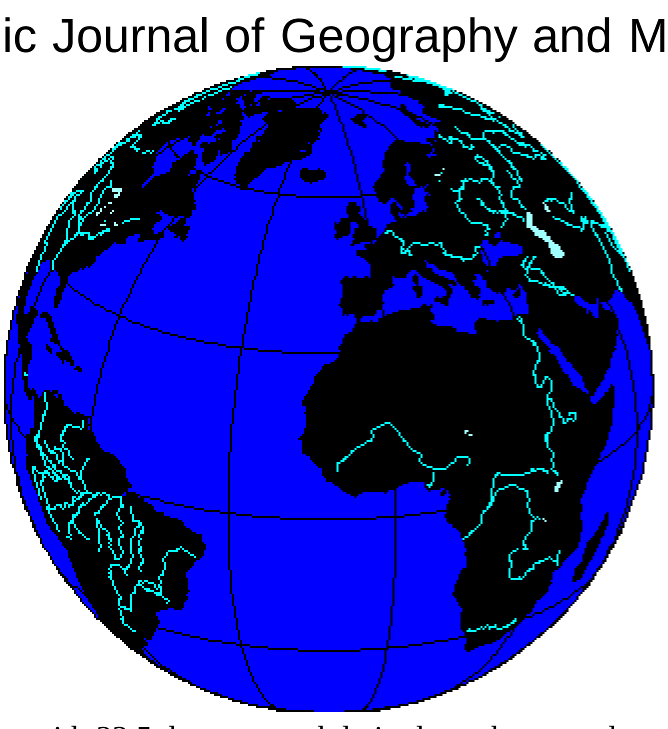
Solstice:

An Electronic Journal of Geography and Mathematics



Earth: with 23.5 degrees north latitude as the central parallel.

Volume XIII
Number 1
June, 2002

Institute of Mathematical Geography (IMaGe)

SOLSTICE: AN ELECTRONIC JOURNAL OF GEOGRAPHY AND MATHEMATICS

http://www.imagenet.org

SUMMER, 2002

VOLUME XIII, NUMBER 1

ANN ARBOR, MICHIGAN

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The purpose of Solstice is to promote interaction between geography and mathematics. Articles in which elements of one discipline are used to shed light on the other are particularly sought. Also welcome are original contributions that are purely geographical or purely mathematical. These may be prefaced (by editor or author) with commentary suggesting directions that might lead toward the desired interactions. Individuals wishing to submit articles or other material should contact an editor, or send e-mail directly to sarhaus@umich.edu.

SOLSTICE ARCHIVES

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Animated Map Timeline, Syria

Sandra Arlinghaus, Salma Haidar, and Mark Wilson
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respectively:
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and Department of Epidemiology (School of Public Health) and Director, Global Health Program.

Cartographic evidence can often be used to find pattern in large sets of data that are widely scattered in time and space. Thus, when co-author Haidar considered spreadsheets with many thousands of entries, it seemed useful to map the data in her quest to look for pattern in incidence of the disease, Leishmaniasis, in Syria. She wished to view the data by Syrian province over a period of eight years, on a monthly basis. (See Figure 1 for a map of "Syria: By Province.") In that way she hoped to be able to see, at a glance, variation in incidence from north to south in a seasonal framework. The animated map offered one approach to that task.

To create the sequence of animated maps below (Figure 2), monthly thematic maps are shaded, in a GIS, according to standard deviations above (red) and below (blue) the mean (white) of data (incidence of Leishmaniasis) for each year. Intervals are 0.25 standard deviations. The deeper the color the farther from the mean. The calendar below the group of maps is also animated to coordinate with the changes in the maps. Thumbnail-sized maps are aligned below to show general contrast in cyclical pattern between north and south and in annual variation of disease incidence. For a more detailed view, click on small maps to see enlarged maps, one at a time. To get the benefit of map coordination, the display must be viewed on a high-speed connection or downloaded and viewed on a CD (for example).

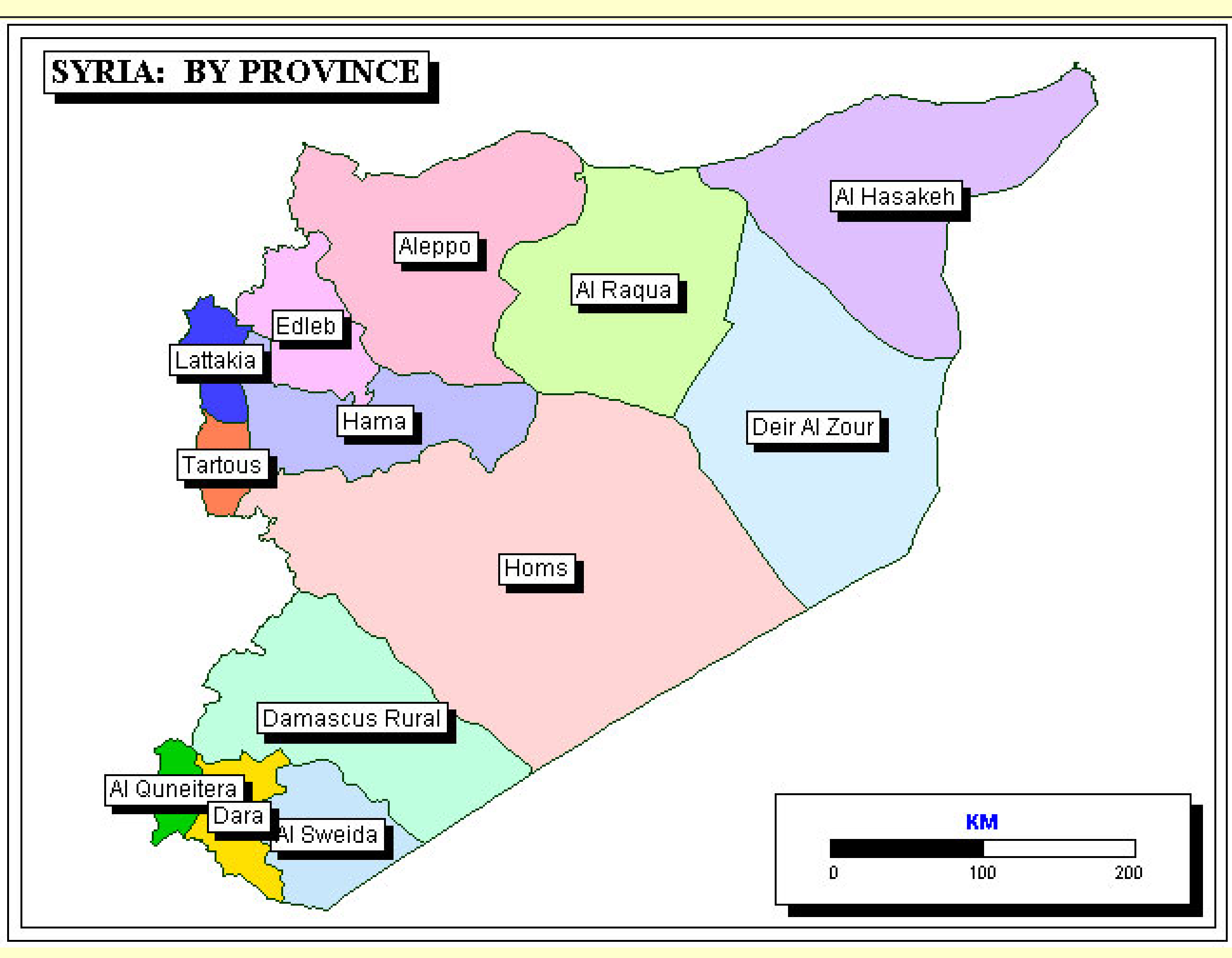
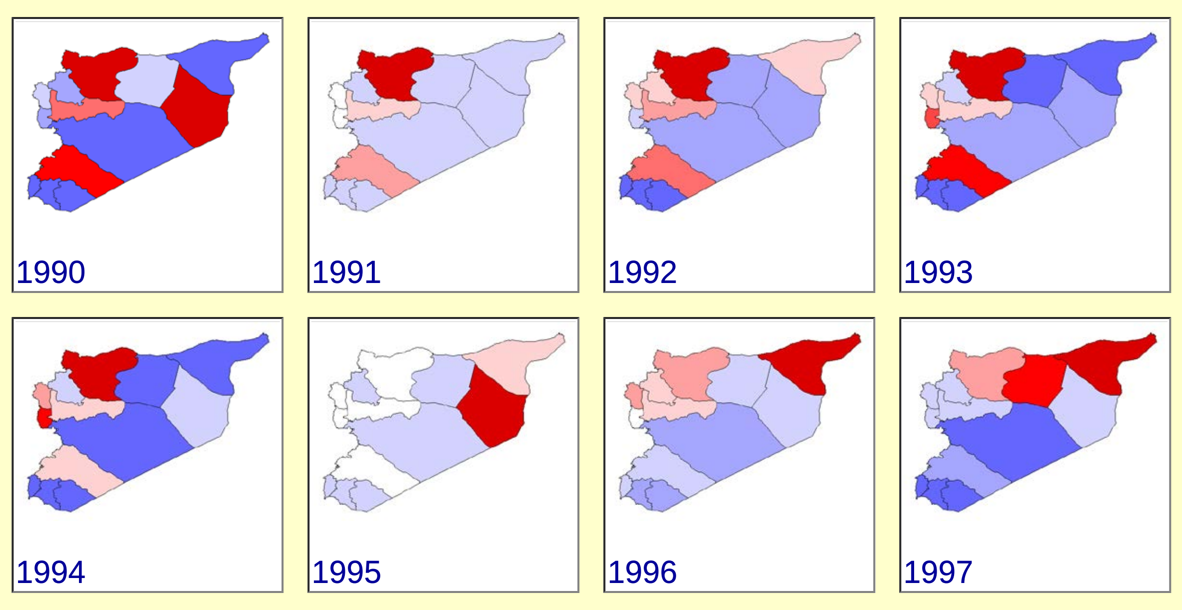


Figure 1. Provinces of Syria. Source: [Community Systems Foundation.](#)



January

Figure 2. Animated map sequence showing changing pattern of Leishmaniasis incidence, over time, in Syria (by province).

There are a number of questions one might ask, based on observing this set of maps. If some of the questions have known answers then this display might be calibrated as a "model" after which one might then consider other questions with unknown answers. A few natural observations might be:

- From 1995 on, the province of Damascus is always below the mean; prior to 1995, it was not and exhibited apparent seasonal variation, with values above the mean (for the most part) in Oct., Nov., Dec., Jan., and Feb. What did Damascus do in 1994/95; was some sort of disease control measure implemented? If so, it may be working. What is the lesson, therefore, for Aleppo which always appears above the mean? The controls applied in Damascus may require certain climatic/rainfall regimes or presence or absence of vegetation. Whatever the requirements, is the environment of Aleppo conducive to using the same sorts of control procedure that Damascus has employed?
- From 1995 on, provinces to the east of Aleppo begin to appear above the mean in a consistent pattern; why is this (some in 1994) the case? The variation appears seasonal with high values in (Nov), Dec., Jan, Feb, and March and in that regard is similar to the situation in Damascus (1990-94); is that mere coincidence? What happened in 1994 to shove incidence to the east on an apparently persistent basis? Is there a relation to the Euphrates River Valley and to water projects to the north, in Turkey?
- Aleppo is almost always above the mean. The provinces to the west of Aleppo come in and out of the picture; is there some explanation for the pattern that appears?
- From 1995 on, Al Quneitera (the Golan Heights) appears not to be synchronized with the rest of the southern region as it had been before; why is this?
- The year 1994 seems a bit unusual, as if it were a transition point of some sort; what happened in 1994? Sometimes it appears to fit with the new grouping from 1995 on, and at other times it seems to fit with the old grouping from 1990-1993.

Animated maps, that view spatial change over time, can generate quick sets of questions. For a full view of the health-related substance of this topic the reader is referred to author Haidar's forthcoming dissertation.

Animap papers published in previous volumes of Solstice are listed below, and linked to the article, for the interested reader; please also refer to other related articles in the current issue:

- [Animaps](#)
- [Animaps, II](#)
- [Animaps III: Color Straws, Color Voxels, and Color Ramps](#)
- [Animaps IV: Of Time and Place](#)
- [Animaps, Again](#)
- [Animap Sequences](#)

Classification techniques in complex spatial databases.
On the assessment of a network of world cities.

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ABSTRACT

In linking the power centers of the world-economy, a network of world cities provides the spatial outline for the reproduction of society as a capitalist world-system. An exploratory analysis of this global urban system is necessary to attain insight in its functioning, but specifications and analyses based on the use of classic data analysis techniques are hampered by the fact that they cannot assess the various sources of vagueness in this complex network of world cities. It is argued that by replacing the premises of the classic two-valued framework of conventional mathematics by a fuzzy set-theoretical approach where degrees of membership are computed rather than a mere assessment of crisp memberships in clusters, the inherent vagueness of possible classifications of world cities can be taken into account. This assertion is tested by comparing the results of some mainstream data analysis techniques (principal component analysis, crisp c-means clustering) to the results of a classification based on the premises of fuzzy set theory (fuzzy c-means clustering).

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Introduction: fuzzy set theory and its applications

The theory of fuzzy sets was formally introduced by Zadeh (1965), and addressed problems in which the absence of sharply defined criteria is involved. In particular, fuzzy sets aim at mathematically representing the vagueness and lack of preciseness, which are intrinsic in linguistic terms and approximate reasoning. As such, through the use of the fuzzy set theory, ill-defined and imprecise knowledge and concepts can be treated in an exact mathematical way (Tzafestas, 1994). However, this fact does not imply that fuzziness is mere ambiguity or stems from total or partial ignorance. Rather, fuzziness deals with the natural imprecision associated with everyday events (Cox, 1994). To illustrate the problem of imprecision in formalising linguistic terms, take, for instance, a simple statement like “John is tall”. Interpreting this statement in the classical two-valued logical framework of conventional mathematics, this would imply that we would have to design a criterion that unambiguously describes a person as either “tall” or “not tall”. However, in reality, such a statement is abundant with vague and imprecise concepts that are difficult to translate in more precise language without losing some of its semantic value. For example, the statement “John’s height is 178 cm.” does not explicitly state whether he is tall, and if we would state that 180 cm. is tall, this does generally not imply that 178 cm. is not to be considered tall. Furthermore, a person can be considered both tall and not tall depending on one’s perspective. Any crisp analysis resulting in disjoint groups fails to grasp this semantic vagueness (Lakoff, 1972; Zadeh, 1972). Fuzzy set theory aims to provide the mathematical underpinnings for the specification of this inherent vagueness. More formally, Zadeh (1965, p. 338) defined a fuzzy set as “a class of objects with a continuum of grades of membership”. Fuzzy sets are characterized by a membership function which assigns to each object of the set a grade of membership ranging from zero (non-membership of the set) to one (full-membership of the set). Apart from the apparent fuzziness in standard linguistic terminology and everyday events, vagueness is also a problem in classification schemes framed upon the unravelling of patterns in large data sets (Bezdek, 1981; Pal & Dutta Majumder, 1986; Bezdek & Sankar, 1992; Pal and Mitra, 1999). This simple and straightforward example, then, is merely a first step to possible broader applications in the field of mathematical assessments of vagueness drawing on the premises of fuzzy set theory.

The purpose of this article is to provide evidence about the assertion that it is possible to account for different sources of vagueness in large geographical databases by using a fuzzy classification technique. The assertion that a fuzzy set algorithm should be able to offer a more sensitive classification than conventional, crisp methods will be empirically tested by comparing results of more classic data analysis techniques (principal component analysis, crisp clustering algorithm) with results obtained by a clustering algorithm based on the premises of fuzzy set theory. The argument will proceed as follows. First, focusing on possible applications in geography, a brief overview of the premises of both types of classifications is provided in order to distinguish clearly between crisp and fuzzy classifications. Second, a description of the database on the network of world cities, as constructed by the Globalization and World Cities Study Group and Network (GAWC), will be provided. Special attention will be given to theoretical and practical sources of vagueness related to classification analyses in this database. This database on relations between world cities is useful for our analysis for three reasons:

1. Any classification scheme based on the database on world cities should take into account the fact that patterns will never be clear-cut, since the network of world cities is characterized by complexity rather than by a simple hierarchy (Taylor *et al*. 2001a; Sassen, 2000)

2. A great deal of information in this database rests on sparse data, yielding vagueness in *any* classification (Beaverstock *et al*., 1999; Taylor *et al*., 2001b).
3. Some "classical" data analysis techniques (principal component analysis) have been applied on this database (Taylor *et al*., 2001b), providing us the opportunity to assess possible advantages and disadvantages of the use of a fuzzy set-algorithm.

The outset and results of the fuzzy clustering algorithm will be preceded by the outset and results of the associated crisp clustering algorithm. This enables us to show the methodological differences between both approaches, as well as providing additional results that can be compared.

Crisp and fuzzy classifications in geography

The main purpose of unsupervised classification (clustering) of a set of objects is to detect subgroups (clusters) based on similarity or dissimilarity between objects. There are many different approaches to clustering depending on the definitions and interpretation of these subgroups, and each of them may give a different grouping of a dataset. The choice of a particular method will depend on the type of output desired, the known performance of method with particular types of data, and the size of the dataset. For instance, clustering methods may be divided into two categories based on the cluster structure they produce. Non-hierarchical methods divide a dataset into disjoint clusters, whereas hierarchical methods produce a set of nested clusters in which each pair of objects or clusters is progressively nested in a larger cluster until only one cluster remains. The choice of either of these two techniques in this instance, then, depends primarily on the form of the desired output (Kaufman & Rousseeuw, 1990; Everitt *et al*., 2001).

Although hierarchical and non-hierarchical algorithms are two distinct approaches towards the classification of objects, they both share one essential feature: any partition of a set of n objects results in mutually exclusive clusters. In the case of non-hierarchical clustering, the state of clustering is expressed by an n x C matrix $\mathbf{U}=(u_{ic})$, where $u_{ic}=1$ if object i belongs to the cluster c, otherwise $u_{ic}=0$. To ensure that the clusters are disjoint and non-empty, u_{ic} must then satisfy the following conditions (Sato *et al*., 1996):

$$\sum_{c=1}^{C} u_{ic} = 1 \qquad [1]$$

$$u_{ic} \in \{0,1\} \qquad [2]$$

for

$$i = 1,...,n$$
$$c = 1,...,C$$

This classification scheme has certain distinct advantages. For one thing, results are clear-cut, and possible cumbersome interpretations of in-between values are expelled from any analysis since there is no overlap in cluster membership. When applied to the classification of regions or countries based on certain criteria, this fact implies that the only admissible spatial boundaries are unambiguous ones (MacMillan, 1995; e.g. Dezzani, 2001; Arrighi & Drangel, 1986; Van Rossem, 1996). Any location is either entirely situated in a region or a country, or it is not. As a consequence, interpretation of the clustering results is straightforward.

In some cases, however, it is not expected that classifications will be clear-cut. As Leung (1987, p. 125) points out, "regions are fundamental analytical units on which most spatial analyses are based. Conventionally, a region is treated as a spatial construct which can be precisely identified and delimited". However, "…regions may not be precisely identified and boundaries generally exist as zones rather than lines". In addition to this inherent vagueness in classifications, the clustering of objects based on sparse data is another source of vagueness with respect to the classification of locations.

A possible solution for this problem lies in the use of a fuzzy set-theoretical approach to clustering; that approach discards the unambiguous mapping of the data to classes and clusters, and instead computes degrees of membership specifying to what extent objects belong to clusters. If $u_{ic} \in \{0,1\}$ in [2] is replaced by

$$m_{ic} \in [0,1] \qquad [3]$$

then the clustering result is more sensitive to vagueness in classifications (Sato *et al*., 1996). In using a crisp clustering algorithm, minor shifts in the data may yield a completely different outcome although the basic pattern in the data may in fact remain pretty much the same. In a fuzzy framework, all places may have a membership in *any* region. In classifying regions where it is more natural to treat them as transient regions between any two areas as fuzzy domains in which the degree of fairness, the cases having almost the same profile or pattern and the gradual change between sample spaces are in fact the expression of fuzziness (Leung, 1987; Rolland-May, 1986; Harris *et al*., 1993).

Since its original outset, fuzzy set theory has been employed in many areas to simulate and manage vague information (Höppner *et al*., 1999). Obviously, these vagueness problems also apply to large geographical databases. MacMillan (1995) has pointed out that fuzzy thinking has been around in geography for as far back as the 1970s. MacMillan himself (1978) and Gale (1972a, 1972b) applied fuzzy set theory with respect to locational decision-making and behavioural geography. However, "at that stage, it did not become fashionable in geographical circles (…)" (MacMillan, 1995, p. 404). More recent examples of applications of the use of fuzzy sets in geography can be found in the domains of spatial analysis (e.g. Leung, 1987; 1988), site selection (e.g. Witlox, 1998), and land-use planning (e.g. Smith, 1992; Xiang *et al*., 1992). Although there are, then, quite a few examples of the use of fuzzy set theory, research topics and methodology issues relying on the use of fuzzy set theory are as yet not a part of mainstream geography. Furthermore, the outset of the basic premises of fuzzy set theory itself was merely the start for myriad studies leading to an explosive growth of both the original core ideas and possible extensions, such as research of expert knowledge systems and neural networks. Possible applications for geographers, then, are not limited to the application of the basic ideas. A whole range of new methods and applications are available now.

One of the major advantages of the use of a fuzzy set-theoretical approach lies in the fact that it is possible to capture various aspects of vagueness (Everitt *et al*., 2001). For instance, fuzzy sets can at the same time capture vagueness due to the sparsity of data and vagueness due to the lack of theoretically defined pre-existent categories. Hence, a minor shift in the data does not necessarily result in a major shift of the classification of in-between values. Rather, a minor shift in the dataset will be reflected by minor changes in membership degree, allowing for a more sensitive approach of the classification scheme. In general, four of the main useful features of fuzzy set methodologies are (Höppner *et al*., 1999; Chi *et al*., 1996):

(i) Fuzzy set theory provides a systematic basis for quantifying vagueness due to incompleteness of information;
(ii) Classes with unsharp boundaries can be easily modelled using fuzzy sets;
(iii) Fuzzy reasoning is a formalism that allows the use of expert knowledge, and is able to process this expertise in a structured and consistent way;

(iv) There is no broad assumption of complete independence of the evidence to be combined using fuzzy logic, as required for probabilistic approaches.

Features and specification of the network of world cities

Urban geographers have long sought to unravel and describe the systematic nature of the spatial arrangement of urban centers. The original outline of Christaller's central place-theory (1933) and Lösch's extensions of this central place-theory (1954) are but two classic examples of such an endeavour. Most of the studies oriented towards the description of the spatial arrangement of such an urban system inherit their physical boundaries from their definition as an integrated economy. Since the beginning of the twentieth century, the world-economy is truly global (Wallerstein, 1983), and hence all cities can be thought of as participating in a single urban system in a Christallerian sense. This global urban network should then theoretically be characterised by functional specialisations as predicted by the spatial optimization processes described by central place-theory.

Although the original outline of central place-theory may still do a reasonably good job in describing the spatial pattern of urbanization on a regional scale or in assessing the location of some service and retail industries at a regional scale, it is not suited to explain patterns of global urbanization. At the most basic level, there are at least four (heavily intertwined) alterations that should be taken into account with respect to the assessment of a global urban network:

(i) The original hierarchy needs to be supplemented by some additional levels (Hall, 2001);
(ii) The combined effect of an ever-increasing globalization and a shift from capitalist production primarily based on manufacturing to a capitalist system focused on knowledge production, suggests that there are new and previously unassessed central place functions in place. This holds especially true with reference to the additional global levels of urbanization (Sassen, 2000);
(iii) Under contemporary globalization, cities are increasingly defined by mutual relations in spaces-of-flows, rather than by relations to their immediate hinterland (Castells, 1996).
(iv) The presumed equivalence between hierarchical position in the urban system and central place functions seems to be altered due to functional specializations among cities (Sassen, 2000).

This extremely brief overview of the most salient features of a global network of world cities has a profound impact on the assessment of this urban system. Clearly, an analysis of this network should concentrate on flows between cities (Smith and Timberlake, 1995; Castells, 1996). Moreover, the flows generated by the spatial strategies of advanced producer services are crucial determinants in this overall space of flows where world cities act as nodes in a complex network (Sassen, 2000). However, irrespective of these theoretical underpinnings on the importance of both (i) relational data and (ii) the role of advanced producer services in these relations, a more precise and practical specification of this network of world cities is obvious. For without such a specification, there can be no detailed study of its nodes, the connections, and how these connections and nodes constitute an integrated whole (Taylor *et al*., 2001b).

This need for the construction of geographical databases focusing on relations between world cities has been recognized from the very beginning of world city-research (Smith and Timberlake, 1995), but the construction itself has been hampered by methodological problems. This is due to the fact that the bulk of information on cities is attributional data (Short *et al*., 1996). Hence, although all of the definitions and specifications of a network of world cities should be premised upon the existence of worldwide transactions, most of recent research efforts on cities have been centred on studying the internal structures of individual cities and comparative analyses of these cities (Taylor, 1999). Moreover, some earlier attempts towards a specification of the relational character of the network of world cities have remained "ambition rather than reality" (Taylor *et al*., 2001), resulting in *ad hoc* classifications (Friedmann, 1986; Knox, 1995; Sassen, 2000), often limited to the highest ranks in the hierarchy (e.g. Sassen, 1991). The overall aim of the Globalization and World Cities Study Group and Network (GaWC) has been to provide data and research on the relational character of world cities. Arguably one of the most important accomplishments of GaWC was Taylor's (2001) specification of the world city network, by outlining the construction of connectivity matrices based on data on the presence of advanced producer firms in world cities (Beaverstock *et al*., 1999; Table 1). Connectivities as measure of flows between world cities were derived for each pair of world cities by applying a specific kind of network analysis. Using a specific kind of network analysis was deemed necessary because the nodes in this network (the world cities) are in fact connected by constituent subcomponents (global service firms). That is, although world cities are the formal nodes in this network, they are by themselves at best modest actors in the flows in this network. World cities are only perceived as nodes in that they harbor advanced producer firms that are connected in a complex web of flows. The network of world cities as an interlocking network characterized by boundary penetration relations is defined at two levels: a system-level where the network operates (the network of world cities), and a unit-level consisting of the nodes as actors whose behaviour define the relations (global service firms). Drawing on the formal outline by Knoke and Kuklinski (1982), connectivity measures were derived by computing the sum of the cross products of all of the firms for any pair of cities. These sums reflect the similarity between the cities in terms of global services, and can hence be thought off as a surrogate for particular flows of information and knowledge between the cities when two assumptions are made. First, offices generate more flows within a firm's network than to other firms in the sector. Although not formally empirically tested, this assumption is plausible, for flows of information and knowledge are indispensable for a seamless service. Second, the larger the office, the more flows will be generated, which will have a multiplicative effect on inter-city relations (Taylor, 2001; Taylor *et al*., 2001c).

To summarize, data on the presence of global service firms in cities (55 cities x 46 firms, Table 1) has been used to derive measures of inter-locking connectivity between cities, resulting in indices of network connectivity, where positions of cities within the world city network can be assessed (55 cities x 55 cities, Table 2). The resulting matrices with connectivities between cities then give way "to various forms of analysis available to simpler types of network. This means the wide repertoire of network techniques from elementary derivation of indices to scaling, ordinating, factoring, clustering and blocking" (Taylor, 2001, p. 192). It is the purpose of this article to complement the specification of this unusual network by a non-classic approach to data analysis.

Exploratory analyses of the network of world cities using 'standard' classification techniques

A Hierarchical classification

GaWC-researchers themselves have undertaken efforts to apply some 'standard' techniques to their data. First, in search for a roster of world cities, Beaverstock *et al*. (1999) identified three hierarchical levels of world cities. Based upon the scores in four global service centers (advertising, banking, accountancy and legal services), 10 Alpha world cities, 10 Beta world cities, and 35 Gamma world cities were identified (Table 3). The initial database consisted of 123 cities, but only 55 cities were classified as world cities. A city was designated as a world city if it served as a global service center for at least two sectors, where at least one of those sectors could be designated as a major service provider. The remaining cities, then, were merely showing evidence of world city formation processes, but this evidence was not strong enough to really call them world cities.

A classification based on principal component analysis

Another classification was provided by Taylor *et al*. (2001b), in applying an exploratory research design using principal component analysis. Principal components analysis (PCA) is a member of the factor-analytic family of multivariate techniques, commonly used to define patterns of independent sources of variation in a data matrix. As such, they are a popular means of producing parsimonious descriptions of large and complex sets of data. It is important to note that the application of this PCA-analysis on world cities was used as an exploratory rather than a confirmatory research design. This choice for an exploratory research design stemmed from the fact that there are 'uncertainties' in the application of the factor analytic family of techniques, and the fact that the world city-network seems to be a complex network rather than a simple hierarchy (Taylor, 2000; Friedmann, 1986). This exploratory research design, then, resulted from a positive approach towards vagueness: the creation of alternative results provides a means for exploring a set of data. Instead of searching for some sort of ideal classification, a multiple-number design allowed for the comparison of results over a range of levels of data reduction (Yates, 1987).

Factor allocation for two components resulted in the identification of two groups of world cities ("Inner Wannabes" versus "Outer Wannabes", Table 4). The generic names of these clusters of cities were derived from the fact that these cities invariably have policies helping them strive for world city status (Short *et al*., 2000). The labelling of these two "wannabe" categories was quite straightforward. Cities with high loadings on the first component were situated in what used to be called the 'third world', plus eastern European cities and some more peripherally located cities in Western Europe, notably in the far south (Mediterranean and Iberian cities) and far north (Scandinavian cities), hence the designation as "Outer Wannabes". Cities with high loadings on the second component were termed "Inner Wannabes", since they are primarily relatively minor US cities plus the 'second cities' in western European countries (Manchester, Birmingham, Barcelona, Lyon, Rome and Rotterdam), and second cities in selected associated countries (Montreal, Melbourne, Cape Town, Rio de Janeiro and Abu Dhabi). Unallocated cities in this analysis cover all parts of the world, but they share one notable feature: they are the major world cities (in the previous allocation termed as Alpha en Beta world cities). Next to this dichotomization of the data, a PCA with 5 and 10 components was applied, yielding new classifications in 'outer cities', 'US cities, 'Pacific-Asian cities', 'Euro-German cities' and 'Old Commonwealth Cities' (Table 5). To summarize, whereas Beaverstock *et al*. (1999) provide a hierarchical classification, Taylor *et al*. (2001b) were able to discern a classification based on a spatial pattern reflecting functional specializations in the network of world cities.

A classification based on a crisp clustering algorithm

Cluster analysis is a rather loose collection of multivariate statistical methods that seek to organize information on variables so that relatively homogenous groups can be formed. All members belonging to the same group or cluster have certain properties in common. Hence, the resultant classification may provide some insight into the data. The classification has the effect of reducing the dimensionality of a data table by reducing the number of rows (cases). The aim of a classical crisp cluster analysis is thus to partition a given set of data or objects into clusters (subsets, groups, classes), with the following properties (Everitt *et al*., 2000):

- Homogeneity within the clusters: data belonging to the same cluster should be as similar as possible.
- Heterogeneity between clusters: data belonging to different clusters should be as different as possible.

The classification of the data is based upon a measure of dissimilarity between the different data points in the matrix. The Euclidean distance is the most simple and common measure of dissimilarity. However, one should consider the fact that (i) different variables as constituent components of the classification analysis may be of different relevance for the classification, and (ii) the range of values should be suitably scaled in order to obtain reasonable distance values (Kaufman & Rousseeuw, 1990). Generally, the second problem can be accounted for by using standardized data (z-scores), for this yields a "unit free" measure. However, since we use connectivity measures that were derived using a singular method and based on real-valued vectors bearing the same meaning (Table 1), this is of no concern here.

Apart from the overall general method (i.e. cluster analysis), one has to choose a particular clustering algorithm. This choice depends both on the type of data available and on the particular purpose (Chi *et al*., 1996). The clustering algorithm that will be used here is a c-means clustering algorithm. A formal specification of this method will be outlined in order to highlight the differences with its fuzzy counterpart. This c-means partitioning method constructs clusters that satisfy the standard requirements of a crisp partition:

- Each group must contain at least one object (no empty clusters).
- Each object must belong to exactly one group (exclusivity of the assignment to a cluster).

Both conditions imply that the maximum number of clusters (C) cannot be greater than the number of objects to classify (n), hence C ¡Ün. The second condition also implies that two different clusters cannot have any objects in common and that the C clusters together add up to the full data set. Defined more formally, the outset of the crisp clustering problem can be stated as follows (Chi *et al*., 1996).

Let:

$$X = \{x_1, x_2, ..., x_n\} \quad [4]$$

be a set of samples to be clustered into C classes. The clustering process can be considered as an iterative optimization procedure. Suppose that the samples have already been partitioned into c classes, be it by random assigning the data points to clusters or through theoretical considerations on potential clusters. The task at hand, then, is to adjust the partition so that the similarity measure (based on the Euclidean distance) is optimized. The criterion function for this optimization procedure is equal to:

$$J(V) = \sum_{k=1}^{n} \sum_{x_k \in C_i} \left| x_k - v_i \right| \qquad [5]$$

where v_i is the center of the samples in cluster *i*, and

$$V = \{v_1, v_2, ..., v_c\} \qquad [6]$$

In order to improve the similarity of the samples in each cluster, we can minimize this criterion function so that all samples are more compactly distributed around their cluster centers. Setting the derivative of **J(V)** with respect to v_i to zero, we obtain

$$\frac{\partial J(V)}{\partial v_i} = \sum_{k=1}^{n} \sum_{x_k \in C_i} (x_k - v_i) = 0 \qquad [7]$$

Thus, the optimal cluster center of cluster center v_i is

$$v_i = \frac{1}{n_i} \sum_{x_k \in C_i} x_k \qquad [8]$$

where n_i is the number of samples in class *i* and C_i contains all samples in class *i*.

Starting with the initial clusters and their center positions (be it randomly chosen or initially assigned), the samples can now iteratively be regrouped so that the criterion function **J(V)** is minimized. Once the samples have been regrouped, the cluster centers need to be recomputed to minimize **J(V)**. This process then continues for the new cluster centers: the samples are regrouped in order to reduce **J(V)** yielding a new classification with associated cluster centers, and so forth. This iterative process can be repeated until **J(V)** cannot be further reduced or drops below a pre-defined small number ǎ. Obviously, the criterion function is minimized if each sample is associated with its closest cluster center. This means that x_k will be reassigned to cluster i so that $(x_k - v_j)^2$ is minimum when $j=i$. Up to this point, each sample x_k appears only once, that is, it is associated with only one cluster center.

Note that we subscribe to an exploratory rather than a confirmatory research design: we are not looking for a ‘best result’, rather, the fact that very different results can be found in using a different number of clusters is perceived as the most fruitful approach towards uncertainty in the resulting classifications (Yates, 1987). Here, we shall describe the clustering results for 2, 4 and 8 clusters. In the case with two clusters (c=2, Table 6), we note that there is a strong dichotomy between the cities with a high connectivity versus cities with a lower connectivity. Hong Kong, London, Los Angeles, New York, Paris, Singapore and Tokyo are all assigned to the first cluster, all of the other world cities are assigned to the second cluster. All world cities belonging to the first cluster are identified by Beaverstock *et al.* (1999) as Alpha world cities. Only Milan, Frankfurt and Chicago are Alpha world cities that are not classified in the first cluster. However, this is not a surprise when compared to the results of Beaverstock *et al*. (1999), since these cities are found amongst the lower ranked Alpha world cities.

The clustering result for four clusters (c=4, Table 7) reveals two clusters containing a subset of the most important Alpha world cities, and two clusters containing the rest of the world cities. The rather odd appearance of a cluster only consisting of Los Angeles and Washington DC may be traced back to the concentration of law firms in Los Angeles and Washington DC, whereas the other cluster containing Alpha world cities is characterised by a concentration in banking and finance services. This corresponds to Sassen’s (2000) expectations on functional specializations among American world cities. Taylor *et al*. (2001b; 2001c) were able to define a spatial pattern in their 5-component cut, but the crisp cluster analysis fails to do so. Both clusters 3 and 4 include European cities, cities from the semi-periphery of the world-economy, and a number of American cities, hence no apparent spatial pattern can be discerned.

Arguably the most interesting results were found with the application of the algorithm for eight clusters (c=8, Table 8). It shows both the possibilities and the restrictions of the crisp clustering algorithm when applied to the network of world cities. An apparent spatial pattern in the connectivities can be observed. North American cities, German cities and European cities around the old European core form a cluster, Latin American cities and cities in the old European core are assigned to another cluster. The Pacific-Asian world cities have similar connectivities and are, hence, assigned to another cluster (due to their similar relative strength in banking services). However, as in the classification provided by Taylor *et al*. (2001b; 2001c), the classification of some cities (e.g. Johannesburg, Osaka, Toronto, Warsaw) remains open to interpretation.

Summary: classifications based on classical two-valued logic (figure 1)

Exploratory research resting on the application of principal component analysis and cluster analysis clearly reveals some basic patterns in the large and complex data matrices on world cities. However, the use of these standard techniques, although often revealing and promising, still leaves way for additional analysis, i.e.:

(i) The classification of some cities rests on the fact that they are not allocated to any of the components (Taylor, 2001b). As such, the only similarity they bear is the fact that the retrieved factors cannot explain the observed variance in the observed patterns for these unallocated cities.

(ii) The first GaWC classification (Beaverstock *et al*., 1999) assesses a hierarchical classification, whereas the second GaWC classification (Taylor *et al*., 2001b; 2001c) and the crisp clustering algorithm primarily assess spatial patterns. A classification that assesses both functional and hierarchical tendencies, however, would provide some major advantages.

(iii) The original intention of Beaverstock *et al*. (1999) was to account for the bottom end of the scale of the roster of world cities, where uncertainty in classifications reigned.

Classification of this “grey area” under the clearly discernible higher rungs of the global urban hierarchy, however, merely resulted in the conceptualisation of world cities in the “dark grey area”. Cities were dropped from the analysis (316 to 123 (sometimes even to 55)) because of the sparsity of the data. Although the classification of these cities is a huge step forward as compared to the previous *ad hoc* classifications (Friedmann, 1986; Friedmann & Wolff, 1982) and the focus on the top end of the hierarchy (Sassen, 1991), it is still far from complete. The uncertainty due to the sparsity of data, however, tends to prevent the classification of cities only showing weak signs of world city formation.

<u>Fuzzy c-means clustering algorithm</u>

Methodology

In the classical crisp clustering process, each city is assigned to only one cluster and all clusters are regarded as disjoint gatherings of the data set. However, previously, it was argued that the network of world cities constitutes a distinctively non-hierarchical urban structure (Taylor, 2001, p. 192). In other words, the global urban hierarchy of world cities is a complex network system rather than a simple hierarchy. Although the first two ranks stand out (London and New York), this urban system is not a so-called “double-primate” city pattern.

There may or may not be hierarchical patterns within the spatial organisation of individual firms at the global scale (depending on their particular strategies), but when aggregated the result is a world city network. It is therefore unlikely that classical, disjoint clusters resulting in clear-cut patterns will be able to provide the most salient results. From both a methodological and a theoretical point of view, it is hardly acceptable that a crisp classification process cannot cater for such a situation. Therefore, we propose to replace the separation of the clusters by a fuzzy notion, in order to represent the real data structures more accurately. The criterion function for the crisp clustering algorithm in [5] is replaced by a fuzzy notion (Chi *et al.*, 1996; Höppner *et al.*, 1999; all drawing on the seminal work by Bezdek, 1981), based on the iterative minimization of

$$J(U,V) = \sum_{i=1}^{c} \sum_{k=1}^{n} u_{ik}{}^{m} \left| x_k - v_i \right|^2 \qquad [9]$$

where

- $x_1, x_2, \ldots, x_n$ are n data sample vectors
- $\mathbf{V}=\{v_1,v_2,\ldots,v_n\}$ are cluster centers
- $\mathbf{U}=[u_{ik}]$ is a Cxn matrix, where u_{ik} is the ith membership value of the kth input sample x_k,

and the membership values satisfy the following conditions

$$0 \le m_{ik} \le 1$$

$$\sum_{i=1}^{C} m_{ik} = 1$$

$$0 < \sum_{i=1}^{C} m_{ik} < n$$

for $i=1,2,\ldots,C$ and $k=1,2,\ldots,n$.

- $m \in]1,\infty[$ is an exponent weight factor. This weight factor m reduces the influence of small membership values. The larger the value of m, the smaller the influence of samples with small membership values in the optimization procedure outlined below.

The altered objective function is the sum of the squared Euclidean distances between each input sample and its corresponding cluster center, with the distances weighted by the fuzzy memberships. The algorithm is iterative and makes use of the following equations:

$$v_i = \frac{1}{\sum_{k=1}^{n} m_{ik}{}^{m}} \sum_{k=1}^{n} m_{ik}{}^{m} x_{ik} \qquad [10]$$

$$m_{ik} = \frac{\left(\frac{1}{\left| x_k - v_i \right|^2} \right)^{1/(m-1)}}{\sum_{j=1}^{c} \left(\frac{1}{\left| x_k - v_j \right|^2} \right)^{1/(m-1)}} \qquad [11]$$

For the calculation of a cluster center, all input samples are considered in accordance with their membership value. For each sample, its membership value in each cluster depends on its distance to the corresponding cluster center. Following Chi *et al.* (1996), the clustering procedure consists of the following steps:

1. Initialize $\mathbf{U^{(0)}}$ randomly or based on an approximation (for instance, the results of the crisp c-means clustering) by initializing $\mathbf{V^{(0)}}$ and calculating $\mathbf{U^{(0)}}$. The iteration counter á is set to 1, and the number of clusters C and the exponent weight m are chosen.

2. Using the criterion function, the cluster centers ($\mathbf{V}^{(a)}$) can be computed based on the values of the membership values ($\mathbf{U}^{(a)}$).

3. The membership values ($\mathbf{U}^{(a)}$) are then updated based on the new cluster centers ($\mathbf{V}^{(a)}$). This iteration is stopped if $\max | u_{ik}^{(a)} - u_{ik}^{(a-1)} | \leq e$, else let $a = a + 1$ and go to step 2, where å is a pre-specified small number representing the smallest acceptable change in $\mathbf{U}^{(a)}$.

Note that the crisp c-means clustering algorithm can be considered as a special case of the fuzzy c-means clustering algorithms. If u_{ik} is 1 for only one class and zero for all other classes in equation [11], then the criterion function **J(U,V)** used in the fuzzy c-means clustering algorithm is the same as the criterion function **J(V)** used in the crisp c-means cluster algorithm. This is the so-called extension-principle.

Classifications of world cities based on the fuzzy c-means clustering algorithm

Again, in our attempt to provide an alternative classification approach based on fuzzy set-theory, we subscribe to an exploratory research design: there is no definitive way as to the number of clusters we are likely to expect in the data matrix. Therefore, any number of clusters can yield a result that has some interesting conclusions. For two clusters (c=2, Table 9), the results are straightforward. When thresholds are placed on a membership degree of greater than 0.75 and in the interval [0.3-0.75] in the first cluster, we get two cuts of ten world cities comparable to the results of Beaverstock *et al*. (1999). Nine of the ten world cities originally described as Alpha world cities have a membership degree exceeding 0.75 in the first cluster. The only difference is Chicago and Sydney changing places. A minor difference, since Chicago was ranked as one of the lower ranked Alpha world cities, whereas Sydney was originally ranked as one of the higher Beta world cities. Apart from the Chicago/Sydney switch, three of the world cities ranked in the [0.3-0.75] interval are not identified as Beta world cities by Beaverstock *et al*. (1999). Three semi-peripheral cities (São Paulo, Mexico City and Seoul) are replaced by two American cities (Miami and Washington DC) and Taipei. Again, the replaced cities were among the lower ranked Beta world cities, whereas the replacing cities (except for Miami) are to be found in the higher ranks of the Gamma world cities. In short, our results are consistent with the results of Beaverstock *et al*. (1999), since only a few cities located at the edge of the initial classification change their position in the classification based on the fuzzy c-means algorithm.

Computing membership degrees for four clusters (c=4), we can distinguish among several groups. World cities with high membership degrees in the second cluster (>0.75) are exclusively world cities situated in the Pacific-Asian part of the semi-periphery of the world-economy: Seoul, Shangai, Bangkok, Bejing, Jakarta, Kuala Lumpur, Manila and Taipei. This fact indicates that all these cities show a remarkable resemblance in their connectivity profiles. This classification resembles the third category (Pacific-Asian cities) provided by Taylor *et al*. (2001b, Table 8). In contrast with the classification provided by Taylor *et al*. (2001b), Tokyo and Hong Kong are not assigned to a cluster of Asian-Pacific cities, since their highest membership degrees are primarily found in a cluster representing the Alpha world cities: *all* cities scoring > 0.7 in the third cluster are identified by Beaverstock *et al*. (1999) as Alpha world cities. In addition, Tokyo also scores 0.27 in the second cluster. This score means that Tokyo's connectivity profile bears both (i) strong resemblance to that of other Alpha world cities and (ii) some significant (though less strong) resemblance to the Asian-Pacific cluster. This observation implies that this classification scheme is more sensitive towards interpretations, since it provides us with the possibility to discern world cities that have some sort of in-between profile. On the other hand, this classification grasps both hierarchical tendencies (third cluster: Alpha world cities) and functional connectivity patterns (second cluster: Asian-Pacific cities).

Other spatial patterns are found when assessing the membership degrees in the first and the fourth cluster: all Latin American world cities (Buenos Aires, Mexico City, São Paulo, Santiago and Caracas) score >0.8 in the first cluster, whereas most US cities (Atlanta, Boston Dallas, Houston, Minneapolis and Montreal) score high in the fourth cluster. The European cities are scattered mostly over two clusters, with a concentration of German cities in one group, bearing resemblance with the classification provided by Taylor *et al*. (2001b).

Some cities are very hard to classify (e.g. San Francisco's minimum membership degree is 0.1942 and its maximum membership degree is 0.3476), while other cities seem to be 'hanging' in-between two clusters, yielding additional interesting profiles. For instance, Melbourne and Sydney have a very fuzzy profile, yielding memberships of about 0.4 in both the second cluster (Asian-Pacific world cities) and the first cluster (Latin American world cities). Rather than bearing solely resemblance with Asian-Pacific world cities, as would be the case in classifications based on a two-valued logic, Melbourne and Sydney have a connectivity profile in-between that of Latin American world cities and Asian-Pacific cities, yielding almost equal membership degrees in both clusters. Using the fuzzy c-means algorithm, then, vagueness in the connectivity profile of Melbourne and Sydney can be assessed. In other words, a marginal shift in service profiles and hence connectivity structure could lead to a complete (and unwanted) shift in classification in a crisp classification, whereas the use of the fuzzy clustering algorithm adapts its resulting classification in a more sensitive way.

Conclusion

The data provided by the Globalization and World Cities Study Group and Network (GaWC) on the relational character of the network of world cities can be analysed with routine data analysis techniques. However, principal component analysis and a crisp clustering algorithm make it very hard to assess patterns in the relational data, since it is often characterized by different sources of vagueness. Sparse data at the basis of all classifications and theoretical considerations on the presence of a complex pattern rather than a clear-cut hierarchy make that crisp classifications of world cities have a highly uncertain character. Therefore, rather than applying data analysis strategies based on the classical two-valued framework of conventional mathematics, we have applied a clustering algorithm that is based on the premises of fuzzy set theory.

After outlining the results of other attempts towards an exploratory analysis on the network of world cities, we have described the crisp and fuzzy c-means clustering algorithms for unsupervised classification. In both algorithms, the distance of an input sample to the center of the cluster is used as a criterion to measure the cluster compactness. In the hard c-means algorithm, an input sample belongs to one cluster only, while in the fuzzy c-means algorithm the degree to which an input sample belongs to a cluster is represented by a membership value. Preliminary results of the application of a fuzzy set-algorithm on the 55x55-matrix provided by GaWC, point out that it is possible (i) to assess both hierarchical tendencies and connectivity patterns (e.g., the case of Tokyo), and (ii) to reveal previously hidden information, especially with respect to the assessment of world cities exhibiting an ‘in-between’ connectivity profile (e.g. Melbourne and Sydney). Therefore, the use of membership values provides more flexibility and makes the clustering result more useful in practical applications, especially when (i) the data is hampered by sparsity and (ii) identifying in-between values is the specific aim for the data analysis. Using this technique, then, it might be possible to assess connectivity patterns for cities originally expelled from the analysis due to sparsity of the data.

There are, however, some drawbacks. First, although the use of a fuzzy clustering algorithm may reveal some additional information in exposing more sensitivity in the classification, the classification of some objects is hard to interpret. San Francisco, for instance, has for c=4 significant memberships in *all* clusters, yielding a very fuzzy pattern, and making it impossible to classify it in a convincing way. Moreover, since membership values are computed for all clusters using an intensive optimization procedure, a more sensitive interpretation also implies a larger task at hand in interpretation itself.

Acknowledgement
The data used is from Data Set 7 from the GaWC Research Group and Network (http://www.lboro.ac.uk/gawc/). It was created by P.J. Taylor and D.R.F. Walker as part of their project "World City Network: Data Matrix Construction and Analysis" and is based on primary data collected by J.V. Beaverstock, R.G. Smith and P.J. Taylor (ESRC project "The Geographical Scope of London as a World City" (R000222050)).

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Table 1: Extract of the distribution of offices for 46 global advanced producer service firms over 55 world cities (collected by Taylor, P.J. and Walker, D.R.F.).

	KPMG	Coopers & Lybrand	Ernst & Young International	…
Amsterdam	3	3	1	…
Atlanta	3	3	2	…
Bangkok	1	1	1	…
…	…	…	…	…

<u>Table 2:</u> Extract of the inter-city matrix on the symmetrical relations between 55 world cities (collected by Taylor, P.J. and Walker, D.R.F.).

	Amsterdam	Atlanta	Bangkok	…
Amsterdam	0,333333343	0,118421055	0,285087705	…
Atlanta	0,118421055	0,157894731	0,100877196	…
Bangkok	0,285087705	0,100877196	0,342105269	…
…	…	…	…	…

Table 3: A roster of world cities (Beaverstock *et al*. 1999).

Alpha world cities	London, Paris, New York, Tokyo, Chicago, Frankfurt, Hong Kong, Los Angeles, Milan and Singapore
Beta world cities	San Francisco, Sydney, Toronto, Zurich, Brussels, Madrid, Mexico City, Sao Paulo, Moscow and Seoul
Gamma world cities	Amsterdam, Boston, Caracas, Dallas, Dusseldorf, Geneva, Houston, Jakarta, Johannesburg, Melbourne, Osaka, Prague, Santiago, Taipei, Washington, Bangkok, Beijing, Montreal, Rome, Stockholm, Warsaw, Atlanta, Barcelona, Berlin, Buenos Aires, Budapest, Copenhagen, Hamburg, Istanbul, Kuala Lumpur, Manila, Miami, Minneapolis, Munich and Shanghai

<u>Table 4</u>: Cities allocated to two components in a principal component analysis (Taylor *et al*., 2001b).

	Component I: "Outer Wannabes"	Component II: "Inner Wannabes"
>0.7	Istanbul, Athens, Cairo, Montevideo, Sofia, Beirut, Prague	St Louis, Indianapolis
0.6-0.69	Dubai, Bucharest, Mumbai, Karachi, Tel Aviv, Budapest, Casablanca, Nairobi, Manila, Zagreb, Warsaw, Lisbon, Santiago, Quito, Moscow, Taipei	Charlotte, Kansas City, Atlanta, Seattle, Vancouver, Perth, Pittsburgh, Brisbane, Denver, Manchester, Adelaide
0.5-0.59	Panama City, Kuwait, Calcutta, Jakarta, Bangalore, Chennai, Caracas, Seoul, Kuala Lumpur, Lima, Vienna, Kiev, Johannesburg, Auckland*, Jeddah, Madrid, Amsterdam, Nicosia, Helsinki, Copenhagen, Dublin, Ho Chi Minh City	Portland, Houston, Philadelphia, Boston, Dallas, Minneapolis, Cleveland, Montreal, Melbourne, Birmingham, Cape Town, San Diego, Auckland, Barcelona, Calgary
…	…	…

* indicates second highest loading for a city

Cities unallocated to two components:
Antwerp, Berlin, Chicago, Cologne, Dusseldorf, Frankfurt, Hamilton, London, Luxembourg, Mexico City, Munich, Nassau, New York, Singapore, Stockholm, Sydney, Tokyo, Wellington, Zurich.

Table 5: Cities allocated to five components in a principal component analysis (loadings above 0.4; Taylor *et al*., 2001b).

I	II	III	IV	V
OUTER CITIES	US CITIES	PAC.-ASIAN CITIES	EURO-GERM. CITIES	OLD-COMM. CITIES
784 Tel Aviv	769 St Louis	740 Taipei	782 Berlin	716 Perth
767 Sofia	703 Cleveland	726 Tokyo	768 Munich	715 Adelaide
753 Kuwait		725 Bangkok	703 Hamburg	
730 Helsinki		703 Jakarta		
730 Quito				
724 Beirut				
696 Casablanca	680 Dallas	664 Beijing	697 Cologne	687 Brisbane
681 Athens	664 Kansas City	658 Manila	660 Stuttgart	657 Hamilton
670 Nairobi	650 Pittsburgh	633 Seoul		616 Birmingham
666 Montevideo	634 Portland	630 Kuala Lumpur		
664 Jeddah	633 Atlanta	607 Hong Kong		
660 Bucharest	631 Seattle			
650 Indianapolis	623 Charlotte			
645 Cairo	622 Denver			
642 Lagos	620 Detroit			
629 Panama	607 Philadelphia			
624 Lima				
608 Vienna				
599 Dubai	560 Boston	598 Guangzhou	593 Frankfurt	547 Manchester
595Copenhagn	557 San Diego	593 Shanghai		504 Nassau

595 Oslo 592 Zagreb 590 Karachi 586 Chennai 584 Bangalore 572 Istanbul 570 Lisbon 553 Bratislava 535 Kiev 534 Nicosia 533 Calcutta	524 Washington 524 Minneapolis 502 San Francis 500 Houston	560 Ho Chi Min 516 Istanbul 511 Mumbai 500 Singapore	569 Paris 530 Budapest 530Dusseldorf 519 Warsaw 511 Milan 508 Luxembg	501 Vancouver 501 Nicosia
495 Riyadh 492 Prague 468Auckland 461 Moscow 457 Johannesbg 452 Cape Town 448 Manila 446 Budapest 427 Mumbai 424 Warsaw 421 Port Louis 418 Santiago	499 Melbourne 473 Los Angeles 462 Vancouver 437 Chicago 425 Miami 410 Montreal 409 Toronto	455 Sao Paulo 443 Caracas 416 New Delhi 405 Santiago	482 Antwerp 460 Prague 452Rome 437 Lyons 433 Amsterdam 402 Moscow	457 Abu Dhabi 453 Montreal 442 Auckland 441 Calgary 426 London 423 Dubai 410 Port Louis 408 Dublin 402 Wellington

Table 6: Crisp c-means clustering algorithm for *c*=2.

Cluster 1: Alpha world cities	Cluster 2
Hong Kong, London, Los Angeles, New York, Paris, Singapore, Tokyo	All other world cities

Table 7: Crisp c-means clustering algorithm for c=4.

Subset of Alpha world cities		Other world cities	
Cluster 1	Cluster 2	Cluster 3	Cluster 4
LosAngeles, Washington D.C.	London, Paris, Tokyo, Hong Kong, New York	Amsterdam, Buenos Aires, San Francisco, Singapore,…	Copenhagen, Joahannesburg, Atlanta, Kuala Lumpur,…

Table 8: Crisp c-means clustering algorithm for *c*=8.

Alpha and Beta world cities					Gamma world cities		Pacific-Asian world cities
Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8
London, New York	Chicago, San Francisco	Paris, Brussels.	Los Angeles	Washington D.C.	Seven North-American cities: Atlanta, Boston, Dallas, Houston, Miami, Minneapolis, Montréal. Four German cities: Hamburg, Düsseldorf, Berlin, Münich. Six cities around the old European: Prague, Budapest, Istanbul, Rome, Stockholm, Copenhagen. Osaka, Johannesburg.	Six European core cities: Barcelona, Frankfurt, Amsterdam, Milan, Madrid, Zürich. Five Latin American cities: São Paulo, Buenos Aires, Santiago, Mexico City, Caracas. Moscow, Toronto, Tokyo, Warsaw.	Bangkok, Bejing, Hong Kong, Jakarta, Kuala Lumpur, Manila, Seoul, Shangai, Singapore, Taipei, Melbourne.

Table 9: Memberships degrees for *c*=2 (*m*=1.2).

Alpha world cities
Beta world cities

	Cluster 1	Cluster 2
Amsterdam	0.0983	0.9017
Atlanta	0.0405	0.9595
Bangkok	0.1841	0.8159
Barcelona	0.0864	0.9136
Bejing	0.0665	0.9335
Berlin	0.0121	0.9879
Boston	0.1037	0.8963
Brussels	0.6399	0.3601
Budapest	0.0429	0.9571
Buenoas Aires	0.0398	0.9602
Caracas	0.0315	0.9685
Chicago	0.4336	0.5664
Copenhagen	0.0186	0.9814
Dallas	0.1202	0.8798
Dusseldorf	0.0724	0.9276
Frankfurt	0.8678	0.1322
Geneva	0.0589	0.9411
Hamburg	0.0254	0.9746
Hong Kong	0.9617	0.0383
Houston	0.0338	0.9662
Istanbul	0.0567	0.9433
Jakarta	0.1904	0.8096
Johannesburg	0.041	0.959
Kuala Lumpur	0.0872	0.9128
London	0.9631	0.0369
Los Angeles	0.7787	0.2213
Madrid	0.7118	0.2882
Manila	0.0254	0.9746
Melbourne	0.1186	0.8814
Mexico City	0.4149	0.5851
Miami	0.2053	0.7947
Milan	0.8017	0.1983
Minneapolis	0.0258	0.9742
Montréal	0.0412	0.9588
Moscow	0.4468	0.5532
Münich	0.0148	0.9852
New York	0.9385	0.0615
Osaka	0.0142	0.9858
Paris	0.9459	0.0541
Prague	0.1187	0.8813
Rome	0.018	0.982
San Francisco	0.733	0.267
São Paulo	0.3059	0.6941
Santiago	0.0469	0.9531

Seoul	0.181	0.819
Shangai	0.0805	0.9195
Singapore	0.9212	0.0788
Stockholm	0.0518	0.9482
Sydney	0.8455	0.1545
Taipei	0.4264	0.5736
Tokyo	0.9629	0.0371
Toronto	0.4132	0.5868
Warsaw	0.1359	0.8641
Washington DC	0.5621	0.4379
Zürich	0.6725	0.3275

Table 10: Membership degrees for c=4 (m=1.2).

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Amsterdam	0.524123	0.306897	0.004424	0.164556
Atlanta	0.02802	0.050987	0.001817	0.919177
Bangkok	0.049657	0.918786	0.004012	0.027546
Barcelona	0.49155	0.352507	0.004947	0.150996
Bejing	0.053499	0.88279	0.001879	0.061832
Berlin	0.018868	0.026729	0.000344	0.954059
Boston	0.097505	0.188287	0.009952	0.704257
Brussels	0.615905	0.189492	0.061804	0.132799
Budapest	0.270859	0.538072	0.003472	0.187597
Buenoas Aires	0.650816	0.284257	0.00114	0.063787
Caracas	0.633092	0.196391	0.001641	0.168876
Chicago	0.329475	0.23966	0.059238	0.371627
Copenhagen	0.076183	0.072819	0.001196	0.849802
Dallas	0.203804	0.171604	0.01073	0.613862
Dusseldorf	0.137256	0.240522	0.006825	0.615397
Frankfurt	0.643882	0.149012	0.13084	0.076266
Geneva	0.221924	0.551812	0.0037	0.222564
Hamburg	0.0401	0.050294	0.00107	0.908535
Hong Kong	0.05245	0.049765	0.886345	0.01144
Houston	0.076289	0.186034	0.002741	0.734937
Istanbul	0.150946	0.487548	0.007376	0.35413
Jakarta	0.171782	0.799264	0.002761	0.026192
Johannesburg	0.162217	0.370754	0.004099	0.46293
Kuala Lumpur	0.064078	0.787284	0.005949	0.142689
London	0.006198	0.003729	0.988516	0.001557
Los Angeles	0.074831	0.106491	0.743886	0.074792
Madrid	0.88104	0.085558	0.012942	0.02046
Manila	0.047634	0.928858	0.000408	0.023101
Melbourne	0.378934	0.412471	0.006964	0.201632
Mexico City	0.855859	0.100751	0.005759	0.03763
Miami	0.341053	0.292682	0.032896	0.33337
Milan	0.808024	0.098918	0.045067	0.047991
Minneapolis	0.030464	0.069439	0.00156	0.898537
Montréal	0.091494	0.080668	0.002173	0.825666
Moscow	0.457956	0.261764	0.075146	0.205134
Münich	0.023434	0.033815	0.000455	0.942296
New York	0.009922	0.006757	0.979927	0.003394
Osaka	0.021008	0.061036	0.000636	0.917321
Paris	0.165979	0.078834	0.724841	0.030346
Prague	0.364467	0.354509	0.014034	0.26699
Rome	0.11081	0.188571	0.001409	0.69921
San Francisco	0.347625	0.194246	0.263695	0.194434
São Paulo	0.95959	0.030323	0.000983	0.009104
Santiago	0.809093	0.120572	0.001107	0.069227
Seoul	0.081293	0.865856	0.004585	0.048267
Shangai	0.057417	0.808512	0.005624	0.128447
Singapore	0.263969	0.296401	0.406517	0.033113

Stockholm	0.372888	0.158211	0.004673	0.464227
Sydney	0.417064	0.417061	0.108132	0.057743
Taipei	0.102919	0.846042	0.01474	0.036299
Tokyo	0.008328	0.271475	0.696712	0.023484
Toronto	0.80892	0.118192	0.007306	0.065582
Warsaw	0.401989	0.292484	0.014729	0.290798
Washington DC	0.185934	0.182946	0.328281	0.302839
Zürich	0.77475	0.13121	0.032399	0.06164

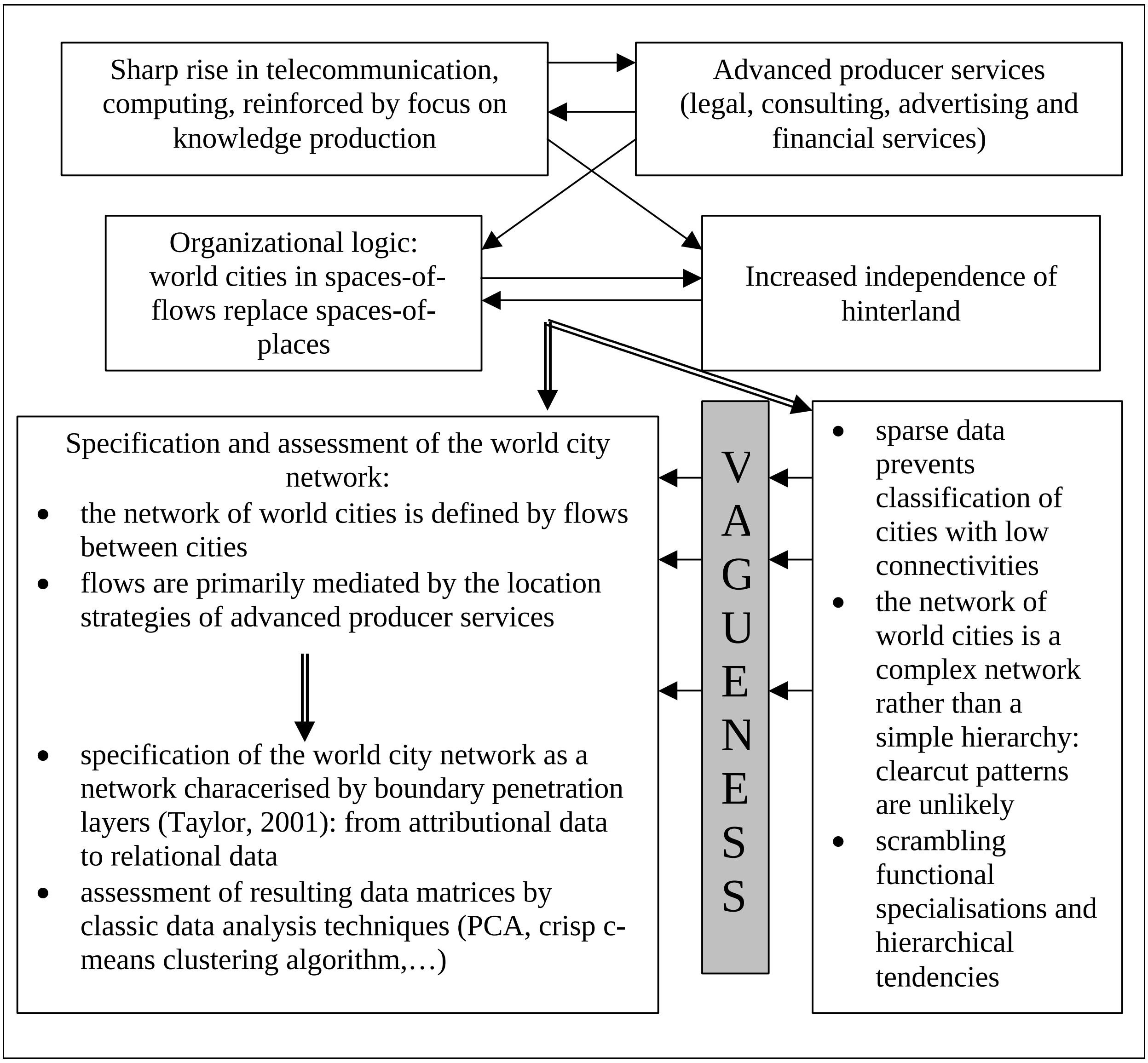

Figure 1: Vagueness in the assessment of a network of world cities.

The Thünen Society, North American Division

by John D. Nystuen
Ann Arbor, Michigan

Click here for The Thünen Society, North American Division webpage.

The Thünen Society, North American Division is an American organization interested in fostering the memory and current applications of the works and spirit of Johann Heinrich von Thünen (1783-1850), a 19th Century German landowner, farmer and intellectual. Thünen's seminal ideas on agricultural location theory, the economic notion of the marginal rate of return, social welfare and the value of individual freedom of choice in matters economic and political have influenced generations of regional economists and geographers worldwide. His ideas are still current today and can be used as a guide in understanding the future.

The Thünen Society exists in large measure through the efforts of two people, Herr Rolf-Peter Bartz, Director of the Thünen Museum at Tellow and Professor Robert W. Peplies, a geographer at East Tennessee State University. Herr Bartz is founder and Director of the Thünen Museum at Tellow in Mecklenburg near the Baltic Sea in northern Germany. Tellow is the original estate owed and operated by Thünen and the source of much of the empirical evidence Thünen used to support his theories. Many of the original buildings still exist and now house the current museum. An organization, the Thünengesellschaft e.V., the German counterpart to the Thünen Society, North American Division, supports the museum. The latter was founded in 1992 by Dr. Peplies after he visited Tellow in September of 1990 and was present at the meeting in which the Thünengesellschaft e.V. was established. This was during the time that the estate was part of a larger collective farm under the control of the communist German Democratic Republic (DDR). It was only through an heroic, two-decade long effort on the part of Herr Bartz, a schoolteacher in a nearby village, that Tellow was recognized as an historical site and that Thünen was an historical Mecklenburg citizen well worth remembering. The communist regime had surpressed knowledge of Thünen and his works as he had been a landowner and capitalist who had acknowledged an intellectual debt to Adam Smith (1723-1790), the Scottish economist whose writings defined capitalism. Herr Bartz's purpose was to instill a sense of local pride in schoolchildren through knowledge of the history of rural Mecklenburg. He was surprised to learn from Dr. Peplies that Thünen was well known worldwide.

The Thünen Society, North American Division was established at a meeting in Asheville, North Carolina in August 1992. Since then the society has met five times, usually in September, to hear scholarly papers addressing historical, theoretical and empirical topics that relate to Thünen's ideas as they apply to modern times. Notable meeting have been held at the German Embassy, Washington, D.C. (1993), St. Louis, Missouri, sponsored by Anheuser-Busch, Inc. (1994), an International Symposium held at the University of Rostock, co-sponsored by the Thünengesellschaft e.V. and Thünen Society, N. A. (1995) and twice at the East Tennessee State University, Johnson City, Tennessee (1996, 1997).

In addition to Thünen's theories and observations on public policy and society, Thünen's methodologies are of consequence. By far, his most well known work is The Isolated State (von Thünen, J. H. (1826) Der Isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie, Hamburg: Frederich Perthes. See an English translation, Peter Hall, editor (1966) Von Thünen's Isolated State. Oxford: Pergamon Press). This work contained a simple geographic model of agricultural production, certainly the most famous quantitative model in geography. It is found in nearly every economic geography text and commonly taught in introductory economic geography courses throughout the West. It is an example of a deductive theory. It is unabashedly an application of the positivist scientific method to investigate a social issue. Current methodological commentary frequently refers to positivist thinking about social issues in a pejorative sense, albeit, often in a straw man role. Thünen understood very well the value of using restricting axioms to greatly simplify relationships between variables as a means of understanding associations despite the abstractions being far removed from reality. He justifies this approach:

> "�Finally I should like to ask the readers who intend to devote their time and attention to this work not to be deterred by the initial assumptions which deviate from reality and not to consider them as arbitrary and without purpose. On the contrary, these assumptions are necessary in order to clearly understand the effect which a given variable has. In actual life we have only a vague idea of the effect and operation of any single variable because it appears always in conflict with other variables operating at the same time. This procedure has thrown light on so many problems in my life and seems to me to be so generally applicable that I consider it the most important feature of my work." (From the preface of Der Isolierte Staat, 2nd edition, published in Rostock, 1842 and translated in part by Kapp and Kapp, editors, Readings in Economics (New York: Barnes and Noble, 1949).

To Thünen, abstract theory was a means to an end. He was pragmatic and interested in applying knowledge to practical ends. He wanted to be successful in his farming enterprise and he wanted to influence public policy in ways that would improve the quality of life for all members of society. He was from an upper social class but he was concerned with the welfare of his workers, again from pragmatic considerations. He believed farm workers would perform more effectively if they received reasonable compensation for their labors. This was not in concert with the views of his fellow landowners of the day. Nor is it in line with the thinking of modern day corporate executives who earn five hundred times the compensation of their lowest paid employees. His concern for labor welfare was so deep that, in the end, he requested that the abstract expression of his theory of the natural wage be engraved on his tombstone. It was done as he wished.

It is this independent and humanitarian spirit along with the application of rational inquiry into the affairs of humanity that makes Thünen and his writings worthy exemplars for a scholarly group that seeks to improve interdisciplinary studies in the social sciences and humanities. That Tellow still stands is only an added benefit. It is a beautiful place that we are pleased to try to help maintain. When you are in Europe next, consider a trip to the Baltic Sea. Tellow is less than an hour's drive south of the City of Rostock.
The Thünen Society, North American Division is scheduled to meet next September 16-17, 2002 at the German Embassy, Washington D. C. In addition to presentation of scholarly papers, an agenda item at this meeting will be discussion of the formation of a Thünen Foundation the purposes of which will be to support an International Center at Tellow and to promote scientific, scholarly, and humanistic endeavors in the spirit of the man, Johann Heinrich von Thünen.

For information about the September 2002 meeting in Washington D. C. contact
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fax: 423 439 8499

**Welcome to the
Thünen Society, North American Division**

Johann Heinrich von Thünen, 1783-1850

MISSION STATEMENT

The objective of the Thünen Society, North American Division, is to contribute to the understanding of society and nature by examining Thünen's contribution from an historical perspective as well as in derivatives of his work in a variety of disciplines.

This society is dedicated to the preservation of the works, both intellectual and physical, of Johann Heinrich von Thünen. If interdisciplinary studies are to realize their true significance, then works of founding ancestors must be recognized and protected.

The Thünen Society, North American Division,
is affiliated with
Thünengesellschaft e.V.,
the headquarters of which are located at Tellow,
the estate of Johann Heinrich von Thünen,
in Mecklenburg, northern Germany.

Rolf-Peter Bartz
Direktor des Thünen-Museums und Geschaftsführer der Thünengesellschaft e.V.
Tellow@t-online.de, Tel: 039976-541-0, Fax: 039976-541-16.

Resources on Johann Heinrich von Thünen

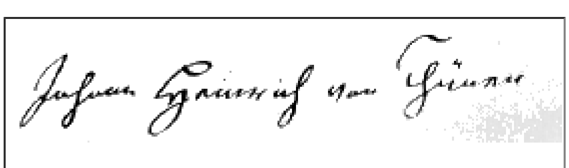
- HET Pages: Production Function, Neoclassical Theory of Distribution
- Johann von Thünen Museum at Tellow (Thünen old estate)
- Johann von Thünen Resources at Washington
- Thünen Address from 1960 given in Korea by Forrest R. Pitts
- Johann Heinrich von Thünen Lecture at Verein für Socialpolitik
- Johann-Heinrich von Thünen Medal at Kiel
- Von Thünen Slideshow
- von Thünen's Model of Land Use
- Johann von Thünen and von Thünen Models at x-refer
- http://cepa.newschool.edu/het/profiles/thunen.htm
- The Von Thünen Geography Model
- von Thünen Page (in German)
- Die Theorie von Thünen 1826 (in German)
- Johann von Thünen at *Die Zeit* (in German)

Photo Album

Thünen estate at Tellow.
Thünen gravesite

Flyer about estate at Tellow (in German).

Folder about estate at Tellow (in German).



Thünen was a North German landowner from Mecklenberg and was educated at Göttingen. Most of his life was devoted to managing his North German rural estate, Tellow. His major academic work was embodied in *Der Isolierte Staat* (*The Isolated State)* (Volume 1,1826; Volume 2, 1850 and 1863; Volume 3, 1863). In the first volume he set forth principles of spatial economics based on economic rent. In the second volume he developed some of the mathematical foundations of marginal productivity theory. One of his last wishes was that his famous equation for the natural wage, w = Öap, be carved into his tombstone.

Contacts in North America are:

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pepliesr@etsu.east-tenn-st.edu

John D. Nystuen (President), University of Michigan,
Ann Arbor, Michigan
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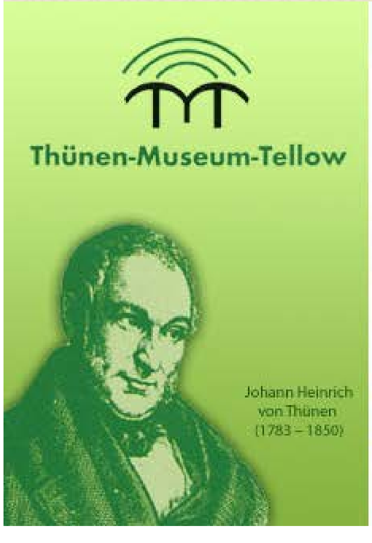

Willkommen
Museum
Gutsmarkt und Café
Thünenkate
Unterkünfte
Veranstaltungen
Aktuelles
Tagungen und mehr
Gruppen
Lagekarte & Routenplaner
Kontakt

Thünengut Tellow gGmbH

OT Tellow 15
17168 Warnkenhagen

Telefon »
E-Mail »

Willkommen auf unserer Gutsanlage in Tellow zwischen Teterow und Rostock

Das Thünen-Museum-Tellow ist hat seinen Namen von Johann Heinrich von Thünen (1783 - 1850), der bis zur Mitte des 19. Jahrhunderts in Tellow gelebt und sehr positiv für Mecklenburg gewirkt hat.

Natürlich erfährt der Besucher **Interessantes über Thünens Leben und Werk**. Daneben gibt es aber auf dem gewachsenen Gutsensemble auch viel aus der jüngeren Geschichte der Region zu entdecken, wie z.B. die alte Landtechnik oder die beiden ausgestalteten Neubauernhäuser.

Im Kornspeicher an der Thünenscheune lädt ein Gutsmarkt und ein Museumscafé zum Verweilen ein. Unsere Spezialität ist **Mecklenburger Platenkauken**, besonders Zucker- und Streuselkuchen. Ohne Firlefanz, aber original - so, wie wir Mecklenburger!

Idyllisch und empfehlenswert ist übrigens auch der **urwüchsige ehemalige Gutspark**, der schon Thünen die besten Ideen bescherte...

Unsere Lage:

Tellow liegt östlich von Güstrow und südlich von Rostock unweit der Bundesstraße B 108 unweit in einer **idyllischen Landschaft** am Rande der Mecklenburgischen Schweiz.

» Museum | » Veranstaltungen | » Unterkünfte | » Lagekarte | » Kontakt

+++ News +++

Aktuell vom Thünengut
erstellt am 21.07.2014

Sonderausstellung in der Tellower Speichergalerie

Schöne Frauen

aus der Sammlung von Anselm Wolter aus Teterow.

Eindrucksvolle Gem...

weiterlesen »

Besuchen Sie uns wieder unter www.Thuenen-Museum-Tellow.m-vp.de

Johann-Heinrich von Thünen (Resources)

(http://faculty.washington.edu/krumme/450/thunen.html)

JOHANN HEINRICH VON THÜNEN
1783–1850

Related and Suporting Pages:

- A simple Thünen Land Use (Lab-) Exercise and graph with "competing" locational rent functions.
  - www.rri.wvu.edu/WebBook/Giarratani/fig6-4.GIF
  - www.rri.wvu.edu/WebBook/Giarratani/fig6-5.GIF
- Thünen's Rent Functions & Symbols
- Selected Land Use Theory
- Land Use Readings & References

Thünen + Translations:

Thünen, Johann Heinrich von, Der isolierte Staat in Beziehung auf Landwirtschaft und Nationaloekonomie Jena : G Fischer, 1910 [University of Washington: 330.1 T424i 1910 (Allen Temporary Storage)]

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Thünen, Johann-Heinrich von, 1783-1850 Der isolierte Staat in Beziehung auf Landwirtschaft und Nationaloekonomie [microform] Berlin, Wiegandt, Hempel & Parey, 1875 [University of Washington: Microfilm A856 1 microfilm reel]

Japanese translation: EAsia General Stacks HD1411 .K58 v.1 [628, 8 p. ; 22 cm Kond/o Yasuo chosakush/u ; dai 1-kan Bibliography: p. 1-8 (2d group) Ch/unen koritsukoku, n/ogy/o to kokumin keizai ni kansuru koritsukoku -- Ch/unen koritsukoku no kenky/u]

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Other Thuenen Resources [GeoCities/lkshorace]

The Thünen Page at the Mining Company (M.Rosenberg)

Thünen Resource Page (Economics, New School) [http://cepa.newschool.edu/het/profiles/thunen.htm]

Traditional Land Use Theory [pdf] [with graphs] [www.nau.edu/library/courses/geography/pl501-hawley/reserve/hartshorn4.pdf] [Hartshorn, T.A., Land Use Dynamics, In Interpreting the City: An Urban Geography 2nd, Wiley & Sons, Inc., New York) 1992. pp. 225-226, 228-234]

Clippings:

- Squeezed out by urban pressures, dairy farmers go east Seattle PI, Thursday, May 30, 2002; By LISA STIFFLER

> Since 1989, the number of dairies in Western Washington has dropped by more than half, from 1,017 to 488,... King County dairies declined from 84 to 42 during the same period. The exodus is being blamed in part on rising land prices and taxes west of the Cascades, buoyed by urban sprawl into traditional farmland.

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Thünen Graphs:

- CSISS, Santa Barbara [Scott Crosier]
- Vogeler, Wisconsin
- Watkins, San Jose
- http://eratos.erin.utoronto.ca/res/vbr/web/gifs/landuseS.gif [University of Toronto]
- Rent Function with Production Costs
- Chinese Land-Use Map predicted by the GTR-model

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von Thünen Institutions:

Thunen Gesellschaft [das Portal fuer die Verbreitung des wissenschaftlichen und humanistischen Thuenenerbes]

- Links

Verein für Socialpolitik: Johann-Heinrich-von-Thünen-Vorlesung [Mit der Johann-Heinrich-von-Thünen-Vorlesung wird seit dem Jahre 1986 ein verdientes Mitglied des Vereins für Socialpolitik geehrt.]

Thuenen Institut fuer Regionalentwickling e.V."

> "The Institut für Internationale Bildung Berlin "Johann Heinrich von Thünen" (Thuenen Institute), founded in March 1991, is a private, non-profit organization. Its objectives are teaching and research on political, economic, social and cultural issuess in Germany and in Europe. Particular emphasis is put on transition issues in East-Central Europe, Russia and other post-Soviet republics."

Thunen Society: North American Division

- The Thunen Society, North American Division by John D. Nystuen, Ann Arbor, Michigan

> "That Tellow still stands is only an added benefit. It is a beautiful place that we are pleased to try to help maintain. When you are in Europe next, consider a trip to the Baltic Sea. Tellow is less than an hour's drive south of the City of Rostock."

Von Thünen Society "is having its annual meeting at East Tennessee state University 27-28 September 1997. The theme is "Thünen and a Sustainable World". They are looking for papers and participants."

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"The Land Use Model of von Thünen"

Forrest R. Pitts
Economic Development Council
Ministry of Reconstruction, Republic of Korea

(An address prepared for delivery at
Ewha Women's University, Seoul, Korea,
in December 1960.)

Central place theory, and that portion of economic geography which considers the relations between primary agricultural production and its marketing, started with the contributions of Johann Heinrich von Thünen (1783-1850). His three-volume Die isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie (Hamburg and Rostock, 1826-63; H. Schumacher, Berlin, 1875) has unfortunately been more admired at a distance than read closely. However, the main outline of his theory of land use determinants is clear, and well known to most geographers and economists.

In the verbal statement of von Thünen, he assumed a single market town in the center of a uniformly fertile and arable plain, accessible equally in all directions. He stated that prices of farm goods in the market and the cost of taking them to the market would determine rather regularly how near to, or far from, the market these goods would be produced.

For the purpose of studying systematically the ways in which goods production and land use vary by distance from the market, we may phrase von Thünen's verbal model thusly: "Because market price equals the cost of production plus the cost of transport plus the profit to producer, land use will vary systematically with distance of the producing unit from the market point." Symbolically this reads: $M = P + T + G$
where M is market price, P is production cost, T is transport cost, and G is gain, or profit.

The easiest situation to deal with in logic or laboratory is one in which all possible complicating factors have been eliminated. After understanding how a model works under conditions of restraint or limitation, we can progressively approach reality by relaxing the theoretical restraints. For our present purpose, the basic restraints on the von Thünen model may be assumed as follows:

a) a single selling point, the market;
b) a single good produced on each production unit;
c) equal level of fertility everywhere;
d) equal land transport facilities everywhere;
e) no political regulation of the economic factors in the model;
f) a constant market price for a given good;
g) no upper limit on the amount of arable land;
h) one political unit.

With $M = P + T + G$ as our working model, and under the eight restraints noted above, we may derive a series of logical statements:

1. Goods incurring high production costs will be produced at places where transport costs are minimal, i.e., near the market.

2. Goods incurring low production costs may absorb higher transport costs, and will be produced at places less near the market.

3. Bulky goods, defined here as having low return per unit of weight, will be produced at places where transport costs per unit of weight are minimal, i.e., near the market.

4. Perishable goods, defined here as having low storage life, will be produced at places from which transport time to market will be minimal, i.e., near the market.

5. When profit to producer approaches zero, and transport costs are constant, the producer must reduce production costs in order to raise profits, by shifting to a less intensive form of production of the same good.

6. When profit to producer approaches zero, and production costs are constant, producer must reduce transportation costs to raise profits, by processing at the production unit before the good is transported to market.

The familiar dairy example well illustrates this. The zones of production away from a market--fresh milk, cream, butter, and cheese--each involves a good that requires a successively greater amount of processing.

7. When profit approaches zero, and both transport costs and production costs are constant, production of good K must give way to production of good Q, which will increase profits by having lower production and/or lower transport costs than good K.

8. As production of a good becomes less intensive (per Statement 5), land cost per acre decreases; i.e., land cost and intensity of cultivation or production both decrease away from the market.

9. As production becomes less intensive (per Statement 5), the scale of production (in terms of capital invested, and return per acre) decreases; i.e., scale of production and intensity of cultivation or production both decrease away from the market.

10. As land cost per acre decreases (per Statement 8), the producer can, and probably will, operate a larger unit.

11. As the area of the producing unit gets larger (per Statement 10), labor demand in man-hours per acre decreases, because the operator desires to minimize production costs.

12. Where labor costs per man are constant, the operator of a larger unit (per Statement 11) may minimize production costs by a) mechanizing his operation, or by
b) using labor of family members rather than hiring more laborers.

13. As producing units get larger (per Statement 10), and as man-hour per acre demands decrease (per Statement 11), population density will decrease away from the market, as shown in Figure 1.

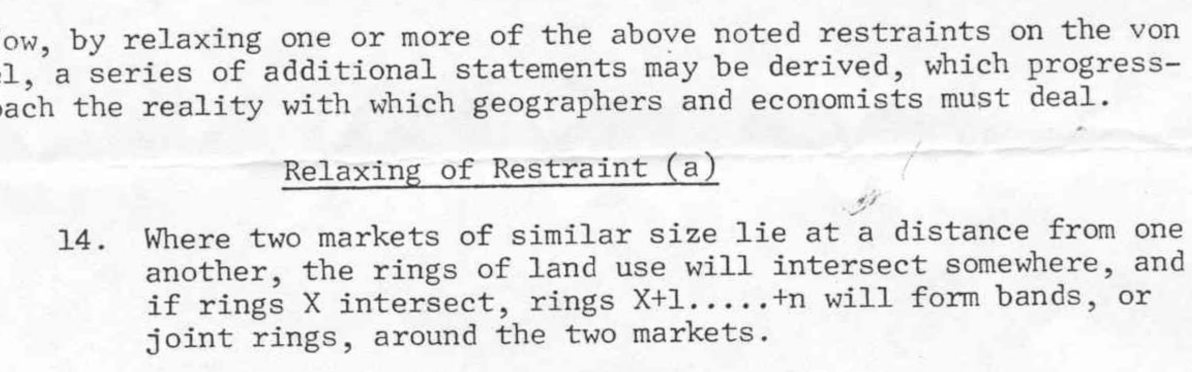

Figure 1. Decreasing Population Density Away from the Market

Now, by relaxing one or more of the above noted restraints on the von Thünen model, a series of additional statements may be derived, which progressively approach the reality with which geographers and economists must deal.

Relaxing of Restraint (a)

14. Where two markets of similar size lie at a distance from one another, the rings of land use will intersect somewhere, and if rings X intersect, rings X+1.....+n will form bands, or joint rings, around the two markets.

Relaxing of Restraint (b)

15. Where a production unit can produce more than one good, production associations (e.g.: mixed farming, i.e., livestock-and-grain farming) are possible.

For illustration of production associations, see the empirical study of Olof Jonasson, Economic Geography, 1925. Jonasson's work is summarized by R. L. Dickenson in his City Region and Regionalism, pages 193-194, footnote.

16. The relative importance of the factors in the association on any production unit changes as market prices, production costs, and transport costs change. "Diversification is the key to economic survival."

Relaxing of Restraint (c)

17. Where soil fertility is greater, production costs will be less, and profits greater; hence increased soil fertility has the effect of being a natural subsidy.

Relaxing of Restraint (d)

18. Where navigable rivers flow through the market point, transport costs are reduced, and the river acts also as a natural subsidy.

Relaxing of Restraint (e)

19. Where political restrictions artificially add to production costs and/or transport costs, the land use rings will average a closer distance to the market.

20. Where political regulations artificially subtract from production costs and/or transport costs, the land use rings will average a greater distance away from the market.

Relaxing of Restraint (f)

21. Where political regulations artificially support the profit to producer (e.g.: parity programs), the land use rings will average a greater distance away from the market.

22. In periods of ~~deflation~~ recession, defined here as lowering of the aggregate purchasing power of the market center, the market price decreases, and if transport costs and production costs are constant, land use rings will average closer to the market.

23. Where population is increasing in the market center (per capita purchasing power remaining constant), the aggregate demand for a good increases, and this extends the average distance of land use rings from the market center, and/or intensifies per acre production of the desired good.

24. Where individual purchasing power in the market center is increasing (total population remaining constant), the aggregate demand for a good increases, and this extends the average distance of land use rings from the market center, and/or intensifies the per acre production of the desired good.

25. If the demand for the good produced in ring X results in an aggregate yield increase of that good, the increase will come about by a) intensification of per acre yield in the marketward portion of the ring.
and by b) an expansion of acreage (yield per acre remaining constant) in the peripheral portion of the ring.
See Figure 2.

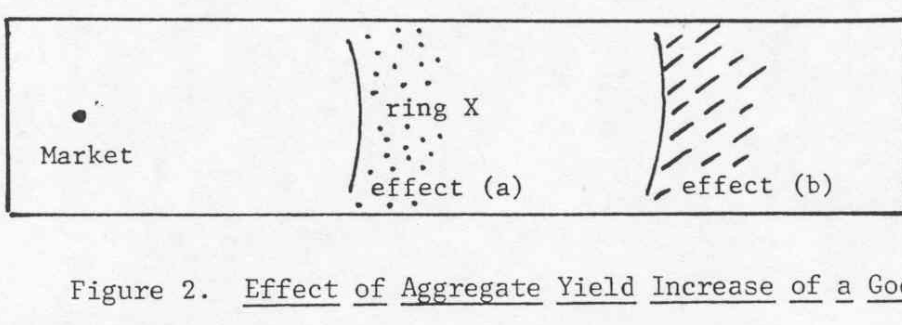

Figure 2. Effect of Aggregate Yield Increase of a Good

26. The changes in ring X (per statement 25) will induce production units in ring X-1 (next marketward ring) further to intensify their production; and will induce production units in ring X+1 (next more peripheral ring) to mechanize.

Relaxation of Restraint (g)

27. If the total amount of arable land reaches an upper limit, and market price becomes constant owing to leveling off of both purchasing power and population totals, a condition of ring equilibrium will result.

28. With a limited amount of arable land, a population increase (per capita purchasing power remaining constant) will increase market price, and the land use rings must intensify production of single goods, or diversify the goods produced.

My studies in Japan indicate that historically intensification in that country has generally preceded diversification, and that mechanization has followed closely upon diversification.

29. With a limited amount of arable land, an increase in per capita purchasing power (population remaining constant) will increase market price, and the land use rings must either intensify production of single goods, or diversify.

30. Where arable land is limited and no source of outer rings' products is available, per capita consumption of these products will decline, unless the demand for them is absorbed by diversification of production of them in other rings.

31. With arable land being limited, price of land per acre increases, and operating units decrease in size (contra Statements 8 and 10).

32. With operating units decreasing in size, more people will be needed to operate them, and rural population will
a) have a decreased rate of movement to the city, and/or
b) draw upon urban population;
thus in both cases exerting a damping effect upon urban growth.

33. With operating units decreasing in size (per Statement 31), rural per capita income declines, and less capital exists to pay for transportation facilities and improvements; transport costs to producers rise, with consequences predictable by the basic statement of the model.

Joint Relaxing of Restraints (g) and (h)

34. Where arable land is limited, and where--owing to increases in population and/or per capita purchasing power--the rings of land use are expanding, the outer ring will disappear, and its products be sought from other political units. Other rings will tend to disappear also, as urban population and/or income increases, with subsequent like effects.

35. Where arable land is limited and when market prices no longer return profits to producers, there will be attempts to reduce population size by emigration. (This stage is antithetical, and subsequent in time, to the situation described in Statement 32.)

The last nine statements, 27 through 35, have particular relevance to agricultural countries having a shortage of arable land, such as the Republic of Korea and Greece. A careful study of the statements derived here from the von Thünen model will indicate sectors in the economies of underdeveloped countries where improvement is possible. Diversification of agricultural production and a moderate amount of mechanization of production and processing are examples.

Eugene, Oregon, Spring 1960
Seoul, Korea, November 1960

[San José State University](#)
[Department of Economics](#)

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Von Thünen's Model of Land Use

Early in the 19th century Johann Heinrich von Thünen (1783-1850) developed a model of land use that showed how market processes could determine how land in different locations would be used. Von Thünen was a skilled farmer who was knowledgable in economics.

It is simplest to explain von Thünen's model in terms of agricultural land use but it is not limited to that land use.

Suppose the land surrounding a city market can be used for:

- **truck farms for growing tomatoes**
- **orchards for growing apples**
- **wheat farms**

The costs for transporting the crops from these uses differ. Let b_x be the cost for transporting the product of one acre of land use x a distance of one mile. Furthermore, suppose

$$b_{tomatoes} > b_{apples} > b_{wheat}$$

Let us now plot a graph in which the horizontal axis is the distance from the city and the vertical axis is the land rent that a user can pay. Consider first the land rent tomato growers can pay at various distances from the city. Farmers at greater distances can pay only a lower rent because of the higher transportation costs for hauling their product to the city. The relationship is shown below.

When the tomato farmers are in competition with the apple growers for the land the result is:

When wheat farmers compete with tomato farmers and apple growers the result is:

Putting all of this together:

A modern version of von Thünen's ideas is [William Alonso's Bid-Rent Function Theory](#).

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- Oddbins Dictionary of Wine
- Encyclopedia of North American Indians, Houghton Mifflin
- An Historical Encyclopedia of Ships of the World, Houghton Mifflin
- Barron's The New Wine Lover's Companion 2nd Edition
- Guide to the Ancient World, H.W.Wilson
- Dictionary of Foreign Phrases and Abbreviations, H.W.Wilson
- Macquarie Dictionary of Australian Politics
- The Macquarie Dictionary of Trees and Shrubs
- The New Food Lover's Companion, Barron's
- Great American Court Cases, Thomson Gale

Specialist Reference

- The Cambridge Historical Dictionary of Disease
- Blackwell Handbook of Perception
- Blackwell Handbook of Research Methods in Clinical Psychology
- Blackwell Handbook of Research Methods in Experimental Psychology
- Blackwell Handbook of Research Methods in Industrial and Organizational Psychology
- Blackwell Handbook of Social Psychology: Group Processes
- Blackwell Handbook of Social Psychology: Intergroup Processes
- Blackwell Handbook of Social Psychology: Interpersonal Processes
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ESTATE AT TELLOW

Tellow, the original Thünen estate.

Model of the Thünen rings.

Conference room at Tellow.

Restaurant at Tellow features wild game menu.

Bridge in English gardens at Tellow.

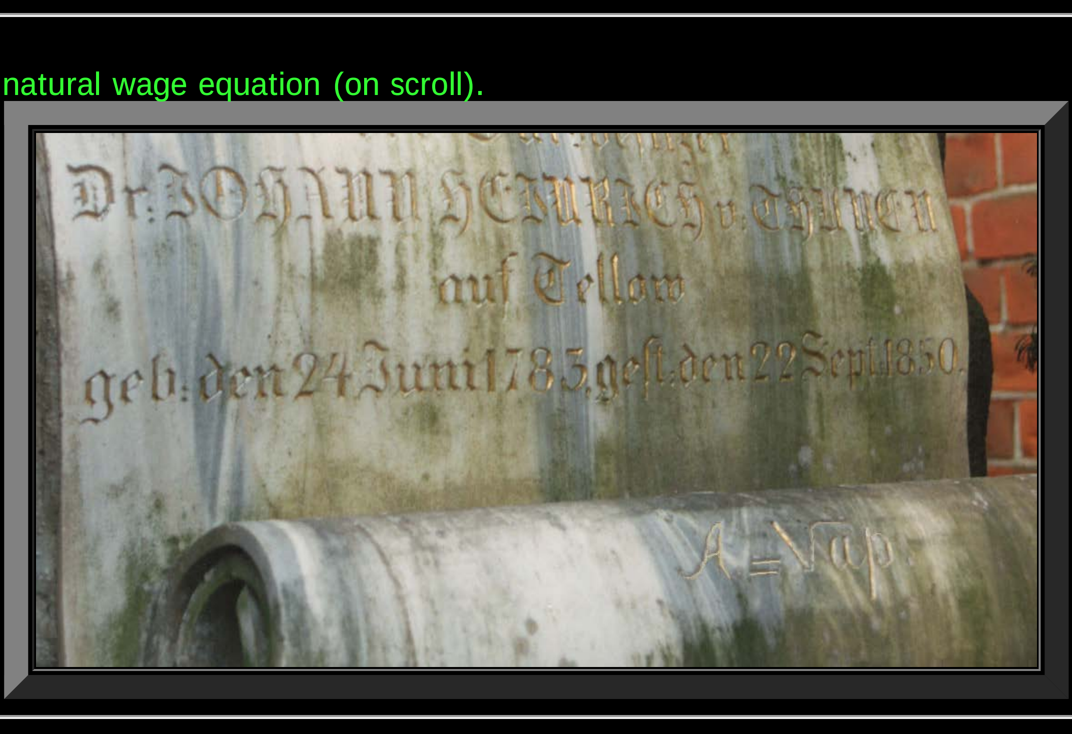
Broader view of English gardens.

Photographs by John D. Nystuen.

Church, in Belitz a village near Tellow, that is the site of Thünen's grave

Thünen's grave is against the church wall.

Tombstone with natural wage equation (on scroll).



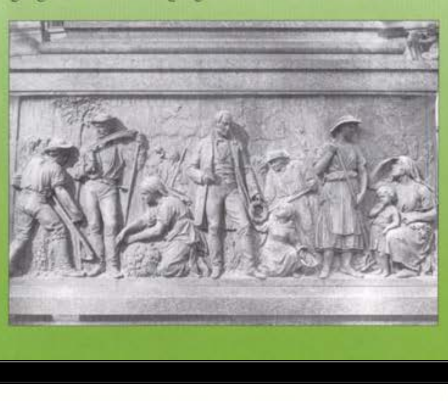
Photographs by John D. Nystuen.

FLYER ABOUT TELLOW

Das Thünen-Museum-Tellow

- befindet sich in einer idyllischen Landschaft am Rande der Mecklenburgischen Schweiz
- beherbergt die „Nationale Thünengedenkstätte" – eine historische Einrichtung der europäischen Wirtschafts- und Sozialgeschichte
- zeigt ein historisch gewachsenes mecklenburgisches Gutsensemble
- dokumentiert regionale Landwirtschaftsgeschichte
- ist der Sitz der Thünengesellschaft e.V. mit internationalen Abteilungen in Europa und Übersee
  USA: Thünen Society - North American Division

Johann Heinrich von Thünen inmitten seiner Gutsarbeiter
- Relief auf dem Thaerdenkmal in Berlin -
J.H. von Thünen führte 1848 mit Erfolg eine Gewinnbeteiligung und Altersversorgung für seine Gutsarbeiter ein.



Tellow – eine klassische Stätte der Nationalökonomie

Seine historische Bedeutung erhielt das Dorf durch das erfolgreiche Wirken seines Gutsbesitzers.

24. Juni 1783	Thünen wurde in Canarienhausen im Jeverland (Oldenburg) geboren.
1789 - 1801	Besuch der Volksschule in Hooksiel und Hohen Schule in Jever sowie dreijährige Landwirtschaftslehre.
1802 - 1804	Akademische Ausbildung in Groß-Flottbek (Hamburg) bei L.A. Staudinger, in Celle bei A.D. Thaer sowie in Göttingen.
1806	Hochzeit mit Helene Berlin in Liepen bei Neubrandenburg und Übernahme des vorpommerschen Gutes Rubkow.
1809	Kauf des 465 ha großen und stark verschuldeten Lehngutes Tellow/Mecklenburg.
24. Juni 1810	Umzug nach Tellow. Beginn der Zusammenarbeit mit Gutsnachbarn, den Reformern Carl, Friedrich und Johann Pogge.
1818 - 1820	Direktor des Teterower Distrikts des Mecklenburgischen Patriotischen Vereins.
1826	Erscheinungsjahr seines Hauptwerkes „Der isolierte Staat in Beziehung auf die Landwirtschaft und Nationalökonomie" (Erster Teil) mit dem Kernstück, der Thünenschen Kreislehre.
1830	Verleihung der Ehrendoktorwürde der Universität Rostock, Gründung der Volksschule Tellow.
1836 - 1838	Zweiter Hauptdirektor des Mecklenburgischen Patriotischen Vereins.
1848	Ernennung zum ersten Ehrenbürger der Stadt Teterow.
1850	Herausgabe „Der isolierte Staat…" (Zweiter Teil).
22. Sept. 1850	Thünen stirbt auf seinem Mustergut in Tellow und wird auf dem Dorffriedhof in Belitz/Mecklenburg beigesetzt.

Johann Heinrich von Thünen (1783 - 1850)

Nationalökonom
Agrarpolitiker
Agrarwissenschaftler
Musterlandwirt
Sozialreformer

Die
Thünenschen Kreise

„…daß in der Nähe der Stadt solche Produkte gebauet werden müssen,
- die im Verhältniß zu ihrem Werth ein großes Gewicht haben, oder einen großen Raum einnehmen…
- deren Transportkosten nach der Stadt so bedeutend sind…
- so wie auch solche Produkte, die dem Verderben leicht unterworfen sind…

Aus diesem Grunde allein werden sich um die Stadt ziemlich scharf geschiedene konzentrische Kreise bilden, in welchn diese oder jene Gewächse das Hauptterzeugniß ausmachen."
aus „Der islolierte Staat…"

Johann Heinrich von Thünen, 1826

Traditionelle Veranstaltungen im Wandel der Jahreszeiten

- Mecklenburgische Kinder-Fasteltage
- Osterkinderfest auf dem Thünengut
- Frühlingssingen der Chöre in der Thünenscheune
- Kinderfest zum 1. Juni
- Parkfest im Tellower Thünenpark
- Bauernmarkt auf dem Thünengut
- Dörpwihnachten up de Tellowsche Däl

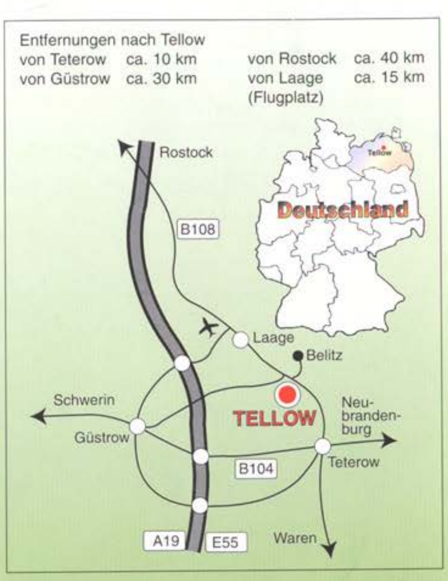
Tagungen und Veranstaltungen

an historischer Stätte nach Absprache möglich

• Thünen-Pogge-Begegnungsstätte	ca. 80 Plätze
• Fritz-Reuter-Stube	ca. 15 Plätze
• Thünenscher Weinkeller	ca. 10 Plätze
• Thünenscheune (auch Ausstellungen)	ca. 500 Plätze
• Tellower Ökokeller	ca. 30 Plätze
• Parkveranda (Wintergarten)	ca. 15 Plätze

Jugendbegegnungsstätte „Thünenkate"

- attraktive Veranstaltungen mit Kindern (Feriengestaltung, Wandertage, Projektunterricht)
- Fahrradausleih
- Beherbergung in historischer Umgebung
- Bekanntmachung mit mecklenburgischen ländlichen Traditionen und Gewerken
- 30 Übernachtungsplätze auf dem Strohboden



Thünen-Museum-Tellow

Museumsbesichtigungen:
täglich von 9.00 bis 16.00 Uhr
Mai - September bis 17.00 Uhr
Gruppenführungen sind auch außerhalb der Öffnungszeiten möglich.

17168 Tellow / Mecklenburg
Telefon: (03 99 76) 5 41 - 0
Fax: (03 99 76) 5 41 - 16

e-mail:
Thuenen-Museum-Tellow@t-online.de
thuenen-museum-tellow@m-vp.de

Internet:
http://www.thuenen-museum-tellow.m-vp.de
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FOLDER ABOUT TELLOW

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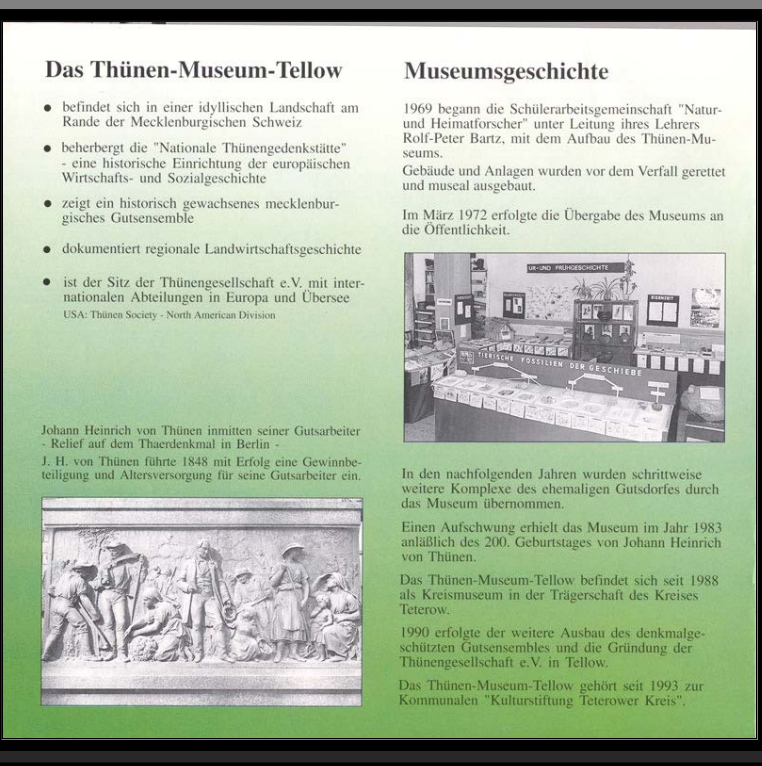

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Johann Heinrich von Thünen inmitten seiner Gutsarbeiter - Relief auf dem Thaerdenkmal in Berlin -

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Museumsgeschichte

1969 begann die Schülerarbeitsgemeinschaft "Natur- und Heimatforscher" unter Leitung ihres Lehrers Rolf-Peter Bartz, mit dem Aufbau des Thünen-Museums.

Gebäude und Anlagen wurden vor dem Verfall gerettet und museal ausgebaut.

Im März 1972 erfolgte die Übergabe des Museums an die Öffentlichkeit.

In den nachfolgenden Jahren wurden schrittweise weitere Komplexe des ehemaligen Gutsdorfes durch das Museum übernommen.

Einen Aufschwung erhielt das Museum im Jahr 1983 anläßlich des 200. Geburtstages von Johann Heinrich von Thünen.

Das Thünen-Museum-Tellow befindet sich seit 1988 als Kreismuseum in der Trägerschaft des Kreises Teterow.

1990 erfolgte der weitere Ausbau des denkmalgeschützten Gutsensembles und die Gründung der Thünengesellschaft e.V. in Tellow.

Das Thünen-Museum-Tellow gehört seit 1993 zur Kommunalen "Kulturstiftung Teterower Kreis".

Traditionelle Veranstaltungen

Tagungen und Veranstaltungen

Gasthof "Zum Thünenstall"

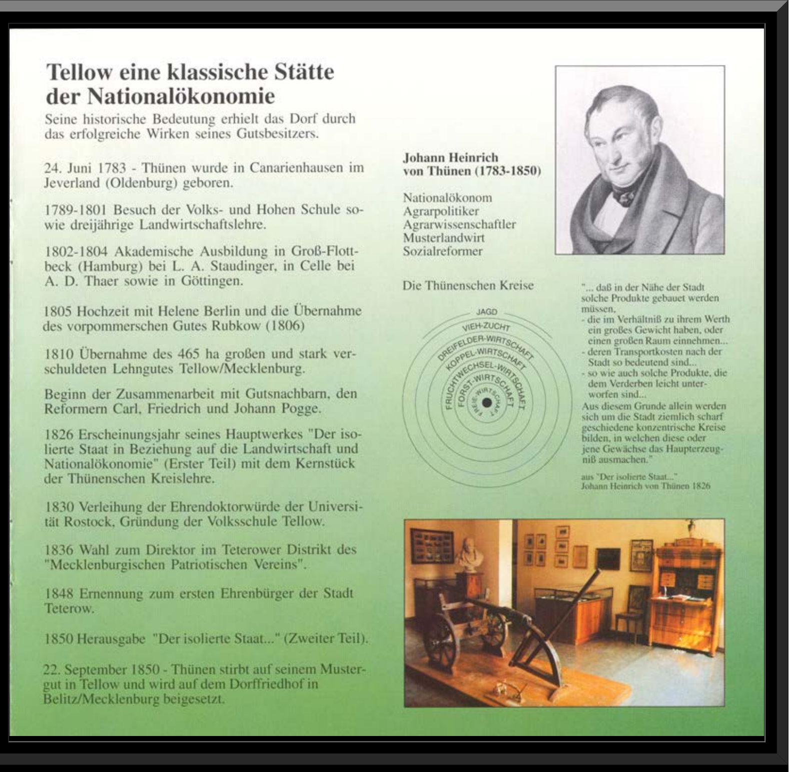
Jugendbegegnungsstätte "Thünenkate"

Museumsbesichtigungen

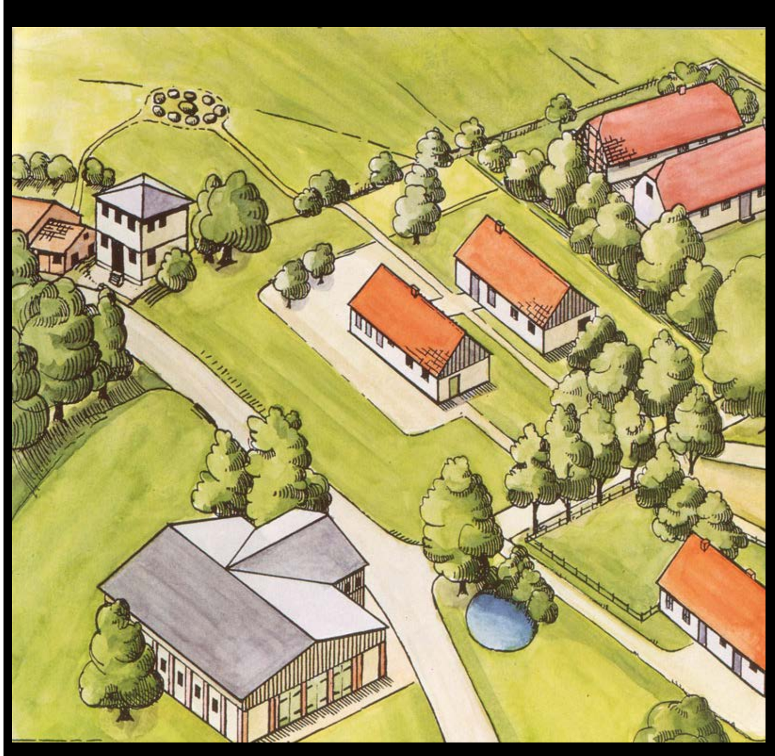
Thünen-Museum -Tellow

A Tellower Gutshofrunde

1. Bereich Gutshaus
   a) Thünenhaus - Gutshaus
   b) Gutshandwerkerhaus*
   c) Kettenburgs Gärtnerhaus*
   d) Eiskeller "Chimborasso"
2. Bereich Thünenstall
   a) Thünenstall (früher Pferdestall)
   - Gasthof "Zum Thünenstall"
   - Thünen-Pogge-Begegnungsstätte
   b) Ententeich
   c) Ausstellung alter Landtechnik
3. Bereich Neubauernhäuser
   a) Neubauernhaus Brosowski
   b) Haustierzoo
   c) Neubauernhaus Schildt



Tellow eine klassische Stätte der Nationalökonomie



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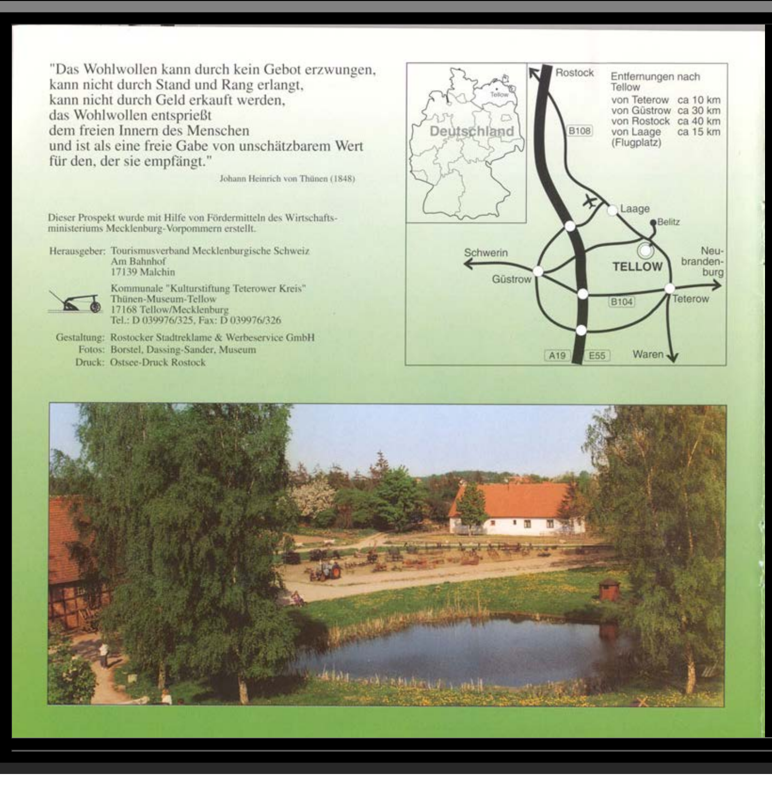


Dr. JOHANN HEINRICH v. THÜNEN
auf Tellow
geb. den 24 Juni 1783, gest. den 22 Sept. 1850.
$A = \sqrt{ap}$


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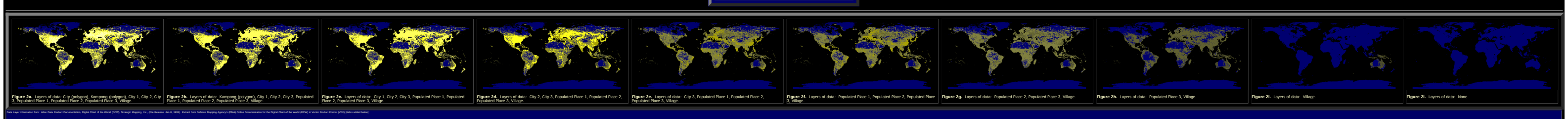
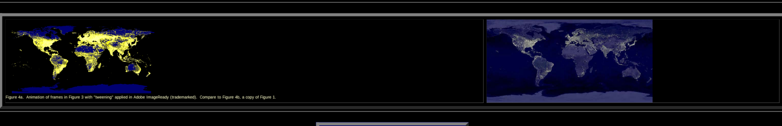




Bus Stops and Bus Users in the City of Detroit

Eun-Young Kim
Ph.D. student, Urban, Technological, and Environmental Planning
Taubman College of Architecture and Urban Planning
The University of Michigan

Introduction

According to the Detroit Area Study (DAS) (R. Marans, see this link for a sample), public transportation use in the Detroit area has been declining. DAS data from 2001 shows that only 8.3 percent of commuters choose bus as their travel mode whereas 69.1 percent of people are driving single occupant cars. Furthermore, 63.1 percent of respondents to the DAS answered that they never use the bus. Frequent users, including daily users and people taking a bus at least once a week, composed about ten percent of the sample.

Previous studies indicate that there are relationships among environmental factors, psychological factors, and transportation use (Bamberg, Sebastian and Peter Schmidt, "The impact of general attitude on decisions" *Rationality and Society*, Thousand Oaks, Feb 1999). GIS data collected in 2000 by SEMCOG (Southeast Michigan Council of Governments) enable one to gauge the condition of bus stops in Detroit. Bus stop condition will be considered one of indicators that represents the environmental condition of public transportation. Also, 2001 DAS shows specific preferences and attitudes toward transportation among Detroiters. Bus stop condition will be examined using GIS. The results are presented, in this paper, as a single interactive, internet map.

Interactive Internet Map

DDOT (Detroit Department of Transportation) and SMART (Suburban Mobility Authority for Regional Transportation) operate buses in the City of Detroit. There are a total of 5618 bus stops located along the routes (Hamtramck and Highland Park are excluded).

Field evidence, including overall condition of bus stops, was observed and photographed for selected stops. Five indicators, stop sign, light, shelter, bench, and sidewalk, are used to evaluate the condition of bus stops. These indicators were then used to formulate an index of bus stop condition, scored as 1 to 5, from poor to good, respectively. The accompanying internet map shows Detroit bus routes and bus stops. The stops that scored 1 or 2 on the index are colored red. Click on a stop to get data concerning that stop; click on a route to look at the database accompanying the mapped route. The map showing bus stop condition alone, has also been combined by the author with results about bus users from the DAS (for internal DAS use only). Hence, the title of this article.

This interactive internet map is used to capture numerous variables in a single image that can be used interactively without owning any software other than a browser. Thus, some of the power of GIS analysis is transferred to members of the public, allowing them to query records that might not otherwise be readily available to them.

Link to Interactive Internet Map, made in ArcView 3.2 using ImageMapper from Alta 4, www.alta4.com.--access to the full map, for qualified viewers, available by contacting IMaGe. Click here to see a link to a partial, but very useful, interactive map showing all bus stops, routes, and bus stop conditions (shelter availability and so forth).

The Relationship between Bicycle Accidents and Lanes of Travel at Downtown Ann Arbor Intersections

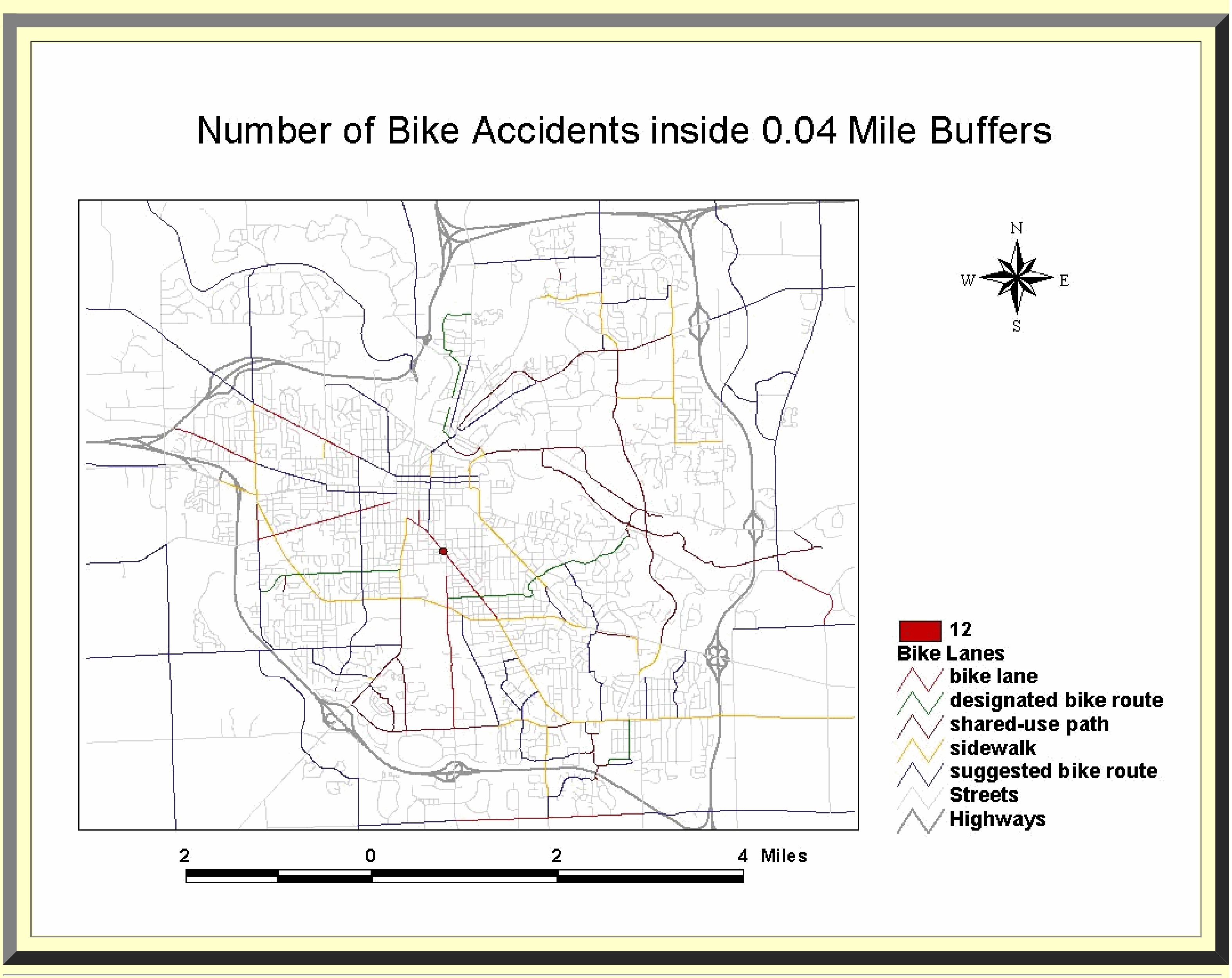
Hyeyun Lee
Masters of Urban Planning Student
University of Michigan
Taubman College of Architecture and Urban Planning

The material in this article represents an accumulation of material related to bicycle issues found within the archives of the University of Michigan. In the summer of 2002, the author will be an intern for the Environmental Coordinator of the City of Ann Arbor, during which time she will have an opportunity to work the current situation in a real-world setting.

The methodology involved the steps listed below, as well as others (see http://www-personal.umich.edu/~hyeyunl for the full project):

- View bicycle-accident map: specifies where bicycle accidents occurred. Select the intersections to study. The number of accidents that occurred from 1983 to 1992 were tabulated at each of those intersections (source: John D. Nystuen for Ann Arbor Police Department data).
- A brief survey was conducted at each intersection to calculate:
  - The number of lanes of traffic in each direction.
  - The angle of the intersection (at 6-way intersections, the angles were averaged.)

Animated map showing locations and numbers of bicycle accidents (scroll over on low-resolution settings to see the entire map).



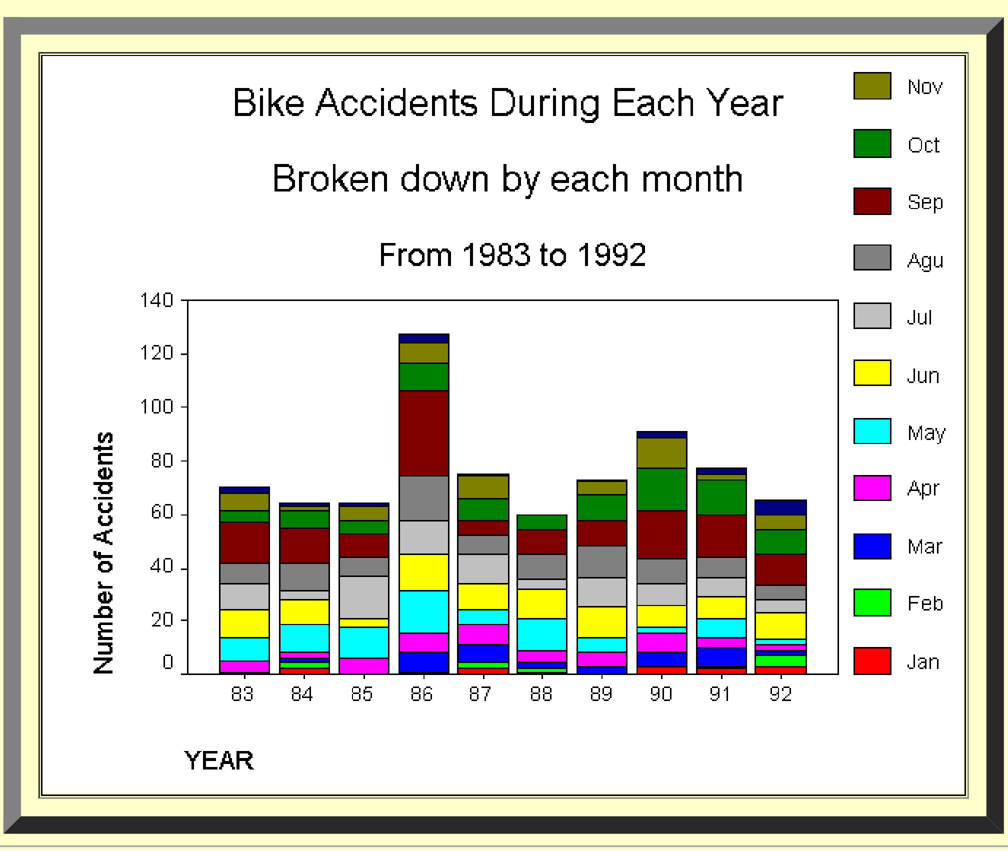
Click here to see the interactive map.

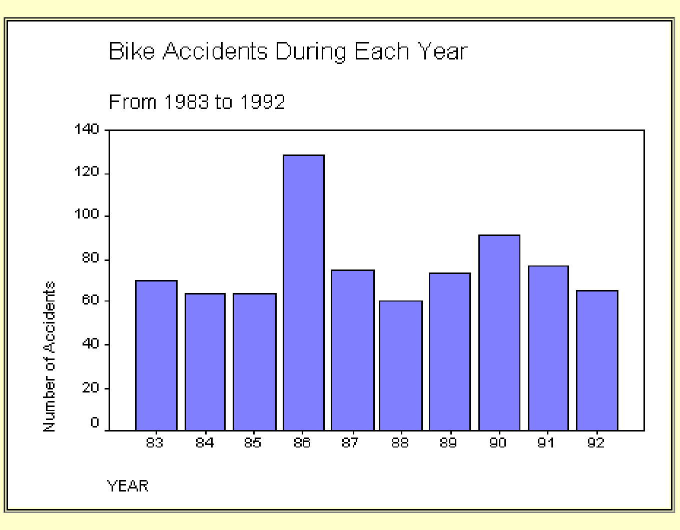
Bike Accidents

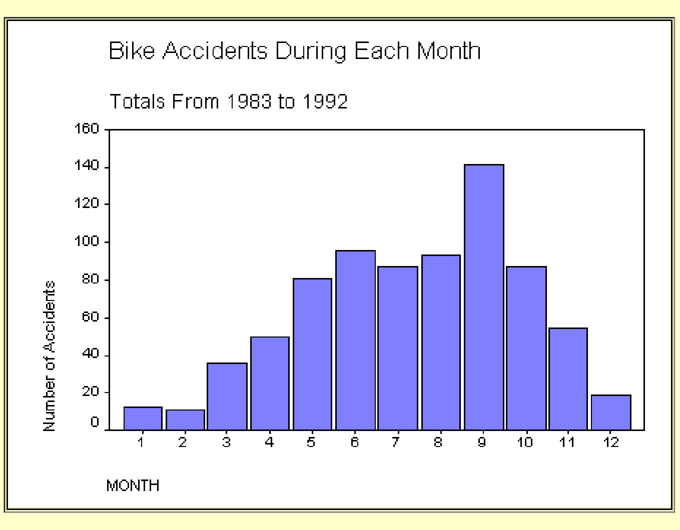
- 794 bike accidents happened in Ann Arbor from 1983 to 1992.
- Buffers are around every intersection and the radius is 0.02 mile. (The radius on the above map is 0.04 mile to show buffers better on the web.)

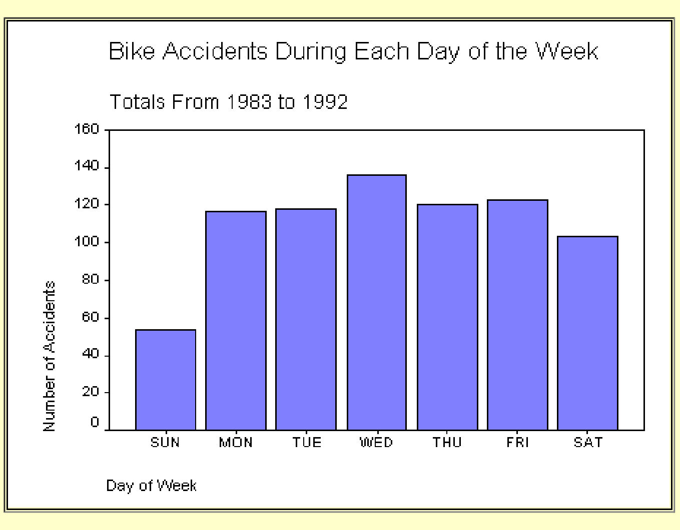
Bike Lanes (suggested by the Park and Recreational Department of City of Ann Arbor, in June 2001).

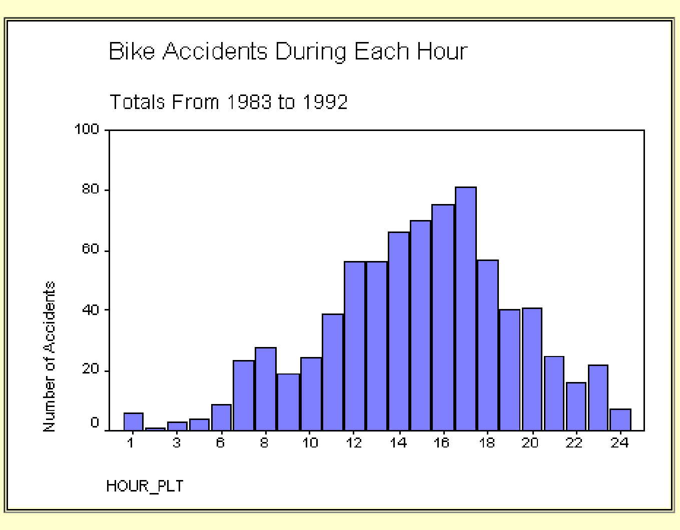
- Bike Lane: On-road travel lane designated for the exclusive use of bicycles.
- Designated Bike Route: Road designated by green �Bike Route� sign, which has either wide outside curb lane or low traffic volume.
- Suggested Bike Route: Road which has either wide outside curb lane or low traffic volume.
- Shared-use Path: Off-road paved path for non-motorized use.
- Sidewalk: Off-road facility bordering a roadway



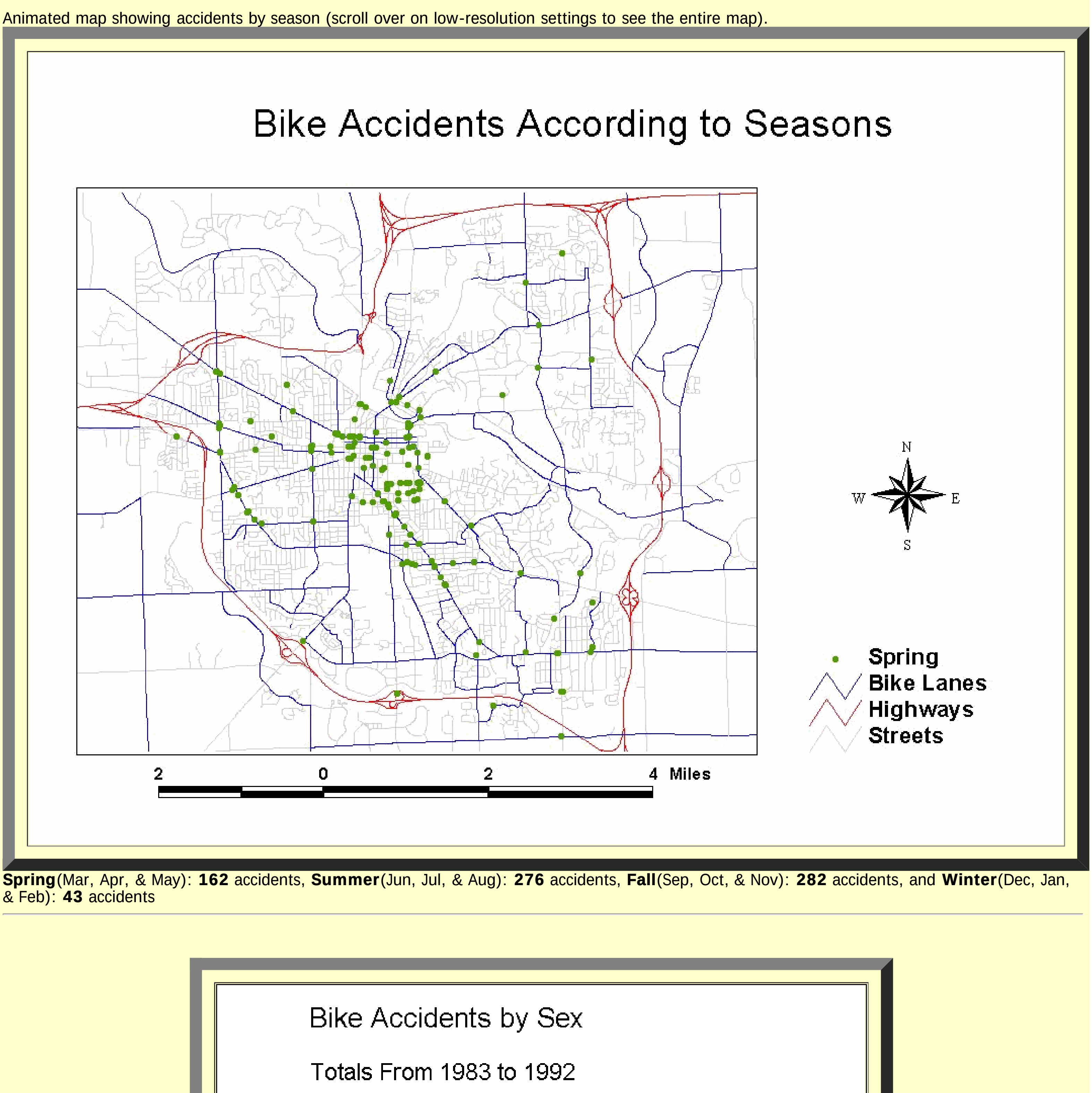




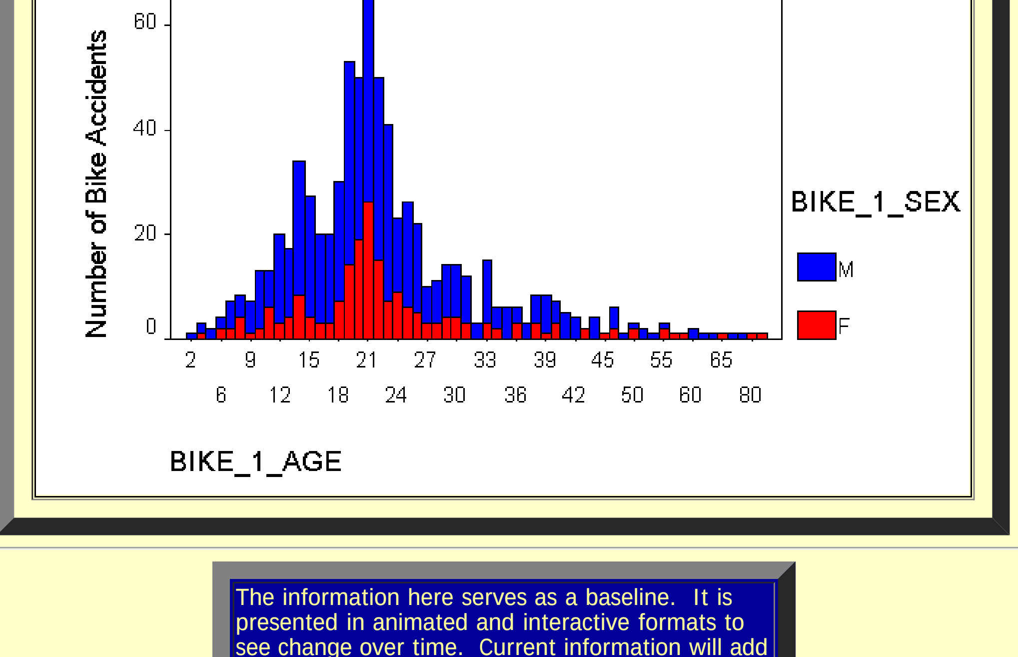




Animated map showing accidents by season (scroll over on low-resolution settings to see the entire map).



Spring(Mar, Apr, & May): **162** accidents, **Summer**(Jun, Jul, & Aug): **276** accidents, **Fall**(Sep, Oct, & Nov): **282** accidents, and **Winter**(Dec, Jan, & Feb): **43** accidents



The information here serves as a baseline. It is presented in animated and interactive formats to see change over time. Current information will add to it and offer directions for analysis that respond to contemporary needs.

Related Literature

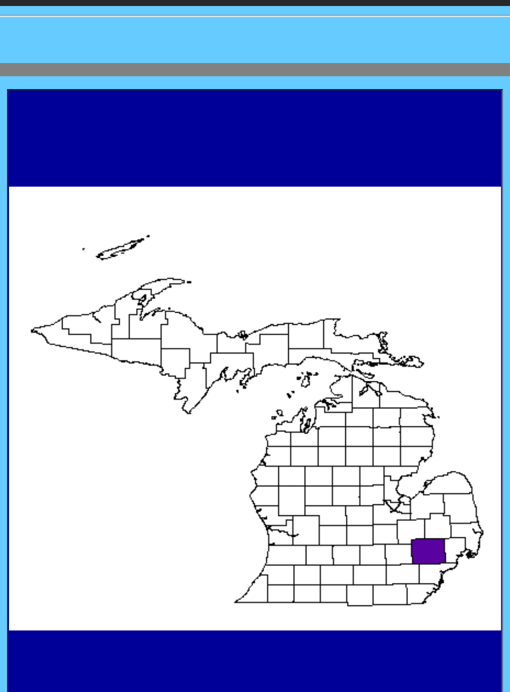
- Northeast Ann Arbor Transportation Plan, Non-motorized Component http://www.greenwaycollab.com/NEAATP.htm
- Successful Bicycle Planning: Adapting Lessons from Communities with High Bicycle Use to Ann Arbor and Washtenaw County http://www-personal.umich.edu/~jlevine/downloads/bikereport.pdf

Beach Closures in Oakland County, Michigan: Using GIS as an Investigative Tool

Jeanine Chura McCloskey
Master's Student, School of Public Health
The University of Michigan

Introduction

The state of Michigan is a prime recreational area during the summer months for tourists as well as for permanent residents. Michigan, the "Great Lakes State," has fine recreational lakes from both a boating and bathing perspective. Oakland County, part of the Detroit "metropolitan area" has numerous small lakes. The county is one of the most affluent in the country and contains over 200 bathing beaches. Unfortunately, over the last few years, beach closings have been on the rise. The Environmental Protection Agency noted that State and local governments across the country issued 4000 beach closings in 1995 alone ("Beach Watch" 1) and that "The number of beach closures reported every year is also on the rise" (1).



EPA's Beach Watch

The beach closure problem became a large enough concern that the Environmental Protection Agency initiated the BEACH Program (Beaches Environmental Assessment, Closure, and Health) in 1997 with the goals of improving U.S. recreational waters and reducing the risk of disease to those who frequent the beaches. Among the official goals of this Beach Watch Program were: strengthening standards, improving beach programs at local governments, increasing communication with the public, and providing funding for research to improve detection methods to protect public health. The BEACH Program led to the passage of the BEACH Act (Beaches Environmental Assessment and Coastal Health Act) on October 10, 2000 ("Beach Act" 2). This Act amended the Clean Water Act and contains three "significant" provisions including:

- requiring states with coastal waters to implement standards (new or revised) for pathogens and their indicators by April 10, 2004,
- requiring the EPA to conduct studies and publish new water quality guidance for pathogens effecting human health by 2005, and
- allowing the EPA to award grants to states in order for them to implement beach and risk communication programs regarding recreational water quality (2).

Causes of Beach Closures

Causes of beach closures are numerous. They include, but are not limited to, the following:

- Rainfall: sewer overflows, storm water runoff, septic systems
- Boating wastes
- Location: land-use, sewers
- Number of users
- Animal wastes

Oakland County's Procedures

Oakland County samples approximately 60 of their 286 beaches yearly; others are on a five-year rotation schedule. Beaches sampled each year include government owned properties, camps, and commercial beaches (or �pay to enter� properties. In addition, any beach that has a history of high bacterial levels, is also sampled each year. Three 100ml samples of beach water, at waist level, are taken at each assigned beach each week. The samples are then analyzed for the presence of E-coli. Initially, if any one of the samples is greater than 300 E-Coli per 100ml the beach must be closed. After one month of sampling, a rolling geometric mean is calculated and the limit is 130 E-Coli per 100ml. The testing method is done on-site in the County�s laboratory and results are obtained after 18 hours. Last summer I had the privilege of interning with the County and worked on the beach program as one of several other responsibilities. The interns were responsible for sampling their assigned beaches for the amount of E-coli per 100ml at least once per week and determining whether or not the beach should remain open from the results of the tests. I had noticed throughout the summer that almost every time it rained it seemed as if many beaches would close the next day.

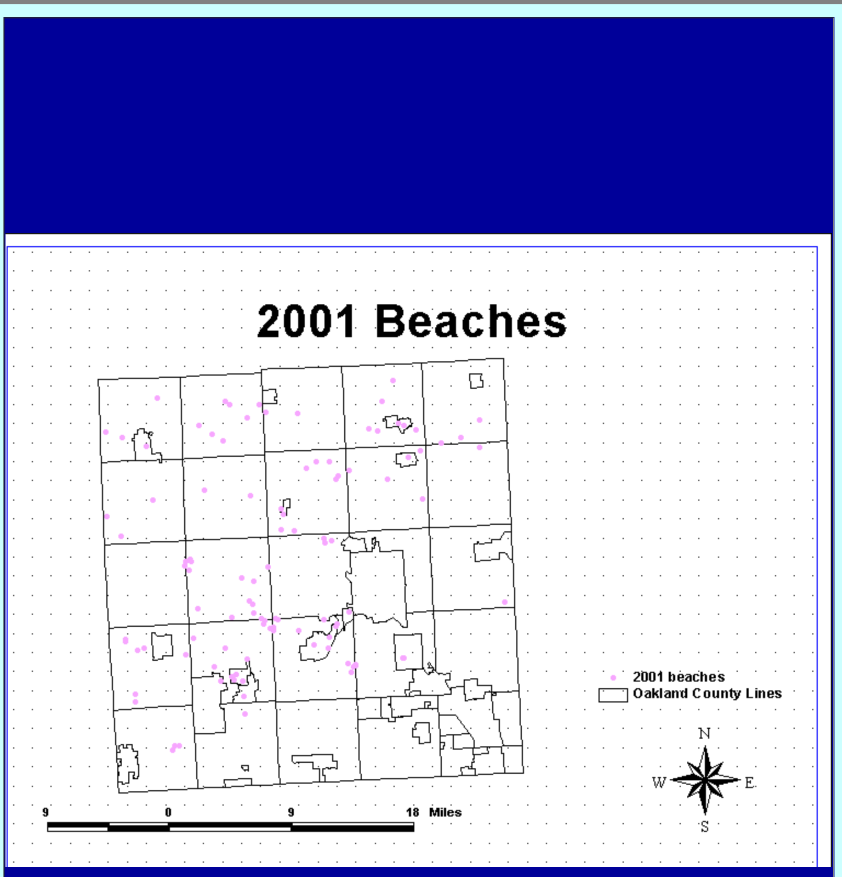
Rainfall, indeed, has been shown to be a beach closure predictor for some beaches although its importance in terms of a determinant have been debated. In a study done in the UK, researchers claim that rainfall is only a minimal component stating that sunshine, wind, and catchment sources were much stronger predictors (Crowther et al. 4029). Other studies, however, claim that rainfall is a major component. Studies done in Australia indicated a �linear relationship between visual indicators and bacterial density . . . and rainfall alone as a predictor is equivalent to or better than visual assessment� (Armstrong et al. 249). Many beaches in Australia use rainfall determined from gauge stations throughout the country to prepare daily beach reports/closures (249).

Hypothesis

In this study I compare rainfall and beach closings in Oakland County, for 1998 and 2001, using GIS as the main investigative tool. Correlations between the two variables is investigated in order to see if this simplified analysis could be utilized for beach closure decision making. GIS might prove to be an invaluable resource in terms of presenting the spatial relationships between rainfall and rain gauge sites in relation to beach locations. Results may aid in predictive modeling for E-coli in recreational waters since the present testing methods require at least 18 hours in order to obtain results. If rainfall alone can be used as a predictor of beach closure in the county then there is the potential to save money spent on beach programs and sampling, to protect individuals from health threats due to "dirty" water, and to avoid time delays waiting for results.

Data

Beach closing information including the beach name, location, and E-coli geometric means were provided by the Oakland County Health Division-Environmental Health Department in tabular format and entered into Excel worksheets. Beach locations and Oakland County boundary line themes were provided in digital format (ArcView 3.2). Rainfall data were obtained from the Oakland County Drain Commissioner�s office. Tables with rainfall from the county�s rain gauge stations and the recorded rainfall at the stations for June and July of 1998 and 2001 were also provided, both in tabular format. Again, Excel was used in order to convert the tabular data into digital, database format. Oakland County street and Highway theme layers were obtained from the University of Michigan Map Library and were already directly usable in ArcView 3.2.



Methods

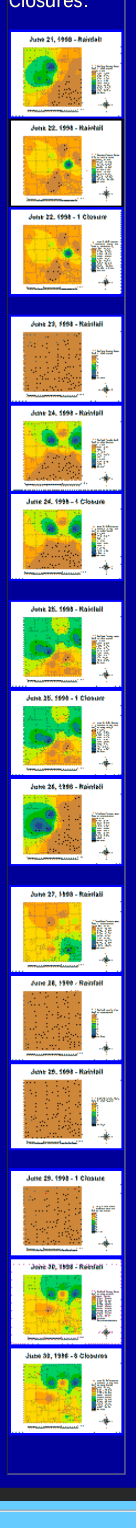
The initial portion of the study determines the �beach closure days� for June and July of 1998 and 2001. To these, "beaches closed" are then added to a database table. The rain gauge locations had are geocoded as U.S. street addresses using the Oakland County street layers from the Map Library at UM as a reference theme. Eighteen rain gauge stations locations are mapped from the twenty-one present (three locations not precise). The rain gauge locations are saved as a new theme or .shp file. With gauge stations defined, the rainfall at each station is then incorporated into the database table for a portion of the month of June (when sampling began) through the end of July in 1998 and 2001. The appropriate Excel tables are transferred to ArcView 3.2 as .dbf files. ArcView 3.2 spatial analysis extension is used to determine the rainfall at each closed beach. The rainfall at the closed beaches on the day of the closure is determined and incorporated into the tables in Excel. Layouts are produced for each day (June-July) showing the spatial analyst interpolated rainfall distribution for the County and the closed beaches. Graphs using Excel are made to show the rainfall amounts in hundredths of inches and bacteria levels in #E-coli per 100ml.

Hardware: Windows based machine.

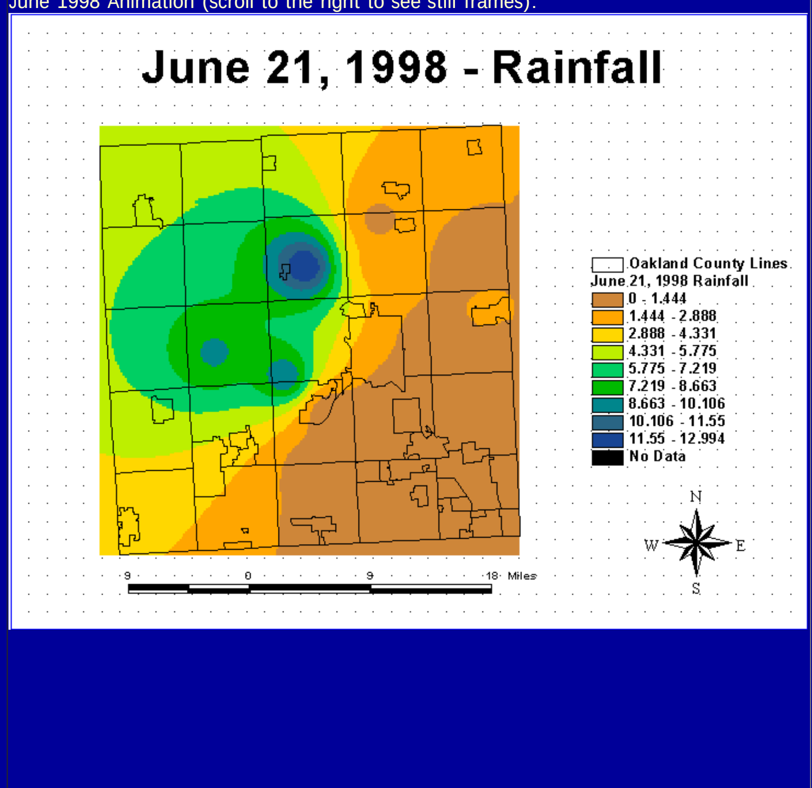
Software: ArcView 3.2 was used to analyze the rainfall and beach closure data. Microsoft Excel was used to create the data tables of the rainfall and beach closing information. Adobe photoshop was used to format all layouts for web use. Gamani Moviegear was used to create the animations.

Results

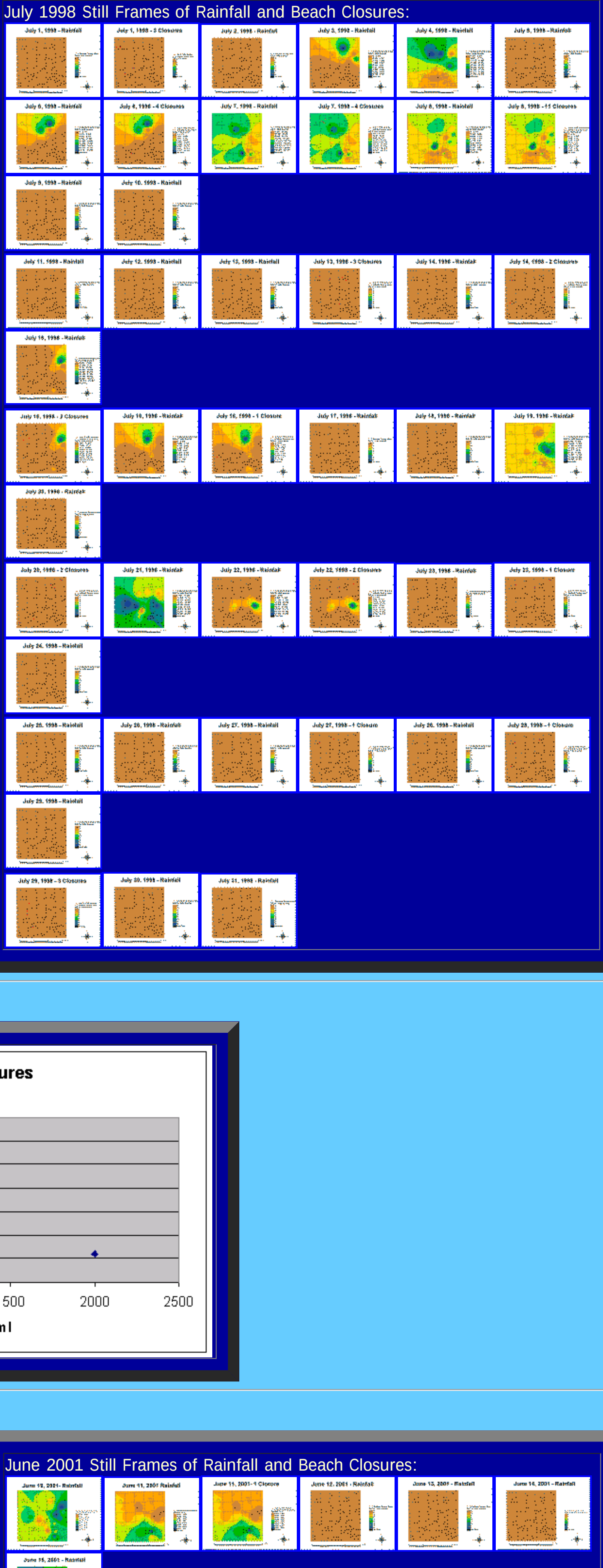
June 1998 Still Frames of Rainfall and Beach Closures:



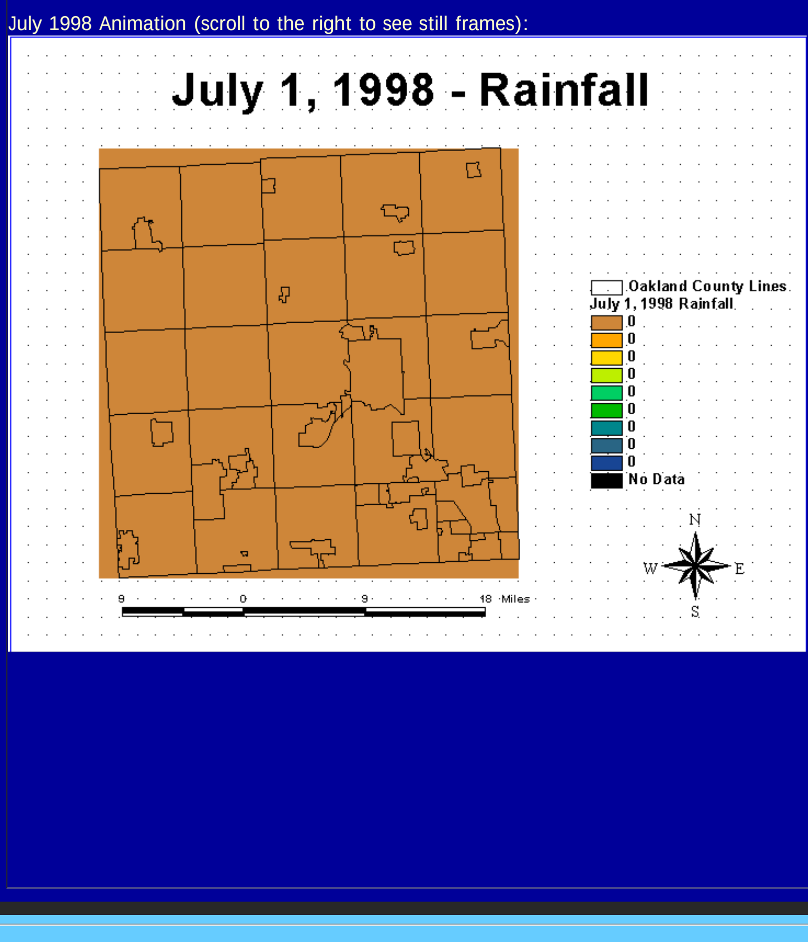
June 1998 Animation (scroll to the right to see still frames):

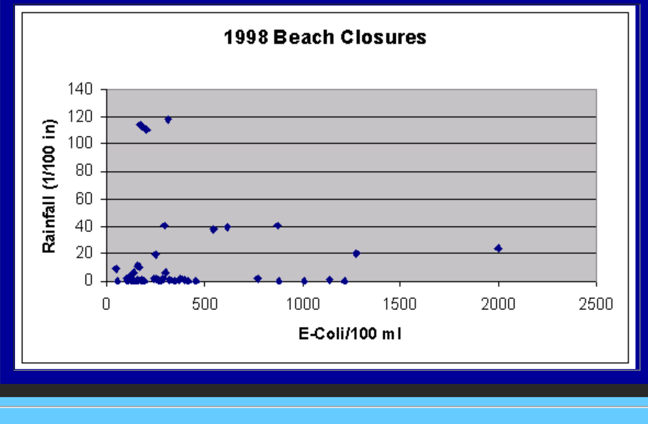


July 1998 Still Frames of Rainfall and Beach Closures:



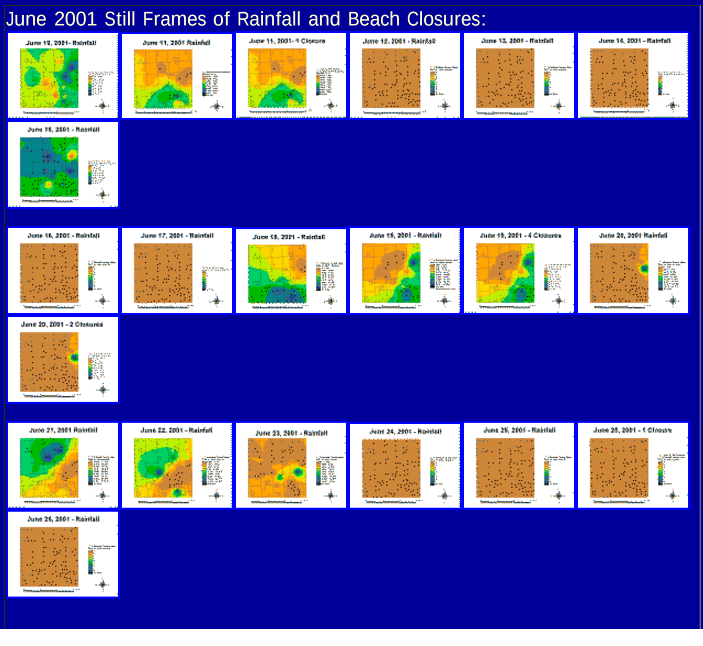
July 1998 Animation (scroll to the right to see still frames):

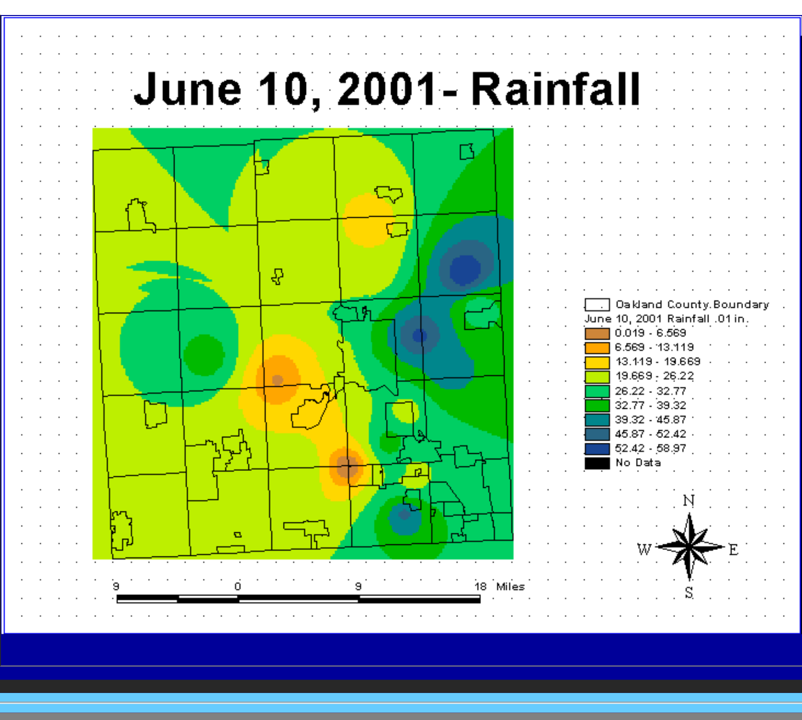


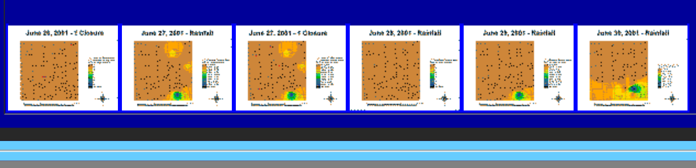


June 2001 Animation (scroll to the right to see still frames):

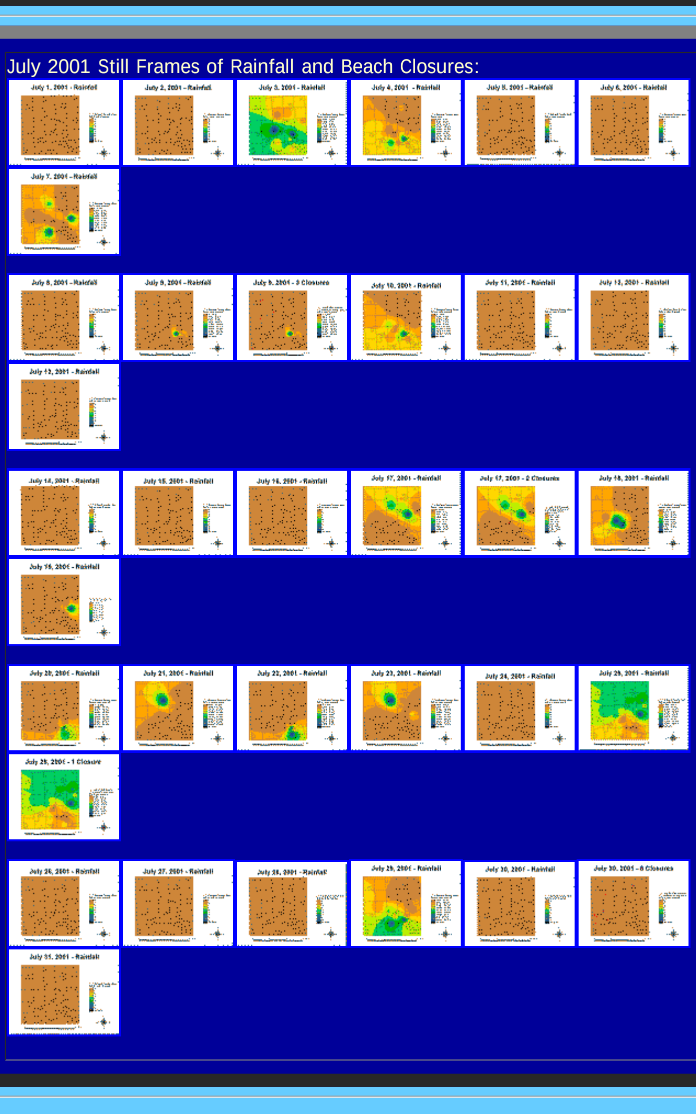
June 2001 Still Frames of Rainfall and Beach Closures:



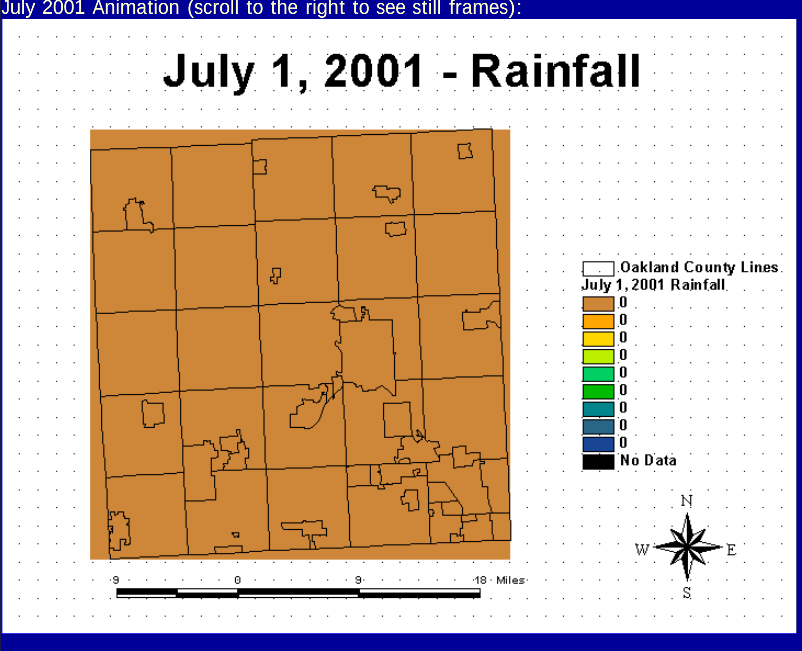


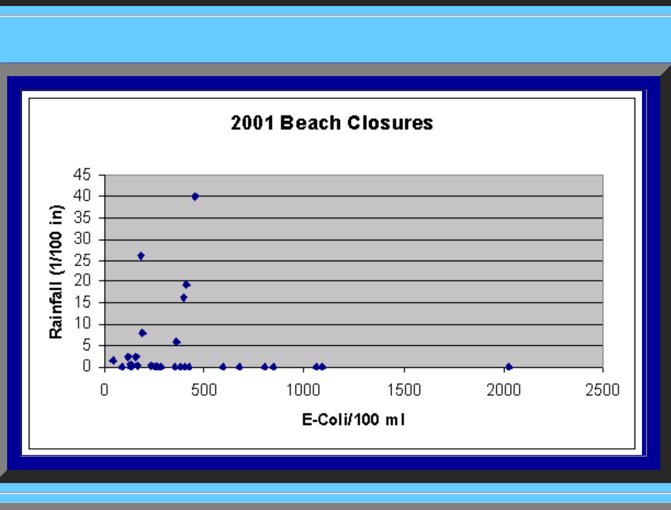


July 2001 Still Frames of Rainfall and Beach Closures:



July 2001 Animation (scroll to the right to see still frames):





Conclusions

1998: In 1998 there were 49 total beach closures in Oakland County. June had 9 closures with one beach closure day receiving zero inches of rain. July had 40 beach closures with sixteen closure days receiving zero inches of rain. Total average rainfall for June was 1.7 inches. July total average rainfall recorded at the gauge stations was 1.8 inches.

2001: In 2001 there were a total of 29 beaches closed. Twelve beaches were closed in June with 4 closure days occurring on zero inch rainfall days. July had 17 closures with 10 closure days occurring on days with zero inches of rain. The total average rainfall for June and July was 2.6 inches and .90 inches, respectively.

Graphs showing E-Coli/100 ml. versus rainfall (1/100 in.) for the 1998 and 2001 closed beaches suggest that there is not a direct correlation between rainfall and beach closures. In fact, the graphs suggest that shorter amounts of rainfall may be more indicative of beach closures. This might be because during short rain storms bacteria get washed into the beach concentrating near the shore, whereas during long storms the bacteria has a chance to disperse further into the lake and not concentrate near the shore and the beach (causing the E.Coli beach levels to diminish).

Most beaches were closed on days that it had rained. Thirty-two of the 49 beaches closed in 1998 and 15 of the 29 beaches closed in 2001 were on "rainy" days. Also, if it had not rained on the beach closure day, most beaches recorded rain measurements on the day prior to the closure. For example, out of the 49 beaches closed in 1998, 10 of these were closed on days recording 0 inches of rain on both the day prior to the closure and the beach closure day itself. In 2001 there were 5 beaches out of 29 closed that did not receive rain on both the day prior and the day of the closure. This time factor might make a difference because no data was available on the time the beach was sampled or on the time of the rain gauge measurement. It must be stressed that this study only took into account rainfall and many other factors including beach location, proximity to sewers and storm drains, amount of use, and animal activity also have the potential to effect bacterial levels and beach closure.

Future Goals

This study is a first step of many that need to be implemented to study beach closures in Oakland County. An attempt was made to correlate the amount of rainfall with beach closures, but it is evident that many other factors need to be incorporated into a closure model, although rain does appear to play a role in beach closures. Other factors such as proximity to septic systems and storm water drains, land use patterns (agricultural vs. industrial), and animal activity might also be included in further study on the exact causes of closures. Most beaches are closed either on the day of significant rainfall, or the day after: timing appears to be critical, as reflected in the animated maps. Thus, further study might well include a quantitative measure of time to supplement the visual measure of showing spatial change through time, offered by animated maps. Generally, one can conclude that it is safer to avoid swimming for at least one day after a significant rain event in order to allow bacterial levels to subside.

References

- Environmental Protection Agency. �Beach Act.� www.epa.gov/OST/beaches .25jul2001: 1-16
- Environmental Protection Agency. �Beach Watch, Frequently Asked Questions.� www.epa.gov/OST/beaches/faq.html . Access 25 Feb 2002: 1-6.
- Crowther, J., Kay, D., and M. Wyer. �Relationships Between Microbial Water Quality and Environmental Conditions.� Water Research. V35n17 (Feb2001): 4029-2038.
- Armstrong, I., Higham, S., Hudson, G. and T. Colley. �The Beachwatch Pollution Monitoring Programme: Changing Priorities to Recognize Changed Circumstances.� Marine Pollution Bulletin. V33n7-12: 249-259.

Based on full website at: http://www-personal.umich.edu/~jchura/

The Possibility of Extending the Streetcar Line in Kagoshima City, Japan

Makoto Noguchi
Masters Student, Urban Planning
Taubman College of Architecture and Urban Planning
The University of Michigan

More and more cars are running in many cities.

Although the car is a very convenient vehicle, it causes serious problems inside city: traffic jams, car accidents, air and noise pollution, and so on.

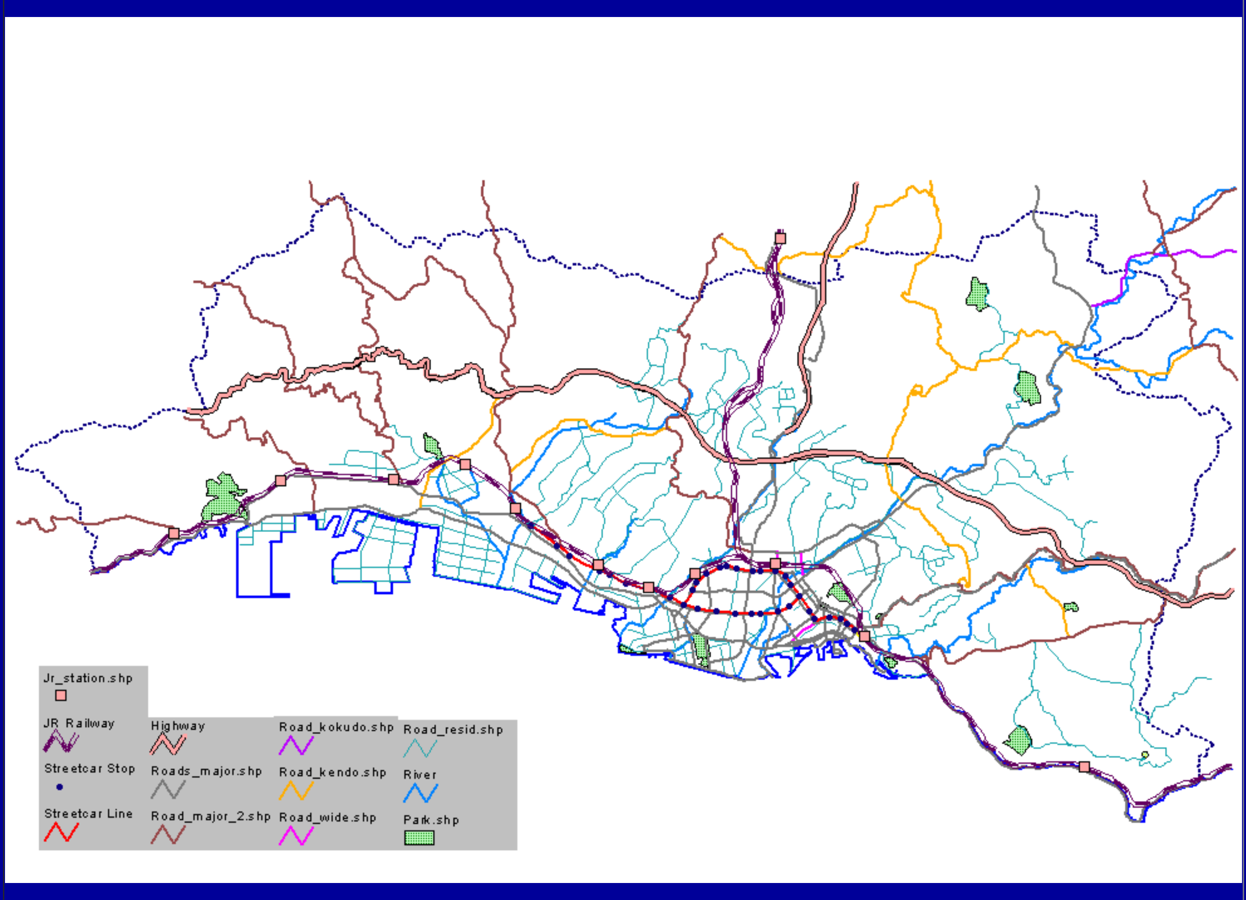
The streetcar can be one of the solutions for these problems.

It does not give off gas in the city, it does not cause congestion, it can be friendly to the elderly, to children, and to disabled people.

In this project, I analyze the existing streetcar line in my hometown of Kagoshima, Japan, as an alternative for cars, and begin to consider the possibility of extending streetcar lines, in order to utilize this facility more effectively. The population of Kagoshima, as of October, 2002, is over 550,000 and Kagoshima is the 18th largest city in Japan.

The map to the right is a map I digitized from a paper map of Kagoshima (2002 source). It covers about 30km from left side to right side. Orientation is north to the right and tipped very slightly toward the top edge.

In this paper, based on a larger project, the role of an animated map is emphasized.



In Kagoshima City, the streetcar line runs from the Central Business District (CBD) to the Southern Residential area. The total length of streetcar lines is 13.1km. Kagoshima City is a car-oriented city: most people use cars. Walking comes second. About 18% of people use the public transportation system. This fact suggests that more convenient public transportation systems might prevent increasing car usage.

The theme of this paper is to begin to identify The Possibility of Extending the Streetcar Line in Kagoshima City, Japan. In order to develop the recommendation, it is necessary to conduct a demand analysis. One important factor in that analysis is to assess the current usage (demand) of streetcar lines. Thus, I will investigate, using animated maps, the current usage (demand) for streetcar lines.

The animated maps below show current streetcar usage: thicker lines (Figure 1) indicate heavier flows of passenger traffic [ed. much as maps of the Napoleonic armies traced declining numbers of soldiers on the eastward thrust to Russia]. In Figure 2, larger circles at streetcar stops mean heavier passenger usage. The survey was conducted on May 18, 2001, by Kagoshima City Transport Company. Data includes all passengers over 5 years old on that day.

The remarkable fact is that the stop with the most passengers' usage is not in city center, but in the suburb, Taniyama, which is located at the south edge of the streetcar line. That implies that the Taniyama streetcar stop is used not only by Taniyama area residents, but also by the residents around Taniyama area.

The other stops with many passengers' usage are more of the sort one might expect:

- City center; Tenmonkan, Izuro, and Takamibaba, in which there are many offices and commercial facilities
- Transit center; Nishi-Kagoshima Station (largest heavy rail Station in Kagoshima City), and Kohrimoto (another streetcar line comes to this point)

Clearly, any plans for future extensions of this streetcar line should consider the demographics of Kagoshima City spread across space at a number of timepoints as well as, perhaps, the decision-making behavior of Taniyama and nearby residents.

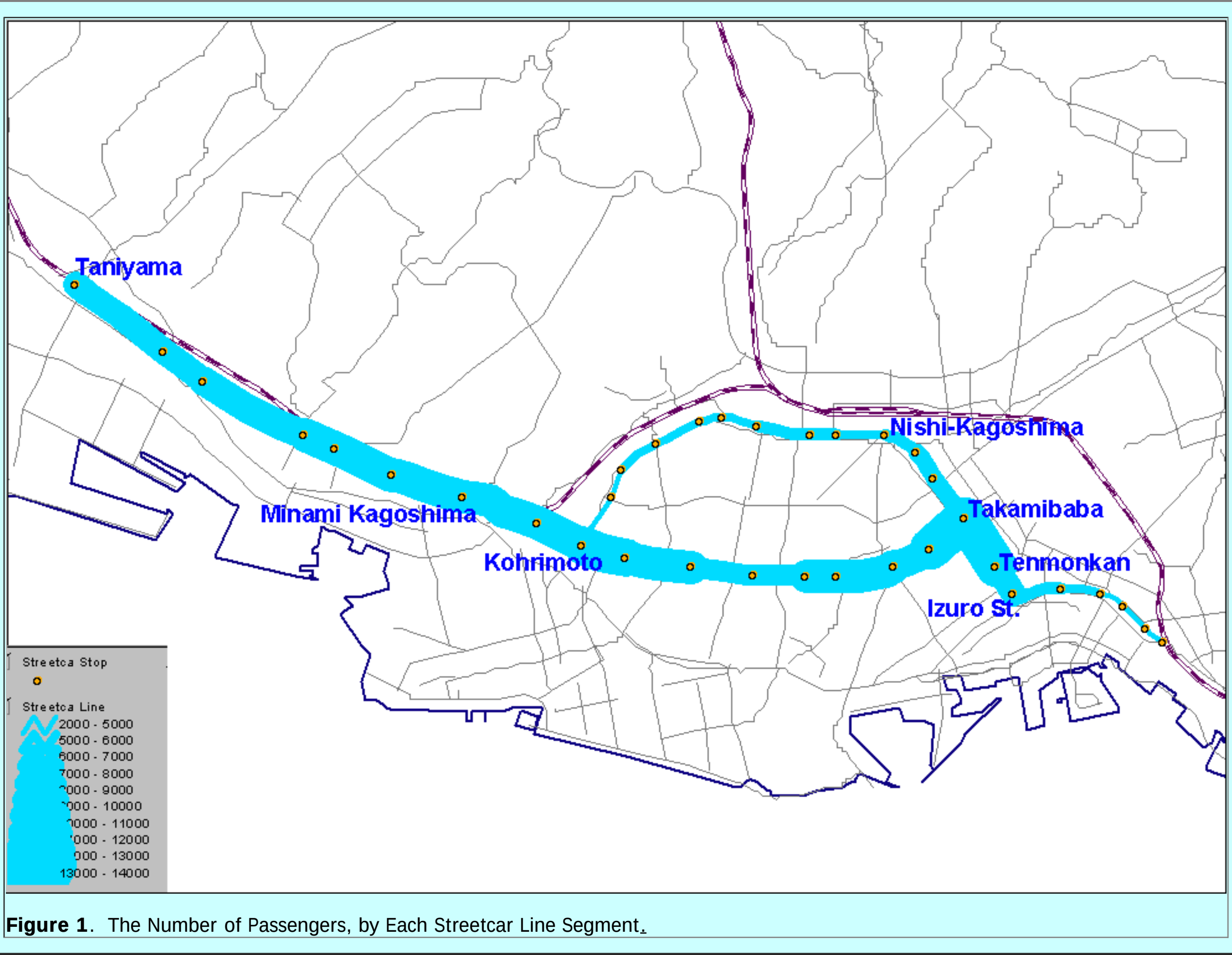


Figure 1. The Number of Passengers, by Each Streetcar Line Segment.

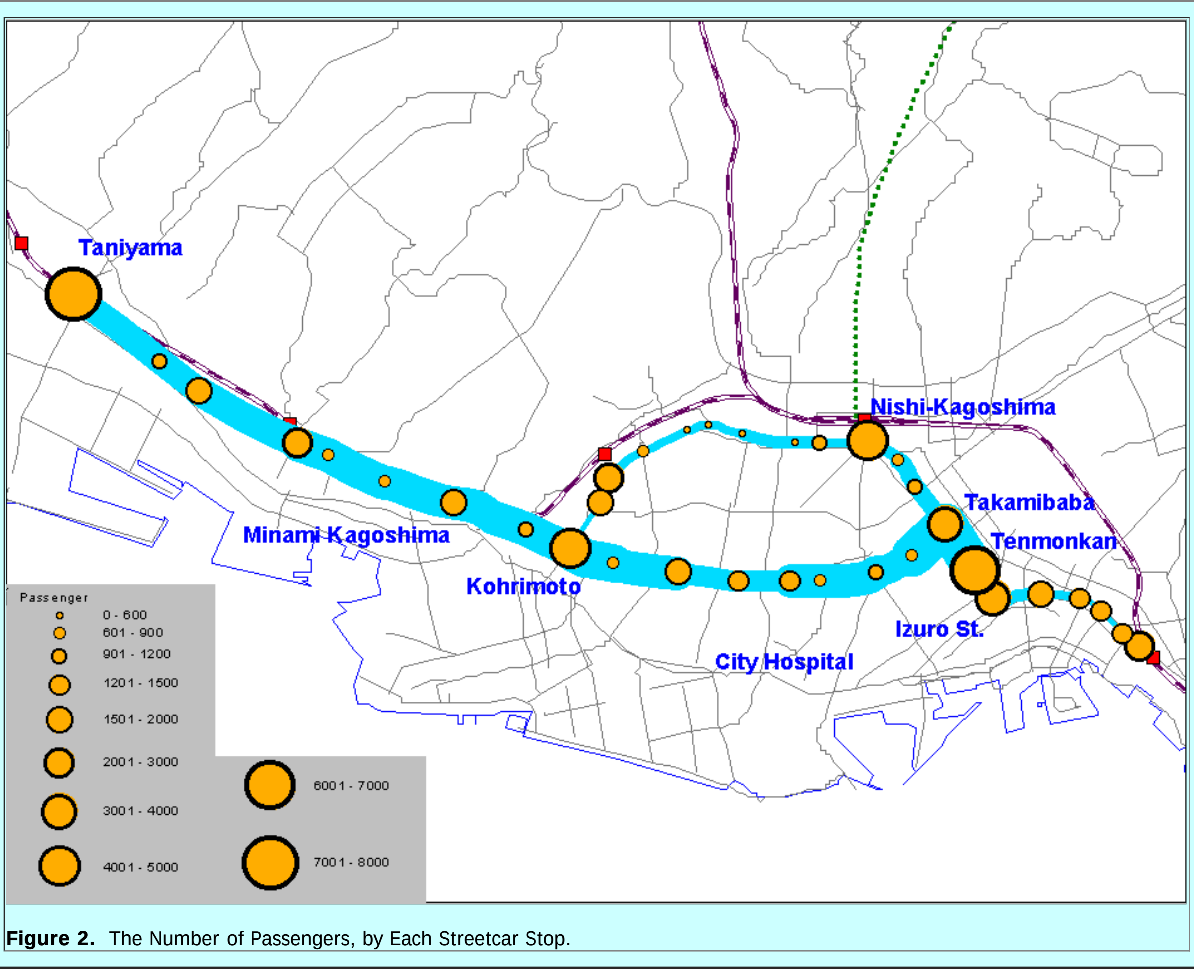


Figure 2. The Number of Passengers, by Each Streetcar Stop.

Materials Received

- Letters
    - John P. Lewis
    - Marc Schlossberg
    - Waldo R. Tobler
- IMaGe Intern, Nathan Annis
- Announcements of Books
    - Arlinghaus, Arlinghaus, and Harary
    - Gould and Pitts (eds.)

Subject: request for solstice information
Date: Mon, 24 Dec 2001 10:28:40 -0500
From: "John P. Lewis" <jplewis@winc.fm>
To: <image@imagenet.org>

I am trying to determine if the summer solstice is the longest day of the year at all latitudes in the Northern Hemisphere. I thought that this was only true north of the Tropic of Cancer, and that between the Equator and the Tropic of Cancer the longest day would be other than the summer solstice. Where can I find information on this? Thank you.

John P. Lewis

Subject:
something you might like
Date:
Mon, 10 Jun 2002 14:30:45 -0700
From:
Marc Schlossberg <schlossb@darkwing.uoregon.edu>
To:
sarhaus@umich.edu

Sandy-

Howdy. Have you been to Kartoo? http://www.kartoo.com/

It is a search engine that graphically "maps" the results. Put in your name and see what comes out.

- Marc
****
Marc Schlossberg
Assistant Professor
Planning, Public Policy, & Management
University of Oregon
128 Hendricks
Eugene, OR 97403
(541) 346-2046
(541) 346-2040 (fax)
schlossb@darkwing.uoregon.edu
www.uoregon.edu/~schlossb
New Home Page for Planning Students to Use:
http://www.uoregon.edu/~schlossb/planning/
****

Subject: Solstice
Date: Fri, 21 Dec 2001 12:47:37 -0800
From: "Waldo Tobler" <wtobler@earthlink.net>
To: <sarhaus@umich.edu>

Sandy,
Thanks for sending Solstice along. It looks good. I also enjoyed your comment on Thiessen polygons. I also looked at Barmore (Vol IV, 1, 1993) on ellipsoids. One additional discrepancy between a sphere and ellipsoid is nicely described in Charles Arden-Close's book "Geographical Byways...". This is that the concept of antipodal point must be modified - it can be generalized in several ways, all of which coincide in the case of a sphere.
Waldo

Nathan Annis.

Junior Mathematics/Geography major at Gustavus Adolphus College in St. Peter, MN.

Interests:
Dynamics, differential equations, nonlinear differential equations, social networks, population dynamics, game theory, internet search engines.

Work at IMaGe during the summer of 2002, virtual connection; project to culminate in research paper.

Graph Theory and Geography: An Interactive View, E-Book,
Sandra L. Arlinghaus, William C. Arlinghaus, Frank Harary. Wiley-Interscience Series in Optimization and Discrete Mathematics, John Wiley & Sons, New York.
http://www.wiley.com (online samples available).

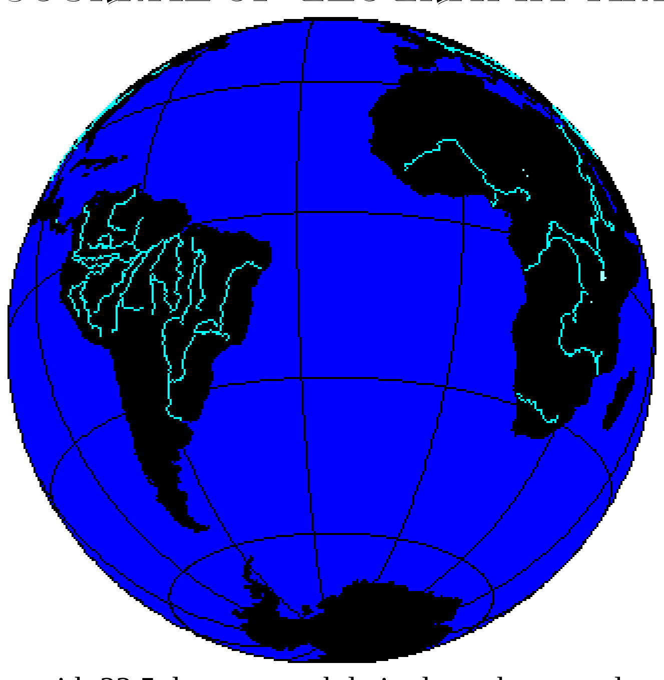
Reviews:
"This educational text surpasses eBooks currently on the market by providing a new realm of interactive content."
(Business Wire, April 29, 2002);
(CBS Marketwatch, April 29, 2002)

Geographical Voices
Edited by Peter Gould and Forrest R. Pitts
Syracuse University Press
http://sumweb.syr.edu/su_press

Contents include:

SOLSTICE:

AN ELECTRONIC JOURNAL OF GEOGRAPHY AND MATHEMATICS



Earth: with 23.5 degrees south latitude as the central parallel.

VOLUME XIII
NUMBER 2
DECEMBER, 2002

SOLSTICE: AN ELECTRONIC JOURNAL OF GEOGRAPHY AND MATHEMATICS

http://www.imagenet.org

WINTER, 2002

VOLUME XIII, NUMBER 2

ANN ARBOR, MICHIGAN

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Visualizing Accessibility with GIS

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Introduction

As the environmental, social, and health costs of sprawling, automobile dependent development patterns become well understood, accessibility, or walkability, becomes a significant goal of planners, policy makers, and citizens. Our current planning environment is one of auto-mobility, which has the goal of reducing the cost per mile of travel within a metropolitan area. An auto-mobility approach may find success for a 15 minute commute that travels fifteen miles at speeds of sixty plus miles per hour � the cost per mile is relatively low in terms of time and delay. Similarly, an auto-mobility approach to regional travel would be considered a failure when congestion inhibits automobile travel from traveling at maximum speed limits; the cost per mile becomes quite high on account of time delays in traffic.

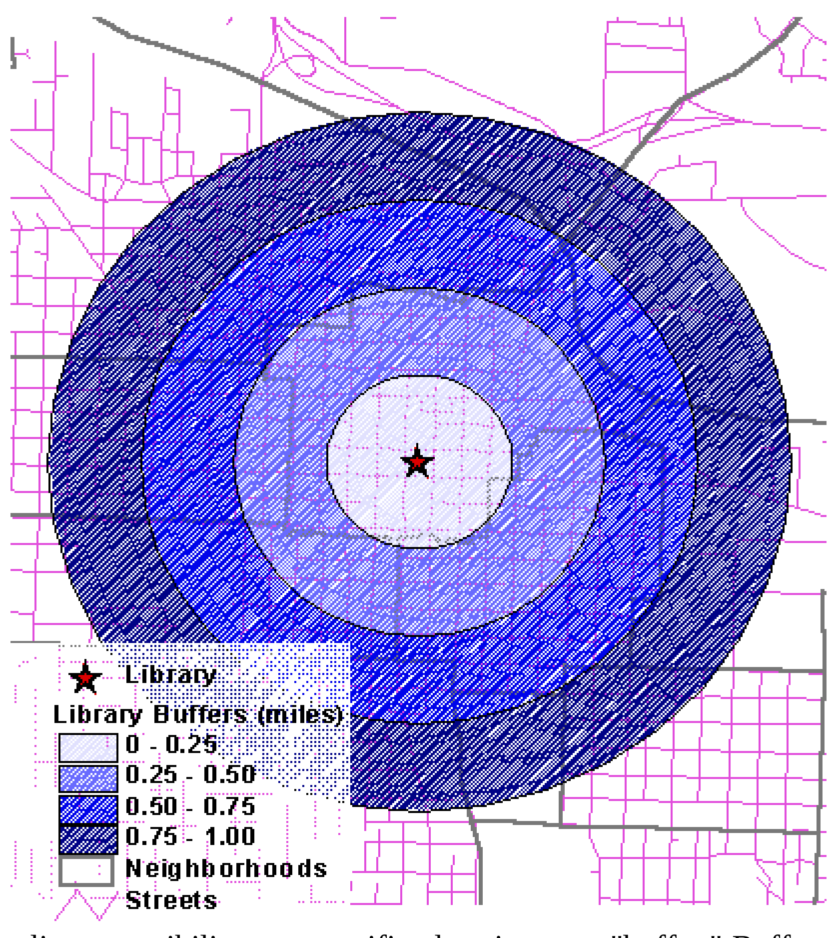
In contrast, an accessibility focus of development seeks to help people gain access to their destinations at a low cost per trip. In an accessibility-centered approach, popular places to visit cause increased numbers of people on sidewalks and in street intersections. These increases in turn tend to slow down the speeds of automobiles in the area. There is a tradeoff of mobility that favors the pedestrian rather than the automobile.

Developers and planners are increasingly incorporating such tradeoffs involving pedestrian accessibility into their visions and plans. They tend to base their decisions on a variety of principles, including increased quality of life, more active community interaction, environmental benefits of reduced automobile dependence, and congestion reduction. These principles are often characterized, in part at least, under a variety of terms: "New Urbanism," "Neotraditional Planning," "Pedestrian Pockets," "Transit Oriented Development," or "Nodal Development." The claimed or potential benefits of these schemes is beyond the scope of the current discussion. The focus here is on visualizing accessibility principles: to visualize is to clarify.

What are the various ways that one can visualize accessibility using Geographic Information Systems (GIS)? This presentation uses the centralized area of Eugene, Oregon (USA) as the case study. Eugene has a centralized downtown with a gridded street network, has several old, established neighborhoods, and has some newer developments as well. Most of Eugene�s topography is flat, except for portions of South Eugene, which ascends up some foothills. Eugene has clearly identified neighborhoods that are recognized by the City and are represented by elected neighborhood association presidents. Measuring accessibility at a neighborhood scale can be facilitated by these pre-existing boundaries of the neighborhoods.

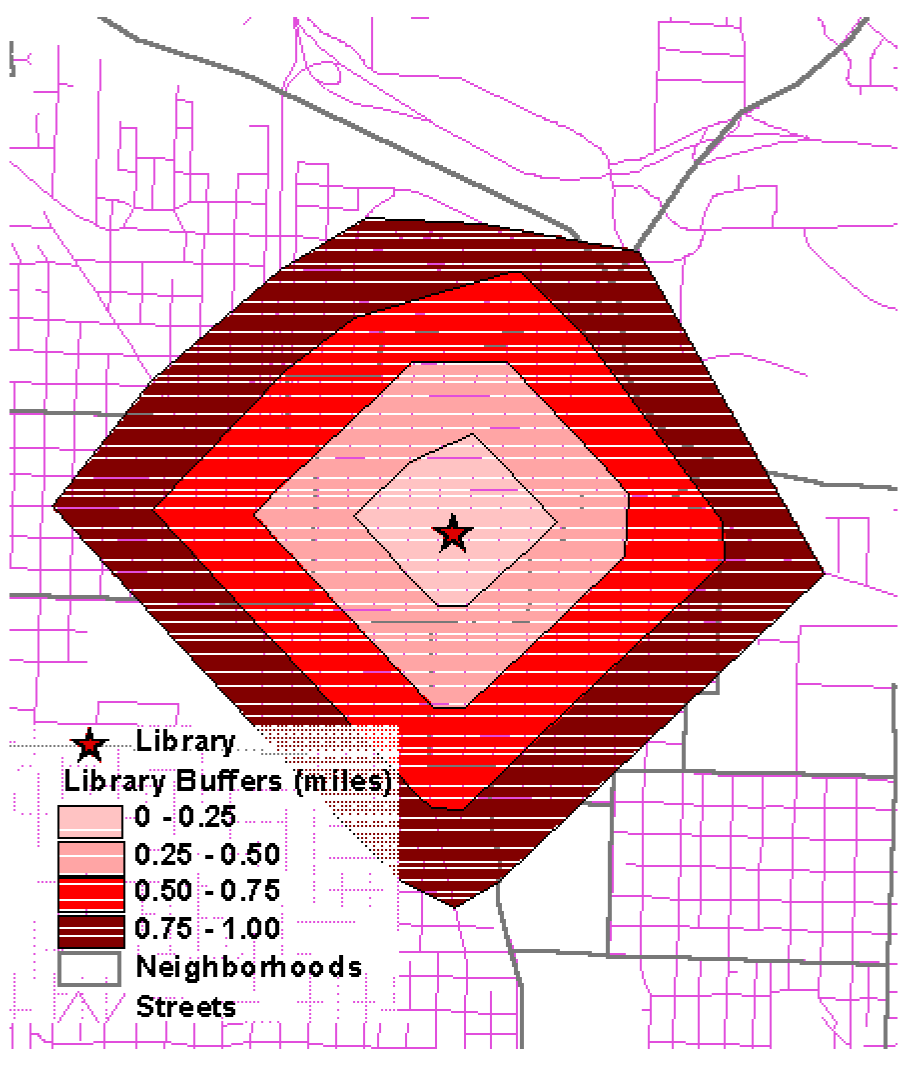
Accessibility through Buffering

Figure 1: 1/4 Mile Buffers as the Crow Flies Around Key Destination



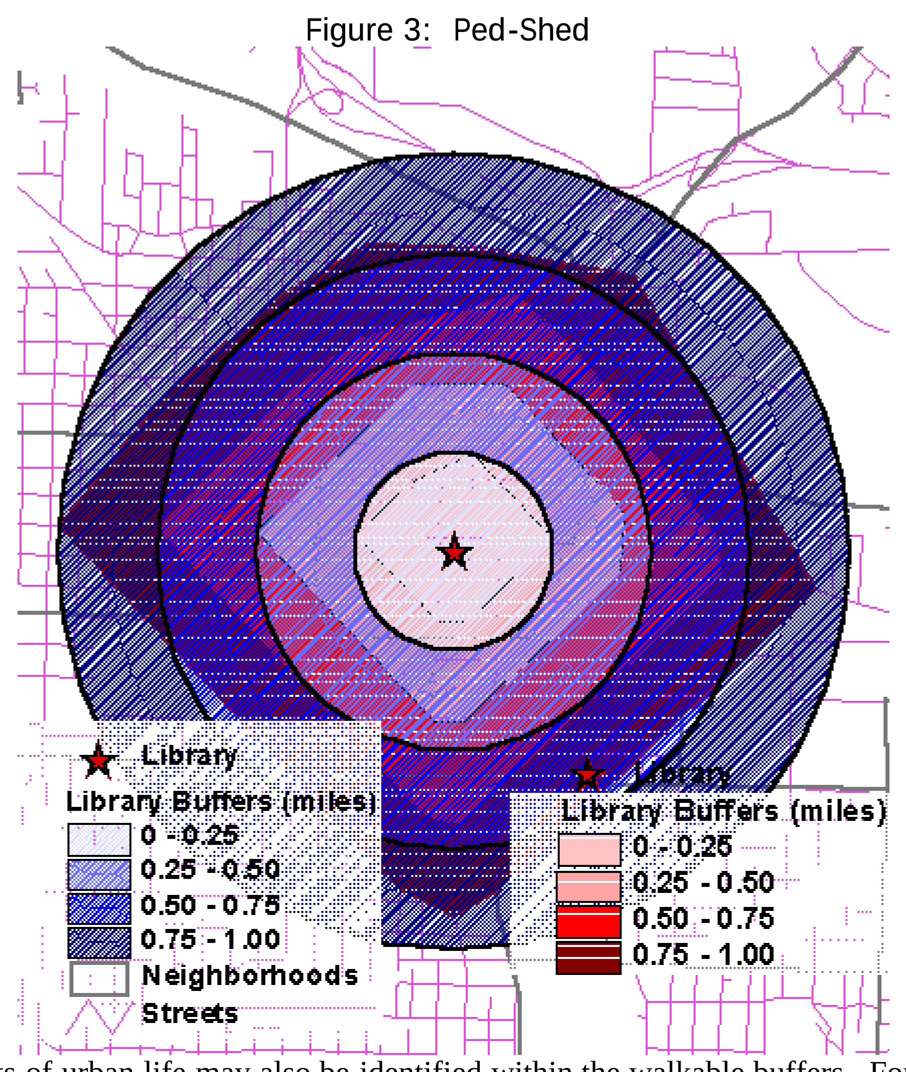
An easy way to visualize accessibility to a specific place is to use "buffer." Buffers target areas all of which are within a given distance of a point, line, or area. Thus, Figure 1 shows four buffers around the Library location. Buffering is a common GIS technique and can be used to quickly identify a geographic area that is considered accessible or walkable to a given location. Planners often consider a ¼ mile distance from a location as being the maximum distance that people are willing to walk to get to the destination they desire. Thus, Figure 1 shows ¼ mile rings of accessibility to a new downtown library that is being constructed in Eugene. The buffer rings (in Figure 1) are �as the crow flies�, and do not take into account the actual paths that people may need to take to access the library. Thus, Figure 2 shows ¼ mile rings around the library based on the actual walking path of the street network (assuming that all streets have sidewalks and that there are no other walking-only paths). The diamond shaped buffer rings reflect the gridded street pattern of this part of Eugene.

Figure 2: 1/4 Mile Walking Buffers Around Key Destination



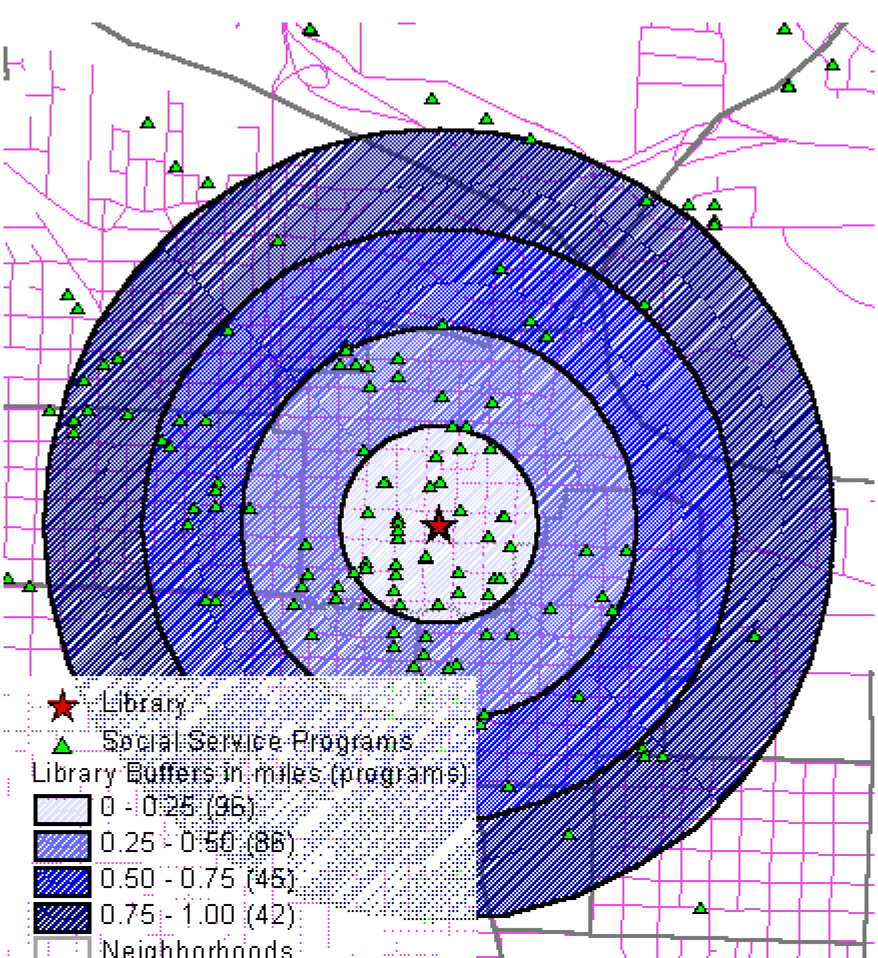
When Figures 1 and 2 are combined as Figure 3, the new Figure shows the overlap between the two different accessibility measurements. In this so-called �Ped Shed� of Figure 3, the ¼ mile buffer area of each technique can be compared by dividing the area of one by the area of the other to calculate a Ped Shed ratio [Rood, n.d.]. Different ratios imply areas that are more or less walkable.

Figure 3: Ped-Shed



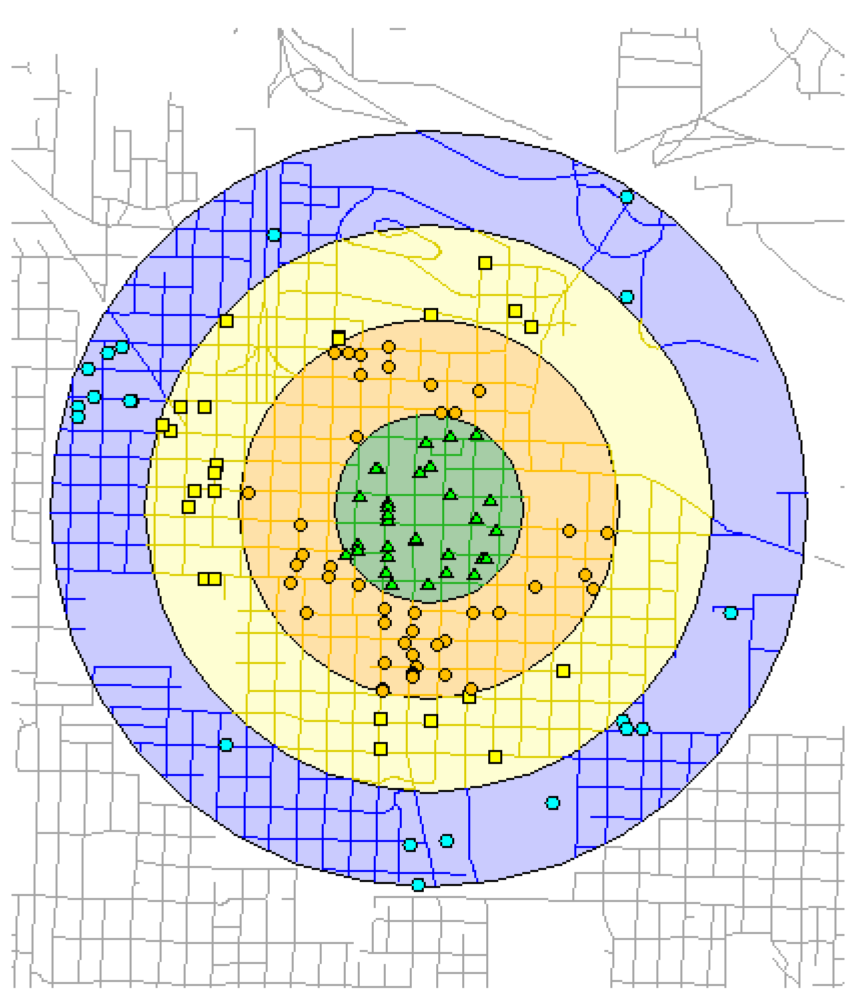
Additional aspects of urban life may also be identified within the walkable buffers. For example, planners at the library may wish to provide sensitive services to people with special needs for social services located near the library. Figure 4, plots the location of social services with the buffer rings to give the library a sense of the type of potential demand it may receive from any of a number of specialized populations.

Figure 4: Potential Social Service Patrons



While the image of Figure 4 is fairly intuitive and easy to read, additional visualization manipulations are possible to increase the clarity of the information being presented. Since the data underlying the image is spatial, data within each buffer can be individually selected and color coded based on its location. Figure 5 illustrates this approach by altering the color of variables (buffer, streets, and social services) based on geographic location. Thus, the visual representation of accessibility is enhanced and the capacity to distinguish or visually segregate the data based on geographical location is improved.

Figure 5: Color Coding Data by Distance



Visualization may be further enhanced by viewing the rings in three dimensions. In Figure 5, there is no discernable change in distance between each ¼ mile buffer and in many cases the line dividing each buffer distance is arbitrary in relation to the movement of people. Instead, tier the distances in a way that conveys the visual message that the geographical dividing lines are not arbitrary, but have real implications for the movement of people through space. Figures 6 and 7 represent the library and its buffers using three dimensional tiers. Color coding of the data within each tier enhances the visual effect.

Figure 6: 3D Tiers of Accessibility

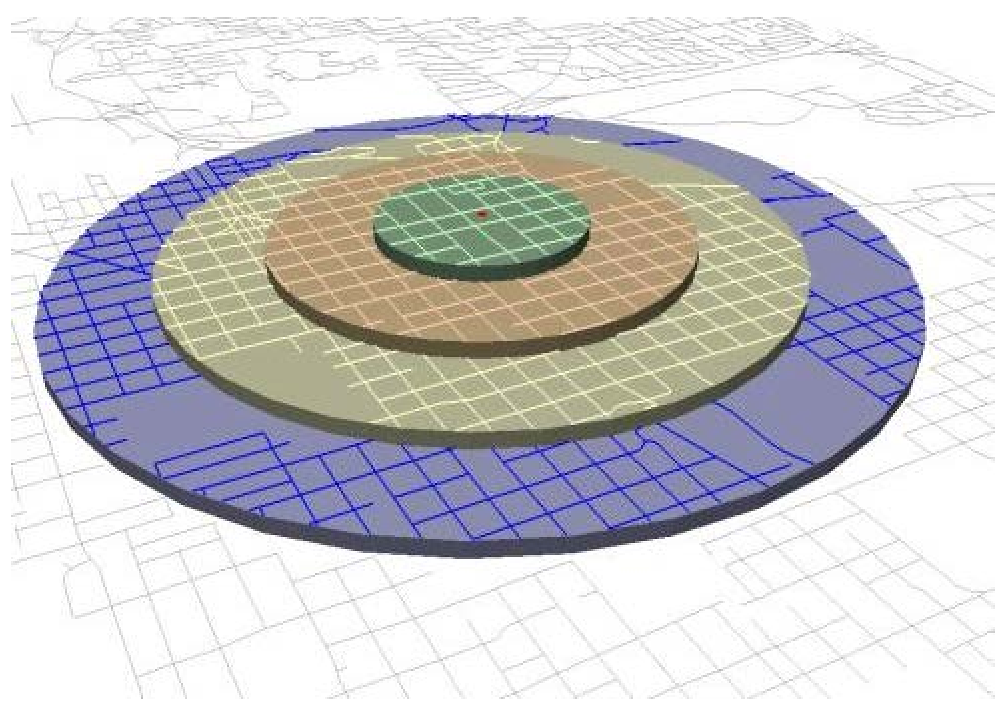
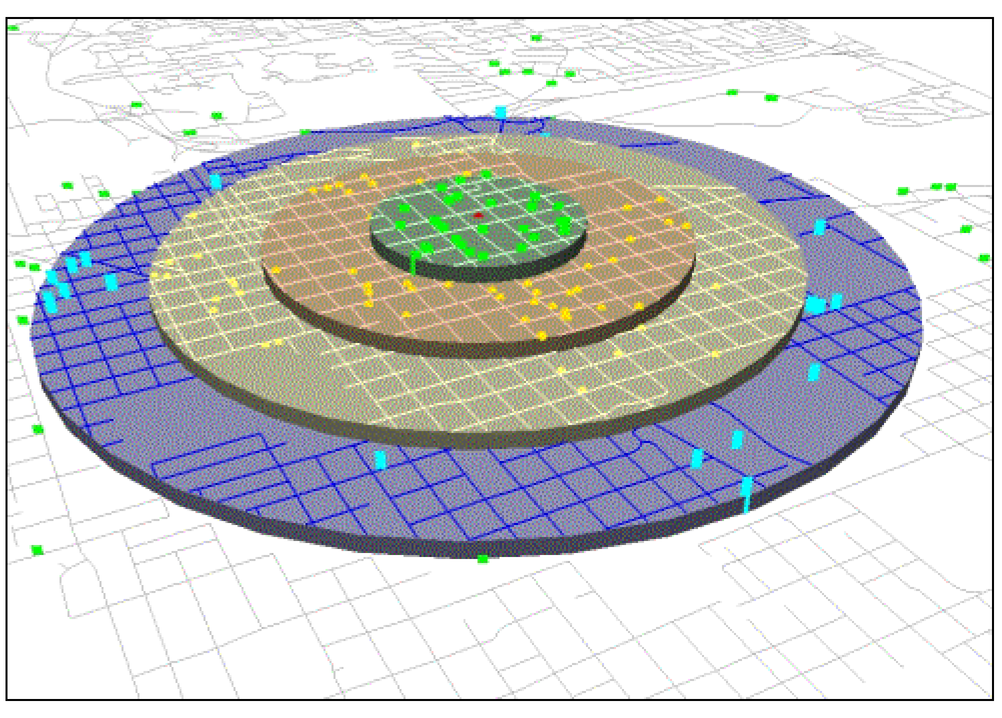


Figure 7: 3D Tiers of Accessibility with Social service Program Locations

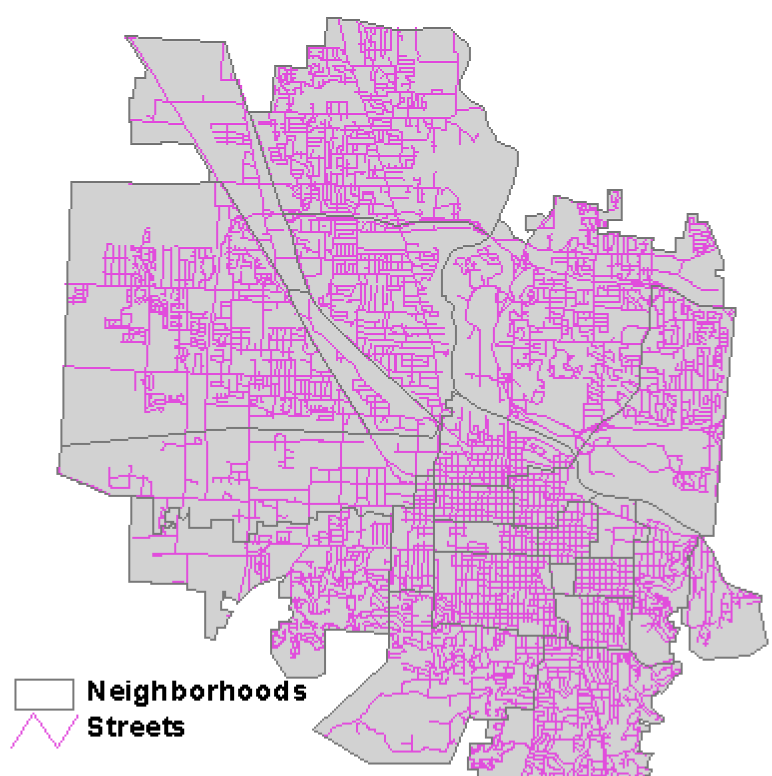


Accessibility through Intersection Density

The images above visualized accessibility in terms of the distance to a specific place. One might, instead, look across a landscape to ascertain which sub-areas are characterized by potentially more accessible movement patterns. Some areas within a region may have street networks (and therefore sidewalk networks) that are more conducive to walkability. Thus, accessibility may be visualized by investigating different patterns of street networks. Within the development schemes mentioned at the outset (New Urbanism, Nodal Development, and so forth), one idea is that street patterns that are based on a grid are more accessible than non-grid patterns. Within a gridded street network, there are redundant paths that walkers can use to access the same destination. This increase in path choice can be represented by areas with numerous street intersections and thus relatively great accessibility. One way to view this idea is to consider the difference in numbers of intersections and accessibility between a downtown street network grid suburban development with many cul-de-sacs. Regions with higher concentrations of intersections are regions with higher potentials for accessibility. The following series of images visualizes this characterization of accessibility.

Figure 8 shows the street pattern within the central Eugene Neighborhoods. The downtown core is located at about the center of the map. From only this simple map of one layer, it is visually possible to get a sense of which areas in Eugene are more walkable.

Figure 8: Eugene Street Network



Although one can get a general sense of accessible places by simply viewing the street layer, it is possible to perform a series of calculations based on the location and density of intersections (or cul-de-sacs). By viewing the concentration of intersections, one can get a better grasp of the connectivity of the street network across space. Figure 9 and Figure 10 visualize the street network based on the location of intersections and cul-de-sacs (or dead-ends).

Figure 9: Intersection and Dead End Points

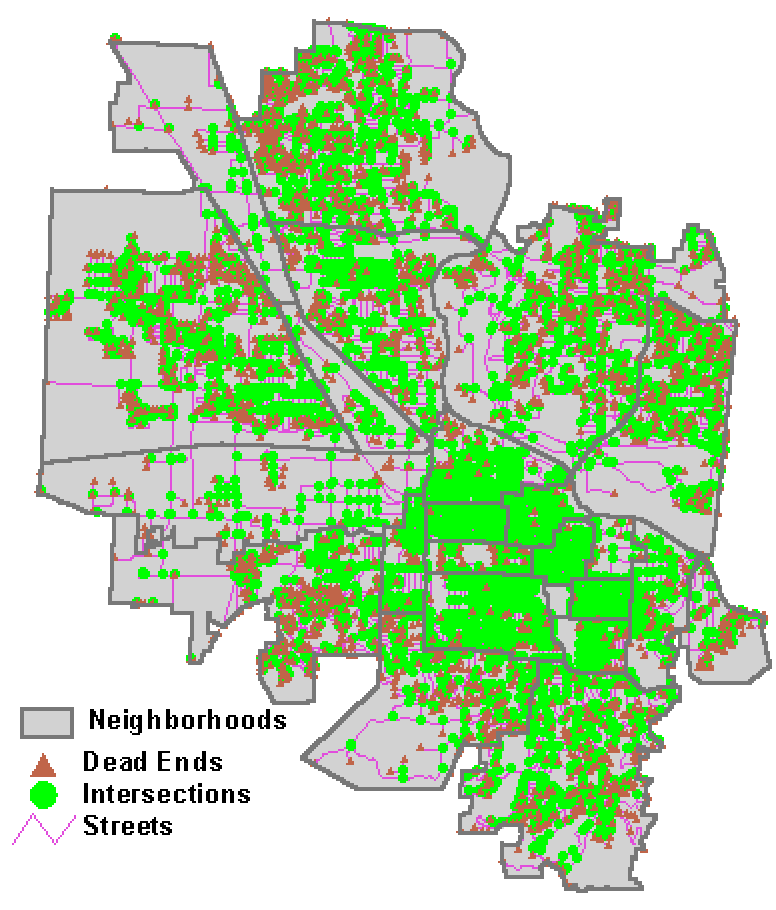
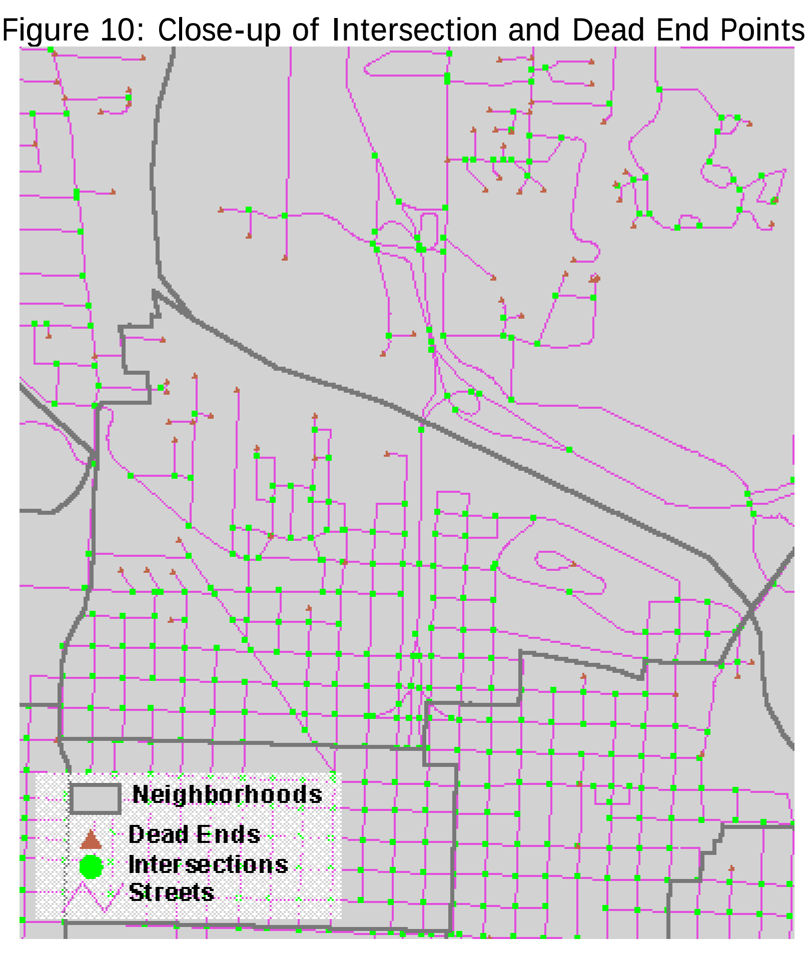


Figure 10: Close-up of Intersection and Dead End Points



Visualizing concentrations of intersections is helpful, but it may be that one would want to characterize the different neighborhoods in Eugene based on the density of intersections within the neighborhoods. Neighborhoods with higher intersection density (intersections per square mile) might be considered as more accessible than those neighborhoods with lower intersection densities. Figure 11 visualizes the aggregation of intersections within each neighborhood divided by the total area of each neighborhood to calculate a relative intersection density figure. Figure 12 visualizes a similar calculation, but is based on the concentration of cul-de-sacs � areas that can be classified as having low accessibility.

In Figure 11 there is a clear pattern of higher accessibility in the centralized area of Eugene, the location with the tightest grid pattern of development. This is the oldest developed portion of Eugene and was developed before the predominance of automobiles. The lighter colored neighborhoods out to the west are areas where more industrial development has occurred and the street network, and thus the density of intersections, follows a much less dense pattern. In Figure 12, the areas that have a more characteristic suburban style of development are clearly visualized. The southern portion is hilly and the street network tends to transect the mountains in long straight swaths with few intersecting streets. The dark area to the north in Figure 12 is an area more recently developed and follows a street pattern much more characteristic of the post-war suburban approach.

Figure 11: Street Intersection Density by Neighborhood

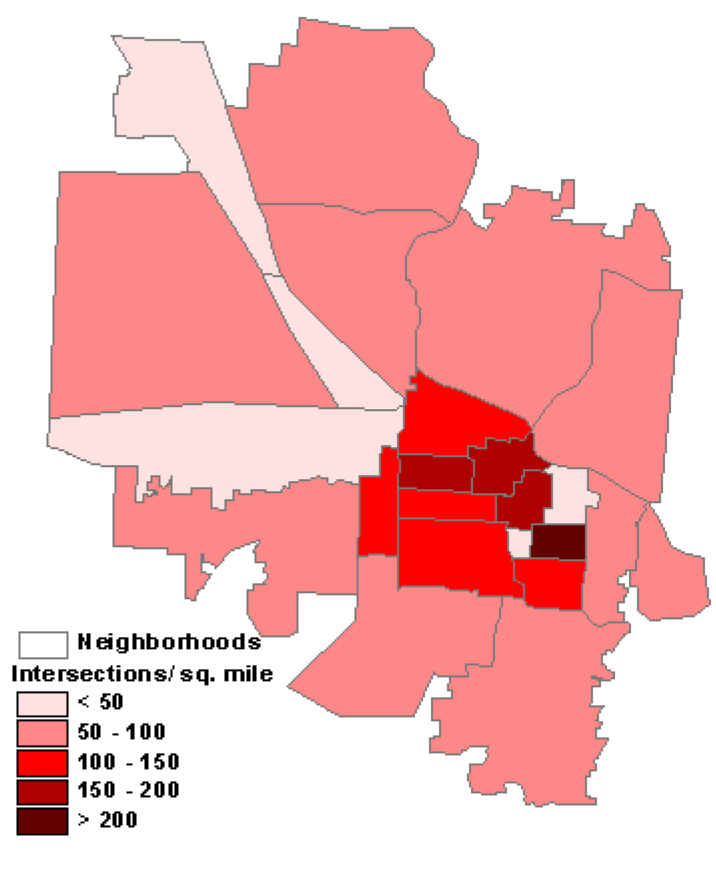
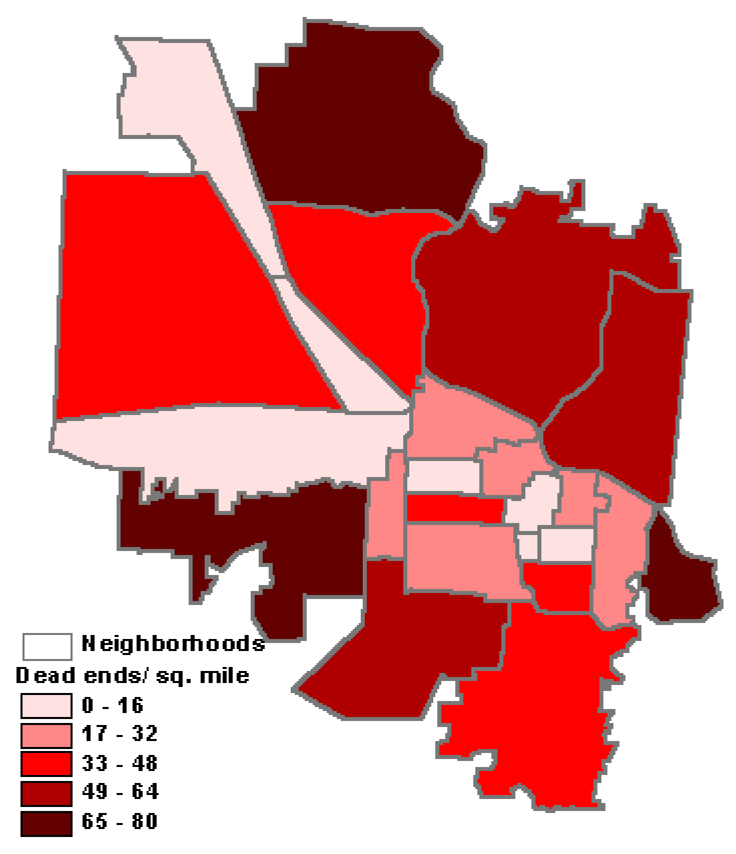
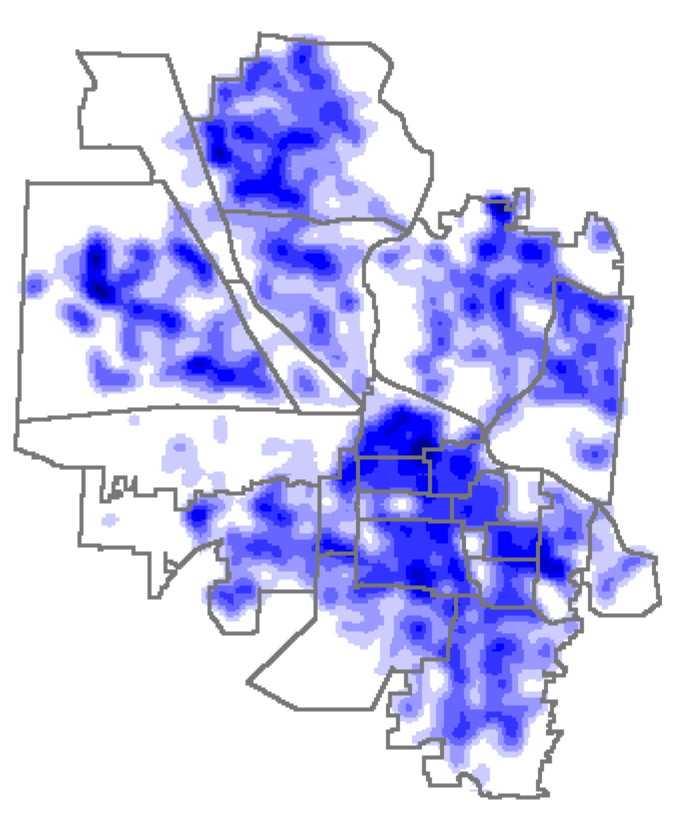


Figure 12: Dead End Density by Neighborhood



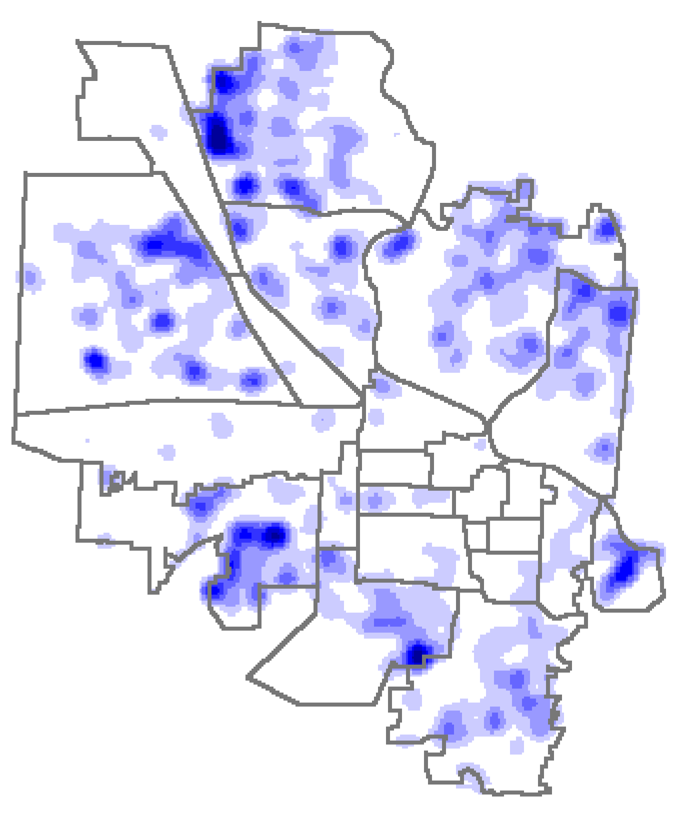
The figures above aggregate intersections to specific Eugene neighborhoods, which allows one to visualize accessibility on a neighborhood by neighborhood basis. Aggregating intersections to these pre-defined boundaries, however, is a bit artificial in nature. Alternatively, as shown in Figure 13, intersection density can be calculated by exact location in space. The intersection density of each spatial location can be calculated and then visualized based on the number of intersections that surround it. By transforming the vector data above to raster data (cells), a computation of the intersections within a ¼ mile of each cell can be calculated and displayed. Individual cells that are centrally located in relation to many intersections will appear in darker colors. Thus, regions of high intersection density can be visualized independent of the arbitrary borders of neighborhoods (or city boundaries, census tracts, and so forth). The neighborhood boundaries in Figure 13 are displayed, however, to give reference to the intersection density visualization.

Figure 13: Intersection Density by Point Location



The same type of calculation and visualization can be conducted on the density of dead-end streets or cul-de-sacs as shown in Figure 14.

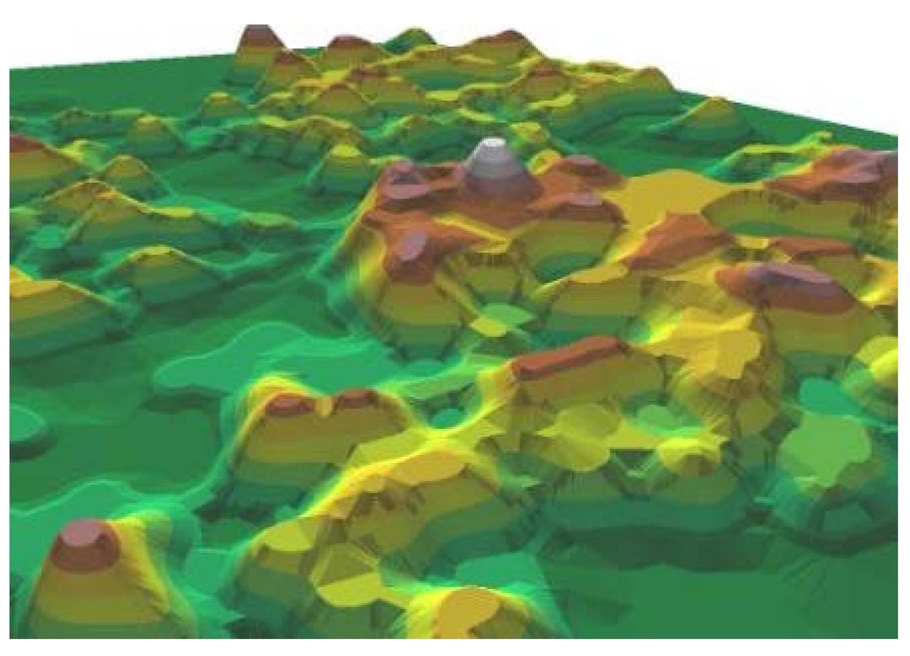
Figure 14: Dead End Density by Point Location



Figures 13 and 14 suggest locations where development has occurred in a way that is highly walkable and highly unwalkable.

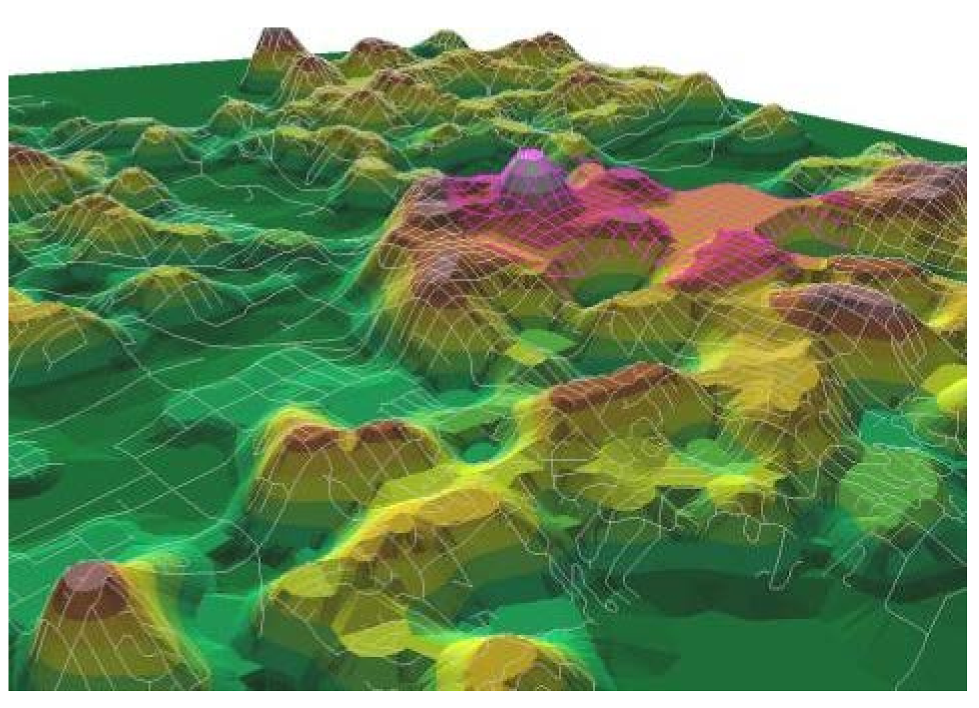
Accessibility using these raster-based calculations can also be viewed in three dimensions, using density of intersections in space, rather than actual elevation of land features, to create the topographic effect. Figure 15 visualizes the central Eugene area using this strategy, with mountain peaks representing areas of highest accessibility (concentration of intersections) and low areas representing places of low accessibility.

Figure 15: Elevation by Intersection



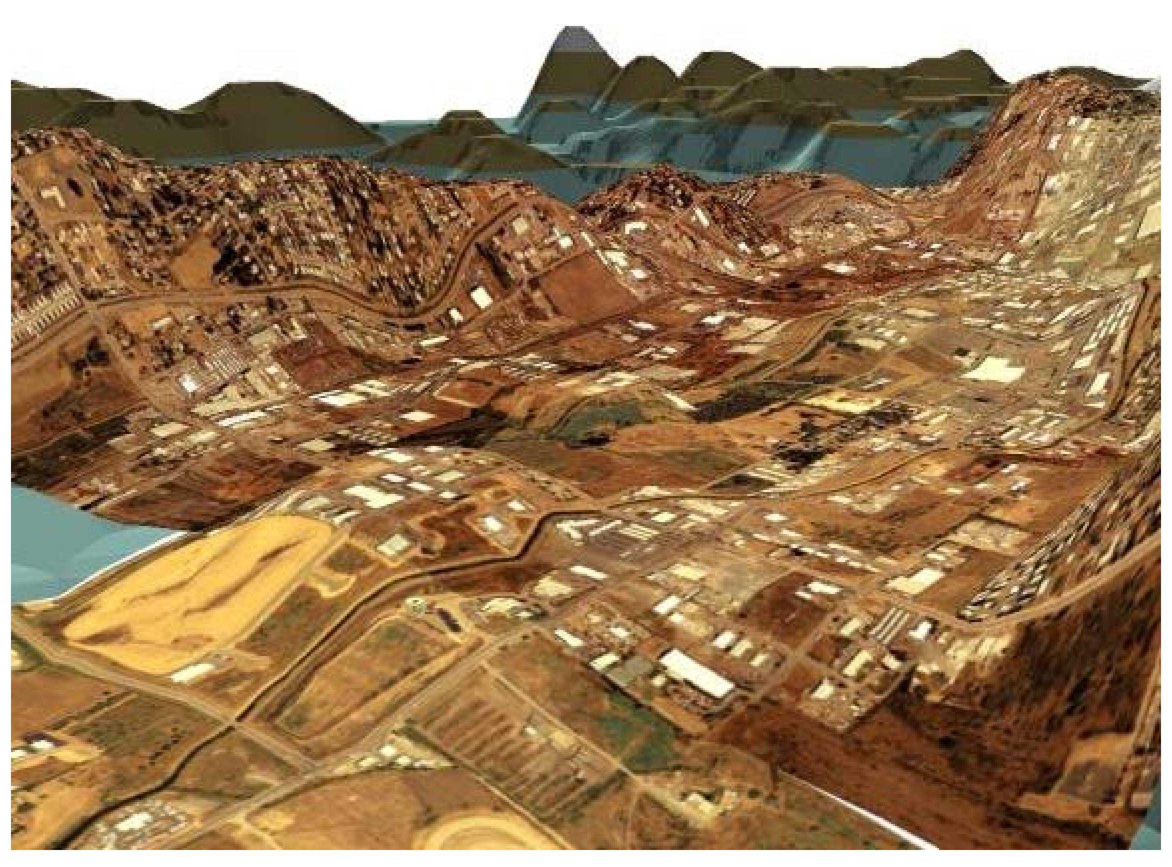
The three dimensional approach can be further augmented by overlaying the street network on top of the intersection topography to help visualize the concept of accessibility. Figure 16 illustrates this combination with streets within ¼ mile of the library highlighted in pink. That Figure also shows that the location of the new library is on the most accessible land of downtown Eugene. While not shown explicitly, the center of the pink streets (the location of the library) is just to the right of the tallest mountain peak (the location of the highest intersection density).

Figure 16: Intersection Elevation and Streets



Finally, aerial photographs can be draped on top of this new intersection topology to allow one to visualize the actual development of an area in relation to intersection density. Figure 17 visualizes accessibility using color aerial photos and the intersection-based topography. Some areas on the image below do not have aerial photos displayed in order to reveal the underlying connectivity as illustrated in Figures 15 and 16.

Figure 17: Intersection Elevation with Aerial Photos



In Figure 17, then, one can visualize the landscape of a city in a new way based on accessibility. Areas of high accessibility can be represented as mountain peaks (or alternatively as flat spaces) and the photographs of actual development can be viewed with this new underlying elevation. A policy connection, as well as a visual connection, might then be made between development patterns and accessibility.

Rood, T. (n.d.). Ped Sheds. Congress for a New Urbanism, Internet: http://www.cnu.org/cnu_reports/CNU_Ped_Sheds.pdf

COST PROXY MODELS IN RURAL TELEPHONE COMPANIES

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Introduction

The Federal-State Joint Board on Universal Service, CC Docket 96-45 ("Joint Board") published its *Recommended Decision* on November 8, 1996. Among other topics considered in that document, the Joint Board discussed the use of cost proxy models to determine the cost of network construction and by extension the cost of unbundled network elements. The Joint Board specified that the "technology assumed in [a cost proxy] model should be the least-cost, most efficient and reasonable technology for providing the supported services that is currently available for purchase."[1] Furthermore, the Joint Board specified that: "All underlying data should be verifiable, engineering assumptions reasonable, and outputs plausible."

Subsequent reports by the FCC and filings by interested parties have documented widespread and deep-rooted philosophical concerns within the telecommunications industry regarding cost proxy models *per se*. The cost proxy models created to date may be appropriate for the larger, urban area-based, incumbent local exchange carriers (ILECs) such as the former Bell operating companies and GTE; no opinion on that issue is offered here. However, it is clear that the cost proxy model procedures and unit prices proposed by the FCC are wholly unsuitable for use in rural areas. This report summarizes several areas in which this fact is evident, with particular emphasis on unit price input choices.

Geographic Considerations

Rural telephone companies face numerous geographic problems not experienced, for the most part, by large, urban-based ILECs. Among the distinctions that have a significant impact on the cost of network construction are the following factors.

Terrain

Many rural companies are located in areas with significant physical relief. Steep slopes pose particular obstacles to construction. For example, aerial plant placed in service in areas with steep slope often requires supplementary guying and support structures. As a second example, buried plant placed in service in areas with steep slope often must be placed at greater depth or with greater attention to cover and compaction to minimize the risk of cable exposure through erosion.

[1] Federal-State Joint Board on Universal Service, CC Docket 96-45, *Recommended Decision*, November 8, 1996, ("Joint Board Decision"), paragraph 277.

These and numerous other issues related to terrain must be addressed by rural telephone companies during network construction. In each instance, the unit cost of construction is higher than would be the case in level terrain. The same issues also affect network maintenance costs and network upgrade costs. Rural telephone companies should be permitted to <u>adopt higher unit prices to accommodate the factor of terrain</u> - both slope and degree of terrain irregularity (roughness).

Although the cost proxy model includes a variable for slope, the model is unsatisfactory because it provides only partial consideration of terrain through its use of an "average slope" factor. Average slope may be a meaningful variable in urban areas where minimal variation is the general rule. Moreover, in urban areas, large volume contracts permit construction contractors to average costs and minimize the perceived effect of price differences due to terrain. However, the tremendous variations in slope that companies often face in rural areas, and the generally much smaller contracts for construction, render this simple measure inadequate. Rural telephone companies should be permitted to <u>adopt higher slope adjustment factors</u>.

Soil/Rock Conditions

Many rural companies are located in areas with significant adverse lithologic conditions. Construction in areas with rocky soil conditions is significantly more expensive than construction in new suburban sub-divisions. Indeed, many rural telephone companies must dedicate a significant proportion of their construction budget to rock sawing, rock drilling and similar placement activities. The comparatively high cost of such methods and the small size of the rural telephone companies mean that the relative cost impact of placing cable in rocky conditions is higher than it would be for urban companies. Rural telephone companies should be permitted to <u>adopt higher rock and rocky soil adjustment factors</u>.

Similarly, many rural companies are located in areas with significant adverse pedologic conditions. Coastal areas such as those in the Carolinas contain significant amounts of sand, which abrades plow shows and related equipment much faster than does suburban topsoil. Rural telephone companies should be permitted to <u>adopt higher sandy soil adjustment factors</u>.

Forested Areas/ Parks/Protected Areas

Many rural companies are located in areas with significant amounts of land reserved for state and national forests, state and national parks, nature preserves, military bases and other public uses. Cumulatively, the presence of these large reserve areas often forces inefficient construction methodologies to be adopted. For example, the shortest route to a remote serving unit cannot necessarily be used if it crosses a military base or contravenes other regulations. Similarly, the rights of Native American property holders (of reservations and other holdings) must be observed and appropriate permit fees must be paid for crossing such property even if permission is obtained. These factors contribute to increases in the cost of construction. Rural telephone companies should be permitted to <u>define and adopt a factor to control for increased construction costs related to the presence of public lands</u>.

Demographic Considerations
By definition, many rural companies are located in areas with relatively small populations and relatively low population densities. Both demographic factors force rural telephone companies to incur significantly higher construction costs.

Population Size
The five largest ILECs serve approximately 80% of the population of the United States. Cumulatively, the top ten ILECs serve almost 95% of the population. This factor of the size of the subscriber base is significant for several aspects of cost proxy model use.

Perhaps most significant, equipment manufacturers design, develop and, at least in the first instance, market equipment primarily for their larger customers. Manufacturers offer substantial discounts for large volume equipment purchases. Indeed, manufacturers have been known to provide equipment to large customers below cost at certain times (for example, early in the product cycle to encourage adoption and late in the year to supplement annual unit sales records).

No such volume discounts for central office and other equipment are available to rural telephone companies. The central office equipment (switch) pricing information contained in the cost proxy model is extremely poor, as argued in several FCC filings and as acknowledged by several model designers, and inappropriate for rural areas. Rural telephone companies should be permitted to define and adopt appropriate unit prices for switches and related equipment

Population Density
Although rural telephone companies may serve only approximately 5% of the US population, they do so over approximately 70% of the land area of the nation. The corresponding low population density for the typical rural telephone company forces such a company to incur disproportionately higher costs to provide service.

Customer Drops
The costs of terminals and drops vary greatly between zones of different population density. Within more densely populated areas, where subscribers are concentrated closer together, a design engineer can spread installation costs over a larger number of subscribers, particularly when pre-cabling subdivisions. Rural telephone companies should be permitted to adopt appropriate unit prices for drops.

This factor also affects the cross-connect or comparable flexibility-point technologies available to rural carriers. With greater drop spacing, the size of access cabinets is proportionately smaller. Rural telephone companies should be permitted to adopt appropriate unit prices for network interface devices.

Distances to subscribers - 1
Rural telephone companies must provide service from a single central office over a substantially larger area than would a large, urban ILEC. Even if one considers the use of remote serving unit technology, the physical network construction cost incurred by the rural telephone companies are substantially higher on a per-customer basis. To maintain network quality for the provision of contemporary services to schools, hospitals, and libraries, and of course, typical subscribers, as

well as enhanced services such as 911, rural telephone companies must engineer their networks with very different assumptions from those guiding the cost proxy model developers. Rural telephone companies should be permitted to define and adopt appropriate loop length calculation methodologies appropriate to the greater physical areas served. In passing, we note that these relatively long loops also will cause the rural telephone companies to incur greater maintenance and operating costs, further justification for modification of the unit costs.

Distances to subscribers - 2

In general, the length of drops to subscribers is greater in rural areas than in urban areas. This is a function of the greater average distance of the customers from the main roads, which itself is a function of the comparatively larger average land holdings typical of rural areas. This spatial characteristic affects the cost proxy model in another significant way. The FCC has determined that actual customer locations should be used with the cost proxy model, accepting the suggestion to use actual geocoded data if available and road network information where actual data are not available. However, According to the FCC's *Fifth Report & Order*, "the majority of commenters indicate that their geocode success rates decrease in rural areas."[2] Complicating the problem is the fact that the larger land holdings render the alternative (that is, use of the road network as a surrogate) non-viable without significant modification. Rural telephone companies should be permitted to define and adopt appropriate mechanisms for calculating rural subscriber locations.

Commercial Considerations

Transportation Costs

The relatively remote nature of rural telephone companies also contributes to higher network construction costs. Rural telephone companies incur higher transportation costs for equipment and material than do urban companies located closer to production facilities. Even in cases where urban carriers are located at some distance, the larger volume of purchases ensures discounts for transportation that are not available to smaller rural telephone companies. Rural telephone companies should be permitted to define and adopt a factor to incorporate equipment and material transportation costs into the unit price scheme. Alternatively, this problem offers further evidence for the need for flexibility in defining unit prices.

Other Service Costs

As with transportation costs, large urban ILECs can demand and expect to receive substantial discounts for construction service prices based on volume. No such volume discounts for construction services are available to rural telephone companies. Similarly, rural telephone companies can expect to pay proportionately higher costs for splicing services (and equipment such as fusion splicers), inspection services, locating services, maintenance and repair services, equipment installation and test services and other similar professional/technical services. Rural telephone companies should be permitted to define and adopt a factor to incorporate professional and technical costs into the unit price scheme. Alternatively, as with transportation, this problem offers further evidence for the need for flexibility in defining unit prices.

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[2] Federal-State Joint Board on Universal Service, CC Docket 96-45 and CC Docket 97-160, *Fifth Report & Order*, October 28, 1998, paragraph 34, footnote 71.

Structure Sharing

All versions of the cost proxy models (whether submitted and/or adopted) endorse sharing network construction costs among several companies where feasible. In brief, the concept assumes that several companies could use some or all support structures in a telephone network simultaneously. For example, in theory several companies could bury cables in a common trench with shared conduits and innerducts.

There are several tangible practical issues associated with structure sharing in rural areas that cost proxy models ignore. Most significant for rural telephone companies is the assumption that shared trench and conduit construction is even an economically feasible option. The predominant placement techniques in rural areas are direct cable plowing and aerial cable placement. For obvious reasons, the opportunities for structure sharing when directly plowing cable are limited. However, numerous problems also limit the opportunity for structure sharing with aerial placement.

The number of companies that may attach facilities to a pole depends primarily on the height of the pole, the class of the pole, and the number of pre-existing attachments. The height of the pole is a factor because federal, state, and local laws and ordinances, as well as safety considerations, mandate certain minimum clearances over roadways and railroad tracks below the cable span. Similarly, the class of the pole, which corresponds to the diameter of the pole, determines the total load that the pole may bear and the support guying required. Other parameters, such as the weight of the cable, also influence the minimum height at which users may attach cables to poles. In combination, these constraints determine the maximum theoretical number of cables that users may attach.

Rural aerial plant generally must cover significant distances at minimum cost through areas not reached by high volume roadways. This dictates that aerial plant will be constructed with poles that are placed at greater intervals than in urban areas. To reduce costs further, shorter poles are used. In combination, this means that mid-span sag will bring the cable much lower to the ground that the cost proxy model designers anticipated. Because the poles are smaller, there are fewer opportunities for structure sharing due to the reduced load-bearing capability of the poles. Consequently, rural telephone companies must be permitted to make significant changes to the assumed percentage of structure sharing in any cost proxy model.

Conclusion

The cost proxy models currently proposed by the FCC were built using input values (unit prices, engineering practices, structure sharing assumptions and similar variables) that were defined by the experience of large, predominantly urban-area ILECs. Such values are completely unsuitable for small, rural telephone companies for the reasons outlined here.

The large urban ILECs recognize the financial and commercial disincentives to providing services in rural areas that have been outlined here. That is why the large urban ILECs frequently have traded properties in rural areas, either to eliminate the problem by getting rid of the franchise area or to aggregate territories to achieve volume discounts in purchasing, transport and construction.

The question of the applicability of cost proxy models in the context of universal service remains open to public debate. To ameliorate the specific issues noted here and to accommodate the concerns of universal service, rural carriers must be allowed significant latitude in redefining, and in some cases supplementing, input values.

**Predicting Pre-monsoon Thunderstorms –
A Statistical View through Propositional Logic**

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Abstract

Thunderstorms very close to a monsoon and not so close to a monsoon are considered in this analysis. Some important predictors are considered. Pearson Correlation Coefficient and lag-1 autocorrelation coefficients are calculated to create necessary universes of discourse for propositional logic. The purpose is to make regression analysis more convenient for prediction of the pre-monsoon thunderstorm weather phenomenon.

Key words: Predictor, Predictand, Pre-monsoon, Pearson Correlation Coefficient, Autocorrelation, Propositional Logic

1. Introduction

The severe thunderstorm is a very important weather phenomenon in Gangetic West Bengal (GWB) during March to May. Thunderstorms of this period are called pre-monsoon thunderstorms. The present study encompasses some important parameters associated with pre-monsoon thunderstorms and tries to identify one or more important predictors and predictands so that in the future, regression analysis (simple or multiple) can be done conveniently to study pre-monsoon thunderstorms. Moreover, the study further tries to understand whether a particular predictor can be used with the same predictand to analyze the thunderstorms very close to a monsoon as well as thunderstorms not very close to a monsoon. Because the dataset is vastly complex, the study has relied on the kind of robust summary offered by a linguistic proposition applied to statistical measures. Two consecutive months of pre-monsoon season are considered in this study.

2. Data

The dataset consists of the values of some parameters associated with severe thunderstorms of April and May occurring over GWB between 1987 and 1998. The total number of thunderstorms considered in this study is 130. Parameters considered for this study are:

- Duration (d) of the thunderstorm
- Change in air pressure (ΔP) during the thunderstorm
- Change in surface temperature (Δ T) during the thunderstorm
- Maximum wind speed (v) associated with the thunderstorm
- Change in relative humidity (Δ R/H) during the thunderstorm.

3. Methodology

The methodology adopted in the present study consists of

- Calculation of Pearson Correlation Coefficient (PCC)
- Testing for persistence
- Propositional logic

3.1 Pearson Correlation Coefficient (PCC)

Pearson Correlation Coefficient (PCC) measures the degree of association between two variables 'x' and 'y'. Mathematically PCC is defined as

$$\rho_{xy} = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2}\ \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \bar{y})^2}} \qquad (1)$$

where, $n \rightarrow$ Total number of observations

$\bar{x} \rightarrow$ mean of the variable 'x'

$\bar{y} \rightarrow$ mean of the variable 'y'

In the present paper the following PCC's are calculated;

$\rho_{d\Delta P}$, $\rho_{d\Delta T}$, ρ_{dv}, $\rho_{d\Delta R/H}$, $\rho_{v\Delta P}$, $\rho_{v\Delta T}$, $\rho_{v\Delta R/H}$, $\rho_{\Delta R/H\Delta P}$, $\rho_{\Delta R/H\Delta T}$, $\rho_{v\Delta R/H}$

The aforesaid quantities are calculated separately for April and May for each year.

3.2 Testing for persistence

Persistence means existence of statistical dependence among successive values of the same variable (Wilks, 1995). Persistence is measured by lag-1 autocorrelation defined as;

$$r_1 = \frac{\sum_{i=1}^{n}\left[(x_i - \bar{x}_-)(x_{i+1} - \bar{x}_+)\right]}{\left[\sum_{i=1}^{n}(x_i - \bar{x}_-)^2 \sum_{i=2}^{n}(x_i - \bar{x}_+)^2\right]^{1/2}} \qquad (2)$$

where $\bar{x}_- =$ Mean of first (n-1) data values

$\bar{y}_+ =$ Mean of last (n-1) data values

In the present paper, PCC's mentioned in section 3.1 are considered as a dichotomous random variable X defined as

$$X = 1 \quad \text{if } |\rho| < 0.5$$
$$= 0 \quad \text{if } |\rho| \geq 0.5 \qquad (3)$$

Then, sequences of entries 0 and 1 are constructed separately for April and May. In the next step, the lag-1 autocorrelation coefficient is calculated for each sequence.

3.3 Propositional logic

Propositional logic is a generalized logic that includes all possible values between 0 and 1. In this logic, a relationship is required to express the distribution of the truth of a variable (Klir and Folger, 2000). A function called a "membership function" is needed to indicate the extent to which a variable 'x' has the attribute 'F'. Membership functions are defined on a universe of discourse indicated by the research variable.

In the present paper, lag-1 autocorrelations create the required universes of discourse. X1 is the universe of discourse for April and X2 is the universe of discourse for May. The proposition 'P' tested for the present study is:

> "The degree of association between any pair of parameters is consistently very high is very true".

Thus, the membership function is framed as

$$\mu(x) = 0 \quad \text{for } x < 0.5$$
$$x/0.6 \quad \text{for } 0.5 \leq x \leq 0.6 \qquad (4)$$
$$1 \quad \text{for } x > 0.6$$

3. Result and discussion

From the above study the following are found (Fig.1) to be highly true:

(a) In the month of April, maximum wind speed associated with a severe thunderstorm is mostly dependent upon the change in air pressure during the thunderstorm. But, the dependence is less in the month of May.

(b) In the month of May, maximum wind speed associated with a thunderstorm depends mostly upon the change in relative humidity during the thunderstorm. Whereas, in April, maximum wind speed has no relationship with the change in relative humidity during the thunderstorm.

(c) Change in the surface temperature during a thunderstorm depends highly upon duration of the thunderstorm in April. But, in May, they have almost no association.

(d) In the month of May, change in relative humidity during thunderstorms depends upon the duration of the thunderstorm. Whereas, in April, these two parameters have no association.

(e) Degree of association between change in air-pressure and change in relative humidity remains almost the same in the months of April and May.

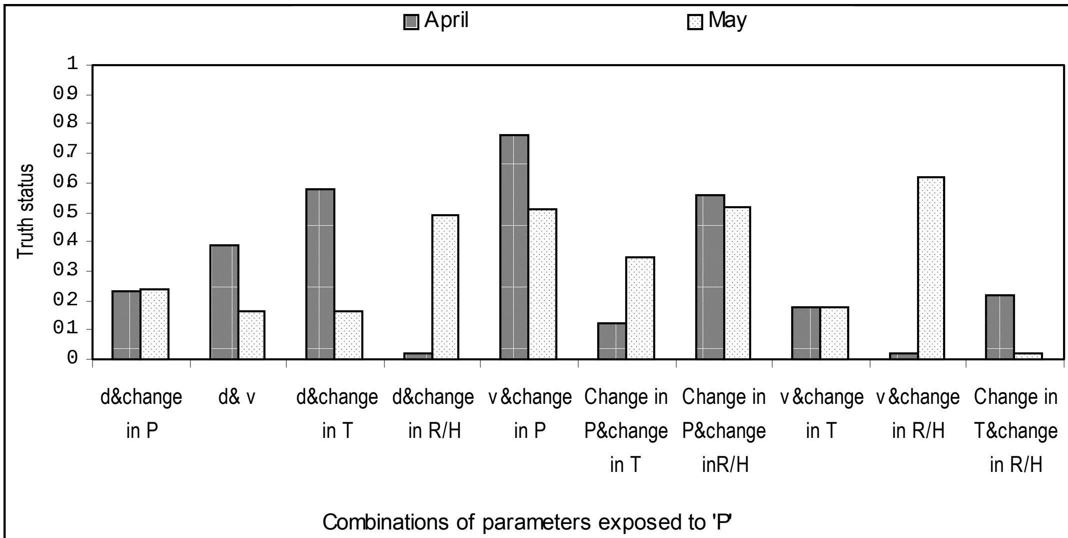

Fig.-1Schematic presentation of the truth status of the proposition 'P'applied to different pairs of parameters associated w ith sev ere pre-monsoon thunderstorms ov er GWB.

4. Conclusion

From the above study it can be concluded, in the study area, that if maximum wind speed associated with a severe thunderstorm is considered as a predictand, then change in air pressure is a good predictor in the month of April and change in relative humidity is a good predictor in the month of May. Duration of a thunderstorm can be used as a good predictor with change in surface temperature as predictand in the month of April and with change in relative humidity as predictand in the month of May. It can further be concluded that relation between change in air pressure and change in relative humidity does not change in spite of advancement of monsoon.

5. Acknowledgement

The author wishes to thank RMO Kolkata for providing data.

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Disaggregation and Targeting of Universal Service Support

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Introduction

The actual cost of providing telecommunications services in rural America is generally higher, per customer, than is the cost of providing these services in urban areas. This difference is due in part to the lower density of population of rural areas. Rural carriers, in contrast to urban carriers, have fewer customers to share basic fixed costs (for example, switches) and these customers are separated by greater distances, increasing outside plant costs, than are their urban counterparts. The disparity in costs is also related to the economies of scale and economies of skill enjoyed by large urban carriers that are not available to rural carriers. For example, the Federal Communications Commission�s forward-looking economic cost model shows a cost of $866.27, without adjustment for overhead costs, to provide a local loop in a Wyoming wire center, compared to a cost of $9.97 to provide a local loop in a New York City wire center.

During the era of monopoly service, the disparity in costs between rural and non-rural service was addressed through implicit subsidies between geographic areas and classes of service. Between 1984 and 1996, a series of opinions, rulings and regulations began to coalesce and focus attention on the need to restructure these subsidies. The Telecommunications Act of 1996 had three primary goals: to promote competition, to reduce regulation, and to ensure all Americans receive the benefits of telecommunications (that is, to ensure universal service). Under the provisions of the Act, universal service would continue to be subsidized, satisfying the third of these goals, but the previously implicit subsidies would be transformed into explicit subsidies. This transformation would also further the first goal by making federal universal service support portable to all certified eligible telecommunications carriers.

Federal universal service support consists of three categories of support, with a fourth category scheduled for implementation in the near future. The first category is High Cost Loop Support, or HCLS. This category focuses on the costs associated with high-cost local loop outside plant costs. The second category is Long Term Support, or LTS. This category provides support for the interstate loop cost of rate-of-return carriers that participate in the National Exchange Carrier Association (NECA) common line pool. The FCC tentatively has concluded that LTS should be merged with Interstate Common Line Support (ICLS) as of July 1, 2003, after which participation in the NECA common line pool would not be required for receipt of support. The third category is Local Switching Support, or LSS. As its name suggests, this category focuses on the relatively higher costs for carriers with fewer than 50,000 access lines of providing basic switching services. All three categories of support are affected by a process known as the �averaging� of support.

Averaging of Support

Under existing embedded cost mechanisms, federal universal service high-cost support for rural carriers is averaged across all lines served by a carrier within its study area. The FCC�s definition of a �study area� confirms a specific service territory and states that �[study area boundaries shall be frozen as they are on November 15, 1984� to reflect �[a] telephone holding company�s operations within a single state. Figure 1 represents an hypothetical study area with a centrally located town (the shaded oval). The difficulty with averaging support across all lines served by a carrier within a study area is that the support in low-cost areas of a study area may exceed the cost of serving those areas while support in high-cost areas may be insufficient to offset the higher cost of serving those areas.

The Rural Task Force (RTF), an independent advisory panel appointed by the Federal�State Joint Board on Universal Service to provide guidance on universal service issues affecting rural telephone companies, produced a series of six white papers detailing the results of its inquiry and its recommendations to the Federal Communications Commissions (FCC), which culminated in an FCC Order.[1] Two of these white papers were dedicated to the question of averaging support. The RTF recommended that rural carriers should be permitted to depart from study area averaging and to disaggregate and target per-line high-cost universal service support (that is, HCLS, LTS and LSS) to geographic areas below (that is, smaller than) the study area level. Disaggregation to this finer level of granularity would define per-line support that would reflect the actual cost of providing service in particular geographic sub-areas within the study area.

Disaggregation Paths

The RTF stated that rural carriers needed flexibility in the manner in which federal high-cost universal service support is disaggregated and targeted due to variations in the characteristics and operating environments of rural carriers. To provide this flexibility, the RTF recommended a disaggregation system that consisted of three options or �paths.� These paths would allow rural carriers to identify zones of relative cost variation (if any) and to develop appropriate methods of specifying which zones should receive more support.

The FCC adopted the RTF�s recommendation of three paths for disaggregation and targeting of high-cost universal service support. The FCC agreed that there should be flexibility in the manner in which support was disaggregated and targeted for rural carriers. The FCC confirmed that support should be disaggregated and targeted below the study area level to ensure that per-line level of support would be more closely associated with the cost of providing services.

- *Path One*

  Path One allows a carrier to certify to the state commission or other appropriate regulatory authority that it does not want to disaggregate support (Figure 2). However, a state could require disaggregation and targeting of support, either on its own motion or on the motion of an interested party, in which case the carrier would be required to disaggregate its support zones. After selection, the plan will remain in effect until a state commission or appropriate regulatory authority requires, on its own motion or upon petition by an interested party (including the affected carrier), a change to a different disaggregation and targeting methodology. The rationale for these restrictions was the desire to eliminate �gaming� of the system.
- *Path Two*

  Path Two is available to carriers that want state commission review and approval of a relatively complex disaggregation plan. Path Two allows a carrier to disaggregate and target support to multiple levels below a wire center. A disaggregation and targeting method can be tailored with precision, subject to state approval, to the cost and geographic characteristics of the carrier and the competitive and regulatory environment (Figure 3). The plan must show a per-line amount of support for each element in each disaggregation zone. Path Two provides the most flexibility in the development of a disaggregation plan, but also provides for regulatory approval to ensure that the methodology implemented is competitively neutral.
- *Path Three*

  Path Three would permit carriers to self-certify a method of disaggregation with the state commission or other appropriate regulatory authority. Path Three Permits carriers to choose 1) a disaggregation plan of up to two cost zones per wire center (Figure 4) or 2) a disaggregation plan that complies with a prior regulatory determination.

  Under the terms of Path Three, self-certifying carriers must provide state regulators (or other appropriate regulatory authority) and the Universal Service Administrative Company (USAC) with a description of the rationale used to disaggregate support, including the methods and data, and a discussion of how the plan complies with the self-certification guidelines. If the plan uses a benchmark, it must be generally consistent with how the total study area level of support for each category of costs (HCLS, LSS and LTS) is derived, to enable a competitor to compare the disaggregated costs used to determine support for each zone. The plan must show a per-line amount of support for each element in each disaggregation zone.

Levels of Support

The FCC order requires that an incumbent carrier�s total support for a given study area using the chosen disaggregated method must equal the total support available in that study area on a non-disaggregated (that is, averaged) basis. In this way, the FCC sought to limit the impact of disaggregation on the universal service funding requirements.

The FCC also requires that the relative per-line support relationships between disaggregation zones for each disaggregated category of support must remain fixed over time and that such relationships must be made publicly available. That is, the FCC requires that the per-line support for each category of support (HCLS, LTS & LSS) in each disaggregation zone must be determined so the relative support relationships between zones will be maintained.

The FCC recognized that there is some variation in costs with different categories of support. Specifically, the HCLS and LTS mechanisms support loop costs and therefore share similar cost characteristics. Carriers would be required to allocate the same ratio of HCLS and LTS to each disaggregation zone. However, a carrier�s local switching cost characteristics might differ from its loop cost characteristics in different disaggregation zones. Therefore, it would be allowed to allocate a different ratio for LSS to the extent that the cost characteristics of providing loop and switching service in disaggregation zones differ.

The FCC requires that the product of all of the ILEC�s lines for each cost zone multiplied by the per-line support for those zones when added together must equal the sum of the ILEC�s total level of support. FCC requires that per-line support amounts for each zone must be recalculated whenever an ILEC�s total annual support changes. The recalculated support amount must be based on the changed support amounts and lines at that point in time.

After a CLEC is designated as a competitive eligible telecommunications carrier (CETC) in a rural study area, determination of per-line amounts of support for the CLEC will be based on the ILEC�s total support levels, lines and disaggregated support relationships.

Timeframes

In its order, the FCC directed carriers to choose a disaggregation path within 270 days of the effective date of the rules adopted in the order. The order stated that carriers that failed to do so would not be permitted to disaggregate and target support unless ordered to by an appropriate regulatory authority. This requirement meant that carriers were required to submit their disaggregation plans to USAC no later than March 18, 2002. The FCC�s Multi-Association Group (MAG) Order extended this date to May 15, 2002. (We note in passing that this extension resolved an ambiguity in the original order that in at one case suggested a date of March 15, rather than March 18.)

A carrier electing Path Two or Path Three must, by May 15, 2002, file with the relevant state regulatory authority its proposed disaggregation plan or its self-certified disaggregation plan. State approval of a carrier�s proposed disaggregation plan pursuant to Path Two would not be required by that date, but the disaggregation plan could not go into effect until approval was received.

After selection, the Path will remain in effect until a state commission or appropriate regulatory authority requires a change to a different disaggregation and targeting methodology. Such a requirement could be based on its own motion or on petition by an interested party (including the affected carrier).

Restrictions

The FCC adopted several general restrictions for all paths.

- *Competitive Carrier Designated*

  For study areas in which a CLEC was designated as a CETC prior to the effective date of these rules, an ILEC could elect Path Three only to the extent that it was self-certifying a disaggregation and targeting plan that had already been approved by the state.

  In all other instances in which an eligible CLEC had been designated as a CETC prior to the effective date of these rules, the ILEC must seek prior state approval of its disaggregation and targeting plan under Path Two.
- *Certifying Boundaries*
  Rural ILECs must submit to USAC maps in which the boundaries of the designated disaggregation zones of support are clearly specified, which USAC will make available for public inspection by competitors and other interested parties.
- *Algorithm Used*

  FCC required that, when submitting information in support of self-certification, a carrier must provide USAC with publicly available information that allowed competitors to verify and reproduce the algorithm used to determine zone support levels. The carrier also must demonstrate that the underlying rationale is reasonably related to the cost of providing service for each cost zone within each disaggregated category.

- *Certification*
  FCC requires carriers electing Path One to submit to USAC a copy of the certification to the state commission or appropriate regulatory authority certifying that it will not disaggregate and target support.
  Carriers selecting Path Two must submit a copy to USAC of the order approving the disaggregation plan submitted by the carrier to the state commission or appropriate regulatory authority. Carriers selecting Path Two also must submit a copy of the disaggregation plan approved by the state commission or appropriate regulatory authority.
  Carriers selecting Path Three must provide the state and USAC with a description of the rationale used to disaggregate support, including the methods and data, and a discussion of how the plan complies with the self-certification guidelines. The plan must show a per-line amount of support for each element in each disaggregation zone.
- *MAG Plan*
  The initial purpose of the disaggregation and targeting Paths was to allocate appropriate levels of support to geographic sub-areas within a study area. This purpose has been extended, at least by implication, as a result of the MAG Plan�s application of the same zones.[2]
  In the MAG Plan Order, the FCC ordered that the RTF system for geographic disaggregation and targeting below the study area level would also apply to the newly-defined Interstate Common Line Support (ICLS) category of portable high-cost universal service support. The FCC noted that disaggregation by allowing ILECs to target explicit universal service support to regions within a study area that costs relatively more to serve would ensure that a competitive entrant would receive targeted support only if it also serves the high-cost region. Disaggregation would prevent the competitive entrant from receiving greater support than was needed to serve relatively low-cost regions, a circumstance that would give the competitive carrier a potential price advantage over the incumbent.
  The FCC noted that the same three paths would be available for the disaggregation of ICLS as for other types of support defined in the RTF Order. The MAG Plan Order extended the deadline for selecting a path to May 15, 2002 and reaffirmed that after that date a carrier would not be permitted to disaggregate and target support unless ordered to do so by a state commission or other appropriate regulatory authority.
  The MAG Plan order confirmed that a carrier�s choice of disaggregation paths would remain in place for four years, unless a state commission or other appropriate regulatory authority ordered disaggregation and targeting of support in a different manner. Rate-of-return carriers would be required to select identical disaggregation zones for all forms of high-cost universal service support, with the exception of forward-looking intrastate high-cost support received by non-rural carriers that are also rate-of-return carriers. For example, if a rural rate-of-return carrier self-certified two cost zones per wire center under Path Three, it would be required to disaggregate all forms of high-cost universal service support -- HCLS, LTS, LSS and ICLS -- to the same two cost zones per wire center. The FCC noted that there was no reason why support should be allocated differently in different disaggregation zones.
  The FCC reaffirmed that there is some variation in costs with different categories of support. The HCLS, LTS and ICLS mechanisms support loop costs and share similar cost characteristics; carriers are required to allocate the same ratio of HCLS, LTS and ICLS to each disaggregation zone. However, a carrier�s local switching cost characteristics might differ from its loop cost characteristics in different disaggregation zones. Therefore, it would be allowed to allocate a different ratio for LSS to the extent that the cost characteristics of providing loop and switching service in disaggregation zones differ.
  The FCC rules for the disaggregation and targeting of portable ICLS and LTS apply to both rural and non-rural rate-of-return carriers. Non-rural rate-of-return carriers are required to adopt a disaggregation and targeting path only for their receipt of ICLS and LTS. Non-rural intrastate high-cost support, including forward-looking high-cost support and interim hold-harmless support, will continue to be targeted to high-cost wire centers, consistent with FCC rules for targeting such support to high-cost wire centers.

Conclusion

Although the deadline for filing a disaggregation plan may have passed by the time this article appears, that deadline may have been extended as it was with the release of the MAG Plan. In any event, any carrier may file a request with the appropriate regulatory authority to investigate a change in disaggregation at any time. Therefore, it remains appropriate to consider whether, and how, a rural rate-of-return carrier should disaggregate and target support.

The range of specific circumstances that rural carriers face prevents us from offering a general recommendation regarding an approach to disaggregation. The significant amounts of support fund that are affected by this issue justify careful analysis of each individual case to ensure the availability of all appropriate support.

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[1] Rural Task Force, Competition And Universal Service, White Paper No. 5, September 2000; Rural Task Force, Disaggregation And TargetingOf Universal Service Support, White Paper No. 6, September 2000; *Federal-State Joint Board on Universal Service*, CC Docket No. 96-45, Recommended Decision, FCC 00J-4 (Joint Board released December 22, 2000) and FCC Fourteenth Report And Order, Twenty-Second Order On Reconsideration, And Further Notice Of Proposed Rulemaking In CC Docket No. 96-45, and Report And Order In CC Docket No. 00-256, released May 23, 2001.

[2] FCC Second Report And Order And Further Notice Of Proposed Rulemaking In CC Docket No. 00-256, Fifteenth Report And Order In Cc Docket No. 96-45, And Report And Order In CC Docket Nos. 98-77 And 98-166, released November 8, 2001.

L^1-CONVERGENCE OF COSINE SERIES WITH HYPER SEMI-CONVEX COEFFICIENTS

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and
S.S.BHATIA

Abstract. In this paper we obtain a necessary and sufficient condition for L^1-convergence of the Fourier cosine series with hyper semi-convex coefficients. Results of Bala R. and Ram B. [1] have been obtained as a special case.

2000 Mathematics Subject Classification: 42A20. 42A32

KEY WORDS AND PHRASES. Cesàro means, L^1-convergence, hyper semi-convexity.

1. Introduction. Consider

$$g(x) = \frac{a_0}{2} + \sum_{k=1}^{\infty} a_k \cos kx \tag{1.1}$$

to be the cosine series with partial sums defined by

$$S_n(x) = \frac{a_0}{2} + \sum_{k=1}^{n} a_k \cos kx$$

and let $g(x) = \lim_{n\to\infty} S_n(x)$

Concerning the L^1-convergence of cosine series (1.1) Kolmogorov [3] proved his well known theorem:

Theorem A. If $\{a_n\}$ is a quasi-convex null sequence, then for the L^1-convergence of the cosine series (1.1) it is necessary and sufficient that $\lim_{n\to\infty} a_n \log n = 0$.

Definition. A sequence $\{a_n\}$ is said to be semi-convex if $\{a_n\} \to 0$ as $n \to \infty$, and

$$\sum_{n=1}^{\infty} n|\Delta^2 a_{n-1} + \Delta^2 a_n| < \infty, \qquad (a_0 = 0)$$

where

$$\Delta^2 a_n = \Delta a_n - \Delta a_{n+1}$$

It may be remarked here that every quasi-convex null sequence is semi- convex.

Bala R. and Ram B. [1] have proved that Theorem A holds true for cosine series with semi-convex null coefficients in the following form:

Theorem B. If $\{a_k\}$ is a semi–convex null sequence, then for the convergence of the cosine series in the metric space L, it is necessary and sufficient that $a_{k-1} \log k = o(1)$.

We define $\{a_n\}$ to be hyper semi-convex of order α, in the following way:

Definition. A sequence $\{a_n\}$ is said to be hyper semi-convex, if

$$\{a_n\} \to 0 \text{ as } n \to \infty,$$

$$\sum_{n=1}^{\infty} n^{\alpha+1}|(\Delta^{\alpha+2}a_{n-1} + \Delta^{\alpha+2}a_n)| < \infty, \qquad \text{for } \alpha = 0, 1, 2 \ldots\ldots\ldots,$$

$$(a_0 = 0).$$

By definition, hyper semi-convexity of order zero is same as semi-convexity.

The purpose of this paper is to generalize the Theorem B for the cosine series with hyper semi-convex null coefficients.

2. Notation and Formulae. In what follows, we use the following notation [4]:

Given a sequence S_0, S_1, $S_2, \ldots\ldots\ldots\ldots$, we define for every $\alpha = 0, 1, 2 \ldots\ldots\ldots$,

the sequence S_0^α, S_1^α, $S_2^\alpha, \ldots\ldots\ldots$, by the conditions

$$S_n^0 = S_n,$$

$$S_n^\alpha = S_0^{\alpha-1} + S_1^{\alpha-1} + S_2^{\alpha-1} + \ldots\ldots + S_n^{\alpha-1} \qquad (\alpha = 1, 2 \ldots\ldots, n = 0, 1, 2 \ldots\ldots).$$

Similarly for $\alpha = 0, 1, 2 \ldots$, we define the sequence of numbers

$A_0^\alpha, A_1^\alpha, A_2^\alpha, \ldots\ldots\ldots$ by the conditions

$$A_n^0 = 1,$$

$$A_n^\alpha = A_0^{\alpha-1} + A_1^{\alpha-1} + A_2^{\alpha-1} + \ldots\ldots + A_n^{\alpha-1} \qquad (\alpha = 1, 2 \ldots\ldots, n = 0, 1, 2 \ldots\ldots).$$

where A_p^α denotes the binomial coefficients and are given by the following relations.

$$\sum_{p=0}^{\infty} A_p^\alpha x^p = (1-x)^{-\alpha-1}$$

and $\tilde{S}_n^{\cdot}$ s are given by

$$\sum_{p=0}^{\infty} S_p^\alpha x^p = (1-x)^{-\alpha} \sum_{p=0}^{\infty} S_p x^p$$

Also

$$A_n^\alpha = \sum_{p=0}^{n} A_p^{\alpha-1}, \qquad A_n^\alpha - A_{n-1}^\alpha = A_n^{\alpha-1}$$

$$A_n^\alpha = \binom{n+\alpha}{n} \simeq \frac{n^\alpha}{\Gamma\alpha+1} \qquad (\alpha \neq -1, -2, -3 \ldots\ldots)$$

Also for $0 < x \leq \pi$, let

$$\tilde{S}_n^0 = \tilde{S}_n = \sin x + \sin 2x + \ldots\ldots\ldots\ldots + \sin nx$$

$$\tilde{S}_n^1 = \tilde{S}_1 + \tilde{S}_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + \tilde{S}_n$$

$$\tilde{S}_n^2 = \tilde{S}_1^1 + \tilde{S}_2^1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + \tilde{S}_n^1$$

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$$\tilde{S}_n^k = \tilde{S}_1^{k-1} + \tilde{S}_2^{k-1} \dots\dots\dots\dots\dots\dots + \tilde{S}_n^{k-1}$$

The conjugate Cesàro means $\tilde{T}_n^\alpha$ of order α of $\sum a_n$ will be defined by

$$\tilde{T}_n^\alpha = \frac{\tilde{S}_n^\alpha}{A_n^\alpha}.$$

2. Lemma. The following Lemma will be used for the proof of our result.

Lemma [2]. If $\alpha \geqslant 0,\ p \geqslant 0$,

(i) $\epsilon_n = o(n^{-p})$,

(ii) $\sum_{n=0}^{\infty} A_n^{\alpha+p} |\Delta^{\alpha+1}\epsilon_n| < \infty$, then

(iii) $\sum_{n=0}^{\infty} A_n^{\lambda+p} |\Delta^{\lambda+1}\epsilon_n| < \infty$, for $-1 \leq \lambda \leq \alpha$ and

(iv) $A_n^{\lambda+p}\Delta^{\lambda}\epsilon_n$ is of bounded variation for $0 \leq \lambda \leq \alpha$ and tends to zero as $n \to \infty$.

3. Main Result. We prove the following theorem:

Theorem 3.1. Suppose $\{a_n\}$ is a hyper semi–convex null sequence. Then the cosine series (1.1) converges in the metric space L if and only if $|a_{n-1}|\log n \to 0$ as $n \to \infty$.

If we take $\alpha = 0$, then this theorem reduces to the Theorem B of Bala R. and Ram B. [2].

Proof. We have

$$\begin{aligned} S_n(x) &= \sum_{k=1}^{n} a_k \cos kx \\ &= \frac{1}{2\sin x}\sum_{k=1}^{n} a_k \cos kx 2\sin x \\ &= \frac{1}{2\sin x}\sum_{k=1}^{n-1}(a_{k-1} - a_{k+1})\sin kx + a_{n-1}\frac{\sin nx}{2\sin x} \\ &\qquad + a_n\frac{\sin(n+1)x}{2\sin x} \end{aligned}$$

$$= \frac{1}{2\sin x}\sum_{k=1}^{n-1}(\Delta a_k + \Delta a_{k-1})\sin kx + a_{n-1}\frac{\sin nx}{2\sin x} + a_n\frac{\sin(n+1)x}{2\sin x}$$

Applying Abel's transformation, we have

$$g_n(x) = \frac{1}{2\sin x}\sum_{k=1}^{n-2}(\Delta^2 a_k + \Delta^2 a_{k-1})\sum_{\nu=1}^{k}\sin \nu x + (\Delta a_{n-1} + \Delta a_{n-2})\sum_{\nu=1}^{n-1}\sin \nu x$$
$$+ a_{n-1}\frac{\sin nx}{2\sin x} + a_n\frac{\sin(n+1)x}{2\sin x}$$

$$= \frac{1}{2\sin x}[\sum_{k=1}^{n-2}(\triangle^2 a_{k-1} + \triangle^2 a_k)\tilde{S}_k^0(x) + (\triangle a_{n-1} + \triangle a_{n-2})\tilde{S}_{n-1}^0(x)$$

$$+a_{n-1}\frac{\sin nx}{2\sin x} + a_n\frac{\sin(n+1)x}{2\sin x}$$

If we use Abel's transformation $\alpha + 1$ times, we have

$$S_n(x) = \frac{1}{2\sin x}\left[\sum_{k=1}^{n-(\alpha+2)}(\triangle^{\alpha+2}a_{k-1} + \triangle^{\alpha+2}a_k)\tilde{S}_k^\alpha(x) + \sum_{k=0}^{\alpha}(\triangle^{k+1}a_{n-k-1}\tilde{S}_{n-k-1}^k(x)\right]$$

$$+\frac{1}{2\sin x}\left[\sum_{k=0}^{\alpha}(\triangle^{k+1}a_{n-k-2}\tilde{S}_{n-k-1}^k(x)\right]$$

$$+a_{n-1}\frac{\sin nx}{2\sin x} + a_n\frac{\sin(n+1)x}{2\sin x}.$$

$$= \frac{1}{2\sin x}\left[\sum_{k=1}^{n-(\alpha+2)}(\triangle^{\alpha+2}a_{k-1} + \triangle^{\alpha+2}a_k)\tilde{S}_k^\alpha(x) + \sum_{k=0}^{\alpha}(\triangle^{k+1}a_{n-k-1}A_{n-k-1}^k\tilde{T}_{n-k-1}^k(x)\right]$$

$$+\frac{1}{2\sin x}\left[\sum_{k=0}^{\alpha}(\triangle^{k+1}a_{n-k-2}A_{n-k-1}^k\tilde{T}_{n-k-1}^k(x)\right] + a_{n-1}\frac{\sin nx}{2\sin x} + a_n\frac{\sin(n+1)x}{2\sin x}$$

Since $\tilde{S}_n$ and $\tilde{T}_n$ are uniformly bounded on every segment $[\varepsilon, \pi - \epsilon]$, $\varepsilon > 0$.

$$f(x) = \lim_{n\to\infty} S_n(x)$$

$$= \frac{1}{2\sin x}\left[\sum_{k=1}^{\infty}(\triangle^{\alpha+2}a_{k-1} + \triangle^{\alpha+2}a_k)\tilde{S}_k^\alpha(x)\right]$$

Thus

$$f(x) - S_n(x) = \frac{1}{2\sin x}\left[\sum_{k=n-(\alpha+1)}^{\infty}(\triangle^{\alpha+2}a_{k-1} + \triangle^{\alpha+2}a_k)\tilde{S}_k^\alpha(x)\right]$$

$$-\frac{1}{2\sin x}\left[\sum_{k=0}^{\alpha}(\triangle^{k+1}a_{n-k-1}A_{n-k-1}^k\tilde{T}_{n-k-1}^k(x)\right]$$

$$-\frac{1}{2\sin x}\left[\sum_{k=0}^{\alpha}(\triangle^{k+1}a_{n-k-2}A_{n-k-1}^k\tilde{T}_{n-k-1}^k(x)\right]$$

$$-\left(a_{n-1}\frac{\sin nx}{2\sin x} + a_n\frac{\sin(n+1)x}{2\sin x}\right)$$

$$\|f(x) - S_n(x)\| \leq \int_0^\pi\left|\frac{1}{2\sin x}\left[\sum_{k=n-(\alpha+1)}^{\infty}(\triangle^{\alpha+2}a_{k-1} + \triangle^{\alpha+2}a_k)\tilde{S}_k^\alpha(x)\right]\right|dx$$

$$+\int_0^\pi\left|\frac{1}{2\sin x}\sum_{k=0}^{\alpha}(\triangle^{k+1}a_{n-k-1}A_{n-k-1}^k\tilde{T}_{n-k-1}^k(x)\right|dx$$

$$+\int_0^\pi\left|\frac{1}{2\sin x}\left[\sum_{k=0}^{\alpha}(\triangle^{k+1}a_{n-k-2}A_{n-k-1}^k\tilde{T}_{n-k-1}^k(x)\right]\right|dx$$

$$+\int_0^\pi\left|\left(a_{n-1}\frac{\sin nx}{2\sin x} + a_n\frac{\sin(n+1)x}{2\sin x}\right)\right|dx$$

$$
\begin{aligned}
\|f(x)-S_n(x)\| \le\; & C\left[\sum_{k=n-(\alpha+1)}^{\infty}(\Delta^{\alpha+2}a_{k-1}+\Delta^{\alpha+2}a_k)\int_0^{\pi}\left|\tilde{S}_k^{\alpha}(x)\right|dx\right] \\
& +C\left[\sum_{k=0}^{\alpha}A_{n-k-1}^{k}|\Delta^{k+1}a_{n-k-1}|\int_0^{\pi}\left|\tilde{T}_{n-k-1}^{k}(x)\right|dx\right] \\
& +C\left[\sum_{k=0}^{\alpha}A_{n-k-1}^{k}|\Delta^{k+1}a_{n-k-2}|\int_0^{\pi}\left|\tilde{T}_{n-k-1}^{k}(x)\right|dx\right] \\
& +\int_0^{\pi}\left|\left(a_{n-1}\frac{\sin nx}{2\sin x}+a_n\frac{\sin(n+1)x}{2\sin x}\right)\right|dx \\
\le\; & C\left[\sum_{k=n-(\alpha+1)}^{\infty}A_k^{\alpha}|(\Delta^{\alpha+2}a_{k-1}+\Delta^{\alpha+2}a_k)|\int_0^{\pi}\left|\tilde{T}_k^{\alpha}(x)\right|dx\right] \\
& +C\left[\sum_{k=0}^{\alpha}A_{n-k}^{k}|\Delta^{k+1}a_{n-k-1}|\int_0^{\pi}\left|\tilde{T}_{n-k-1}^{k}(x)\right|dx\right] \\
& +C\left[\sum_{k=0}^{\alpha}A_{n-k}^{\alpha}|\Delta^{k}a_{n-k-2}|\int_0^{\pi}\left|\tilde{T}_{n-k-1}^{k}(x)\right|dx\right] \\
& +\int_0^{\pi}\left|\left(a_{n-1}\frac{\sin nx}{2\sin x}+a_n\frac{\sin(n+1)x}{2\sin x}\right)\right|dx \\
\le\; & C_1\sum_{k=n-(\alpha+1)}^{\infty}A_k^{\alpha+1}|(\Delta^{\alpha+2}a_{k-1}+\Delta^{\alpha+2}a_k)| \\
& +C_1\sum_{k=0}^{\alpha}A_{n-k+1}^{k}|\Delta^{k+1}a_{n-k-1}| \\
& +C_1\sum_{k=0}^{\alpha}A_{n-k+1}^{\alpha}|\Delta^{k}a_{n-k-2}| \\
& +O(a_{n-1}\log n) \qquad (C_1 \text{ is an absolute constant})
\end{aligned} \tag{3.1}
$$

The first three terms of the above inequality are of $o(1)$ by the Lemma and the hypothesis of theorem.

Because,

$$
\begin{aligned}
& \int_0^{\pi}\left|\left(a_{n-1}\frac{\sin nx}{2\sin x}+a_n\frac{\sin(n+1)x}{2\sin x}\right)\right|dx \\
& \le |a_{n-1}|\int_0^{\pi}|D_n(x)|dx \\
& = O(a_{n-1}\log n) \qquad \text{as } \int_0^{\pi}|D_n(x)|dx \sim \log n.
\end{aligned}
$$

$\int_0^{\pi}|f(x)-S_n(x)|dx \to 0$ if and only if $|a_{n-1}|\log n \to 0$ as $n\to\infty$.

This completes the proof of the theorem.

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Spatial Synthesis: A Research Program

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�Spatial Analysis� is a term in current use in a variety of disciplines: from geography to regional analysis, to economics, to anthropology, to (no doubt) a host of others [1]. Merriam-Webster�s online Collegiate Dictionary defines �analysis� as a �separation of a whole into its component parts� [2]. Often, however, one wishes to consider not only separation but also composition: the composition of the whole from a set of parts. Thus, the same source defines �synthesis� as �the composition or combination of parts or elements so as to form a whole.�

We take the occasion of this Winter Solstice issue to invite the world at large to come together and offer a synthesis of ideas involving spatial concepts and theories, as a part of a broadly-based research program. Volume I of this work will concern the concept of spatial hierarchy. Book 1 (by the authors of this article) of Volume I, to appear, is entitled Centrality and Hierarchy: Regular Lattices, Geometry, and Number Theory. Other topics, that we might foresee, involve more books on Centrality and Hierarchy within Volume I as well as Volumes on topics such as (but not limited to): Distance and Geodesic; Adjacency and Connection; Minimax, Absolute/relative, and Density; Scale, Orientation, and Dimension; Partition, Separation, and Diffusion; and, Transformation and Symmetry.

The authors of this article would assemble, edit, obtain reviews, and work to obtain a publisher for a series of eBooks entitled �Spatial Synthesis.� In doing so, they would draw on their recent experience in publishing an eBook, and in developing websites, to make the final product one that employs a variety of interactive tools for communicating information on the internet [3, 4]. Issues involving agreements concerning publication would be dealt with at the outset according to the format of the publisher. If you would like to submit an idea for preliminary review, for suitability for inclusion, or if you would like to suggest yet other directions for this synthesis of spatial concepts and theories, please feel free to e-mail us or send e-mail attachments to: sarhaus@umich.edu. We wish to have this work be synthetic: from its method of creation through its content formulation. Please consider joining this venture in spatial synthesis.

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