3	3.4	-6.0	9.5	6.8
5736	EFP	20.1	22.7	22.9	0.2	5.1	2.1	-2.1	4.2	7.5
5744	Thebes	-	20.7	29.2	8.5	-	10.9	4.3	6.7	7.3
5745	Thebes	4.1	12.4	22.6	10.2	0.4	10.8	4.9	5.9	6.2
5747	Thebes	17.3	17.5	30.4	13.0	1.0	13.3	6.0	7.3	8.9
5749	Dalton	19.7	19.3	26.1	6.7	1.9	6.0	0.3	5.8	7.5
5754	Kirk	-	18.9	-	-	-	9.0	-	-	7.4
5756	Thebes	13.9	18.8	28.8	10.0	1.1	8.7	2.8	5.9	10.4
5757	Thebes	-	14.4	28.9	14.5	-	14.2	9.1	5.1	9.5
5758	Dalton	19.8	17.8	23.6	5.9	3.1	6.9	-0.7	7.6	6.2
5759	Thebes	10.6	17.6	30.5	12.9	1.4	10.8	5.2	5.6	8.8
5762	Kirk	15.7	21.9	26.3	4.5	0.7	6.6	2.2	4.4	8.1
5765	Kirk	-	20.9	27.6	6.7	-	9.2	4.4	4.8	6.7
5769	Kirk	16.0	20.6	28.9	8.3	0.4	6.7	1.6	5.1	6.8
5775	Kirk	21.0	21.7	27.1	5.4	0.8	8.9	1.8	7.1	8.5
5777	Dalton	27.0	-	29.6	-	10.9	-	-9.6	-	6.9
5780	Dalton	21.2	23.0	23.7	0.7	10.5	-3.4	-7.9	4.5	5.6
5785	Dalton	25.9	-	30.1	-	7.8	-	-5.2	-	8.3

Point ID	Group	A	B	C	E	F	G	H	I	Max. Thick.
5787	Dalton	20.3	-	24.8	-	1.9	-	0.4	-	6.3
5788	Kirk	-	15.0	21.0	6.0	-	6.9	2.5	4.4	6.2
5796	Dalton	18.2	19.5	20.3	0.8	3.1	2.5	-1.6	4.1	6.4
5797	Dalton	15.5	16.4	19.2	2.8	2.6	4.0	-0.5	4.6	-
5798	Kirk	-	20.2	30.5	10.3	-	9.9	3.5	6.4	7.7
5801	Kirk	-	17.9	25.7	7.8	-	6.5	2.1	4.4	7.3
5802	Kirk	22.6	22.3	33.0	10.7	0.9	8.9	2.2	6.7	8.3
5814	Thebes	-	22.6	36.5	13.9	-	15.6	6.1	9.5	10.0
5816	Thebes	22.7	25.8	46.5	20.8	0.7	17.3	7.6	9.7	10.5
5819	Thebes	24.6	25.8	34.2	8.5	2.2	8.9	1.9	7.0	10.1
5820	Thebes	-	20.9	30.2	9.2	-	8.9	4.3	4.6	9.8
5823	Thebes	-	21.3	37.0	15.7	-	15.6	6.3	9.2	12.5
5824	Thebes	-	22.6	35.3	12.7	-	13.4	4.9	8.5	9.9
5825	Thebes	12.2	24.1	31.6	7.5	0.7	12.6	3.2	9.4	11.5
5835	Dalton	22.1	20.1	23.9	3.8	6.4	2.2	-3.8	5.9	-
5836	Dalton	19.6	23.9	24.3	0.3	3.5	4.8	-1.4	6.2	-
5837	Dalton	20.5	20.7	22.6	1.9	4.8	9.6	-1.7	11.3	-
5838	Dalton	17.5	21.0	22.9	1.8	3.5	5.0	-2.4	7.5	-
5840	Dalton	22.8	23.7	27.0	3.3	7.5	4.4	-6.0	10.4	-
5842	Dalton	17.4	-	-	-	5.3	-	-	-	-
5843	Dalton	23.9	23.2	25.9	2.7	8.6	2.7	-7.5	10.1	-
5867	Kirk	12.4	16.1	22.8	6.7	0.4	8.4	2.5	5.9	-
5868	Kirk	15.2	16.9	18.6	1.7	1.9	3.3	0.2	3.1	-
5869	Kirk	-	20.5	28.1	7.6	-	12.5	2.7	9.8	-
5870	Kirk	-	13.2	20.2	7.0	-	11.1	2.8	8.4	-
5872	Kirk	-	13.3	18.6	5.3	-	7.6	1.9	5.6	-
5874	Kirk	-	16.4	22.8	6.4	-	7.8	2.4	5.4	-
5875	Kirk	10.8	23.5	27.3	3.7	0.4	6.0	1.1	4.9	-
5876	Kirk	15.0	14.8	21.4	6.6	1.0	6.1	1.1	5.1	-
5878	Kirk	14.2	17.2	21.6	4.3	0.5	5.8	1.0	4.8	-
5880	Kirk	-	17.9	23.1	5.2	-	8.1	1.7	6.4	-

Appendix E

LITHIC RAW MATERIALS OF PROJECTILE POINTS IN ARCHAEOLOGICAL DATASET

This appendix provides the raw material data used in analysis of the archaeological dataset. Projectile points are ordered by identification number ("Point ID"). Raw material groups correspond to those described in Table 7.12.

Point ID	Group	Raw Material	Raw Material Group
10	EFP	Wyandotte	1
15	EFP	Holland Dark Phase/Upper Mercer	3
267	Kirk	Wyandotte	1
274	Hi-Lo	Attica	2
298	EFP	Attica	2
307	EFP	Wyandotte	1
352	EFP	Holland	3
353	Dalton	Wyandotte	1
354	EFP	Attica	2
358	Dalton	Wyandotte	1
362	EFP	Wyandotte	1
364	EFP	Wyandotte	1
365	EFP	Wyandotte	1
379	EFP	Wyandotte	1
552	Hi-Lo	Attica	2
578	Hi-Lo	Holland Dark Phase/Upper Mercer	3
591	EFP	Attica	2
598	Hi-Lo	Attica	2
649	Hi-Lo	Attica	2
676	Kirk	Attica	2
681	Thebes	Attica	2
684	Thebes	Attica	2
756	Hi-Lo	Attica	2

Point ID	Group	Raw Material	Raw Material Group
768	Hi-Lo	Attica	2
769	Hi-Lo	Attica	2
802	Hi-Lo	Attica	2
812	EFP	Attica	2
817	EFP	Attica	2
818	EFP	Attica	2
820	EFP	Attica	2
822	EFP	Attica	2
823	EFP	Attica	2
824	EFP	Attica	2
825	EFP	Attica	2
826	EFP	Attica	2
828	Dalton	Attica	2
830	EFP	Wyandotte	1
904	Kirk	Attica	2
914	EFP	Wyandotte	1
915	EFP	Wyandotte	1
916	EFP	Holland	3
923	EFP	Wyandotte	1
926	EFP	Holland	3
927	EFP	Holland	3
928	EFP	Wyandotte	1
935	EFP	Wyandotte	1
938	EFP	Wyandotte	1
951	EFP	Holland Dark Phase/Upper Mercer	3
954	EFP	Upper Mercer	3
955	EFP	Wyandotte	1
956	EFP	Wyandotte	1
957	EFP	Upper Mercer	3
960	EFP	Upper Mercer	3
962	EFP	Upper Mercer	3
964	EFP	Cobden/Dongola	1
965	EFP	Attica	2
968	EFP	Cobden/Dongola	1
972	EFP	Wyandotte	1
975	EFP	Wyandotte	1
980	EFP	Upper Mercer	3
985	EFP	Upper Mercer	3
986	EFP	Attica	2
989	EFP	Wyandotte	1

Point ID	Group	Raw Material	Raw Material Group
992	EFP	Wyandotte	1
994	EFP	Wyandotte	1
1003	EFP	Burlington/Avon	4
1005	EFP	Wyandotte	1
1006	EFP	Wyandotte	1
1009	EFP	Holland	3
1010	EFP	Wyandotte	1
1011	EFP	Wyandotte	1
1012	EFP	Holland	3
1017	EFP	Wyandotte	1
1018	EFP	Holland	3
1020	EFP	Holland	3
1021	EFP	Wyandotte	1
1023	EFP	Wyandotte	1
1024	EFP	Wyandotte	1
1025	EFP	Holland	3
1026	EFP	Wyandotte	1
1028	EFP	Wyandotte	1
1030	EFP	Attica	2
1034	EFP	Wyandotte	1
1035	EFP	Wyandotte	1
1036	EFP	Holland	3
1037	EFP	Wyandotte	1
1038	EFP	Wyandotte	1
1039	EFP	Wyandotte	1
1041	EFP	Burlington/Avon	4
1042	EFP	Wyandotte	1
1043	EFP	Wyandotte	1
1044	EFP	Burlington/Avon	4
1046	EFP	Holland	3
1047	EFP	Holland	3
1048	EFP	Holland	3
1049	EFP	Holland	3
1051	EFP	Attica	2
1052	EFP	Wyandotte	1
1053	EFP	Wyandotte	1
1054	EFP	Wyandotte	1
1056	EFP	Burlington/Avon	4
1061	EFP	Wyandotte	1
1062	EFP	Burlington/Avon	4

Point ID	Group	Raw Material	Raw Material Group
1063	EFP	Wyandotte	1
1065	EFP	Cobden/Dongola	1
1066	EFP	Wyandotte	1
1067	EFP	Wyandotte	1
1072	EFP	Wyandotte	1
1080	EFP	Wyandotte	1
1083	EFP	Upper Mercer	3
1086	EFP	Upper Mercer	3
1087	EFP	Wyandotte	1
1088	EFP	Wyandotte	1
1089	EFP	Upper Mercer	3
1090	EFP	Upper Mercer	3
1091	EFP	Upper Mercer	3
1095	EFP	Wyandotte	1
1096	EFP	Wyandotte	1
1099	EFP	Upper Mercer	3
1101	EFP	Upper Mercer	3
1104	EFP	Upper Mercer	3
1105	EFP	Holland	3
1107	EFP	Upper Mercer	3
1110	EFP	Upper Mercer	3
1113	EFP	Wyandotte	1
1114	EFP	Upper Mercer	3
1118	EFP	Upper Mercer	3
1120	EFP	Wyandotte	1
1123	EFP	Upper Mercer	3
1125	EFP	Holland Dark Phase/Upper Mercer	3
1127	EFP	Upper Mercer	3
1128	EFP	Upper Mercer	3
1129	EFP	Upper Mercer	3
1130	EFP	Upper Mercer	3
1142	EFP	Upper Mercer	3
1144	EFP	Wyandotte	1
1146	EFP	Wyandotte	1
1148	EFP	Upper Mercer	3
1152	EFP	Holland Dark Phase/Upper Mercer	3
1154	EFP	Upper Mercer	3
1155	EFP	Holland Dark Phase/Upper Mercer	3
1159	EFP	Upper Mercer	3
1161	EFP	Wyandotte	1

Point ID	Group	Raw Material	Raw Material Group
1167	EFP	Holland Dark Phase/Upper Mercer	3
1169	EFP	Upper Mercer	3
1171	EFP	Upper Mercer	3
1173	EFP	Upper Mercer	3
1183	EFP	Holland Dark Phase/Upper Mercer	3
1185	EFP	Upper Mercer	3
1189	EFP	Upper Mercer	3
1190	EFP	Upper Mercer	3
1192	EFP	Holland Dark Phase/Upper Mercer	3
1193	EFP	Upper Mercer	3
1200	EFP	Upper Mercer	3
1201	EFP	Upper Mercer	3
1204	EFP	Upper Mercer	3
1209	EFP	Holland Dark Phase/Upper Mercer	3
1210	EFP	Upper Mercer	3
1222	EFP	Upper Mercer	3
1225	EFP	Holland Dark Phase/Upper Mercer	3
1228	EFP	Upper Mercer	3
1232	EFP	Holland Dark Phase/Upper Mercer	3
1233	EFP	Upper Mercer	3
1234	EFP	Upper Mercer	3
1238	EFP	Upper Mercer	3
1239	EFP	Upper Mercer	3
1241	EFP	Holland Dark Phase/Upper Mercer	3
1245	EFP	Wyandotte	1
1246	EFP	Upper Mercer	3
1249	EFP	Upper Mercer	3
1250	EFP	Upper Mercer	3
1251	EFP	Upper Mercer	3
1252	EFP	Upper Mercer	3
1254	EFP	Holland Dark Phase/Upper Mercer	3
1258	EFP	Upper Mercer	3
1259	EFP	Holland Dark Phase/Upper Mercer	3
1260	EFP	Upper Mercer	3
1262	EFP	Holland Dark Phase/Upper Mercer	3
1263	EFP	Holland Dark Phase/Upper Mercer	3
1273	EFP	Upper Mercer	3
1275	EFP	Upper Mercer	3
1277	EFP	Upper Mercer	3
1280	EFP	Upper Mercer	3

Point ID	Group	Raw Material	Raw Material Group
1282	EFP	Upper Mercer	3
1283	EFP	Upper Mercer	3
1284	EFP	Upper Mercer	3
1287	EFP	Upper Mercer	3
1295	EFP	Upper Mercer	3
1308	EFP	Upper Mercer	3
1309	EFP	Wyandotte	1
1312	EFP	Upper Mercer	3
1313	EFP	Holland Dark Phase/Upper Mercer	3
1314	EFP	Upper Mercer	3
1315	EFP	Holland Dark Phase/Upper Mercer	3
1316	EFP	Holland	3
1320	EFP	Wyandotte	1
1323	EFP	Holland	3
1324	EFP	Holland	3
1328	EFP	Upper Mercer	3
1330	EFP	Upper Mercer	3
1331	EFP	Wyandotte	1
1332	EFP	Upper Mercer	3
1333	EFP	Wyandotte	1
1336	EFP	Wyandotte	1
1341	EFP	Upper Mercer	3
1345	EFP	Attica	2
1348	EFP	Upper Mercer	3
1352	EFP	Wyandotte	1
1358	EFP	Wyandotte	1
1362	EFP	Holland	3
1366	EFP	Wyandotte	1
1367	EFP	Wyandotte	1
1478	EFP	Wyandotte	1
1485	EFP	Wyandotte	1
1489	EFP	Wyandotte	1
1493	EFP	Wyandotte	1
1494	EFP	Wyandotte	1
1497	EFP	Wyandotte	1
1502	EFP	Wyandotte	1
1503	EFP	Wyandotte	1
1505	EFP	Holland	3
1506	EFP	Holland	3
1507	EFP	Wyandotte	1

Point ID	Group	Raw Material	Raw Material Group
1508	EFP	Holland	3
1511	EFP	Holland	3
1512	EFP	Attica	2
1513	EFP	Wyandotte	1
1514	EFP	Wyandotte	1
1517	EFP	Holland	3
1520	EFP	Holland	3
1522	EFP	Wyandotte	1
1523	EFP	Attica	2
1525	EFP	Wyandotte	1
1526	EFP	Holland	3
1531	EFP	Holland	3
1535	EFP	Holland	3
1546	EFP	Wyandotte	1
1548	EFP	Upper Mercer	3
1557	EFP	Wyandotte	1
1559	EFP	Wyandotte	1
1563	EFP	Wyandotte	1
1569	EFP	Upper Mercer	3
1570	EFP	Wyandotte	1
1580	EFP	Wyandotte	1
1585	EFP	Wyandotte	1
1592	EFP	Wyandotte	1
1593	EFP	Holland	3
1618	Thebes	Attica	2
1629	Hi-Lo	Bayport	5
1649	Hi-Lo	Bayport	5
1654	Thebes	Bayport	5
1656	Hi-Lo	Bayport	5
1674	Hi-Lo	Bayport	5
1684	Hi-Lo	Bayport	5
1692	Hi-Lo	Bayport	5
1694	Thebes	Bayport	5
1696	Thebes	Bayport	5
1711	Hi-Lo	Bayport	5
1721	EFP	Upper Mercer	3
1778	EFP	Holland	3
1779	Kirk	Wyandotte	1
1784	EFP	Wyandotte	1
1789	Dalton	Wyandotte	1

Point ID	Group	Raw Material	Raw Material Group
1790	Dalton	Wyandotte	1
1792	Dalton	Wyandotte	1
1794	Dalton	Wyandotte	1
1799	Dalton	Wyandotte	1
1801	Dalton	Wyandotte	1
1823	Dalton	Wyandotte	1
1827	Kirk	Wyandotte	1
1833	Dalton	Wyandotte	1
1838	Kirk	Wyandotte	1
1839	Kirk	Wyandotte	1
1842	Kirk	Wyandotte	1
1843	Kirk	Wyandotte	1
1844	Kirk	Wyandotte	1
1848	Kirk	Wyandotte	1
1856	Thebes	Wyandotte	1
1866	Thebes	Wyandotte	1
1869	Kirk	Wyandotte	1
1870	Dalton	Wyandotte	1
1871	Kirk	Wyandotte	1
1873	Hi-Lo	Bayport	5
1920	Hi-Lo	Bayport	5
1988	Hi-Lo	Bayport	5
1990	Hi-Lo	Bayport	5
1993	Thebes	Bayport	5
1994	Hi-Lo	Bayport	5
2000	Kirk	Bayport	5
2003	Hi-Lo	Bayport	5
2004	Hi-Lo	Bayport	5
2020	EFP	Holland Dark Phase/Upper Mercer	3
2022	Dalton	Wyandotte	1
2025	EFP	Wyandotte	1
2029	Thebes	Wyandotte	1
2032	Thebes	Wyandotte	1
2034	Kirk	Wyandotte	1
2037	Kirk	Wyandotte	1
2042	Kirk	Attica	2
2047	Kirk	Attica	2
2056	Kirk	Attica	2
2079	Kirk	Wyandotte	1
2081	Kirk	Wyandotte	1

Point ID	Group	Raw Material	Raw Material Group
2082	Thebes	Wyandotte	1
2086	Thebes	Wyandotte	1
2097	Kirk	Attica	2
2099	Thebes	Wyandotte	1
2101	Kirk	Wyandotte	1
2103	Kirk	Wyandotte	1
2106	Kirk	Wyandotte	1
2110	Kirk	Wyandotte	1
2111	Dalton	Wyandotte	1
2112	Kirk	Wyandotte	1
2134	Thebes	Attica	2
2136	Thebes	Holland Dark Phase/Upper Mercer	3
2149	Kirk	Wyandotte	1
2152	Kirk	Wyandotte	1
2162	Kirk	Wyandotte	1
2173	Kirk	Holland	3
2175	Thebes	Holland	3
2192	Kirk	Wyandotte	1
2194	Kirk	Holland	3
2210	Thebes	Attica	2
2211	Kirk	Wyandotte	1
2214	Kirk	Attica	2
2219	Thebes	Attica	2
2220	Thebes	Wyandotte	1
2221	Kirk	Wyandotte	1
2230	Kirk	Wyandotte	1
2233	EFP	Upper Mercer	3
2250	Thebes	Upper Mercer	3
2252	Kirk	Upper Mercer	3
2253	Thebes	Upper Mercer	3
2254	Thebes	Upper Mercer	3
2264	Thebes	Upper Mercer	3
2267	Thebes	Upper Mercer	3
2276	Thebes	Upper Mercer	3
2277	Thebes	Upper Mercer	3
2302	Kirk	Upper Mercer	3
2316	Kirk	Upper Mercer	3
2322	Thebes	Upper Mercer	3
2337	Thebes	Upper Mercer	3
2338	Kirk	Upper Mercer	3

Point ID	Group	Raw Material	Raw Material Group
2342	Thebes	Upper Mercer	3
2343	Thebes	Upper Mercer	3
2350	Kirk	Upper Mercer	3
2353	Thebes	Upper Mercer	3
2354	Kirk	Upper Mercer	3
2365	Kirk	Upper Mercer	3
2370	EFP	Upper Mercer	3
2382	EFP	Upper Mercer	3
2385	EFP	Attica	2
2391	EFP	Upper Mercer	3
2392	EFP	Upper Mercer	3
2396	EFP	Upper Mercer	3
2405	EFP	Upper Mercer	3
2428	Kirk	Attica	2
2429	Kirk	Attica	2
2438	Thebes	Wyandotte	1
2439	Thebes	Attica	2
2442	EFP	Holland	3
2470	Kirk	Wyandotte	1
2483	Thebes	Holland	3
2484	Kirk	Attica	2
2489	Thebes	Holland	3
2492	Kirk	Wyandotte	1
2502	Kirk	Attica	2
2510	Thebes	Attica	2
2523	Thebes	Attica	2
2527	Thebes	Attica	2
2540	Kirk	Wyandotte	1
2546	Thebes	Attica	2
2550	Thebes	Attica	2
2551	Thebes	Attica	2
2564	Thebes	Wyandotte	1
2565	Thebes	Wyandotte	1
2566	Thebes	Holland	3
2567	Thebes	Holland	3
2571	Thebes	Wyandotte	1
2573	Thebes	Wyandotte	1
2578	Thebes	Wyandotte	1
2579	Thebes	Wyandotte	1
2580	Thebes	Wyandotte	1

Point ID	Group	Raw Material	Raw Material Group
2586	Kirk	Holland	3
2587	Kirk	Holland	3
2589	Kirk	Holland	3
2595	Kirk	Wyandotte	1
2597	Kirk	Holland	3
2599	Kirk	Holland	3
2600	Kirk	Holland	3
2602	Kirk	Holland	3
2604	Kirk	Wyandotte	1
2605	Kirk	Holland	3
2606	Kirk	Holland	3
2607	Kirk	Holland	3
2608	Kirk	Wyandotte	1
2609	Kirk	Wyandotte	1
2610	Kirk	Holland	3
2612	Kirk	Wyandotte	1
2617	Kirk	Wyandotte	1
2620	Kirk	Holland	3
2621	Kirk	Holland	3
2624	Kirk	Holland	3
2626	Kirk	Holland	3
2628	Kirk	Holland	3
2629	Thebes	Wyandotte	1
2632	Kirk	Wyandotte	1
2633	Kirk	Holland	3
2634	Kirk	Wyandotte	1
2637	Kirk	Wyandotte	1
2638	Kirk	Wyandotte	1
2642	Kirk	Wyandotte	1
2645	Kirk	Wyandotte	1
2647	Thebes	Wyandotte	1
2648	Thebes	Wyandotte	1
2650	Thebes	Holland	3
2651	Thebes	Wyandotte	1
2652	Kirk	Holland	3
2653	Kirk	Wyandotte	1
2871	Kirk	Holland	3
2875	Kirk	Attica	2
2897	Kirk	Upper Mercer	3
2905	Thebes	Holland	3

Point ID	Group	Raw Material	Raw Material Group
2907	Kirk	Wyandotte	1
2908	Kirk	Attica	2
2910	Thebes	Upper Mercer	3
2915	Thebes	Holland Dark Phase/Upper Mercer	3
2917	Kirk	Attica	2
2918	Thebes	Attica	2
2930	Thebes	Attica	2
2934	Kirk	Attica	2
2935	Kirk	Attica	2
2936	Kirk	Attica	2
2939	Thebes	Upper Mercer	3
2941	Kirk	Attica	2
2942	Kirk	Attica	2
2945	Kirk	Wyandotte	1
2946	Thebes	Attica	2
2948	Kirk	Attica	2
2971	Thebes	Upper Mercer	3
2979	Kirk	Holland	3
2991	Thebes	Wyandotte	1
2995	Thebes	Holland	3
3003	Kirk	Wyandotte	1
3004	Kirk	Wyandotte	1
3006	Kirk	Wyandotte	1
3008	Kirk	Wyandotte	1
3013	Thebes	Wyandotte	1
3014	Thebes	Wyandotte	1
3016	Kirk	Wyandotte	1
3017	Kirk	Wyandotte	1
3022	Thebes	Wyandotte	1
3025	Kirk	Wyandotte	1
3027	Thebes	Wyandotte	1
3029	Kirk	Wyandotte	1
3035	Thebes	Wyandotte	1
3044	Kirk	Attica	2
3046	Kirk	Attica	2
3047	Kirk	Attica	2
3048	Kirk	Attica	2
3049	Thebes	Holland	3
3057	Kirk	Attica	2
3076	Kirk	Attica	2

Point ID	Group	Raw Material	Raw Material Group
3079	Kirk	Wyandotte	1
3080	Kirk	Wyandotte	1
3089	Kirk	Holland	3
3098	Kirk	Attica	2
3099	Kirk	Attica	2
3101	Kirk	Attica	2
3102	Kirk	Attica	2
3103	Thebes	Attica	2
3105	Kirk	Attica	2
3106	Kirk	Attica	2
3108	Kirk	Attica	2
3112	Thebes	Attica	2
3119	Kirk	Holland	3
3131	Kirk	Wyandotte	1
3134	Kirk	Wyandotte	1
3137	Thebes	Wyandotte	1
3141	Thebes	Holland	3
3153	Kirk	Wyandotte	1
3179	Kirk	Holland	3
3191	Thebes	Holland	3
3194	Kirk	Holland	3
3203	Kirk	Wyandotte	1
3204	Thebes	Wyandotte	1
3208	Thebes	Wyandotte	1
3212	Kirk	Holland	3
3216	Thebes	Holland	3
3218	Kirk	Wyandotte	1
3221	Kirk	Wyandotte	1
3223	Dalton	Wyandotte	1
3225	Kirk	Attica	2
3229	Kirk	Holland	3
3230	Kirk	Wyandotte	1
3234	Kirk	Holland	3
3236	Kirk	Wyandotte	1
3246	Thebes	Wyandotte	1
3249	Kirk	Wyandotte	1
3250	Kirk	Wyandotte	1
3251	Thebes	Wyandotte	1
3253	Kirk	Wyandotte	1
3254	Kirk	Wyandotte	1

Point ID	Group	Raw Material	Raw Material Group
3255	Kirk	Wyandotte	1
3256	Kirk	Wyandotte	1
3258	Kirk	Wyandotte	1
3259	Kirk	Wyandotte	1
3260	Kirk	Wyandotte	1
3261	Kirk	Wyandotte	1
3263	Kirk	Wyandotte	1
3264	Kirk	Wyandotte	1
3265	Kirk	Wyandotte	1
3267	Kirk	Wyandotte	1
3270	Thebes	Wyandotte	1
3271	Thebes	Wyandotte	1
3274	Thebes	Wyandotte	1
3275	Thebes	Wyandotte	1
3276	Thebes	Wyandotte	1
3287	Thebes	Holland	3
3297	Thebes	Wyandotte	1
3300	Thebes	Wyandotte	1
3302	Thebes	Holland	3
3305	Kirk	Wyandotte	1
3306	Kirk	Wyandotte	1
3307	Kirk	Wyandotte	1
3308	Kirk	Wyandotte	1
3310	Kirk	Wyandotte	1
3320	Dalton	Wyandotte	1
3327	Kirk	Wyandotte	1
3332	Kirk	Wyandotte	1
3334	Kirk	Wyandotte	1
3335	Kirk	Wyandotte	1
3336	Kirk	Wyandotte	1
3337	Kirk	Wyandotte	1
3338	Kirk	Wyandotte	1
3339	Kirk	Wyandotte	1
3340	Kirk	Wyandotte	1
3341	Kirk	Wyandotte	1
3342	Kirk	Wyandotte	1
3343	Kirk	Wyandotte	1
3346	Kirk	Wyandotte	1
3347	Kirk	Wyandotte	1
3348	Kirk	Wyandotte	1

Point ID	Group	Raw Material	Raw Material Group
3349	Kirk	Wyandotte	1
3371	Thebes	Burlington/Avon	4
3372	Thebes	Burlington/Avon	4
3373	Thebes	Burlington/Avon	4
3376	Kirk	Wyandotte	1
3377	Dalton	Wyandotte	1
3402	Thebes	Attica	2
3403	Thebes	Attica	2
3404	Kirk	Attica	2
3405	Thebes	Attica	2
3407	Thebes	Attica	2
3438	Kirk	Attica	2
3441	Kirk	Attica	2
3463	Thebes	Attica	2
3467	Thebes	Attica	2
3473	Thebes	Upper Mercer	3
3474	Thebes	Upper Mercer	3
3477	Thebes	Upper Mercer	3
3481	Thebes	Attica	2
3487	Thebes	Upper Mercer	3
3489	Thebes	Attica	2
3493	Kirk	Upper Mercer	3
3495	Kirk	Wyandotte	1
3496	Kirk	Wyandotte	1
3497	Kirk	Upper Mercer	3
3520	Hi-Lo	Bayport	5
3521	Hi-Lo	Bayport	5
3522	Hi-Lo	Bayport	5
3526	Hi-Lo	Bayport	5
3530	Hi-Lo	Bayport	5
3533	Hi-Lo	Bayport	5
3534	Hi-Lo	Bayport	5
3536	Hi-Lo	Bayport	5
3580	EFP	Upper Mercer	3
3615	EFP	Upper Mercer	3
3837	Dalton	Burlington/Avon	4
3842	EFP	Burlington/Avon	4
3893	Kirk	Cobden/Dongola	1
3910	Thebes	Burlington/Avon	4
3917	Thebes	Attica	2

Point ID	Group	Raw Material	Raw Material Group
3933	Kirk	Attica	2
3937	Kirk	Wyandotte	1
3948	Kirk	UM/Holland (light)	3
3949	Kirk	Attica	2
3966	Kirk	Bayport	5
3993	Thebes	Burlington/Avon	4
3995	Thebes	Wyandotte	1
4001	Kirk	Wyandotte	1
4003	Thebes	Wyandotte	1
4011	Kirk	Bayport	5
4023	Kirk	Bayport	5
4050	Thebes	Wyandotte	1
4051	Thebes	Wyandotte	1
4052	Kirk	Attica	2
4054	Kirk	Wyandotte	1
4059	Kirk	Attica	2
4061	Kirk	Holland	3
4064	Kirk	Wyandotte	1
4068	Thebes	Burlington/Avon	4
4069	Thebes	Burlington/Avon	4
4079	Thebes	Burlington/Avon	4
4080	Thebes	Burlington/Avon	4
4086	Thebes	Burlington/Avon	4
4087	Thebes	Burlington/Avon	4
4088	Thebes	Burlington/Avon	4
4089	Thebes	Burlington/Avon	4
4090	Thebes	Burlington/Avon	4
4091	Thebes	Burlington/Avon	4
4092	Thebes	Burlington/Avon	4
4093	Thebes	Burlington/Avon	4
4094	Thebes	Burlington/Avon	4
4095	Thebes	Burlington/Avon	4
4096	Thebes	Burlington/Avon	4
4097	Thebes	Burlington/Avon	4
4099	Thebes	Burlington/Avon	4
4100	Kirk	Burlington/Avon	4
4101	Kirk	Burlington/Avon	4
4103	Kirk	Burlington/Avon	4
4111	Thebes	Burlington/Avon	4
4115	Thebes	Burlington/Avon	4

Point ID	Group	Raw Material	Raw Material Group
4117	Thebes	Burlington/Avon	4
4118	Thebes	Burlington/Avon	4
4119	Thebes	Burlington/Avon	4
4120	Thebes	Burlington/Avon	4
4121	EFP	Burlington/Avon	4
4124	Kirk	Burlington/Avon	4
4131	Thebes	Burlington/Avon	4
4134	Kirk	Burlington/Avon	4
4135	Kirk	Burlington/Avon	4
4136	Thebes	Burlington/Avon	4
4148	Thebes	Burlington/Avon	4
4198	Thebes	Burlington/Avon	4
4199	Thebes	Attica	2
4205	Kirk	Attica	2
4209	Thebes	Burlington/Avon	4
4213	Thebes	Burlington/Avon	4
4216	Thebes	Cobden/Dongola/Wyandotte	1
4233	Thebes	Cobden/Dongola	1
4236	Thebes	Burlington/Avon	4
4237	Thebes	Cobden/Dongola/Wyandotte	1
4238	Kirk	Burlington/Avon	4
4239	Thebes	Burlington/Avon	4
4260	Thebes	Cobden/Dongola/Wyandotte	1
4265	Thebes	Cobden/Dongola	1
4270	Dalton	Cobden/Dongola	1
4275	Dalton	Burlington/Avon	4
4277	Thebes	Cobden/Dongola	1
4278	Thebes	Cobden/Dongola	1
4280	Thebes	Cobden/Dongola	1
4284	Thebes	Cobden/Dongola	1
4285	Kirk	Wyandotte	1
4292	Thebes	Burlington/Avon	4
4297	Kirk	Wyandotte	1
4299	Kirk	Attica	2
4302	Thebes	Attica	2
4307	Kirk	Attica	2
4315	Kirk	Holland Dark Phase/Upper Mercer	3
4320	Kirk	Attica	2
4321	Thebes	Bayport	5
4323	Thebes	Holland	3

Point ID	Group	Raw Material	Raw Material Group
4328	Kirk	Attica	2
4356	Thebes	Wyandotte	1
4372	EFP	Wyandotte	1
4373	EFP	Burlington/Avon	4
4378	EFP	Upper Mercer	3
4379	EFP	Wyandotte	1
4384	EFP	Upper Mercer	3
4386	EFP	Upper Mercer	3
4387	EFP	Wyandotte	1
4397	Thebes	Wyandotte	1
4402	EFP	Wyandotte	1
4410	Kirk	Bayport	5
4414	Kirk	Bayport	5
4437	Kirk	Burlington/Avon	4
4442	Kirk	Wyandotte	1
4443	Kirk	Burlington/Avon	4
4447	Kirk	Burlington/Avon	4
4451	Kirk	Burlington/Avon	4
4452	Thebes	Burlington/Avon	4
4455	Thebes	Burlington/Avon	4
4458	Thebes	Burlington/Avon	4
4465	Dalton	Burlington/Avon	4
4466	Dalton	Burlington/Avon	4
4467	Dalton	Burlington/Avon	4
4468	Dalton	Burlington/Avon	4
4471	Thebes	Cobden/Dongola	1
4476	Kirk	Burlington/Avon	4
4477	Kirk	Burlington/Avon	4
4480	Thebes	Cobden/Dongola	1
4501	Thebes	Attica	2
4506	Kirk	Attica	2
4528	Kirk	Burlington/Avon	4
4529	Kirk	Burlington/Avon	4
4530	Kirk	Burlington/Avon	4
4531	Thebes	Burlington/Avon	4
4532	Thebes	Burlington/Avon	4
4537	Kirk	Burlington/Avon	4
4538	Thebes	Burlington/Avon	4
4540	Kirk	Burlington/Avon	4
4541	Kirk	Burlington/Avon	4

Point ID	Group	Raw Material	Raw Material Group
4550	Kirk	Burlington/Avon	4
4554	Kirk	Burlington/Avon	4
4558	Thebes	Burlington/Avon	4
4559	Thebes	Burlington/Avon	4
4560	Thebes	Burlington/Avon	4
4561	Kirk	Burlington/Avon	4
4563	EFP	Burlington/Avon	4
4575	Kirk	Burlington/Avon	4
4579	Thebes	Burlington/Avon	4
4582	Kirk	Burlington/Avon	4
4584	Thebes	Burlington/Avon	4
4585	Thebes	Burlington/Avon	4
4589	Kirk	Burlington/Avon	4
4591	Dalton	Burlington/Avon	4
4593	Thebes	Burlington/Avon	4
4595	Thebes	Burlington/Avon	4
4597	Thebes	Cobden/Dongola	1
4600	Dalton	Burlington/Avon	4
4602	Thebes	Burlington/Avon	4
4605	Kirk	Burlington/Avon	4
4606	Thebes	Burlington/Avon	4
4608	Dalton	Burlington/Avon	4
4611	Thebes	Burlington/Avon	4
4613	Thebes	Burlington/Avon	4
4614	Thebes	Burlington/Avon	4
4615	Thebes	Burlington/Avon	4
4617	Kirk	Burlington/Avon	4
4620	Dalton	Burlington/Avon	4
4624	Thebes	Burlington/Avon	4
4625	Kirk	Burlington/Avon	4
4626	Thebes	Burlington/Avon	4
4629	Kirk	Burlington/Avon	4
4637	Thebes	Burlington/Avon	4
4640	Kirk	Burlington/Avon	4
4643	Dalton	Burlington/Avon	4
4647	Kirk	Burlington/Avon	4
4650	Thebes	Burlington/Avon	4
4652	Dalton	Burlington/Avon	4
4658	Thebes	Burlington/Avon	4
4660	Thebes	Burlington/Avon	4

Point ID	Group	Raw Material	Raw Material Group
4661	Thebes	Burlington/Avon	4
4663	Kirk	Burlington/Avon	4
4664	Kirk	Burlington/Avon	4
4665	Kirk	Burlington/Avon	4
4666	Kirk	Burlington/Avon	4
4668	Kirk	Burlington/Avon	4
4745	Kirk	Cobden/Wyandotte	1
4758	Thebes	Attica	2
4770	Thebes	Wyandotte	1
4771	Thebes	Wyandotte	1
4774	Kirk	Wyandotte	1
4775	Kirk	Wyandotte	1
4782	Thebes	Wyandotte	1
4783	Kirk	Wyandotte	1
4784	Kirk	Wyandotte	1
4785	Kirk	Wyandotte	1
4787	Kirk	Wyandotte	1
4808	EFP	Wyandotte	1
4809	EFP	Wyandotte	1
4810	Thebes	Wyandotte	1
4811	Kirk	Wyandotte	1
4812	Kirk	Wyandotte	1
4817	Thebes	Wyandotte	1
4818	Kirk	Wyandotte	1
4819	EFP	Wyandotte	1
4820	Kirk	Wyandotte	1
4826	Kirk	Wyandotte	1
4829	Dalton	Wyandotte	1
4834	Kirk	Wyandotte	1
4839	Dalton	Wyandotte	1
4851	Kirk	Wyandotte	1
4918	Kirk	Wyandotte	1
4919	Kirk	Wyandotte	1
4922	Kirk	Wyandotte	1
4923	Kirk	Wyandotte	1
4925	Kirk	Wyandotte	1
4926	Kirk	Wyandotte	1
4929	Kirk	Wyandotte	1
4930	Kirk	Wyandotte	1
4949	Dalton	Wyandotte	1

Point ID	Group	Raw Material	Raw Material Group
4960	Thebes	Wyandotte	1
4975	Kirk	Wyandotte	1
4976	Kirk	Wyandotte	1
4978	Kirk	Wyandotte	1
4979	Dalton	Wyandotte	1
4981	Kirk	Wyandotte	1
4985	Kirk	Wyandotte	1
5003	Kirk	Wyandotte	1
5029	Kirk	Wyandotte	1
5030	Kirk	Wyandotte	1
5035	Kirk	Wyandotte	1
5036	Kirk	Wyandotte	1
5039	Kirk	Wyandotte	1
5047	Kirk	Wyandotte	1
5048	Kirk	Wyandotte	1
5050	Kirk	Wyandotte	1
5051	Kirk	Wyandotte	1
5053	Kirk	Wyandotte	1
5106	EFP	Upper Mercer	3
5148	EFP	Upper Mercer	3
5151	EFP	Upper Mercer	3
5152	EFP	Upper Mercer	3
5154	EFP	Upper Mercer	3
5157	EFP	Wyandotte	1
5166	EFP	Upper Mercer	3
5173	EFP	Upper Mercer	3
5187	EFP	Wyandotte	1
5188	EFP	Wyandotte	1
5189	EFP	Upper Mercer	3
5195	EFP	Wyandotte	1
5208	EFP	Upper Mercer	3
5210	EFP	Upper Mercer	3
5219	EFP	Wyandotte	1
5229	EFP	Upper Mercer	3
5235	EFP	Upper Mercer	3
5237	EFP	Upper Mercer	3
5247	EFP	Wyandotte	1
5248	EFP	Upper Mercer	3
5254	EFP	Upper Mercer/Nellie	3
5258	EFP	Wyandotte	1

Point ID	Group	Raw Material	Raw Material Group
5262	EFP	Wyandotte	1
5266	EFP	Wyandotte	1
5279	EFP	Upper Mercer	3
5285	EFP	Wyandotte	1
5295	Kirk	Upper Mercer	3
5296	Thebes	Upper Mercer	3
5301	Thebes	Upper Mercer	3
5303	Kirk	Upper Mercer	3
5307	Kirk	Wyandotte	1
5309	Kirk	Upper Mercer	3
5311	Kirk	Upper Mercer	3
5316	Thebes	Upper Mercer	3
5318	Thebes	Upper Mercer	3
5329	Kirk	Upper Mercer	3
5331	Thebes	Upper Mercer	3
5334	Thebes	Upper Mercer	3
5341	Kirk	Upper Mercer	3
5344	Thebes	Upper Mercer	3
5349	Kirk	Upper Mercer	3
5361	Kirk	Upper Mercer	3
5374	Hi-Lo	Upper Mercer	3
5384	Thebes	Upper Mercer	3
5387	Thebes	Upper Mercer	3
5399	Thebes	Bayport	5
5400	Kirk	Upper Mercer	3
5401	Kirk	Upper Mercer	3
5402	Kirk	Upper Mercer	3
5403	Kirk	Upper Mercer	3
5409	Kirk	Upper Mercer	3
5415	Kirk	Upper Mercer	3
5419	Kirk	Upper Mercer	3
5420	Thebes	Upper Mercer	3
5422	Thebes	Upper Mercer	3
5427	EFP	Upper Mercer	3
5474	Kirk	Upper Mercer	3
5476	Kirk	Upper Mercer	3
5485	Kirk	Upper Mercer	3
5486	Kirk	Upper Mercer	3
5487	Thebes	Upper Mercer	3
5498	Kirk	Upper Mercer	3

Point ID	Group	Raw Material	Raw Material Group
5499	Thebes	Upper Mercer	3
5501	Thebes	Upper Mercer	3
5508	Kirk	Upper Mercer	3
5511	Kirk	Upper Mercer	3
5526	Thebes	Upper Mercer	3
5529	Kirk	Wyandotte	1
5530	Thebes	Upper Mercer	3
5558	Thebes	Attica	2
5559	Thebes	Wyandotte	1
5560	Thebes	Bayport	5
5563	EFP	Upper Mercer	3
5578	Kirk	Wyandotte	1
5596	Kirk	Wyandotte	1
5619	Dalton	Burlington	4
5626	Dalton	Wyandotte	1
5629	Dalton	Cobden/Wyandotte	1
5635	Dalton	Burlington	4
5636	Dalton	Cobden/Wyandotte	1
5640	Dalton	Burlington	4
5652	Dalton	Burlington	4
5653	Dalton	Wyandotte	1
5657	Dalton	Burlington	4
5665	EFP	Burlington	4
5680	Dalton	Burlington	4
5684	Dalton	Burlington	4
5685	Dalton	Cobden	1
5687	Dalton	Cobden/Wyandotte	1
5702	Dalton	Cobden/Wyandotte	1
5704	Dalton	Burlington	4
5705	Dalton	Burlington	4
5723	Dalton	Burlington	4
5732	Dalton	Burlington	4
5740	Dalton	Cobden/Wyandotte	1
5745	Thebes	Cobden/Wyandotte	1
5757	Thebes	Cobden/Wyandotte	1
5759	Thebes	Cobden/Wyandotte	1
5762	Kirk	Cobden/Wyandotte	1
5765	Kirk	Burlington	4
5769	Kirk	Burlington	4
5777	Dalton	Burlington	4

Point ID	Group	Raw Material	Raw Material Group
5782	Dalton	Burlington	4
5783	Dalton	Burlington	4
5787	Dalton	Burlington	4
5788	Kirk	Burlington	4
5797	Dalton	Cobden/Wyandotte	1
5798	Kirk	Cobden/Wyandotte	1
5810	Thebes	Burlington	4
5811	Thebes	Burlington	4
5814	Thebes	Burlington	4
5815	Thebes	Burlington	4
5816	Thebes	Burlington/Salem	4
5818	Thebes	Burlington	4
5819	Thebes	Burlington	4
5823	Thebes	Burlington	4
5824	Thebes	Burlington	4
5825	Thebes	Burlington	4
5827	Thebes	Burlington	4
5828	Thebes	Burlington	4
5829	Thebes	Burlington	4
5840	Dalton	Burlington/Crescent Hills	4
5841	Dalton	Burlington/Crescent Hills	4
5842	Dalton	Burlington	4
5843	Dalton	Burlington	4

Appendix F

UTM COORDINATES ASSOCIATED WITH COUNTY-LEVEL PROVENIENCES FOR PROJECTILE POINTS IN ARCHAEOLOGICAL DATASET

This appendix provides a table of UTM coordinates (Zone 16 using North American Datum 1983) that were used to perform the spatial analyses in Chapter 7. Each projectile point was associated with a pair of UTM coordinates based on its county-level provenience (see Appendix B). Coordinates were determined for the approximate center of each county in Illinois, Indiana, Kentucky, Michigan, and Ohio, as well as the provinces of southern Ontario. Points with provenience within a single county were associated with these approximate center coordinates. Points for which provenience was only known within two or three adjacent counties were associated with the coordinates of a location along the boundary between the counties.

State	County	UTM Easting	UTM Northing
IL	Adams IL	142610	4435151
IL	Alexander IL	291085	4118898
IL	Bond IL	288609	4306950
IL	Boone IL	349771	4687668
IL	Brown IL	179759	4431752
IL	Bureau IL	289968	4586661
IL	Calhoun IL	184130	4342157
IL	Carroll IL	257991	4661930
IL	Carroll/Ogle IL	277699	4660945
IL	Cass IL	222493	4429081
IL	Champaign IL	397628	4444135
IL	Christian IL	304318	4379792

State	County	UTM Easting	UTM Northing
IL	Clark IL	431378	4354540
IL	Clay IL	370676	4291654
IL	Clinton IL	288851	4277085
IL	Coles IL	395443	4375664
IL	Cook IL	436452	4632794
IL	Crawford IL	434291	4317634
IL	Crawford/Lawrence IL	436032	4300403
IL	Cumberland IL	393257	4348227
IL	DeKalb IL	353170	4639592
IL	DeWitt IL	338068	4449234
IL	Douglas IL	395685	4402858
IL	DuPage IL	409501	4634008
IL	Edgar IL	435748	4392418
IL	Edwards IL	408068	4252562
IL	Effingham IL	363150	4324675
IL	Fayette IL	324544	4318605
IL	Ford IL	390805	4494760
IL	Franklin IL	328963	4207036
IL	Fulton IL	231525	4485169
IL	Gallatin IL	393791	4180571
IL	Greene IL	208653	4361824
IL	Grundy IL	381336	4572214
IL	Hamilton IL	365141	4216506
IL	Hancock IL	148923	4480798
IL	Hardin IL	390392	4154105
IL	Henderson IL	167619	4526203
IL	Henry IL	237037	4582776
IL	Iroquois IL	430382	4511027
IL	Jackson IL	288414	4184698
IL	Jasper IL	400056	4318605
IL	Jefferson IL	331585	4240908
IL	Jersey IL	208896	4331959
IL	Jersey/Madison IL	218935	4321574
IL	Jo Daviess IL	237838	4695437
IL	Johnson IL	334304	4148035
IL	Kane IL	381336	4644206
IL	Kankakee IL	425769	4554489
IL	Kendall IL	381093	4605721
IL	Knox IL	229826	4536401
IL	Lake IL	416785	4686697

State	County	UTM Easting	UTM Northing
IL	LaSalle IL	342730	4578770
IL	Lawrence IL	438176	4286069
IL	Lee IL	309951	4624539
IL	Livingston IL	366525	4528024
IL	Logan IL	298248	4442892
IL	Macon IL	330541	4414270
IL	Macoupin IL	247817	4350170
IL	Madison IL	252188	4302337
IL	Marion IL	333285	4279759
IL	Marshall IL	303153	4542956
IL	Mason IL	244103	4453119
IL	Massac IL	346445	4120598
IL	McDonough IL	188257	4484926
IL	McHenry IL	380850	4687182
IL	McLean IL	342487	4484198
IL	Menard IL	262313	4434665
IL	Mercer IL	186291	4567480
IL	Monroe IL	222323	4241393
IL	Montgomery IL	286181	4340457
IL	Morgan IL	227835	4401401
IL	Moultrie IL	358949	4389018
IL	Ogle IL	308737	4657317
IL	Peoria IL	266489	4519161
IL	Perry IL	292493	4217841
IL	Piatt IL	363320	4430052
IL	Pike IL	164463	4393389
IL	Pope IL	360770	4142208
IL	Pulaski IL	310995	4122055
IL	Puntnam IL	305823	4564325
IL	Randolph IL	252188	4216506
IL	Richland IL	405883	4285584
IL	Rock Island IL	202073	4592246
IL	Saint Clair IL	244418	4263731
IL	Saline IL	364412	4180085
IL	Sangamon IL	271054	4404558
IL	Schuyler IL	192142	4451419
IL	Scott IL	201855	4393675
IL	Shelby IL	348824	4361824
IL	Stark IL	264061	4553397
IL	Stephenson IL	280815	4692524

State	County	UTM Easting	UTM Northing
IL	Tazewell IL	281786	4487354
IL	Union IL	300555	4149249
IL	Vermillion IL	437205	4448263
IL	Wabash IL	426279	4253533
IL	Warren IL	195542	4528388
IL	Washington IL	288366	4247706
IL	Wayne IL	375533	4254505
IL	White IL	391606	4202423
IL	Whiteside IL	255563	4626967
IL	Will IL	418485	4591639
IL	Williamson IL	330177	4177657
IL	Winnebago IL	321120	4689610
IL	Woodford IL	310680	4517705
IN	Adams IN	674184	4512794
IN	Adams/Wells IN	662805	4512308
IN	Allen IN	662027	4550628
IN	Bartholomew IN	596280	4340354
IN	Benton IN	473782	4495336
IN	Blackford IN	642040	4481720
IN	Boone IN	545326	4433771
IN	Brown IN	566810	4338798
IN	Carroll IN	537001	4492710
IN	Carroll/Tippecanoe IN	525693	4487504
IN	Cass IN	552815	4512454
IN	Clark IN	609750	4259581
IN	Clay IN	492359	4360584
IN	Clinton IN	545306	4461490
IN	Crawford IN	546775	4238379
IN	Daviess IN	491600	4283896
IN	Dearborn IN	676499	4334908
IN	Decatur IN	630379	4351928
IN	DeKalb IN	667279	4584814
IN	Delaware IN	636399	4454293
IN	DuBois IN	510857	4246402
IN	Elkhart IN	595054	4606114
IN	Fayette IN	657222	4389470
IN	Floyd IN	596007	4241685
IN	Fountain IN	478762	4441260
IN	Franklin IN	667356	4364766
IN	Fulton IN	563737	4544354

State	County	UTM Easting	UTM Northing
IN	Gibson IN	449828	4240713
IN	Grant IN	614029	4485902
IN	Greene IN	503369	4320951
IN	Hamilton IN	580855	4436203
IN	Hancock IN	604800	4408776
IN	Harrison IN	576167	4227777
IN	Hendricks IN	542311	4402260
IN	Henry IN	637692	4421517
IN	Howard IN	574679	4482109
IN	Huntington IN	627548	4520915
IN	Jackson IN	583490	4306849
IN	Jasper IN	489800	4539000
IN	Jay IN	669214	4478316
IN	Jefferson IN	635164	4294156
IN	Jennings IN	619505	4317304
IN	Johnson IN	576352	4372775
IN	Knox IN	465000	4282631
IN	Kosciusko IN	596027	4566627
IN	LaGrange IN	630972	4611512
IN	Lake IN	468832	4585057
IN	Lake/Porter IN	481315	4588787
IN	LaPorte IN	523803	4599500
IN	Lawrence IN	545219	4299554
IN	Madison IN	608972	4446609
IN	Marion IN	573657	4403816
IN	Marshall IN	561792	4575283
IN	Martin IN	517082	4284674
IN	Miami IN	579755	4513621
IN	Monroe IN	540910	4334908
IN	Montgomery IN	509204	4432410
IN	Morgan IN	547816	4370796
IN	Newton IN	466206	4533948
IN	Noble IN	631750	4584280
IN	Ohio IN	677374	4313316
IN	Orange IN	544052	4266195
IN	Owen IN	511324	4351636
IN	Parke IN	483625	4402746
IN	Perry IN	531700	4214793
IN	Pike IN	479054	4250196
IN	Porter IN	493750	4588899

State	County	UTM Easting	UTM Northing
IN	Posey IN	422887	4209590
IN	Pulaski IN	525261	4543479
IN	Putnam IN	513114	4390832
IN	Randolph IN	669409	4447193
IN	Ripley IN	663952	4305828
IN	Rush IN	631643	4386747
IN	Rush/Shelby IN	617638	4381592
IN	Saint Joseph IN	560527	4607767
IN	Scott IN	608807	4282583
IN	Shelby IN	603924	4375854
IN	Spencer IN	498311	4206770
IN	Starke IN	531097	4570128
IN	Steuben IN	666569	4612290
IN	Sullivan IN	464416	4326009
IN	Switzerland IN	672122	4299506
IN	Tippecanoe IN	509097	4471021
IN	Tipton IN	580631	4462949
IN	Union IN	678055	4388206
IN	Vanderburgh IN	448009	4211049
IN	Vermillion IN	461917	4411888
IN	Vigo IN	466974	4364864
IN	Wabash IN	601833	4522471
IN	Warren IN	469989	4466450
IN	Warrick IN	473588	4214648
IN	Washington IN	578695	4272711
IN	Wayne IN	670274	4415000
IN	Wells IN	651902	4510217
IN	White IN	511422	4509828
IN	Whitley IN	624854	4555442
KY	Adair KY	653264	4107350
KY	Allen KY	571451	4067667
KY	Anderson KY	678043	4208250
KY	Ballard KY	320707	4103359
KY	Barren KY	593304	4091947
KY	Bath KY	785241	4225611
KY	Bell KY	798134	4070337
KY	Boone KY	697710	4315934
KY	Bourbon KY	743600	4234230
KY	Boyd KY	877021	4256690
KY	Boyle KY	687512	4166488

State	County	UTM Easting	UTM Northing
KY	Bracken KY	752948	4281213
KY	Breathitt KY	823385	4159447
KY	Breckinridge KY	551299	4182999
KY	Bullitt KY	613214	4201937
KY	Butler KY	530005	4117927
KY	Caldwell KY	424628	4111857
KY	Calloway KY	386507	4053827
KY	Campbell KY	727818	4314477
KY	Carlisle KY	323378	4080050
KY	Carroll KY	664931	4281456
KY	Carter KY	847642	4248677
KY	Casey KY	683142	4132253
KY	Christian KY	457163	4083206
KY	Clark KY	750398	4206793
KY	Clay KY	790539	4118366
KY	Clinton KY	666631	4066695
KY	Crittenden KY	405203	4134923
KY	Cumberland KY	641865	4072523
KY	Daviess KY	490185	4170373
KY	Edmonson KY	568052	4118655
KY	Elliott KY	843999	4226339
KY	Estill KY	769459	4175836
KY	Fayette KY	727818	4213228
KY	Fleming KY	789368	4252077
KY	Floyd KY	875346	4165274
KY	Franklin KY	690668	4237265
KY	Fulton KY	308081	4048242
KY	Gallatin KY	685327	4291654
KY	Garrard KY	715920	4169159
KY	Grant KY	705722	4280727
KY	Graves KY	352515	4065481
KY	Grayson KY	557612	4146092
KY	Green KY	629725	4125211
KY	Greenup KY	857354	4273929
KY	Hancock KY	521434	4188098
KY	Hardin KY	591604	4173044
KY	Harlan KY	834069	4084663
KY	Harrison KY	731945	4258147
KY	Hart KY	586505	4129582
KY	Henderson KY	449151	4183970

State	County	UTM Easting	UTM Northing
KY	Henry KY	662948	4257734
KY	Hickman KY	321921	4061111
KY	Hopkins KY	449151	4129824
KY	Jackson KY	765355	4145607
KY	Jefferson KY	617827	4227675
KY	Jessamine KY	713978	4194410
KY	Johnson KY	868037	4194532
KY	Kenton KY	713735	4313263
KY	Knott KY	859806	4141965
KY	Knox KY	779923	4087334
KY	Larue KY	613457	4155319
KY	Laurel KY	756129	4113314
KY	Lawrence KY	873136	4222940
KY	Lee KY	790850	4166002
KY	Leslie KY	820982	4112524
KY	Letcher KY	866847	4116713
KY	Lewis KY	814620	4271258
KY	Lincoln KY	707179	4147549
KY	Livingston KY	382380	4119141
KY	Logan KY	511794	4078836
KY	Lyon KY	406174	4097289
KY	Madison KY	738987	4178385
KY	Magoffin KY	844242	4180692
KY	Marion KY	653034	4154348
KY	Marshall KY	381894	4082963
KY	Martin KY	895231	4194046
KY	Mason KY	778199	4277085
KY	McCracken KY	348630	4102145
KY	McCreary KY	723690	4068881
KY	McLean KY	481444	4153619
KY	Meade KY	569266	4200481
KY	Menifee KY	797867	4204487
KY	Mercer KY	688240	4187369
KY	Metcalfe KY	624140	4093647
KY	Monroe KY	613457	4063782
KY	Montgomery KY	770915	4213956
KY	Morgan KY	826518	4203030
KY	Muhlenberg KY	488485	4120112
KY	Nelson KY	632153	4186155
KY	Nicholas KY	762417	4247463

State	County	UTM Easting	UTM Northing
KY	Ohio KY	511309	4148035
KY	Oldham KY	633609	4251227
KY	Owen KY	689454	4266645
KY	Owsley KY	793520	4146821
KY	Pendleton KY	729032	4286069
KY	Perry KY	835040	4130067
KY	Pike KY	911281	4157504
KY	Powell KY	781113	4191861
KY	Pulaski KY	713978	4109186
KY	Robertson KY	756104	4267859
KY	Rockcastle KY	737773	4138080
KY	Rowan KY	812192	4233623
KY	Russell KY	675615	4095832
KY	Scott KY	710578	4241029
KY	Shelby KY	656676	4231802
KY	Simpson KY	537775	4066695
KY	Spencer KY	648906	4210921
KY	Taylor KY	649877	4136866
KY	Todd KY	484358	4076893
KY	Trigg KY	419529	4073979
KY	Trimble KY	645021	4276114
KY	Union KY	416615	4165274
KY	Warren KY	552756	4094618
KY	Washington KY	661532	4179842
KY	Wayne KY	694796	4075193
KY	Webster KY	441381	4152648
KY	Whitley KY	770697	4065481
KY	Wolfe KY	809764	4184091
KY	Woodford KY	697710	4212135
MI	Alcona MI	770122	4953699
MI	Alger MI	530532	5138095
MI	Allegan MI	591334	4715879
MI	Alpena MI	762654	4992534
MI	Antrim MI	648739	4984734
MI	Arenac MI	748945	4884079
MI	Baraga MI	393073	5168484
MI	Barry MI	638798	4717539
MI	Bay MI	737660	4843751
MI	Benzie MI	576713	4943244
MI	Berrien MI	549794	4645181

State	County	UTM Easting	UTM Northing
MI	Branch MI	660987	4642857
MI	Calhoun MI	664356	4679368
MI	Cass MI	583816	4641198
MI	Charlevoix MI	652390	5010292
MI	Cheboygan MI	696436	5035683
MI	Chippewa MI	675124	5133375
MI	Clare MI	672670	4872628
MI	Clinton MI	695639	4757452
MI	Crawford MI	689233	4950546
MI	Delta MI	507873	5086640
MI	Dickinson MI	432571	5095706
MI	Eaton MI	677467	4718369
MI	Emmet MI	662248	5042986
MI	Genesee MI	769524	4768903
MI	Genesee/Lapeer MI	788389	4774061
MI	Gladwin MI	709613	4874122
MI	Gogebric MI	288408	5144875
MI	Grand Traverse MI	612892	4947393
MI	Gratiot MI	694146	4796287
MI	Hillsdale MI	699373	4640368
MI	Houghton MI	368343	5201411
MI	Huron MI	820806	4861343
MI	Ingham MI	715305	4719364
MI	Ionia MI	656904	4756622
MI	Iosco MI	767964	4914699
MI	Iron MI	380128	5119161
MI	Isabella MI	673666	4834291
MI	Jackson MI	722276	4677543
MI	Jackson/Washtenaw MI	736476	4682950
MI	Kalamazoo MI	621372	4678206
MI	Kalkaska MI	651228	4949716
MI	Keewenaw MI	409412	5246375
MI	Kent MI	617904	4765418
MI	Lake MI	596130	4871466
MI	Lapeer MI	807529	4777865
MI	Leelanau MI	592479	4970627
MI	Lenawee MI	743270	4642525
MI	Livingston MI	753393	4721522
MI	Luce MI	611490	5147773
MI	Mackinac MI	663795	5106703

State	County	UTM Easting	UTM Northing
MI	Macomb MI	834913	4735048
MI	Manistee MI	576049	4909222
MI	Marquette MI	465883	5127061
MI	Mason MI	560283	4871632
MI	Mecosta MI	635164	4833462
MI	Menominee MI	456248	5047909
MI	Midland MI	710609	4835951
MI	Missaukee MI	651892	4911048
MI	Monroe MI	786253	4647836
MI	Montcalm MI	645619	4797117
MI	Montmorency MI	729960	4982908
MI	Muskegon MI	569244	4793797
MI	Newaygo MI	596794	4823006
MI	Oakland MI	796377	4729571
MI	Oceana MI	557461	4831968
MI	Ogemaw MI	728964	4913039
MI	Ontonagon MI	329787	5154013
MI	Osceola MI	634301	4872296
MI	Oscoda MI	728632	4943742
MI	Otsego MI	688403	4988219
MI	Ottawa MI	581559	4756788
MI	Presque Isle MI	741079	5025726
MI	Roscommon MI	690229	4911878
MI	Saginaw MI	740647	4802261
MI	Saint Clair MI	849517	4764754
MI	Saint Joseph MI	622318	4641529
MI	Sanilac MI	838232	4816534
MI	Schoolcraft MI	558855	5116380
MI	Shiawassee MI	745958	4747329
MI	Tuscola MI	790767	4818691
MI	Van Buren MI	580878	4677377
MI	Washtenaw MI	760861	4683019
MI	Wayne MI	802849	4688164
MI	Wexford MI	613390	4910384
MO	Benton MO	-51873	4257372
MO	Jefferson MO	188224	4242024
MO	Saint Louis MO	197777	4282670
NY	Genessee NY	1215112	4798871
OH	Adams OH	805612	4305782
OH	Allen OH	741622	4517486

State	County	UTM Easting	UTM Northing
OH	Ashland OH	898706	4532752
OH	Ashland/Richland OH	886940	4528328
OH	Ashtabula OH	1019360	4636147
OH	Athens OH	924810	4365670
OH	Auglaize OH	735096	4494880
OH	Belmont OH	1013594	4446983
OH	Brown OH	772418	4314169
OH	Butler OH	708599	4368422
OH	Butler/Hamilton OH	708667	4353796
OH	Carroll OH	1000358	4508968
OH	Carroll/Columbiana/Starke OH	999643	4525294
OH	Champaign OH	775851	4448032
OH	Clark OH	774017	4423526
OH	Clermont OH	745292	4325963
OH	Clinton OH	776611	4367898
OH	Columbiana OH	1023291	4531770
OH	Coshocton OH	933001	4473586
OH	Coshocton/Muskingam OH	930619	4457777
OH	Coshocton/Tuscawaras OH	957158	4482420
OH	Crawford OH	844139	4530395
OH	Cuyahoga OH	944493	4599848
OH	Darke OH	702571	4445214
OH	Defiance OH	707944	4577767
OH	Delaware OH	840011	4466444
OH	Erie OH	866600	4587267
OH	Fairfield OH	874384	4409046
OH	Fayette OH	803777	4384933
OH	Fayette/Ross OH	816882	4373336
OH	Franklin OH	840142	4432110
OH	Fulton OH	739263	4609348
OH	Gallia OH	906844	4304996
OH	Geauga OH	984370	4610528
OH	Greene OH	767594	4398300
OH	Guernsey OH	971397	4448032
OH	Hamilton OH	711482	4341557
OH	Hancock OH	780543	4543564
OH	Hardin OH	783203	4506674
OH	Harrison OH	1002979	4477124
OH	Henry OH	746340	4579994
OH	Highland OH	792769	4342737

State	County	UTM Easting	UTM Northing
OH	Highland/Ross OH	812339	4354960
OH	Hocking OH	888904	4385064
OH	Holmes OH	929947	4502481
OH	Holmes/Knox OH	908266	4497788
OH	Holmes/Wayne OH	930363	4514317
OH	Huron OH	870531	4564334
OH	Jackson OH	879456	4328191
OH	Jefferson OH	1029057	4493767
OH	Knox OH	889323	4482038
OH	Lake OH	978736	4632085
OH	Lawrence OH	887318	4281670
OH	Licking OH	885523	4447573
OH	Logan OH	774410	4475944
OH	Lorain OH	905914	4584777
OH	Lucas OH	778708	4614983
OH	Madison OH	808010	4422216
OH	Mahoning OH	1024994	4559158
OH	Mahoning/Portage/Trumbull OH	1003612	4570979
OH	Marion OH	822687	4500057
OH	Medina OH	928244	4566038
OH	Meigs OH	926907	4337757
OH	Mercer OH	700736	4490556
OH	Miami OH	736276	4437352
OH	Miami/Montgomery OH	734917	4422978
OH	Monroe OH	1008208	4414288
OH	Montgomery OH	732082	4403935
OH	Morgan OH	945516	4398038
OH	Morrow OH	856261	4494487
OH	Muskingum OH	930511	4436303
OH	Noble OH	973081	4416128
OH	Ottawa OH	817406	4605417
OH	Paulding OH	703750	4554703
OH	Perry OH	909373	4409439
OH	Pickaway OH	839290	4395745
OH	Pike OH	840601	4332188
OH	Pike/Ross OH	840732	4344899
OH	Portage OH	986991	4573835
OH	Preble OH	701522	4401838
OH	Putnam OH	742933	4545398
OH	Richland OH	875380	4523317

State	County	UTM Easting	UTM Northing
OH	Ross OH	840077	4362721
OH	Sandusky OH	823827	4585498
OH	Scioto OH	850717	4302768
OH	Seneca OH	825006	4559944
OH	Shelby OH	736145	4468278
OH	Stark OH	975158	4533473
OH	Summit OH	958515	4567086
OH	Trumbull OH	1022374	4592902
OH	Tuscarawas OH	969300	4491408
OH	Union OH	806437	4467426
OH	Van Wert OH	704799	4525479
OH	Vinton OH	887463	4354531
OH	Warren OH	744243	4368029
OH	Washington OH	974005	4384409
OH	Wayne OH	931258	4532359
OH	Williams OH	700736	4603845
OH	Wood OH	780150	4584581
OH	Wyandot OH	810984	4527904
ON	Algoma ON	688662	5284533
ON	Brant ON	1044206	4798038
ON	Bruce ON	953936	4922250
ON	Chatham-Kent ON	901218	4709213
ON	Cochrane ON	838872	5568583
ON	Dufferin ON	1047816	4899141
ON	Durham ON	1145308	4905640
ON	Elgin ON	977045	4747487
ON	Essex ON	849945	4677438
ON	Frontenac ON	1310683	5001687
ON	Grey ON	1003765	4930916
ON	Haldimand-Norfolk ON	1057927	4771318
ON	Haliburton ON	1171306	5034907
ON	Halton ON	1075981	4842090
ON	Hamilton-Wentworth ON	1071648	4813204
ON	Hastings ON	1244966	4998799
ON	Huron ON	947436	4850034
ON	Kawartha Lakes ON	1151807	4963413
ON	Kenora ON	390812	5866112
ON	Lambton ON	899052	4759042
ON	Lanark ON	1341013	5045017
ON	Leeds-Grenville ON	1378566	5010353

State	County	UTM Easting	UTM Northing
ON	Lennox-Addington ON	1286129	4987966
ON	Middlesex ON	952491	4775651
ON	Muskoka ON	1101978	5026241
ON	Niagra ON	1127254	4792983
ON	Nipissing ON	1111366	5149008
ON	Northumberland ON	1227634	4927305
ON	Ottawa-Carelton ON	1378566	5076792
ON	Oxford ON	1005931	4790817
ON	Parry Sound ON	1056482	5084013
ON	Peel ON	1077425	4870976
ON	Perth ON	981378	4833424
ON	Peterborough ON	1203081	4969190
ON	Prescott-Russell ON	1436338	5106400
ON	Prince Edward ON	1279630	4920805
ON	Rainy River ON	95529	5414201
ON	Renfrew ON	1260131	5089791
ON	Simcoe ON	1074536	4948970
ON	Stormont-Dundas-Glengarry ON	1450782	5071015
ON	Sudbury ON	887016	5263350
ON	Thunder Bay ON	412637	5519476
ON	Timiskaming ON	1003524	5314382
ON	Waterloo ON	1021096	4833424
ON	Wellington ON	1029040	4864477
ON	York ON	1107756	4902029

Appendix G

RAW MATERIAL TRANSPORT DISTANCE DATA FROM MODEL EXPERIMENTS

This appendix provides the raw material transport distance data for model experiments discussed in the "Patterns of Mobility and Raw Material Transport" section of Chapter 8. The first three columns give model settings. The column "Group Mobility Setting" lists the alphabetic designation given to combinations of *pGroupMove* and *groupMobilityRadiusCells* described in Chapter 5. The column "*popDensityModel*" gives the value for the parameter that sets the density of persons in the world (persons/km^2) at the start of a model run (see Chapter 4). The column "*pPersonMove*" gives the value of the parameter controlling the frequency of person-level movement between groups (see Chapter 4). The next three columns give model results in terms of source-to-discard (S-t-D) distances of assemblages from the model run: mean, maximum, and standard deviation. All distances are in km. The column "*n*" gives the number of artifacts from a model run used to calculate the distance metrics. The columns "Experiment" and "Run" list the designations given to each individual experiment.

Group Mobility Setting	***popDensityModel***	***pPersonMove***	**Mean S-t-D Dist.**	**Max. S-t-D Dist.**	**SD S-t-D Dist.**	***n***	**Experiment**	**Run**
B	0.001	0.37	114.3	450.3	72.5	710	001-21-22-09	1
B	0.001	0.213	101.2	355.5	60.9	348	001-21-22-09	2
B	0.001	0.491	101.4	397.4	67.1	739	001-21-22-09	3
B	0.001	0.439	102.3	467.8	67.6	1277	001-21-22-09	4
B	0.001	0.26	102.8	323.6	61.3	490	001-21-22-09	5
B	0.001	0.332	86.6	346.0	56.3	636	001-21-22-09	6
B	0.001	0.404	116.6	348.3	68.9	439	001-21-22-09	7

Group Mobility Setting	***popDensityModel***	***pPersonMove***	**Mean S-t-D Dist.**	**Max. S-t-D Dist.**	**SD S-t-D Dist.**	***n***	**Experiment**	**Run**
B	0.001	0.433	90.1	346.5	59.3	841	001-21-22-09	8
B	0.001	0.151	113.0	400.4	63.8	376	001-21-22-09	9
B	0.001	0.125	97.0	519.7	64.0	1229	001-21-22-09	10
B	0.001	0.466	123.9	383.0	67.8	315	001-21-22-09	11
B	0.001	0.151	94.8	334.1	56.5	653	001-21-22-09	12
B	0.001	0.176	103.4	451.8	66.6	504	001-21-22-09	13
B	0.001	0.49	48.2	324.5	56.5	1174	001-21-22-09	14
B	0.001	0.287	97.7	409.3	57.9	694	001-21-22-09	15
B	0.001	0.456	87.7	356.8	55.7	825	001-21-22-09	16
B	0.001	0.111	110.4	385.7	67.1	661	001-21-22-09	17
B	0.001	0.428	96.4	396.1	58.5	565	001-21-22-09	18
B	0.001	0.322	105.8	364.3	58.7	469	001-21-22-09	19
B	0.001	0.36	102.8	390.4	63.8	862	001-21-22-09	20
B	0.002	0.303	94.0	412.4	58.9	1109	002-21-25-25	1
B	0.002	0.26	94.5	423.0	59.7	1739	002-21-25-25	2
B	0.002	0.13	97.7	346.5	61.6	2212	002-21-25-25	3
B	0.002	0.359	100.4	365.9	60.1	629	002-21-25-25	4
B	0.002	0.142	96.2	410.4	62.8	1549	002-21-25-25	5
B	0.002	0.118	98.9	445.8	64.3	1123	002-21-25-25	6
B	0.002	0.125	96.6	360.1	59.8	708	002-21-25-25	7
B	0.002	0.13	103.6	381.6	63.8	1657	002-21-25-25	8
B	0.002	0.301	95.8	247.6	48.8	122	002-21-25-25	9
B	0.002	0.118	100.5	455.3	62.3	1424	002-21-25-25	10
B	0.002	0.17	105.5	452.1	67.2	1652	002-21-25-25	11
B	0.002	0.288	94.2	419.4	62.7	1367	002-21-25-25	12
B	0.002	0.176	100.0	395.9	64.8	1103	002-21-25-25	13
B	0.002	0.121	99.7	571.7	67.4	962	002-21-25-25	14
B	0.002	0.468	78.0	370.4	59.9	1281	002-21-25-25	16
B	0.002	0.139	104.6	451.3	65.2	1668	002-21-25-25	17
B	0.002	0.423	106.3	391.3	65.2	988	002-21-25-25	18
B	0.002	0.106	101.2	381.6	64.5	1052	002-21-25-25	19
B	0.002	0.204	102.7	432.8	67.3	1052	002-21-25-25	20
B	0.001	0.344	104.1	390.4	64.1	1804	006-15-22-02	1
B	0.001	0.175	98.8	417.3	61.3	1700	006-15-22-02	2
B	0.001	0.179	92.7	330.6	57.3	1748	006-15-22-02	3
B	0.001	0.137	105.2	330.0	61.4	657	006-15-22-02	5
B	0.001	0.475	114.6	376.4	66.1	1070	006-15-22-02	6
B	0.001	0.281	94.3	401.1	58.2	1312	006-15-22-02	7
B	0.001	0.149	97.1	441.7	62.2	2199	006-15-22-02	8

Group Mobility Setting	***popDensityModel***	***pPersonMove***	**Mean S-t-D Dist.**	**Max. S-t-D Dist.**	**SD S-t-D Dist.**	***n***	**Experiment**	**Run**
B	0.001	0.257	102.8	465.1	58.7	1626	006-15-22-02	9
B	0.001	0.151	106.1	463.6	63.3	2091	006-15-22-02	10
B	0.001	0.139	106.6	360.1	60.3	1156	008-11-01-55	1
B	0.001	0.474	92.7	437.1	62.9	2108	008-11-01-55	2
B	0.001	0.273	111.2	346.4	58.4	486	008-11-01-55	3
B	0.001	0.376	106.5	373.6	65.0	467	008-11-01-55	4
B	0.001	0.2	92.7	480.3	57.7	2769	008-11-01-55	5
B	0.001	0.486	112.8	625.5	72.4	1517	008-11-01-55	6
B	0.001	0.497	105.2	404.5	62.4	1404	008-11-01-55	7
B	0.001	0.136	101.6	445.1	62.7	2077	008-11-01-55	8
B	0.001	0.193	101.0	408.4	65.8	1709	008-11-01-55	9
B	0.001	0.124	107.2	385.7	66.6	1960	008-11-01-55	10
B	0.001	0.148	109.3	445.1	65.2	1624	013-22-03-50	2
B	0.001	0.149	101.6	425.8	62.2	2003	013-22-03-50	3
B	0.001	0.325	98.6	438.6	61.2	2179	013-22-03-50	4
B	0.001	0.223	101.7	441.9	66.2	2786	013-22-03-50	5
B	0.001	0.235	93.1	479.5	59.3	2198	013-22-03-50	6
B	0.001	0.222	104.5	439.7	67.8	1831	013-22-03-50	7
B	0.001	0.323	89.5	487.7	61.8	1625	013-22-03-50	8
B	0.001	0.237	110.1	419.4	64.5	1818	013-22-03-50	10
B	0.001	0.389	85.0	459.0	64.0	3317	013-22-03-50	11
B	0.001	0.259	102.7	497.9	65.5	1643	013-22-03-50	12
B	0.001	0.413	103.2	415.8	67.9	2541	013-22-03-50	13
B	0.001	0.133	102.4	407.1	63.7	1581	013-22-03-50	14
B	0.001	0.304	92.8	363.7	56.1	1412	013-22-03-50	15
B	0.001	0.186	111.5	592.3	73.0	1802	013-22-03-50	16
B	0.001	0.226	99.0	376.4	61.4	1772	013-22-03-50	17
B	0.001	0.409	103.6	415.8	67.2	1261	013-22-03-50	18
B	0.001	0.141	107.0	504.8	64.4	1836	013-22-03-50	19
B	0.001	0.21	115.1	360.1	62.3	1518	013-22-03-50	20
D	0.002	0.384	58.4	232.6	35.6	384	004-05-35-05	2
D	0.002	0.141	62.2	200.8	39.9	476	004-05-35-05	3
D	0.002	0.459	57.9	252.4	39.8	739	004-05-35-05	4
D	0.002	0.235	40.4	225.2	30.6	1876	004-05-35-05	5
D	0.002	0.453	63.3	208.8	40.8	562	004-05-35-05	6
D	0.002	0.279	62.0	244.3	40.4	356	004-05-35-05	8
D	0.002	0.138	62.6	270.6	40.4	823	004-05-35-05	9
D	0.002	0.397	37.9	270.7	26.9	1609	004-05-35-05	10
D	0.002	0.182	58.2	277.9	38.0	553	004-05-35-05	11

Group Mobility Setting	***popDensityModel***	***pPersonMove***	**Mean S-t-D Dist.**	**Max. S-t-D Dist.**	**SD S-t-D Dist.**	***n***	**Experiment**	**Run**
D	0.002	0.202	58.8	192.9	34.8	632	004-05-35-05	12
D	0.002	0.245	62.8	240.2	39.0	534	004-05-35-05	13
D	0.002	0.187	60.0	315.1	38.9	664	004-05-35-05	14
D	0.002	0.466	67.9	350.0	45.2	328	004-05-35-05	15
D	0.002	0.424	64.7	278.8	42.9	423	004-05-35-05	16
D	0.002	0.38	60.1	209.5	39.9	456	004-05-35-05	18
D	0.002	0.466	64.5	166.4	33.9	288	004-05-35-05	19
D	0.002	0.403	44.1	255.1	35.2	725	004-05-35-05	20
D	0.002	0.364	63.4	281.6	41.3	1221	009-11-03-59	1
D	0.002	0.115	62.3	270.0	40.9	1767	009-11-03-59	4
D	0.002	0.24	55.2	255.1	38.8	3021	009-11-03-59	5
D	0.002	0.261	62.7	355.1	41.7	1909	009-11-03-59	7
D	0.002	0.203	60.0	256.3	38.8	2397	009-11-03-59	8
D	0.002	0.198	65.9	223.4	38.7	1090	009-11-03-59	10
D	0.002	0.1	59.5	240.6	37.9	3245	014-07-15-24	2
D	0.002	0.1	62.4	350.3	40.2	5422	014-07-15-24	3
D	0.002	0.1	62.5	288.4	40.0	2523	014-07-15-24	4
D	0.002	0.1	59.3	242.7	39.5	2932	014-07-15-24	5
D	0.002	0.1	62.6	324.5	40.8	3848	014-07-15-24	6
D	0.002	0.1	63.6	322.3	40.8	5103	014-07-15-24	7
D	0.002	0.1	66.2	348.7	42.8	2239	014-07-15-24	9
D	0.002	0.1	57.6	304.1	39.2	5267	014-07-15-24	10
D	0.002	0.1	59.5	377.5	39.8	5241	014-07-15-24	11
D	0.002	0.1	60.5	261.5	39.1	4738	014-07-15-24	14
D	0.002	0.1	31.7	229.1	25.3	10402	014-07-15-24	15
D	0.002	0.1	33.5	255.1	33.0	11696	014-07-15-24	16
D	0.002	0.1	62.6	350.9	40.3	3806	014-07-15-24	17
D	0.002	0.1	62.3	341.2	39.0	5412	014-07-15-24	19
D	0.002	0.1	57.7	242.7	37.5	2485	014-07-15-24	20
E	0.003	0.089	44.6	175.2	26.9	2374	007-14-56-17	1
E	0.003	0.169	41.2	155.2	25.8	1391	007-14-56-17	3
E	0.003	0.187	39.5	158.7	25.0	1229	007-14-56-17	4
E	0.003	0.162	44.5	165.2	28.6	1352	007-14-56-17	5
E	0.003	0.189	41.7	168.2	26.5	1467	007-14-56-17	6
E	0.003	0.064	42.6	203.0	26.0	2993	007-14-56-17	7
E	0.003	0.014	42.2	242.7	26.5	2250	007-14-56-17	10
E	0.003	0.053	42.7	151.0	26.5	2343	007-14-56-17	13
E	0.003	0.111	44.1	199.8	26.3	1509	007-14-56-17	14
E	0.003	0.17	44.7	185.2	27.6	1040	007-14-56-17	16

Group Mobility Setting	***popDensityModel***	***pPersonMove***	**Mean S-t-D Dist.**	**Max. S-t-D Dist.**	**SD S-t-D Dist.**	***n***	**Experiment**	**Run**
E	0.003	0.115	41.0	175.8	25.1	2391	007-14-56-17	17
E	0.003	0.076	40.3	211.7	24.5	3045	007-14-56-17	18
E	0.003	0.016	43.9	200.7	26.2	2492	010-10-58-10	1
E	0.003	0.188	39.8	144.2	23.9	1180	010-10-58-10	2
E	0.003	0.198	42.2	193.1	26.2	1580	010-10-58-10	4
E	0.003	0.072	39.9	173.5	25.0	2599	010-10-58-10	10
F	0.002	0.39	72.7	282.1	48.4	614	005-05-39-15	1
F	0.002	0.152	69.4	351.6	47.5	964	005-05-39-15	2
F	0.002	0.216	76.2	285.8	47.6	515	005-05-39-15	3
F	0.002	0.219	67.3	270.6	43.7	1260	005-05-39-15	4
F	0.002	0.146	74.4	252.4	43.4	681	005-05-39-15	6
F	0.002	0.182	65.8	255.2	45.5	657	005-05-39-15	7
F	0.002	0.334	63.9	329.2	45.3	912	005-05-39-15	8
F	0.002	0.398	70.6	250.0	43.4	645	005-05-39-15	9
F	0.002	0.189	69.6	284.8	44.8	916	005-05-39-15	10
F	0.002	0.2	67.0	239.0	43.5	912	005-05-39-15	11
F	0.002	0.314	62.4	247.6	40.7	1344	005-05-39-15	12
F	0.002	0.397	70.0	260.6	44.4	1021	005-05-39-15	13
F	0.002	0.16	68.0	275.1	43.3	873	005-05-39-15	16
F	0.002	0.262	72.0	310.0	47.1	620	005-05-39-15	17
F	0.002	0.116	70.6	287.9	44.7	867	005-05-39-15	18
F	0.002	0.391	73.0	335.1	45.1	1790	011-11-06-29	2
F	0.002	0.109	66.3	281.6	42.0	2027	011-11-06-29	3
F	0.002	0.28	70.3	325.1	45.7	1823	011-11-06-29	4
F	0.002	0.334	70.1	275.1	45.8	2365	011-11-06-29	5
F	0.002	0.221	68.3	288.3	44.2	3136	011-11-06-29	6
F	0.002	0.101	66.7	260.0	42.5	2597	011-11-06-29	7
F	0.002	0.268	71.9	310.0	48.3	2764	011-11-06-29	8
F	0.002	0.421	70.9	324.2	46.5	2203	011-11-06-29	9
F	0.002	0.343	77.5	312.2	47.9	1991	011-11-06-29	10
G	0.001	0.482	73.4	365.9	51.7	735	003-21-50-30	1
G	0.001	0.226	91.8	252.4	55.7	270	003-21-50-30	2
G	0.001	0.43	90.4	363.7	58.3	338	003-21-50-30	3
G	0.001	0.318	81.3	316.1	57.9	444	003-21-50-30	4
G	0.001	0.262	93.8	435.5	63.9	519	003-21-50-30	5
G	0.001	0.216	91.3	398.9	73.2	139	003-21-50-30	6
G	0.001	0.221	91.5	290.5	58.7	343	003-21-50-30	7
G	0.001	0.302	81.0	430.3	62.4	701	003-21-50-30	8
G	0.001	0.368	94.8	340.4	66.4	369	003-21-50-30	9

Group Mobility Setting	***popDensityModel***	***pPersonMove***	**Mean S-t-D Dist.**	**Max. S-t-D Dist.**	**SD S-t-D Dist.**	***n***	**Experiment**	**Run**
G	0.001	0.404	82.8	326.0	53.5	677	003-21-50-30	10
G	0.001	0.447	87.2	296.1	58.6	575	003-21-50-30	11
G	0.001	0.295	95.7	395.1	64.1	320	003-21-50-30	12
G	0.001	0.269	97.1	305.1	65.0	457	003-21-50-30	13
G	0.001	0.252	87.0	337.8	56.9	440	003-21-50-30	14
G	0.001	0.423	94.4	305.1	60.5	368	003-21-50-30	15
G	0.001	0.267	98.2	441.7	75.7	189	003-21-50-30	16
G	0.001	0.335	88.5	337.2	60.0	590	003-21-50-30	17
G	0.001	0.177	94.3	382.2	67.2	429	003-21-50-30	18
G	0.001	0.152	80.6	356.0	55.4	626	003-21-50-30	19
G	0.001	0.202	85.8	370.3	56.5	527	003-21-50-30	20
G	0.001	0.136	84.0	342.2	58.0	1366	012-14-18-36	1
G	0.001	0.213	89.2	427.6	60.6	1186	012-14-18-36	2
G	0.001	0.339	82.8	365.9	57.8	999	012-14-18-36	3
G	0.001	0.368	84.9	322.3	58.5	1218	012-14-18-36	4
G	0.001	0.174	86.7	321.4	60.2	1374	012-14-18-36	5
G	0.001	0.197	85.7	306.4	58.7	944	012-14-18-36	6
G	0.001	0.314	86.0	429.3	57.4	1447	012-14-18-36	7
G	0.001	0.206	89.6	340.0	60.8	1527	012-14-18-36	9
G	0.001	0.144	88.7	341.2	58.5	1417	012-14-18-36	10

Appendix H

SUMMARY DATA FROM “PASSIVE BARRIER” MODEL EXPERIMENTS

This appendix provides summary data from model experiments discussed in the “’Passive’ Barriers to Interaction between Regions” section of Chapter 8. All runs performed at mobility setting B, *popDensityModel* = 0.001; *pInterBandMarriage* = 0.10. The following abbreviations are used in the table: “*pBC*” = *pBoundaryCross*; “*pCG*” = *pCopyGroup*; “*pPM*” = *pPersonMove*; “MPL” = mean path length; “PPF” = percentage of paths found; “LPP” = mean number of links per person; “ND” = mean network density; “step 75” = number of steps required for signal to reach 75% of the population; “IRL” = mean number of inter-regional links; “EFI I” = Moran’s I for variable EFI; “NS R^2” = R^2 value associated with north-south distribution of variable EFI; “EW R^2” = R^2 value associated with east-west distribution of variable EFI; “Region EFI Diff” = difference in mean values of EFI between Regions 1 and 2. Model parameters are explained in Chapter 4. A sample of 2000 tools was used to calculate all artifact-related measures for each run.

pBC	***pCG***	***pPM***	**MPL**	**PPF**	**LPP**	**ND**	**step 75**	**IRL**	**EFI I**	**NS R^2**	**EW R^2**	**Region EFI Diff**
0.34	0.1	0.1	2.01	100.0	124.4	19.1	799	2808	0.015	0.002	0.023	0.115
0.27	0.1	0.1	2.04	100.0	126.7	16.9	1994	2423	0.002	0.001	0.003	0.016
0.06	0.1	0.1	2.28	99.9	124.0	17.0	1449	564	0.027	0.039	0.014	0.441
0.65	0.1	0.1	2.10	100.0	122.9	20.0	410	1066	0.006	0.000	0.005	0.112
0.85	0.1	0.1	2.35	100.0	134.6	15.9	965	2695	0.018	0.018	0.017	0.211
0.55	0.1	0.1	2.11	100.0	134.5	15.9	381	5549	0.004	0.001	0.003	0.070
0.91	0.1	0.1	2.07	100.0	108.2	16.6	547	2965	0.006	0.009	0.001	0.290
0.93	0.1	0.1	2.10	100.0	152.7	14.9	943	12820	0.003	0.004	0.002	0.124
0.74	0.1	0.1	2.28	97.9	128.6	19.9	977	1941	0.002	0.009	0.000	0.372

pBC	***pCG***	***pPM***	**MPL**	**PPF**	**LPP**	**ND**	**step 75**	**IRL**	**EFI I**	**NS R^2**	**EW R^2**	**Region EFI Diff**
0.58	0.1	0.1	2.18	100.0	128.4	12.1	1452	6051	0.005	0.016	0.004	0.184
0.09	0.1	0.1	2.37	99.3	123.1	15.9	1826	512	0.003	0.000	0.003	0.102
0.19	0.1	0.1	2.11	100.0	127.4	17.0	841	1748	0.013	0.014	0.020	0.373
0.71	0.1	0.1	2.31	100.0	103.8	13.9	527	2455	0.021	0.001	0.000	0.063
0.63	0.1	0.1	2.08	99.9	145.0	16.8	439	6033	-0.001	0.000	0.000	0.040
0.57	0.1	0.1	1.98	100.0	176.4	19.5	1579	4555	0.001	0.005	0.002	0.158
0.39	0.1	0.1	2.24	100.0	155.2	16.4	748	2670	0.063	0.033	0.054	0.574
0.70	0.1	0.1	2.06	100.0	147.3	14.7	462	9203	0.006	0.010	0.011	0.201
0.94	0.1	0.1	2.06	100.0	131.4	15.1	714	7113	0.004	0.006	0.000	0.083
0.54	0.5	0.1	2.21	100.0	127.0	18.8	493	675	0.002	0.005	0.002	0.213
0.59	0.5	0.1	2.08	81.7	115.2	18.1	927	940	0.009	0.015	0.002	0.224
0.31	0.5	0.1	2.21	100.0	127.2	13.8	386	4864	0.024	0.042	0.028	0.370
0.61	0.5	0.1	2.19	100.0	113.1	15.2	465	2370	0.038	0.049	0.050	0.473
0.16	0.5	0.1	2.37	100.0	112.1	13.5	1154	1531	0.100	0.107	0.014	0.875
0.43	0.5	0.1	2.27	100.0	118.7	18.8	661	1167	0.055	0.072	0.058	0.593
0.78	0.5	0.1	2.01	100.0	136.1	19.5	437	5640	0.006	0.012	0.000	0.225
0.66	0.5	0.1	2.40	100.0	144.8	16.6	1409	3409	0.003	0.011	0.001	0.289
0.88	0.5	0.1	2.09	99.8	117.1	15.1	769	7061	0.008	0.019	0.007	0.293
0.35	0.5	0.1	1.94	95.0	139.1	22.5	372	1000	0.014	0.008	0.016	0.275
0.41	0.5	0.1	2.14	100.0	147.0	15.9	408	3840	0.000	0.001	0.008	0.079
0.81	0.5	0.1	2.41	100.0	114.5	12.1	997	2316	0.007	0.013	0.012	0.079
0.49	0.5	0.1	2.01	99.3	125.3	18.1	408	6026	0.009	0.008	0.011	0.182
0.93	0.5	0.1	1.92	100.0	147.6	18.6	413	7518	0.003	0.000	0.003	0.068
0.28	0.5	0.1	2.24	99.4	129.1	14.1	500	6114	0.000	0.000	0.000	0.031
0.26	0.5	0.1	2.32	100.0	120.0	13.7	635	1372	0.012	0.037	0.010	0.499
0.09	0.5	0.1	2.11	100.0	129.4	19.1	800	1165	0.028	0.001	0.051	0.159
0.25	0.5	0.1	2.18	100.0	148.2	15.3	1241	3564	0.205	0.122	0.137	0.768
0.73	0.5	0.1	2.12	100.0	141.6	17.9	572	3342	0.020	0.010	0.034	0.268
0.65	0.1	0.25	2.25	100.0	142.1	18.5	510	3580	0.003	0.003	0.000	0.228
0.82	0.1	0.25	2.14	100.0	147.2	16.3	641	6960	0.012	0.002	0.003	0.121
0.89	0.1	0.25	1.92	100.0	152.7	18.7	867	9845	0.003	0.006	0.004	0.184
0.39	0.1	0.25	2.14	100.0	124.3	16.7	559	2353	0.004	0.004	0.007	0.145
0.79	0.1	0.25	2.32	96.5	141.3	16.7	1968	859	0.033	0.032	0.048	0.364
0.99	0.1	0.25	2.03	100.0	130.0	16.9	529	6449	0.006	0.000	0.010	0.074
0.85	0.1	0.25	2.14	100.0	121.1	17.4	1829	3013	0.000	0.000	0.000	0.037
0.00	0.1	0.25	1.92	51.5	120.3	16.5	0	5	0.014	0.016	0.011	0.350
0.40	0.1	0.25	1.97	100.0	130.4	20.0	911	4026	0.003	0.004	0.007	0.127
0.63	0.1	0.25	1.95	100.0	152.3	21.2	1296	6753	0.002	0.000	0.000	0.021
0.59	0.1	0.25	2.04	99.4	115.1	21.1	877	1408	0.009	0.004	0.012	0.018
0.46	0.1	0.25	2.13	100.0	144.8	19.6	511	4831	0.001	0.003	0.000	0.113

pBC	***pCG***	***pPM***	**MPL**	**PPF**	**LPP**	**ND**	**step 75**	**IRL**	**EFI I**	**NS R^2**	**EW R^2**	**Region EFI Diff**
0.50	0.1	0.25	2.23	100.0	142.8	18.5	1506	1168				0.000
0.57	0.1	0.25	2.04	100.0	138.3	19.8	1214	1520	0.001	0.004	0.003	0.018
0.80	0.1	0.25	2.02	100.0	167.5	16.0	828	16551	0.005	0.006	0.000	0.215
0.84	0.1	0.25	2.29	100.0	116.7	15.1	1081	3829	0.004	0.000	0.013	0.111
0.51	0.1	0.25	2.28	100.0	125.7	17.1	499	2104	0.015	0.002	0.001	0.091
0.41	0.1	0.25	2.12	100.0	134.2	20.0	444	1274	0.025	0.000	0.006	0.119
0.00	0.1	0.1	1.97	54.3	128.0	13.9	0	0	0.013	0.003	0.014	0.040
0.00	0.1	0.1	1.79	52.5	105.8	16.2	0	0	0.008	0.000	0.029	0.026
0.00	0.1	0.1	1.95	56.5	101.1	15.2	0	0	0.004	0.003	0.005	0.002
0.00	0.1	0.1	1.88	47.8	107.0	13.7	0	0	0.012	0.009	0.005	0.147
0.00	0.5	0.1	2.07	59.6	103.5	14.0	0	0	0.012	0.025	0.003	0.312
0.00	0.5	0.1	1.86	52.9	131.9	13.2	0	0	0.001	0.001	0.007	0.085
0.00	0.5	0.1	1.82	50.4	114.7	14.7	0	0	0.025	0.033	0.010	0.438
0.00	0.5	0.1	1.94	50.3	111.7	12.6	0	0	0.032	0.007	0.020	0.245
0.00	0.5	0.1	1.80	51.7	132.6	14.5	0	0	0.014	0.013	0.043	0.071
0.00	0.1	0.25	1.87	53.1	154.4	17.9	0	0	0.030	0.024	0.018	0.281
0.00	0.1	0.25	1.75	51.3	125.0	17.9	0	0	0.011	0.015	0.000	0.284
0.00	0.1	0.25	1.90	50.7	114.4	16.5	0	0	0.044	0.029	0.024	0.353
0.00	0.1	0.25	1.91	48.9	102.3	13.7	0	0	0.001	0.001	0.003	0.137
0.00	0.1	0.25	2.01	50.6	116.6	13.2	0	0	0.002	0.001	0.002	0.009
0.54	0.5	0.25	1.92	100.0	140.4	21.5	591	4731	0.022	0.027	0.002	0.310
0.28	0.5	0.25	2.04	100.0	119.3	20.8	936	3083	0.006	0.006	0.006	0.199
0.14	0.5	0.25	2.42	100.0	113.7	13.3	1001	1637	0.016	0.001	0.014	0.024
0.25	0.5	0.25	2.33	100.0	114.6	14.0	1412	3756	0.110	0.141	0.073	0.734
0.16	0.5	0.25	2.12	100.0	166.5	17.5	1103	2260	0.013	0.006	0.015	0.338
0.51	0.5	0.25	2.01	100.0	128.1	20.7	519	2416	0.002	0.003	0.000	0.060
0.97	0.5	0.25	2.00	99.8	143.9	20.6	566	3527	0.006	0.001	0.010	0.095
0.13	0.5	0.25	2.10	96.8	134.3	19.8	774	1265	0.002	0.002	0.000	0.101
0.34	0.5	0.25	2.16	100.0	128.7	15.6	1477	4005	0.005	0.012	0.006	0.173
0.27	0.5	0.25	2.25	100.0	154.2	17.5	1139	1709	0.002	0.000	0.002	0.030
0.81	0.5	0.25	1.99	100.0	168.6	19.6	362	5783	0.000	0.000	0.001	0.004
0.65	0.5	0.25	1.90	100.0	148.5	21.8	621	5135	0.002	0.004	0.003	0.010
0.36	0.5	0.25	2.22	100.0	123.9	23.0	1262	546	0.015	0.025	0.000	0.314
0.00	0.5	0.25	1.80	57.2	171.4	16.3	9029	0	0.014	0.008	0.019	0.269
0.00	0.5	0.25	1.78	56.5	126.8	18.9	8283	0	0.036	0.025	0.000	0.437
0.00	0.5	0.25	2.03	58.6	120.8	13.5	7067	0	0.018	0.032	0.008	0.381
0.00	0.5	0.25	1.77	51.0	147.1	16.1	0	0	0.034	0.010	0.053	0.083
0.01	0.1	0.1	2.53	91.7	119.9	15.7	1200	109	0.012	0.017	0.001	0.292
0.01	0.1	0.1	2.50	98.2	110.7	18.1	4254	113	0.018	0.009	0.004	0.269
0.00	0.1	0.1	1.96	78.2	132.1	18.4	724	3	0.008	0.008	0.005	0.102

pBC	***pCG***	***pPM***	**MPL**	**PPF**	**LPP**	**ND**	**step 75**	**IRL**	**EFI I**	**NS R^2**	**EW R^2**	**Region EFI Diff**
0.01	0.1	0.1	2.60	83.7	104.5	13.1	1060	31	0.008	0.001	0.000	0.005
0.00	0.1	0.1	2.45	70.9	105.9	16.2	1607	20	0.020	0.017	0.027	0.268
0.00	0.1	0.1	2.65	82.7	122.7	15.3	2236	28	0.011	0.000	0.022	0.102
0.01	0.1	0.1	2.25	68.4	109.8	17.1	8946	14	0.021	0.010	0.005	0.247
0.01	0.1	0.1	2.81	94.5	110.5	13.8	5455	215	0.012	0.002	0.019	0.071
0.00	0.1	0.1	2.01	49.4	121.1	15.8	0	33	0.006	0.001	0.016	0.018
0.00	0.1	0.1	2.14	76.9	130.8	16.4	0	6	0.007	0.013	0.003	0.160
0.01	0.5	0.1	2.88	97.4	122.0	14.2	2153	122	0.004	0.000	0.002	0.003
0.01	0.5	0.1	2.56	100.0	125.8	15.4	1038	146	0.033	0.000	0.066	0.093
0.01	0.5	0.1	2.66	97.7	103.7	17.4	1450	120	0.016	0.018	0.000	0.307
0.01	0.5	0.1	2.49	82.2	117.9	15.3	6436	226	0.060	0.036	0.028	0.290
0.00	0.5	0.1	2.07	60.1	136.9	13.6	0	0	0.011	0.003	0.012	0.079
0.01	0.5	0.1	2.48	87.1	123.2	16.7	5497	39	0.025	0.038	0.029	0.450
0.00	0.5	0.1	1.86	56.5	131.5	12.8	0	0	0.009	0.010	0.003	0.172
0.00	0.5	0.1	2.03	59.7	129.6	14.9	9446	44	0.013	0.008	0.024	0.127
0.01	0.1	0.25	2.78	91.0	144.8	15.2	2083	31	0.003	0.009	0.002	0.131
0.01	0.1	0.25	2.25	65.0	131.1	16.3	0	5	0.017	0.024	0.000	0.416
0.00	0.1	0.25	2.42	76.2	118.9	16.2	7153	64	0.003	0.011	0.002	0.166
0.00	0.1	0.25	2.79	88.9	117.9	16.2	7454	74	0.019	0.018	0.000	0.338
0.00	0.1	0.25	2.38	65.8	101.2	13.3	9508	26	0.094	0.009	0.092	0.087
0.01	0.1	0.25	2.70	85.4	130.4	17.1	2069	51	0.070	0.013	0.127	0.178
0.01	0.1	0.25	2.62	82.1	123.3	15.6	4250	41	0.026	0.005	0.028	0.172
0.01	0.1	0.25	2.44	80.8	149.7	16.6	0	41	0.008	0.001	0.003	0.202
0.00	0.5	0.25	1.99	57.6	138.7	18.7	0	2	0.004	0.003	0.003	0.058
0.01	0.5	0.25	1.71	60.4	144.5	19.7	6020	5	0.004	0.004	0.000	0.225
0.00	0.5	0.25	2.73	96.0	144.5	15.0	4997	66	0.002	0.014	0.000	0.285
0.01	0.5	0.25	2.36	89.0	132.8	17.7	1979	77	0.023	0.001	0.018	0.042
0.00	0.5	0.25	1.75	53.1	124.9	19.1	0	0	0.028	0.007	0.027	0.180
0.01	0.5	0.25	2.53	100.0	132.3	16.0	1367	202	0.008	0.009	0.000	0.168
0.00	0.5	0.25	1.92	60.8	120.7	16.8	6234	0	0.014	0.000	0.019	0.101
0.00	0.5	0.25	1.84	53.1	118.9	18.1	0	14	0.008	0.000	0.005	0.072
0.01	0.5	0.25	2.16	66.3	101.4	16.1	0	13	0.021	0.001	0.012	0.024

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