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Changing Agrarian Landscapes across America

A Comparative Perspective

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Over a mere five or six human generations, agriculture has all but disappeared from rural landscapes in the eastern half of the United States. During an equally brief period, agriculture has transformed forests, valleys, prairies, and plains in the interior of the continent. Economic models have explained the shift in terms of the lower costs of land, the larger scale of farming, and better connections to export markets, via river transport at first and then by rail (Fitzgerald, 2003; Gardner, 2002; Hart, 2003). Enormous gains in agricultural productivity since the green revolution have accelerated these trends, ensuring that the physical extent of agricultural land peaked in the United States in 1950, and the pace of abandonment has quickened (Theobald, 2001; Theobald et al., 2005). In the information age, distance to nearby population centers is an increasingly unimportant factor in predicting the prevalence of agricultural land use. With a nationally integrated market and export-driven demand shaping land-use patterns, the production locations have shifted to landscapes with fertile soils; flat, open terrain; and favorable climates. Still, we know that landscapes in the six areas examined have not escaped the legacies of prior patterns of development. Each was managed in different and path-dependent ways during the past 130 years. Choices framed by the timing of settlement, cultural inheritances, and institutional arrangements continue to shape the overall sustainability of ecosystems long after the initial transformation of landscapes.

The legacies of these distinct agricultural systems are explored in this chapter primarily through the lens of the agricultural census. Scientists have expressed growing interest in understanding the effect of historical land use on ecosystem dynamics. Land-use data have been used to drive ecosystem models capable of

simulating changes in carbon budgets, nutrient cycling, and the overall sustainability of ecosystems (Matson et al., 1997; Parton et al., 2005; Ramankutty and Foley, 1999; Ramankutty et al. 2002). Historical land-use data are an important tool for understanding not only the scale of anthropogenic impacts, but for developing a better understanding of the ecosystem services provided by working agrarian landscapes and successional landscapes. The primary goal of this chapter is to compare historical patterns that have dominated land use among the study areas and then evaluate the broad effects of past practice.

The data needed to inform this exercise are available mainly from published U.S. agricultural censuses. Between 1870 and 1920, the data are summarized every 10 years in county-level tabulations, and roughly every 5 years thereafter. Information is reported on the amount of land harvested by crop, and the overall magnitudes of grazing and total farmland. The temporal and spatial scale of the information requires a number of simplifying assumptions. We are comparing areas of the United States that were transformed during very different historical eras and that had very different rates of development, stabilization, and decline. Information about tillage practices, crop varieties, planting and harvest dates, crop harvest practices, and fertilizer application for dominant crop rotations can be surmised from a variety of historical sources. In a recent paper, Parton et al. use the prescriptive literature of the U.S. Department of Agriculture (USDA) and various federal and state extension services to calibrate a simulation exercise using the CENTURY model (Parton et al., 1993, 2005). Our intention here is to develop regional study area comparisons that can point to further detailed investigations. The chief simplifying assumption is that regional-level data faithfully describe dominant cropping systems. Far more research is needed to understand whether the regional findings discussed here actually scale to local or household levels.

Demographic, Social, and Economic Change in Six Regions of the United States

Population change in the six study areas has followed several broad national trends, including the rapid urbanization of the postwar years. The pace of urban growth between 1940 and 1960 decisively altered the social context in which agricultural landscapes are embedded, turning farm and rural folk into minority populations in all the study areas except southern Appalachia. Rates of natural increase, traditionally higher in the countryside, also stalled in the 1950s, and the continued population growth has come increasingly from a reverse migration of urban residents to nonmetropolitan counties late in the 20th century (Johnson and Beale, 1992, 1998, 2002; Johnson and Fuguitt, 2000; Johnson et al., 2005). The timing of change in each region has not simply mirrored industrial growth. The story is more complex. Industrial growth was far more uniform than population change. Long-running statistical series from the census indicate that, in terms of a simple measure of the volume of manufacturing activity, like the number of manufacturing establishments, each region shared periods of expansion

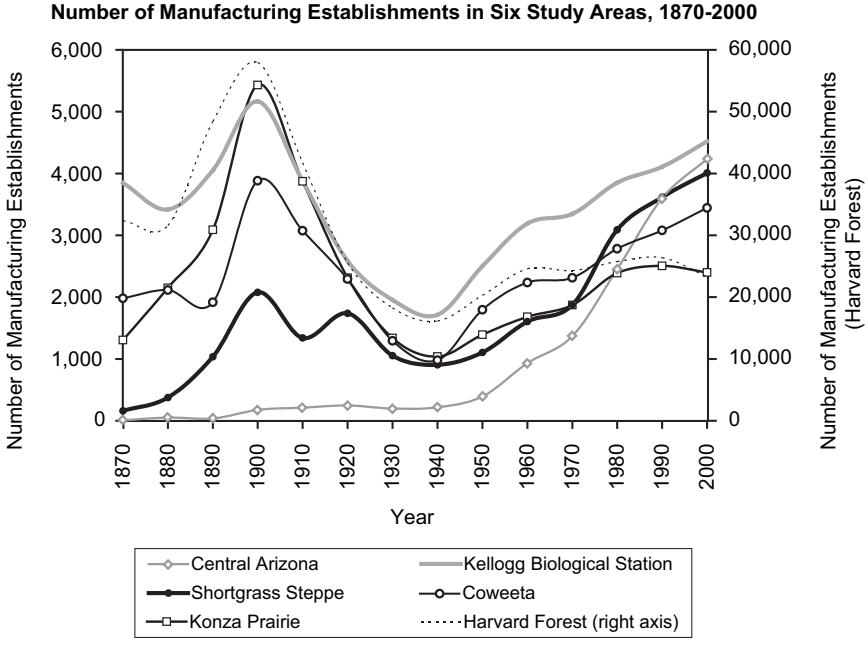

Figure 1.1 Number of manufacturing establishments in six study areas, 1870–2000. Based on summary county data reported in U.S. Department of Commerce, *Census of manufacturing* (1880, 1890, 1900, 1910, 1920, 1930, 1940) and *County and city data book* (1947, 1949, 1950, 1952, 1956, 1962, 1967, 1970, 1972, 1977, 1983, 1988, 1994, 2000).

and contraction simultaneously. The trends visible in Figure 1.1 reflect a well-known story about the first mass production economy based on clothing, food processing, steel making, and rail transportation. A second expansion beginning in the 1940s—based on automobiles, petroleum, chemicals, plastics, a postwar baby boom, increasing consumer demand, and government guarantees in home, farm, and export finance—drove patterns of rural emigration (Rosenberg, 2003; Shuman and Rosenau 1972; Wells, 2003).

However, early industrialization in New England meant that rural depopulation had deeper historical roots. The loss of female labor in particular to textile mills in southern New England limited the land-use alternatives available to farm families that practiced mixed husbandry prior to industrialization—raising corn, small grains, and livestock (Dublin, 1981; Hareven and Langenbach, 1978). In southern New England, Donahue (2004) suggests that as industrialization began, farmers close to Boston turned to raising beef, and in Vermont (where manufacturing was less prevalent) dairying became more common (Barron, 1984, 1997; Jager, 2004). By the beginning of the 20th century, rural population loss was quite advanced in southern New England. The geography of this population change is illustrated in Figure 1.2 for four dates in the 20th century. The maps display the percent change

Figure 1.2 Rural population change during the previous 30 years: 1910, 1940, 1970, and 2000. Based on summary county population data from U.S. Department of Commerce (1880b, 1910b, 1940b, 1970b, 2000b).

in the rural population 30 years prior to each census. In 1940, counties in southern New England were already experiencing a historical forerunner of exurban growth, as former urban dwellers took advantage of commuting trains and automobiles to relocate to the increasingly postagrarian landscapes of Connecticut and Massachusetts. By 1970, the more familiar postwar exodus from rural life is visible across the country, as population losses were common across all study areas. In eastern Kansas, the losses were already visible in 1940 and became generalized across all study areas in the three decades preceding the 1970 census. By 2000, rural population "rebounds" were concentrated close to urban centers in the study areas: Grand Rapids in southwest Michigan, Atlanta in southern Appalachia, Denver in eastern Colorado, Kansas City and Wichita in eastern Kansas, Tucson and Phoenix in Arizona, and in New England, in an urban fringe that extended as far as southern New Hampshire and southern Maine.

Before the mid century, the timing of local population change differed less because of proximity to urban centers than the timing of original settlement. Rural population numbers began to climb in absolute terms (Fig. 1.3) from the early part of the 20th century in the longest settled regions: in New England, southern Appalachia, and southwestern Michigan. In western study areas, rural populations peaked when agricultural land use came close to its maximum extent: in eastern Kansas at the beginning of the 20th century, and in eastern Colorado and central Arizona in the 1950s and 1960s. Nevertheless, after 1945, rural

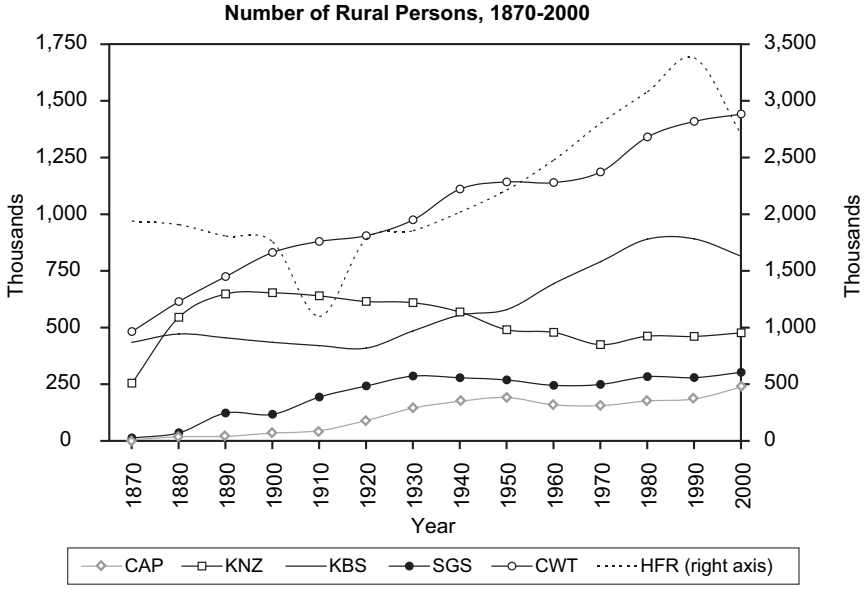

Figure 1.3 Number of rural persons, 1870–2000. CAP, Central Arizona–Phoenix; CWT, Coweeta; HFR, Harvard Forest; KBS, Kellogg Biological Station; KNZ, Konza Prairie; SGS, Shortgrass Steppe.

populations were embedded in rapidly urbanizing societies. The postwar trends affected New England and southern Appalachia least. In New England because the early pattern of exurban growth stabilized the proportion of the population that was nonurban, and in southern Appalachia because urbanization did not explode after the war, but continued a slow but steady increase. The postwar urbanization boom was more typical of the dramatic decrease in the percent of persons living in rural settings in central Arizona, eastern Colorado, eastern Kansas, and southwest Michigan.

Evolution of Land in Farms, Numbers of Farms, and Changes in Farm Size

The six study areas are also representative of several broad land-use trajectories in the past century—particularly, the abandonment of farmland, the growth of residential development at the urban fringe, and declines in the diversity of land use. All occurred much earlier in the northeastern United States, where abandonment expanded the scope for natural succession and for industrial and residential development on former croplands and pastures. The six study areas have also faced an expansion of suburbs, road networks, and industrial development beyond the urban fringe. Hobby farms, vacation homes, and resorts are restructuring rural landscapes around the United States, pressing on planning agendas, begging for answers to questions of which farmland to preserve. In the information age, exurban growth is increasingly free to seek access to natural amenities, shifting from metropolitan counties to nonmetropolitan counties, and the volume of agricultural production is often unrelated to population density, particularly where mechanization has displaced family labor (Brown et al., 2005; Finnegan et al., 2000; Huston, 2005; Maizel et al., 1998; Waisanen and Bliss, 2002).

The six study areas reached peak levels of agricultural land use on distinctly different timescales. The length of these stages varied according to the history of indigenous agriculture and European colonization. Agriculture was more central to central Arizona peoples than to any other ancient North Americans, but horticulture was a part of the traditions of indigenous peoples for several centuries in New England; southern Appalachia; and, to a lesser extent, the woodland–prairie peoples of southwestern Michigan and the grassland dwellers of eastern Kansas and eastern Colorado. Agriculture was more evident at the time of European–native contact in New England and southern Appalachia, and coexisted with European colonization through the early 19th century (Fig. 1.4).

After European colonization began, however, the transformation of landscapes became more extensive and stages of development briefer. In New England, more than 150 years separated the maximum extent of farmland from the time of initial settlement. In southern Appalachia, farmland peaked 80 years after European Americans moved into former Cherokee homelands. In southwestern Michigan, it took half a century for settlers to identify the maximum extent of agricultural land. In eastern Kansas, the timescale was shortened to two generations. Further west, semiarid and arid environments slowed the pace of change. In northeastern

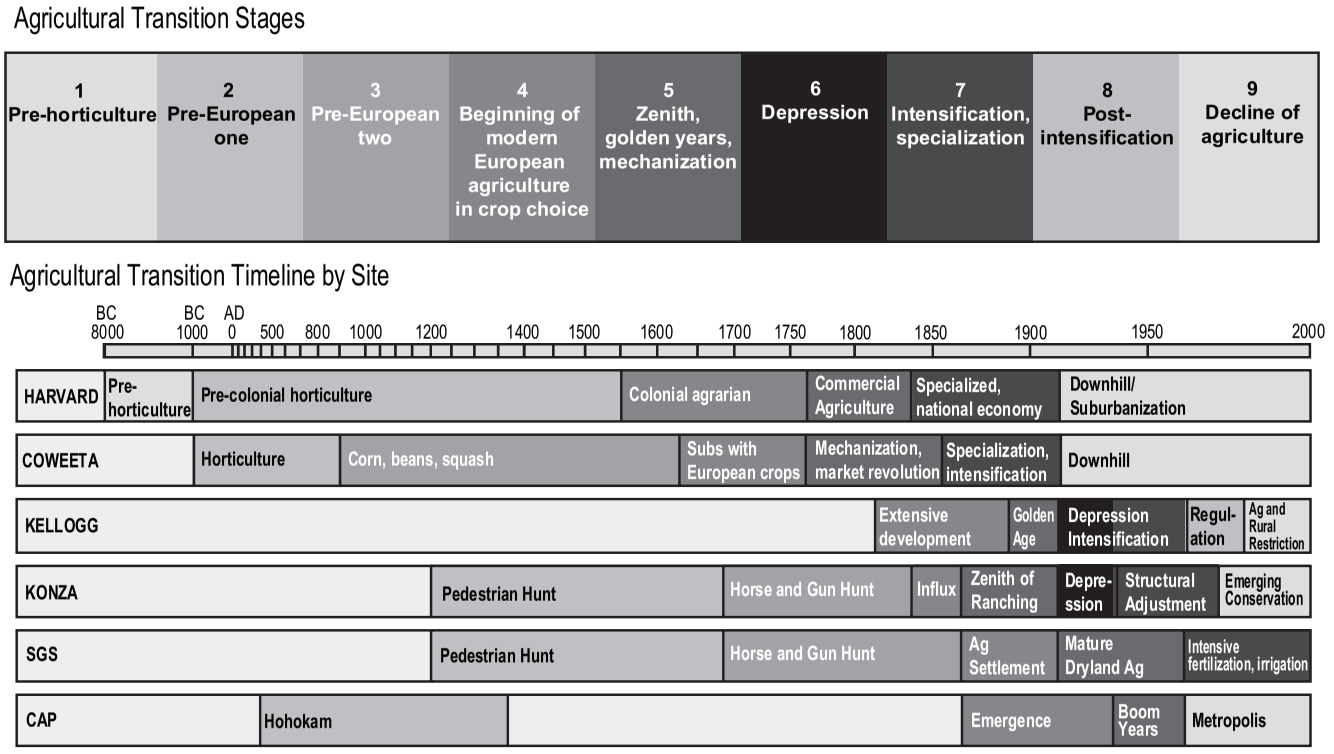

Figure 1.4 Agricultural transition stages and agricultural transition time line by site. Ag, agricultural; CAP, Central Arizona–Phoenix; SGS, Shortgrass Steppe; Subs, subsistence.

Colorado, agricultural land reached its full extent 70 years after settlement began, and in central Arizona, it took 80 years for agriculture to reach its peak.

In Massachusetts, detailed historical investigation using state census and tax assessment records has shown that agricultural settlement, begun during the 17th century, did not peak before 1830 (Hall et al., 2003). Although the earliest settlements were concentrated along the eastern seaboard in the Plymouth and Massachusetts Bay Colonies, the Connecticut River Valley afforded access to the western interior, from early settlements in New Haven, Windsor, Springfield, Longmeadow, and Agawam (Cronon, 1983). But if settlement identified arable lands early, development proceeded deliberately, in part because of the resistance of native peoples to European settlement, the pace of immigration to colonial America, and, to a lesser extent, the proprietary land grant system, the village-centered organization of settlement, and the use of the metes and bounds system to distribute new lands (Cronon, 1983; Hubbard, 1803; Vaughan, 1999). The culture of the time also prefigured a measured pace of development, because (as many local histories have demonstrated) farm families did not experience full integration into the marketplace until the 19th century (Bushman, 1998; Clark, 1990; Donahue, 2004; Kulikoff, 2000; Vickers, 1990).

These same patterns are evident in southern Appalachia, where the search for arable lands negotiated a series of deep steep-sided valleys, dissected by numerous streams. Growth came as a result of expanding numbers of small-holding farm families that dominated the upland south and were generally not part of the plantation system (Hahn, 1983; Hofstra, 2004; Salstrom, 1994). It was these yeoman farmers who spilled over into the Blue Ridge when lands were no longer available in the upland south: to the east in the Piedmont in North Carolina and Virginia, and to the east and to the west in the Great Valley of eastern Tennessee. The northwestern part of the Blue Ridge began to be settled by approximately 1780, but the southwestern portion was still home to the Cherokee, who had adjusted quite successfully to the presence of Europeans, adopting several nonnative foods after making sustained contact with Europeans and Africans beginning in 1670. Watermelon, peaches, apples, horses, pigs, and chickens were especially prized by the Cherokee. By the mid 18th century, the Cherokee participated in growing trade in cattle and hogs, working as drovers tending to herds of cattle and hogs that ranged free in unfenced forests, and supplied meat to major Atlantic sea ports. By 1819, pressure to expel the Cherokee from their homelands was partially realized when a large tract of land was purchased. This was the first major step along a path that led to wholesale removal of the Cherokee to Indian territory west of the Mississippi by Andrew Jackson in 1838 [Garrison, 2002; Remini, 2002; U.S. Congress (21st 1st session) and Evarts, 1830].

The measured pace of growth is evident in the land use visible from the federal census of agriculture. Land in farms across southern Appalachia peaked around 1890, and then began a steady decline (Fig. 1.5). Resources that were prized for so long and came at such a heavy price were, in the end, more of a refuge from the wider market economy than a point of entry. We can see these dynamics in the steady downward drift in farm size during the historical period. From 1880 until 1940, average farm size continued to decline and the numbers of farms increase

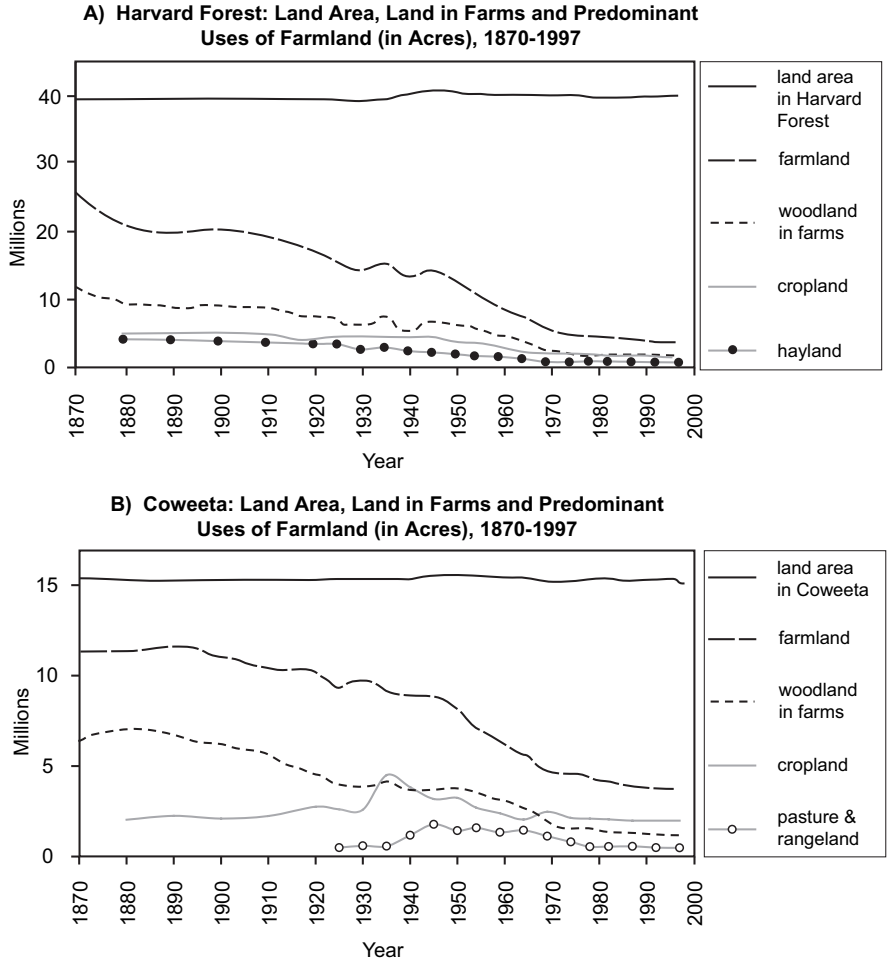

Figure 1.5 (A, B) Land area, land in farms, and predominant uses of farmland (in acres), 1870–1997, for the Harvard Forest (A) and Coweeta (B) regions. U.S. Department of Commerce (1870a, 1880a, 1890a, 1900a, 1910a, 1920a, 1925, 1930a, 1935, 1940a, 1950, 1954, 1959, 1964, 1969, 1974, 1978, 1982, 1987, 1992); U.S. Department of Agriculture (1997).

when Depression-era resettlement programs and urbanization began to reshape life chances in southern Appalachia. Southern Appalachia was the only study area where this pattern existed. In every other region of the country, farm size has increased steadily through the modern era.

Further west in the prairie–forest savannahs of southwestern Michigan (the Kellogg Biological Station region), population settlement left few landscapes untouched. First settled by European Americans in the 1820s, nearly all of southwestern Michigan was recorded as land in farms when the question was first posed in the federal agricultural census in 1870. Although the proportion in

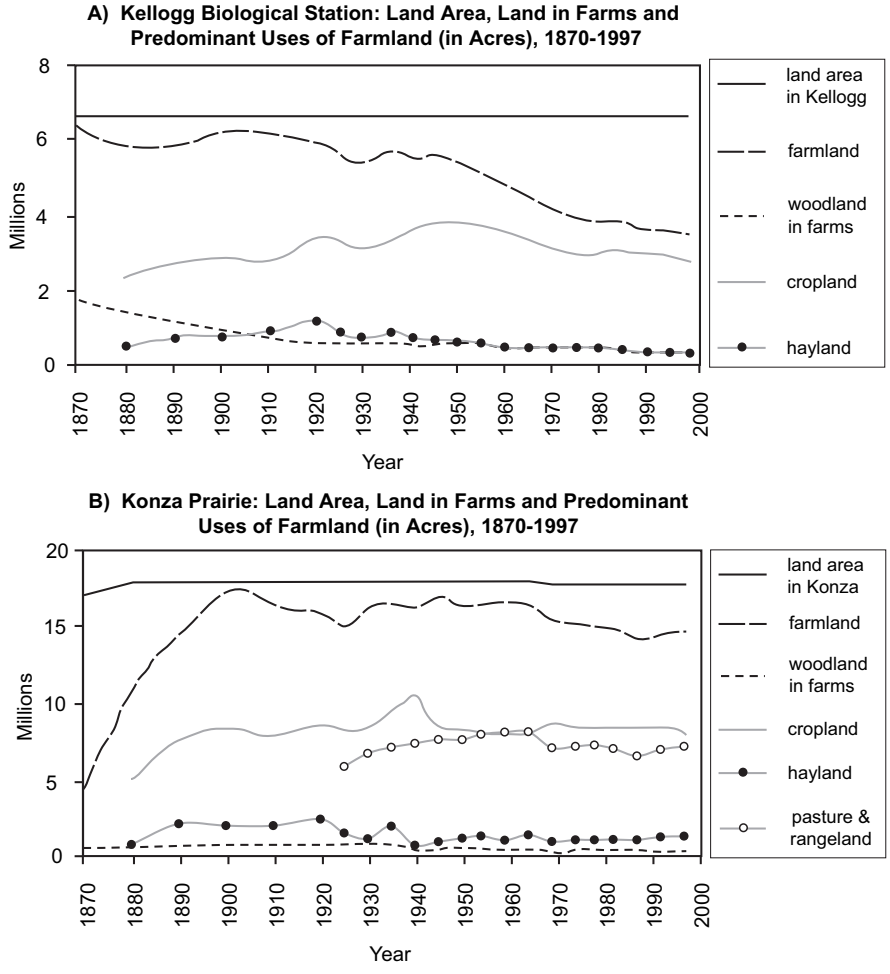

Figure 1.6 (A, B) Land area, land in farms, and predominant uses of farmland (in acres), 1870–1997, for the Kellogg Biological Station (A) and Konza Prairie (B) regions. U.S. Department of Commerce (1870a, 1880a, 1890a, 1900a, 1910a, 1920a, 1925, 1930a, 1935, 1940a, 1950, 1954, 1959, 1964, 1969, 1974, 1978, 1982, 1987, 1992); U.S. Department of Agriculture (1997).

southern Appalachia never exceeded 75% at its peak, nearly all land in southwestern Michigan (some 96%) represented land in farms in the 1890 agricultural census (Fig. 1.6) (U.S. Department of Commerce, 1890a). Not well documented prior to 1870, the transformation of southwestern Michigan reflected the growth of Chicago's hinterland, as the commerce in grain focused on the West's new metropolis after the mid century. With access to rail, European American farmers raised grains on a scale that eclipsed the small plots of Potawatomies and other native peoples who had raised corn around Lake Michigan for generations

(Cronon, 1991). Southwestern Michigan is both an extension of broad northern patterns of agricultural development and the first region discussed here that bears the modernizing stamp of the public land survey system. Average farm size remained bounded by the dimensions of the 68-ha (160-acre) quarter-section parcel well into the 20th century. As late as the region's so-called Golden Age (1900–1920), reported farm scale did not increase much beyond the quarter-section parcel. At the same time, land use in southwestern Michigan remained diverse and intensive. Although the land in farms has declined since 1945 (reaching a mere 52% of land area in 1997), farms are larger and cropped more intensively (U.S. Department of Commerce, 1945a, 1997). In 1925, roughly 60% of the land in farms in the region was cropped, and the proportion has steadily increased. In the 1987, 1992, and 1997 agricultural censuses, an average of 80% of the region's farmland was reported as cropland (U.S. Department of Commerce, 1925, 1987, 1992, 1997).

The pace of land transformation was better documented in the census when European American settlement reached the grasslands of eastern Kansas. Not settled in earnest until after the Civil War, only a quarter of the Konza Prairie study area was in private hands as farmland in 1870. But by 1900, virtually all (some 96%) of the eastern third of the state was reported as land in farms (U.S. Department of Commerce, 1870a, 1900a). In eastern Kansas, the transformation to cropland was never as complete as it had been in the Midwest. The Flint Hills prevented a similar plow-out of the tallgrass prairie that extended from eastern Kansas, northern Missouri, the Dakotas, southern Minnesota, Iowa, and Illinois. The uplands in east-central Kansas are punctuated by limestone outcroppings, making tillage difficult in many steeply sloped landscapes (Knapp et al., 1993). Nevertheless, cropland expanded steadily in the forest–grassland mosaic east of the Flint Hills and in the treeless plains to the west, where terrain is flatter. The ratio of cropland to pasture in the Konza Prairie study area has remained unchanged for generations (Fig. 1.6). After spiking to a high of 64% of land in farms in 1940, cropland has rarely exceeded 55% of the land in farms during the second half of the 20th century, and pastureland occupies a relatively fixed proportion of land use on farms—an average of 47% of land in farms since 1940 (U.S. Department of Commerce, 1940a).

By comparison, the pace of change in semiarid and arid study areas was slower, reflecting the inexperience of settlers with climate conditions of the High Plains of eastern Colorado and desert conditions in the Phoenix basin. Water regimes have controlled the scale of development in both areas more than the humid areas in the eastern half of the United States. In eastern Colorado, population was concentrated in the South Platte River watershed where several gravity flow systems were built in the late 19th and early 20th centuries (Tyler, 1992; Wohl, 2001, 2004). This expanded the area of cropland with access to irrigation water. Land in farms did not peak until after the invention of the horizontal centrifugal pump permitted wells in the High Plains to be sunk deeper than 50 ft. Even so, the proportion of cropland has remained relatively stable during the groundwater era. Land use in the Phoenix basin is tied very closely to water availability. Modern agriculture concentrates along the Salt River, which delivers (on average) more than one million acre-ft. of water per year (Graybill et al., 2006). Cropland has

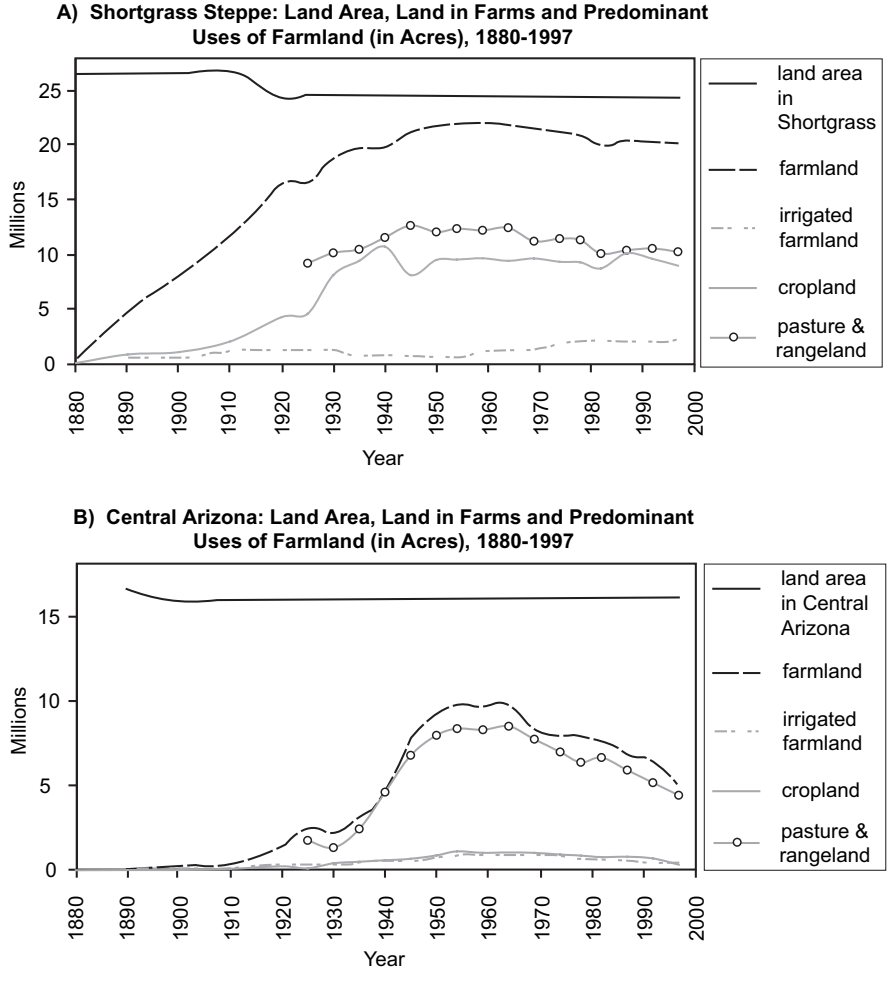

Figure 1.7 (A, B) Land area, land in farms, and predominant uses of farmland (in acres), 1870–1997, for the Shortgrass Steppe (A) and central Arizona (B) regions. U.S. Department of Commerce (1870a, 1880a, 1890a, 1900a, 1910a, 1920a, 1925, 1930a, 1935, 1940a, 1950, 1954, 1959, 1964, 1969, 1974, 1978, 1982, 1987, 1992); U.S. Department of Agriculture (1997).

never reached far beyond farms with access to irrigation (Fig. 1.7). The greatest proportion of land in farms in central Arizona is used as pasture and range, which has declined in step with farmland since peaking in 1964 (U.S. Department of Commerce, 1964).

Today, the distribution of agriculture over the United States is highly predictable in relation to environmental conditions. But historically, arable lands in close proximity to navigable waterways helped to define where early colonial settlements concentrated in the eastern half of the country (Curtin et al., 2001; Hofstra,

2004; Mires, 1993). These constraints were loosened as transportation improved during the 19th century. Long-distance trade began to shift agriculture to the interior of the continent. Farm populations did not immediately collapse in the east. Land no longer in farms has remained in private hands, with many more owners than in the agrarian past. During the late 20th century, the Harvard Forest, Coweeta, and increasingly Kellogg Biological Station regions share this trajectory. But signs of greater intensity are distinctly modern. Across each study area, despite considerable differences in timing of settlement and the types of agriculture practiced, a decisive decline in the number of farms and growth in average farm size occurred during the mid 20th century. Driven by postwar urbanization and green revolution technologies, the countryside lost population everywhere at the same time. Does this mean that historical practices were abandoned or path dependencies made irrelevant?

The Evolution of Land Used for Crops

Much of the literature examining the effects of past land use has tried to identify the physical extent of agricultural land use. Seminal work in the northeastern United States linking historical land use and modern forest composition has demonstrated the importance of understanding sequence and extent of past agricultural activity (Abrams, 1995; Burgi et al., 2000; Foster at al., 1998; Hall et al., 2003; Whitney, 1994). The relative abundance of long-lived tree taxa (e.g., beech, sugar maple, hemlock, yellow birch) has declined in ecological regions with widespread alteration of the landscape, and faster growing species (red maple, black, gray or white birch, poplar, and cherry) have increased. These studies indicate that the relative effect of environmental versus historical factors is strongly dependent on the scale of analysis. At broad geographical scales, despite differences in specific crops or land-use practices, the amount of land cleared for tillage, hay, pasture, or woodland remained relatively constant at the town level in Massachusetts from 1800 to 2000. The environmental variation within New England did not permit differentiation in agricultural practice to affect the extent of disturbance.

Nevertheless, the kind of crop mixtures that prevailed in these landscapes did change enormously and must be considered in context with other landscapes across the country to understand the legacies of past land use. In New England, what was in colonial times a form of mixed husbandry dominated by corn and small grains (wheat, oats, rye, and barley) eventually gave way to a crop system, as we see in summaries of the regional data, dominated by hay, corn, potatoes, and oats (Fig. 1.8). We can detect some of the change in the spatial distribution of these crops over time. At the end of the 19th century, for example, potatoes and corn were still evenly distributed across New England counties, but by 1920 they were increasingly concentrated as a proportion of farmland in counties nearest metropolitan areas (like Fairfield and New Haven, Connecticut; and Newport and Bristol, Rhode Island) and in far-flung Aroostook, Maine, which developed a specialization in potatoes. As a cropping system, the rotations that prevailed were simplified to a corn–oats system in southern New England. Corn served as silage

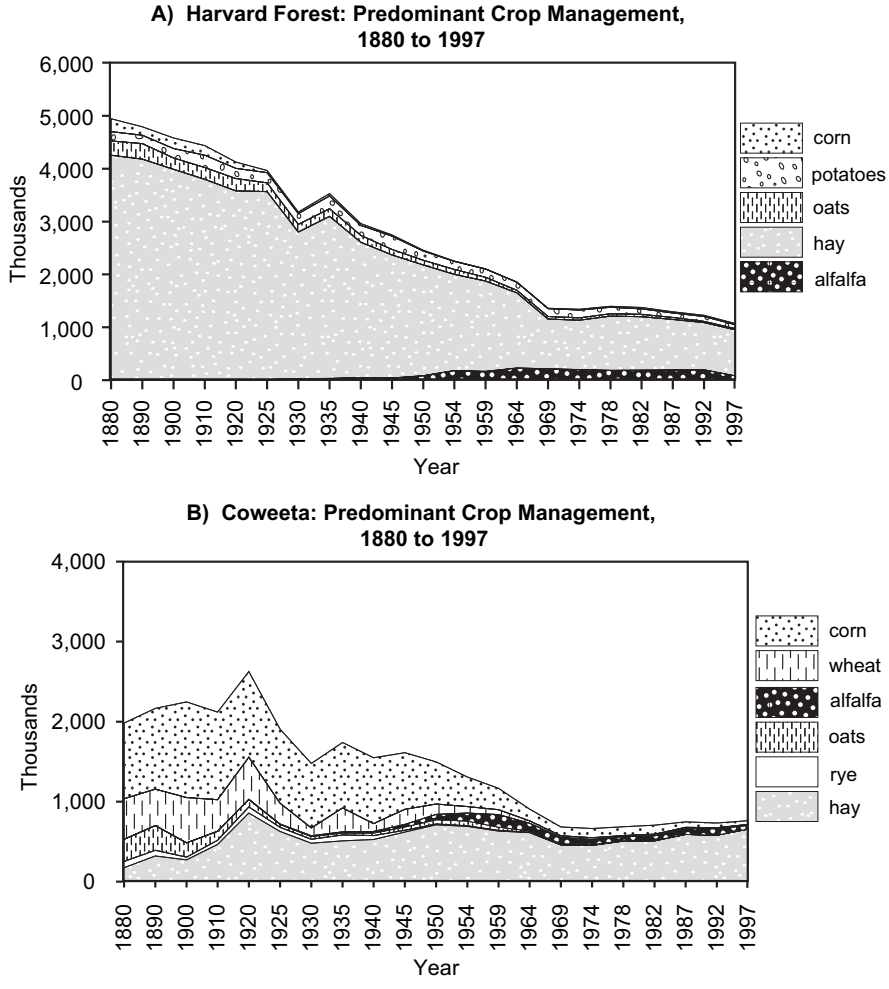

Figure 1.8 (A, B) Predominant crop management, 1880–1997, for the Harvard Forest (A) and Coweeta (B) regions. U.S. Department of Commerce (1870a, 1880a, 1890a, 1900a, 1910a, 1920a, 1925, 1930a, 1935, 1940a, 1950, 1954, 1959, 1964, 1969, 1974, 1978, 1982, 1987, 1992); U.S. Department of Agriculture (1997).

for dairy cattle and oats were important as horse feed before automobile ownership was more widespread in the 1920s. Eventually, dairying was increasingly concentrated in northwestern Vermont, along the eastern shore of Lake Champlain. Declining corn acreages reflected this loss and the reality that it was cheaper to buy corn silage from the Midwest. Competition from other regions in the country made agricultural land use in New England far less diverse in the modern era.

By comparison, the tillage system in the southern Appalachians retained its focus on cereals until the late 19th century before experiencing a similar spatial concentration of production in the 1920s. Wheat and rye, corn and oats, all played

reinforcing roles in a rotation scheme that remained more diverse than in the northeast. More removed from metropolitan centers, less industrialized than the north, the incentives to specialize were not as immediate in the rural south, and southern Appalachia retained a culture based on local exchange longer into the 20th century (Egnal, 1998; Jones, 2002; Kulikoff, 2000; Morgan, 2001; Walker, 2000). Just as the proportion of cropland devoted to wheat and corn began to decline in the 1920s, corn reached its peak as a proportion of cropland, accounting for 35% of the tillage system (U.S. Department of Commerce, 1930a). From the mid 20th century until the present, the intensity of grazing on pasture and hayland, and in woodland in farms has increased in response to steady increases in beef herds and in response to a boom and postwar boom-and-bust cycle in poultry raising. The collapse of the farming of small grains since the 1960s has meant that disturbance phenomena are limited almost exclusively to the maintenance of pasture and hayland in a management system that is far less diverse than more commercially oriented agrarian landscapes in the interior of the continent.

Further west, hard-earned folk wisdoms (Brookfield, 2001; Medin and Atran, 1999)—adapted from imported European practices—were applied to more forgiving landscapes. In southwestern Michigan, eastern Kansas, and eastern Colorado, settlers found ways to reinvent the diversity necessary to make family-scale agriculture work in the east. The same template of European American agriculture—now with corn firmly integrated into the repertoire of food and fodder crops—was applied to the forest–prairie savannah of southwestern Michigan in the 19th century. Landscapes in the Kellogg Biological Station region were a mix of wheat and corn, moving in temporal magnitude with rye and oats, and a proportion of land in hay that increased steadily until 1920 (Fig. 1.9). A transitional period between 1920 and 1960 ushered in the now-dominant midwestern corn–soy rotation, but other nitrogen-fixing legumes like alfalfa made an early appearance in the 1920s, probably in response to the scientific advocacy of agricultural extension programs. Alfalfa has persisted in this system, probably as a complement to wheat, and soy has grown in magnitude to keep pace with the scale of corn production, which reached a peak of 1.2 million acres in 1982.

The region surrounding Konza Prairie did not experience a similar beginning. Corn dominated early tillage, as settlers responded to the unleashing of nitrogen during the early plow-out of the plains. In many places the fertility of prairie soils soon convinced farmers in eastern Kansas to expand dramatically cropland devoted to staple cultivation. Oats were never harvested in magnitudes sufficient to serve as a restorative rotation or a winter cover crop, but eventually, by the early 20th century, successive droughts tempered the widespread devotion to corn. After 1920, corn retreated to the northern part of the state, where cooler temperatures could take advantage of an average rainfall of between 1,000 and 1,100 mm (40–44 in.) per year. After the settlement era, farm practice evolved in a more sustainable direction. With wheat dominating tillage after 1920, alfalfa and oats were sown in greater acreages. A particularly surprising finding was the marked increase the acreage devoted to soy in the region, suggesting that parts of eastern Kansas have adopted the double-cropping wheat–soybean system prevalent in Arkansas, Mississippi, and Alabama (Kyei-Boahen and Zhang, 2006).

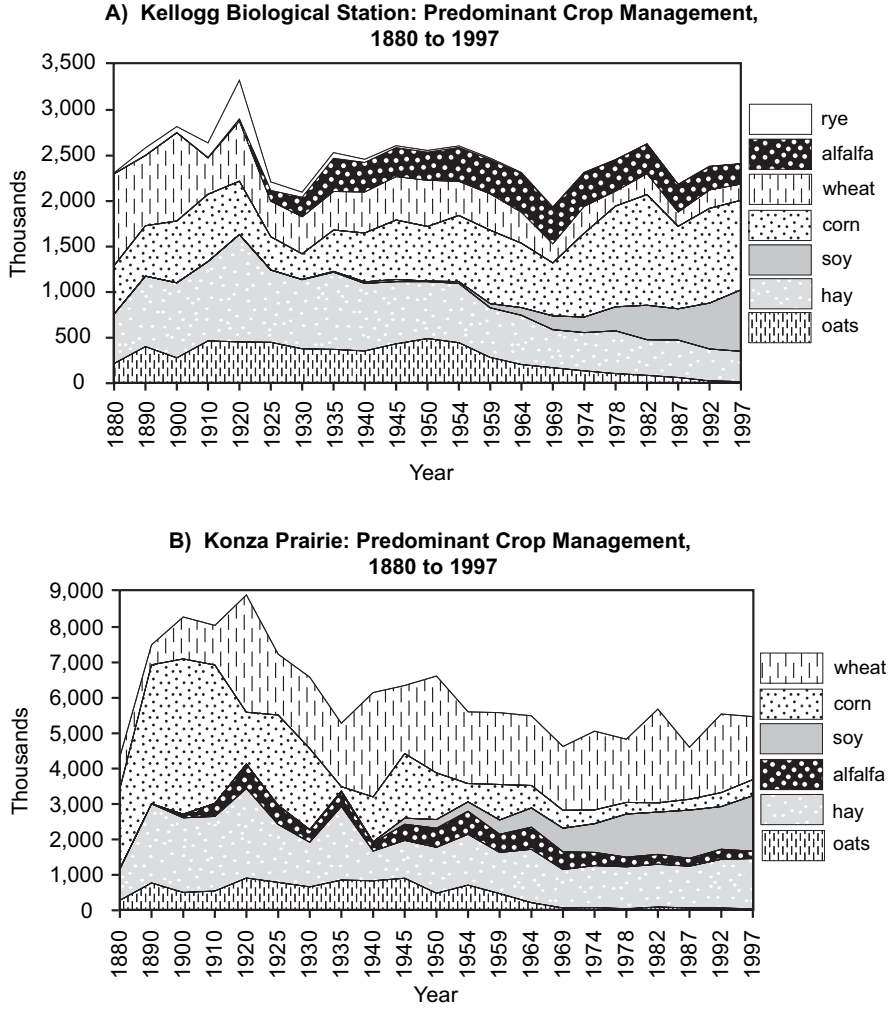

Figure 1.9 (A, B) Predominant crop management, 1880–1997, for the Kellogg Biological Station (A) and Konza Prairie (B) regions. U.S. Department of Commerce (1870a, 1880a, 1890a, 1900a, 1910a, 1920a, 1925, 1930a, 1935, 1940a, 1950, 1954, 1959, 1964, 1969, 1974, 1978, 1982, 1987, 1992); U.S. Department of Agriculture (1997).

In the Shortgrass Steppe, cropland expanded slowly as European Americans experimented with dryland cropping methods. The small-grains template was very much in evidence as the proportion of land devoted to crops slowly but steadily increased. Corn was stubbornly cultivated as a staple and a seasonal fodder for cattle, but was balanced by wheat production (Fig. 1.10). The physical extent of corn relied on gravity flow irrigation during the early settlement period, and it was the widespread adoption of winter wheat varieties, bred in the semiarid climate of the Russian steppes, that permitted acreage to expand to the High Plains

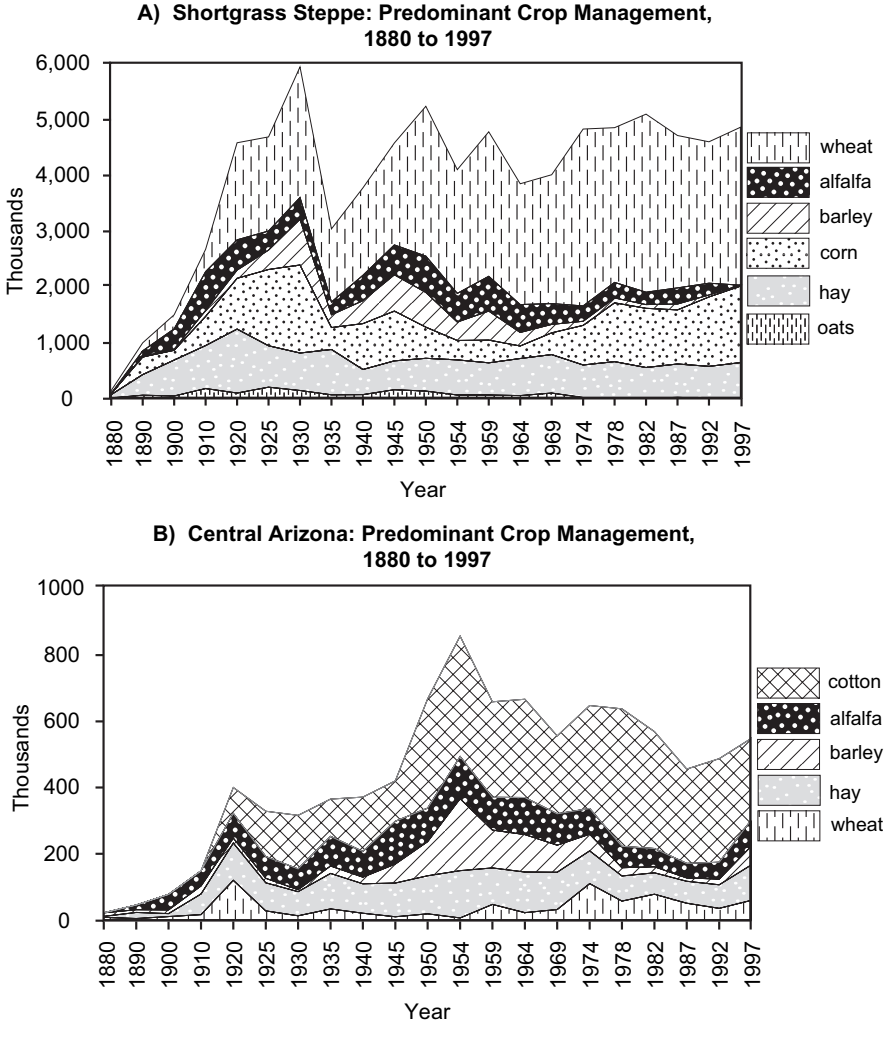

Figure 1.10 (A, B) Predominant crop management, 1880–1997, for the Shortgrass Steppe (A) and central Arizona (B) regions. U.S. Department of Commerce (1870a, 1880a, 1890a, 1900a, 1910a, 1920a, 1925, 1930a, 1935, 1940a, 1950, 1954, 1959, 1964, 1969, 1974, 1978, 1982, 1987, 1992); U.S. Department of Agriculture (1997).

(Kirshenmann, 2002). Again, the diversity of the crop system is striking viewed at this scale. Oats, barley, and alfalfa were all introduced early during the 20th century to fill out corn and wheat rotations. It wasn't until the postwar era that continuous wheat cultivation dominated the cropping profile of the region. With the expansion of irrigated acreage since the 1950s, continuous corn rotations are also increasingly the norm. The ecological implications of this intensification for sustainability are a source of concern. Irrigated cropping has been shown to reach near-equilibrium levels of soil carbon and nitrogen mineralization faster than dryland cropping,

and continuous cropping is better for maintaining soil carbon if tillage practice minimizes soil disturbance. Nevertheless, even if the atmospheric contributions of agriculture to global change are in better balance, intensification can have negative local consequences, including increased soil erosion, reduced biodiversity, pollution of groundwater, and the eutrophication of rivers and lakes (Matson et al., 1997; Parton et al., 2005; Tilman et al., 2002). More research is needed in the evolution of how dominant management practices and the growing scale of farm proprietorship have transformed the dimensions of working landscapes (Belfrage et al., 2005; Kirshenmann, 2002; Langley-Turnbaugh and Keirstead, 2005). The overall diversity of production has stabilized since the 1960s, but the cereals template brought by small farmers to the High Plains has been radically transformed by industrial farm methods.

In central Arizona, the cereals template fits well, even in the Sonoran Desert, taking advantage of winter rains and ancient irrigation canals along the Salt River. Demand came first from the U.S. Cavalry post at Fort McDowell, established to contain the Apache, but the Desert Land Act of 1877 cemented the economic incentives necessary for setters to reexcavate canals abandoned by the Hohokam during the 14th and 15th centuries, and build new ones. For the first 50 years of agricultural development, European Americans did little to revive the Mesoamerican food complex—corn, beans, and squash—that had characterized the region's agriculture in ancient times. Instead, they imported wheat, barley, and alfalfa, a workable subset of European American cultivation that served the purposes of a growing frontier population. Dramatic expansion of agriculture, however, awaited a more reliable flow of water and the reintroduction of another Mesoamerican crop: cotton (Bayman, 2001; Redman, 1999). With the completion of the Roosevelt Dam in 1911, 60 miles upstream from Phoenix, and the disruption of supplies during World War I, it was the Egyptian variety—the long-staple pima cotton so essential in airplane fabric, balloons, and cord tires—that underwrote cotton's return to the Salt River Valley.

Remarkably, however, alfalfa retained its function as a restorative cover crop in rotation with cotton. Barley also made a return to farm fields of central Arizona in the mid 1950s, no doubt in response to a surge in cattle and poultry holdings. Both developments took advantage of the explosive urbanization of the Phoenix basin, as the city's population tripled between the 1950 and 1960 censuses (Gammage, 1999, p. 46). But the expansion of cropland and pasture that accompanied urban expansion did not last. Urban and exurban development encroached on grazing lands, as pastureland began a steady decline during the early 1960s. Cotton production reached a peak in 1978 and has declined steadily since, as well. The boom period was predicated squarely on green revolution technologies, and the regional cropping system has only begun to show signs of more diversity since the late 1980s, as barley, alfalfa, and wheat acreages have increased.

Livestock

Many of the changes in livestock production in the United States during the past half century have come in response to urbanization and increasing consumption

(Princen, 2005; Princen et al., 2002). Higher labor force participation and higher discretionary incomes during the postwar years allowed Americans to consume more animal protein in their diets. Beef led the way, growing from a per-capita consumption of 50 lb. in 1950 to 95 lb. in 1970 (Hart, 2003). Chicken overtook beef and pork in the 1990s, reaching a per-capita consumption of 96 lb. in 2002. The mixed farms that earlier in the century produced a little bit of everything and sold their marketable surpluses in local or regional markets were displaced in terms of sales by more specialized and commercial operations that grew to meet the demands for animals with tender and thicker flesh and consistent presentation on supermarket shelves. The concentration of livestock in increasingly larger farm enterprises that accompanied the drive to mass production has also shifted cereals production to the feeding of animals. Even though the volume of its trade makes the United States the largest agricultural exporter in history, with roughly 20% to 25% of its grain corn harvest, one third of its soybeans, and 40% to 50% of its wheat regularly sold abroad, it is still estimated that roughly 70% of the United States' cereal and legume harvest was fed to animals in the 1990s (Smil, 2001).

Each of these new animal-raising enterprises are far more specialized and spatially concentrated than the animal husbandry that preceded them. Livestock are not raised and fed on mixed farms that integrate their grazing activity and manure output into cereal production, but are bred on contract by smaller calving, farrowing, or hatching operations before being shipped to larger feeding and finishing operations. Hart (2003) describes the resulting concentration of animals as a new macrogeography of American agriculture. By century's end, most farms in the United States had sold their chickens, milk cows, and hogs. Hart (2003) argues that the core areas of cereals production in the United States—found in the Corn Belt states of Ohio, Michigan, Illinois, Wisconsin, Iowa, Missouri, Nebraska, Minnesota, and South Dakota—now produce the feed that nourish cattle, poultry, and hogs in Maryland, North Carolina, northern Georgia, northern Alabama, Arkansas, Oklahoma, the Texas panhandle, northeastern Colorado, and central Arizona. A third region in this new macrogeography is found in California, Florida, and the Northeast, and is increasingly focused on producing vegetables, fruits, nursery and greenhouse products, and other highly specialized crops. Beef cattle are the only exception to the larger trend toward spatial concentration, because they are easier to raise on small part-time farms (Hart, 2003; Hoppe and Kork, 2005). Between 32% and 43% of what the USDA refers to as *limited-resource*, *retirement*, *residential/lifestyle*, and *low-sales farms* specialize in beef cattle—particularly cow–calf operations—which require less attention and are more compatible with off-farm employment (Cash, 2002).

Most of the beef raised on American farms no longer comes from large ranches in the West, but from farms east of the Mississippi. These changes were perceptible in the persistence of cattle in New England farming during the 19th century. Sheep were also an important feature of New England agricultural tradition, but flocks began a steady decline in the 1870s. By the 1920s, local demand for wool was undercut by a relocation of textile manufacturing to the South, and supplies that came from sheep raisers in the Plains and the arid West (Brisbin, 1959; Delfino and Gillespie, 2005; Gemming, 1979; Jager, 2004). Low agricultural prices in the

1920s also forced farmers to reduce corn acreages and scale back hog inventories. Farms in Middlesex and Worcester counties in Massachusetts, near Boston, were the only areas in the New England region with inventories of more than 20,000 hogs in the 1920s. By 1950, Middlesex farmers had increased hog inventories to 34,000, but the growth was sustained mostly with feed from outside the region. Corn acreage during the same period declined from 1,682 acres to 273 acres in Middlesex (U.S. Department of Commerce, 1920a, 1930a, 1950a). Small farmers responded to the loss of farm income (declining beef, sheep, and dairy production) by turning to poultry. Most farm families had maintained small flocks of laying hens before World War II. Farm women usually managed the poultry and gathered the eggs to barter with country merchants for store-bought goods (Jager, 2004; McMurry, 1995; Walker, 2000). When these hens were past their laying days, families baked them for Sunday dinner or sold them live into urban markets. With the change in consumer tastes after the war, a greater demand arose for dressed chickens, already slaughtered and prepared for grocery displays. This led to the breeding of chickens that grew faster with less feed, known in the trade as *broilers* (Hart, 2003).

Northeastern Georgia, Arkansas, and Maryland were broiler-producing areas that received a boost from the War Food Administration in 1942, when it ordered dressed chickens for the armed forces (Sawyer, 1971). These contracts spurred the early development of vertical integration in the poultry business. Operators tired of the insecure supply of chicks and decided to start their own large-scale hatcheries, and then worked on developing feed mills. Eventually, most of the firms also moved into marketing and distributing their broilers. The South was receptive to the broiler trade for many reasons, not the least of which was an infestation of the boll weevil that killed cotton crops across the South during the Depression (Hart, 2003). The South also provided lower startup costs. Building materials and labor were cheaper, on the farm and in the feed mills and processing plants. Over the long term, these advantages help to explain why the South captured most of the broiler industry.

However, during the immediate postwar period, farmers in every study area examined here experimented with broiler production. The growth in poultry inventories was actually more cautious in southern Appalachia than in New England. Inventories doubled in New England between 1940 and 1974, but the growth of poultry inventories did eventually reach the upland farms in the Coweeta study area after 1950, when inventories doubled in just 20 years. Even the central Arizona and Shortgrass Steppe regions joined in the trend, experiencing their own tripling of inventories respectively between 1950 and 1969 and between 1969 and 1987 (U.S. Department of Commerce, 1950a, 1969, 1987). Each of these areas eventually declined in the face of competition from the integrated operations of big producers, centered in Arkansas and Maryland. The exception to the larger pattern of boom and bust occurred in southwestern Michigan, where a higher proportion of poultry inventories have been involved in egg production. Much of the most recent production has in fact been concentrated in Allegan County, Michigan, which reported 2,143,903 laying hens and 2,420,666 broilers in the 2002 census. These totals represent 30% and 60% percent, respectively, of the state inventories of both kinds of poultry (U.S. Department of Agriculture, 2002).

The most lasting impact of the trend toward livestock agribusiness and the jump in scale of production is the divorce of animal husbandry from crop agriculture, with all the negative consequences that the separation implies. Hog farming seems to be the only form of livestock concentration that is still integrated meaningfully into the crop systems of family farms. As larger hog operations grew in the 1960s, they contributed to the transformation of traditional crop rotations. The midwestern Corn Belt tended to follow a 3-year rotation of corn, small grains, and hay. Corn was usually followed by winter wheat or oats during the second year of the rotation, and clover during the third. Increasingly, alfalfa took the place of clover in the midwestern system. From very early in the development of the region's agriculture, Corn Belt farmers fed most of their crops to their livestock, but could shift more into markets if prices were good. Wheat usually ended up in the market, but could also be fed to livestock. Oats were an important feedstock for horses, and hay was an important fodder (Hart, 2003). Crop farmers were the key to expanding the business, and hog producing therefore tended to be concentrated where pasture was limited. Crop farmers who agreed to feed hogs on contract helped to expand the business in the same way that small farmers participated in the expansion of poultry processing. Most farmers explained the benefits of the change as a way to keep their children engaged in the farm enterprise, adding an activity that required more labor and added revenue, and made use of the manure to lower fertilizer costs and keep corn and soybean yields high. The outcomes, as we see in the Kellogg Biological Station region cropping data, have been an increasing focus on corn and soybeans, and a reduction of pasture in the land that remains in farms in southwestern Michigan.

But the recoupling of animal husbandry and cropping remains unlikely in most of the study areas. There is a growing mismatch in the overall scale of cropland and livestock farming in these regions. Recent declines in livestock inventories are a reflection of this (Fig. 1.11). Without the local feed crops to sustain smaller breeder and feeding operations, large-scale operators have come to dominate the confinement regime. The concentration of animals in larger operations means that they are grazing for far less of their much-shortened lives. The loss of herbivory from grassland ecosystems is one important consequence of the change (Gibon, 2005). The concentration of animal wastes also represents a growing problem. Manure management is improving in large-scale livestock facilities, but the spatial concentration means that nutrients are not distributed as widely as they once were, and they pose environmental risks to soil formation and water quality. The effects are very uneven (Acosta-Martinez et al., 2004; Corkal et al., 2004; Osterberg and Wallinga, 2004). Some crop farms may have much-improved access to manure, and others are too far away from the centers of livestock production to benefit from the industrial scale and availability of biologically friendly fertilizer. Ultimately, regions situated at the heart of diverse and commercially oriented cereal agriculture areas—like Konza, Kellogg Biological Station, and Shortgrass Steppe—are in the best position to make the most sustainable use of these restructured resources. With little or no decline in farmland or cropland, livestock numbers are actually closer to historical carrying capacities in the West than in the postagrarian landscapes of the eastern United States (Fig. 1.11).

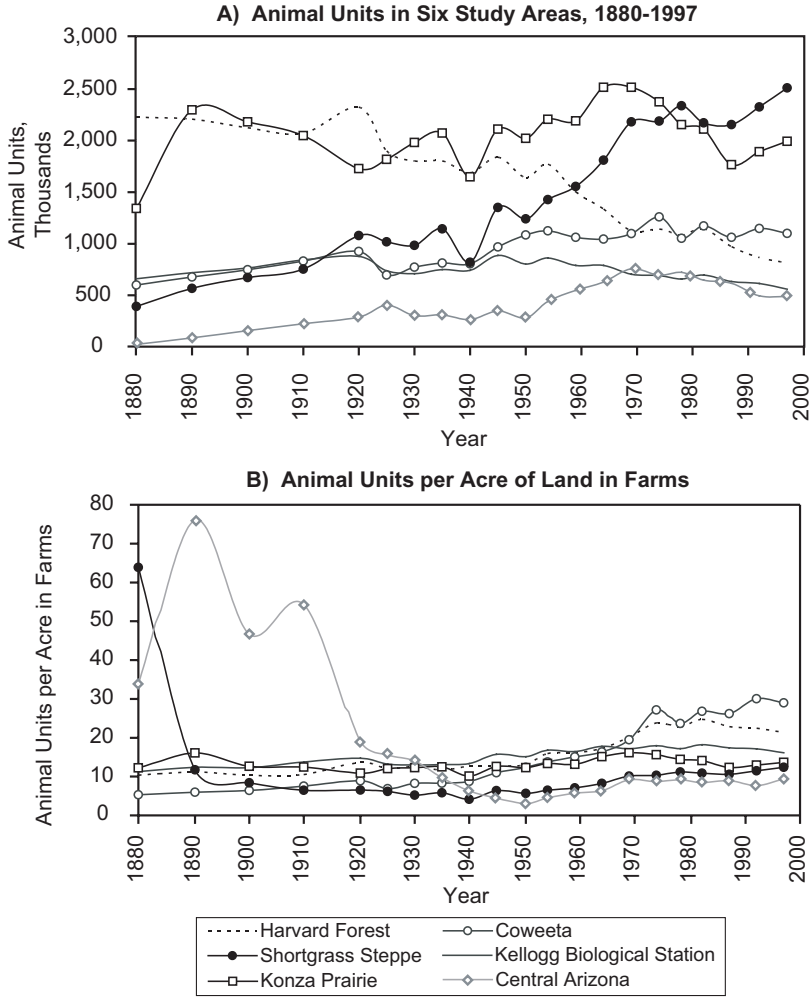

Figure 1.11 (A, B) Animal units in six study areas (A) and animal units per acre of land in farms (B) 1880–1997. U.S. Department of Commerce (1870a, 1880a, 1890a, 1900a, 1910a, 1920a, 1925, 1930a, 1935, 1940a, 1950, 1954, 1959, 1964, 1969, 1974, 1978, 1982, 1987, 1992); U.S. Department of Agriculture (1997).

Implications

In historical terms, then, the ecological impacts of livestock concentration are relatively minor when compared with the movement of cereal production into the center of the continent. This shifting geography was and is the single largest dynamic reshaping landscapes in the regions studied. Few agrarian experiences in the world rival the rapid movement of cereal agriculture across the territories

of the United States between 1870 and 2000. In Europe, the struggle to sort out which land was ultimately marginal for agricultural purposes lasted centuries, and was complicated by social structures that concentrated the ownership of land in very few hands and restricted the movement of ordinary people (Moriceau, 2002; Pollard, 1997). In the United States, freehold tenures and family proprietorship established a common settlement vernacular across the interior of the continent. Less mediated by the state or wealthy landowning classes, the agrarian experience was freer to explore ecological niches and to monitor the response of upland, lowland, prairie, and plains to a small-grains complex brought by Europeans to the Americas. A reciprocal imprinting of a European repertoire of small grains—wheat, rye, barley, oats, and cultivated hays (clover)—and domesticated livestock with the North American landscape began with the adoption of maize as a staple fodder and cereal crop. Corn yielded more plant mass than small grains and was easier to work in small fields in hilly terrain or on steep slopes. Yet, stubbornly, once maize was adopted as part of the system, European Americans applied the same template to every biogeography across the continent, adapting to each only in subtle and gradual fashion.

Part of the advantage of the more discrete regional spaces analyzed here, we argue, is that the scale of observation allows for a meaningful discussion of temporal trends. A national scale analysis is too large to capture phenomena that can be related to local agents of change. The bioregional scale we use is sufficiently aggregated to recognize connections to wider processes, but is scaled close enough to local patterns of change to frame paths of development. The agricultural census provides us with the specific dimensions of those transformations within bioregions and reinforces the importance of understanding what came before the present in every setting. Each has followed paths that have been responsive to broader national trends, but the agriculture of each region has been specific to the biogeography that facilitated agrarian change.

In New England, patterns of stewardship and care that were necessary to make the land productive during the colonial era demonstrated that the land could be used sustainably within the framework of an 18th-century economy and a state confined to the eastern seaboard. But in the context of a continental nation, the hilly terrain and stony soils of New England demanded too great an effort to remain viable as grain surpluses from midwestern prairies grew during the early 19th century. The turn to a pastoral economy was decisive in New England because population densities and rural industry pulled labor away from the internal economies of mixed farms. In southern Appalachia, by contrast, distance from major population centers ensured that the transition to a pastoral economy and industrialization waited until well into the 20th century. In each case, upland geographies did not prefigure the duration of particular agrarian regimes; however, once integrated into the larger economy, neither region could escape the pastoral turn that biogeography set out for agrarian change.

By contrast, in the Midwest and Plains, the fit between the cereals and biogeography was more seamless. Lowland, prairie, and plains geographies, with rich soils and temperate climates, ensured that agriculture would have a stable existence. But, one of the major surprises that emerged from the analysis is how

diverse production remains in these commercially important agricultural regions. Mixed farming has been a consistent feature of farming in the Midwest and the eastern Plains since settlement began. In eastern Kansas, corn was grown to excess between the 1880s and 1920s, but decades of intermittent rains and falling yields eventually broke farmers of corn culture and led to a switch to wheat, as the biogeography itself encouraged a more sustainable path of development. Even in more challenging environments, like the semiarid and arid West, where the fit between cereals and biogeography was problematic, mixed farming framed early development. Only with the introduction of cotton in Arizona in the 1950s has a genuine monoculture emerged (Carriere et al., 2003).

This review of historical patterns indicates that we know too little about the internal dynamics of farm systems to make definitive judgments. Nevertheless, the regional summaries are suggestive of the ecological impacts over the long term. They indicate that biogeography modified human agricultural systems slowly and that agrarian landscapes were far from permanent. They also indicate that diverse production was a common component of agrarian change as it moved across the continent. Despite the varying intensity of commercial change, which affected the pace of change at different stages of national development, each agrarian transformation renewed—rather than abandoned—traditions of mixed farming. Until the mid 20th century, most farms combined livestock raising and grain growing. The collapse of this basic signature of European American agriculture since then implies that the most negative and intense ecological impacts rest in our own time.

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