SIMULATING SPRINGWELLS: A COMPLEX SYSTEMS APPROACH TOWARD UNDERSTANDING LATE PREHISTORIC SOCIAL INTERACTION IN THE GREAT LAKES REGION OF NORTH AMERICA

By

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ABSTRACT

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This dissertation examines the nature of Springwells phase (ca. A.D. 1160 to 1420) sociopolitical interaction and integration during the Late Prehistoric period (post A.D. 1000) in the Great Lakes region of North America. Combined ceramic analysis and computer simulation employing Agent Based Modeling (ABM) supports the interpretation that Springwells phase communities were organized in a form of sociopolitical integration most readily recognized as a loose confederation or interactive network of middle range, tribal societies spanning a broad area. The interpretation presented here differs from those in previous work in that it characterizes tribal sociopolitical organization as the embodiment of a complex system as outlined by the complexity science literature. A revised ceramics typology expands the resolution of the original Springwells phase ceramic typology, thus inserting a more fine-grained understanding of common stylistic design elements. This expanded taxonomy allows for increased resolution relating to the geographic distributions of Springwells stylistic motifs. Agent Based Modeling is then used to explore changes in relationships between cultural transmission (CT) and interactional exchange scenarios. A complexity science approach attributes the overall characteristics of the Springwells social network to emergent properties generated by individual agents that scale up and become recognizable at a system level. The advent of Late Prehistoric social complexity in the form of tribalization is seen as a social

response to widespread political developments in the region. ABM is seen as an important new analytic tool through which to explore the parameters of past social behaviors.

Dedicated to Sabian, Annie, Squeaky and Daisy,
the best family that anyone could ask for.

"Don't believe anything you hear and only half of what you see."
-Epistemological advice from my father, Barry T. Carroll,
paraphrasing Ben Franklin, circa A.D. 1980.

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CHAPTER I

Introduction

The current state of knowledge regarding the Late Woodland period (A.D 500-A.D. 1650) in the Great Lakes region of North America is uneven at best. The early Late Woodland period (A.D. 500-A.D. 1000) has been the subject of a great deal of archaeological research, and as a result, much has been learned about prehistoric Native American lifeways during this time (Brashler et al. 2000; Brashler et al. 1999; Brashler and Holman 1985; Fitting 1965; Halsey 1976; Murphy and Ferris 1990). Comparatively, the later portion of the Late Woodland period (post A.D. 1000), hereafter referred to as the *Late Prehistoric* (Genheimer 2000) is poorly understood. This dissertation reconstructs regional social networks using datasets generated from sites located in the Saginaw Valley as well as locations in southeastern Michigan, southwestern Ontario, and central Indiana during the Springwells phase (defined here as ca. A.D. 1160 to 1420) (Fitting 1965; McCullough and Graham 2010a; Murphy and Ferris 1990) of the Late Prehistoric period.

Late Prehistoric archaeological sites are relatively rare and some have argued that this disparity may be attributed to the wholesale destruction of the physical environments where these sites were located (Fitting and Zurel 1976). This, combined with incomplete survey/excavation data and a lack of synthetic research, are just a few reasons why this period of Great Lakes prehistory remains enigmatic. Several analyses have addressed Late Prehistoric archaeological assemblages and have been instrumental in establishing initial typologies and chronologies for the study region (Brose and Essenpreis 1973; Fitting 1965; Fitting et al. 1968; Greenman 1967; Murphy and Ferris 1990). A much smaller body of literature has reconstructed Late Prehistoric social networks in the aforementioned study region through formalized, systematic, transparent examinations of multiple datasets (Krakker 1983) (see Murphy and Ferris 1990 for a critique of regional synthetic interpretations of this period). Other researchers have addressed social interaction during temporal phases contemporaneous to Springwells but have concentrated their efforts primarily in different geographic locations (Howey 2006; McHale-Milner 1998).

This investigation examines the effects of Springwells social interaction on cultural transmission as established by Cavalli-Sforza and Feldman (1981) and later elaborated by others (Boyd and Richerson 1985; Eerkens and Lipo 2005, 2007; Henrich 2001; O'Brien 2008; O'Brien and Shennan 2010). Cultural transmission’s effect on material culture is examined through the methods of ceramics analysis and computer simulation. Ceramics data drawn from 20 sites across the study area are used to establish initial states for experimentation with a specific type of social science simulation known as Agent Based Modeling (ABM) (Gilbert and Troitzsch 2005; Gilbert 2008). This experiment in computational archaeology uses probabilities generated from simulations to inform interpretations of how indigenous Springwells groups interacted within the context of a regional social network as seen through a Complex Systems theoretical framework (Bentley and Maschner 2003a; Lansing 2006; Messina 2001). The expectation is that different interactional exchange scenarios will produce social effects that scale-up from the level of the individual to produce emergent phenomena at the regional sociospatial scale.

Questions of Anthropological Significance

We may think of the cultural transmission process as analogous to packets of information traveling from node to node within a network (Bentley 2010). If we accept this model then we may ask some basic questions about how a social network functions to facilitate the spread of information, and by extension culture, between its participants. We may ask for example, how information propagating through a social network is affected by the spatial distribution of the participants. How does the social context of exchange affect the rate at which culture is transmitted? We may also ask how the rate of cultural transmission varies between different types of societies such as bands or tribes. These three questions are of primary concern to this research because they have implications for establishing predictions for cultural transmission rates and social organization within networks.

Further, can archaeologists leverage these transmission patterns to interpret cultural processes reflected in the material record? What type of social changes may result in ceramic styles changing much more rapidly during the Late Prehistoric period in the Great Lakes region as compared to preceding periods? A two-pronged methodological approach using ceramic analysis and computer simulation will address these issues.

Project Research Design and Methodological Contribution

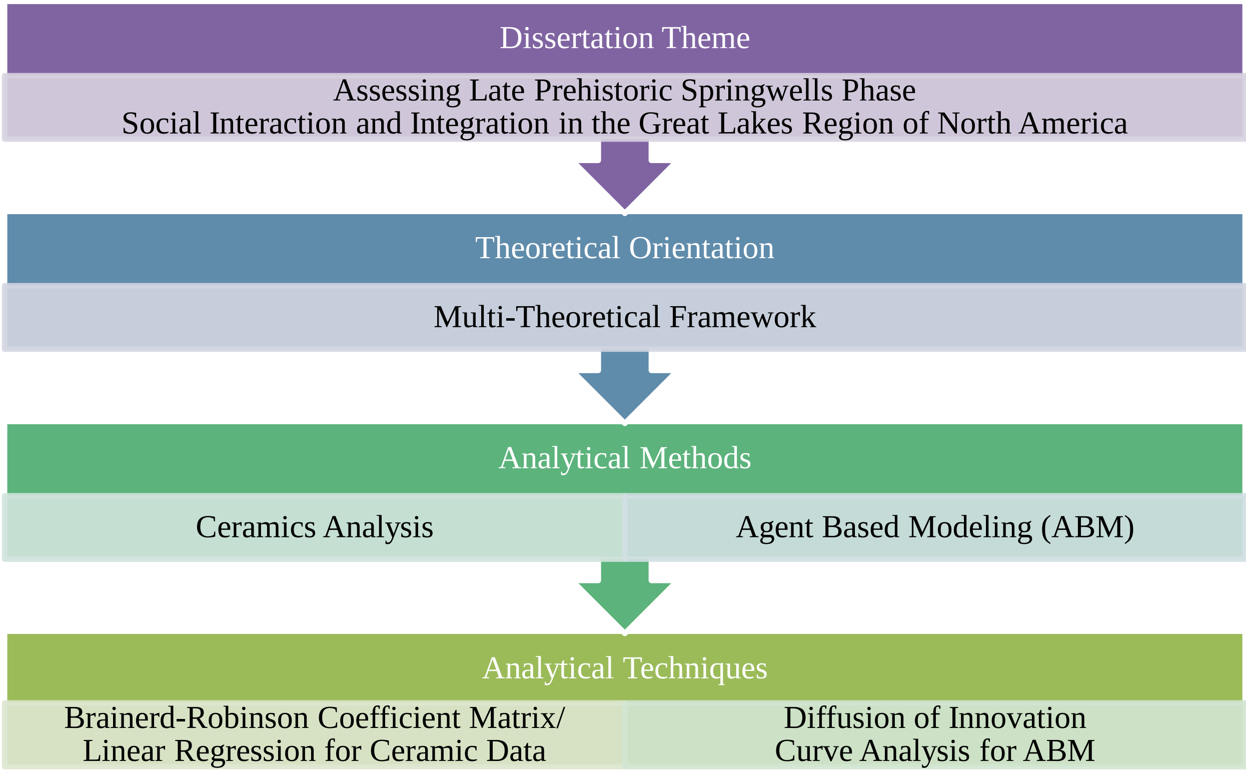
A complex systems approach for examining Late Prehistoric social interaction is chosen for three primary reasons. First, complex systems approaches focus on how entities interact in concert within open systems. As open systems are amenable to a variety of influences (Messina 2001), emergent properties such as changes in social interaction can occur suddenly and at different social and geographic scales (Bentley and Maschner 2003a). Studies that employ a complex systems approach focus on the interactions between agents in a system instead of reducing a system to its component parts for analysis. Second, complex systems approaches lend themselves particularly well to experimentation through modeling and simulation because of a researcher's ability to examine the effects of parameter changes on system interactions. Third, unlike other natural and social science disciplines, few archaeological or anthropological studies have incorporated complex systems approaches (for a more complete review see Beekman and

Baden 2005, Bentley and Maschner 2003b) and therefore the potential contributions of complexity science remain undefined. This is especially true for archaeologists working in the Eastern Woodlands of the United States. One objective of this study is to elucidate how implementing a complex system approach to archaeological interpretation may be achieved through a combination of ceramics analysis and computer simulation.

Specifically, this project demonstrates that computational simulation provides explanatory power for interpreting small archaeological datasets like those associated with the Late Prehistoric period. It does this by generating statistical probabilities regarding specific interactional scenarios. Variables are manipulated to reflect changes in population dynamics, frequencies of interaction, social affiliation and contexts of communication. The result is an ability to establish a "best fit" scenario for expected rates of stylistic change based on statistical probabilities. The research design diagram below (Figure 1) illustrates the logical flow from this dissertation's overarching theme to the theory, methods and techniques used to form the interpretations presented in Chapter VI.

As Bentley and Maschner (2008:262) have stated: "One of the major lessons of complexity theory is that interactions between people are at least as important as objective constants defined with respect to an external environment." By leveraging new theory, methods and data, the interpretations presented here address one such "window in the temple of knowledge" (William A. Lovis, personal communication 2005) regarding the nature and development of Springwells phase social networks in the Midwestern United States.

Figure 1. Research design diagram
(for interpretation of the references to color in this and all other figures, the reader is referred to the electronic version of this dissertation).



Research Objectives

This research analyzes spatial distributions of Springwells ceramic styles from twenty sites across the study area in order to produce a synthetic interpretation of social interaction and integration within a regional social network. Three overarching research questions are addressed:

1. How do social networks function to facilitate the spread of information, and by extension culture, between participants?
2. How does the social context of interactive exchange affect how culture is transmitted?
3. How does cultural transmission vary between societies with different forms of interaction and integration?

These objectives are designed to work in concert to address group interaction in different interactional scenarios within a series of embedded geographic scales. That is, each question is designed to provide information that will allow for the examination of group interaction within locales and between locales throughout the research area.

Context of Research

Why Springwells?

Murphy and Ferris (1990:245) report that the Springwells phase is the most extensively documented of all the Younge/Western Basin Tradition sites in southern Ontario; however, Late Prehistoric sites are still rare when compared to the number of sites dating to preceding periods. New datasets produced through recent field research primarily in Indiana complement an updated discussion of what is currently known about Springwells archaeology (See Figure 2 below for sites included in this analysis). Archaeological interpretation surrounding the Younge/Western Basin Tradition has been largely tied to the particular region from which a researcher is associated (Fitting 1965; Murphy and Ferris 1990; Stothers and Bechtel 2000), and regional syntheses have been skewed in ways that makes it difficult to objectively evaluate Springwells culture history except through a parochial lens. The work presented here employs an expanded geographic extent intended to explore interpretations at multiple scales.

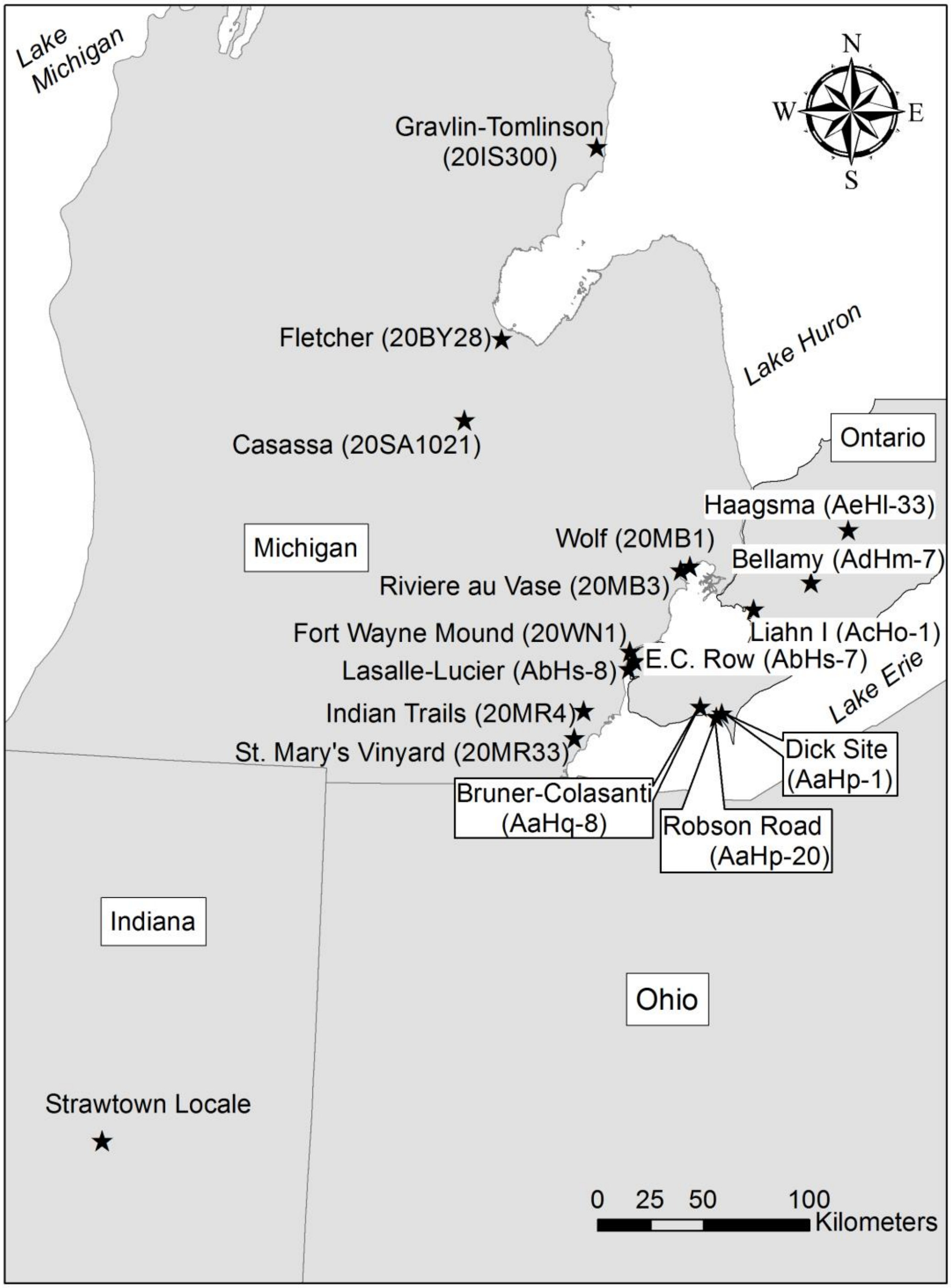
Several terms have been used to refer to Springwells societies and the three-phase Late Prehistoric period to which it belongs. These terms have largely varied by state or region, with the Springwells phase of the Younge Tradition used by those who work in Michigan (Brashler et al. 2000; Fitting 1965, 1975; Fitting and Zurel 1976), the Springwells phase of the Western Basin Tradition used by those who work in Ohio, northern Indiana and Canada (Murphy and Ferris 1990; Prahl et al. 1976; Schneider 2000; Stothers and Bechtel 2000), and the Castor phase used by those who work in central Indiana (McCullough and Graham 2010a:155). For the purposes of this discussion, all ceramics included in this volume (Figure 2) are referred to as "Springwells" regardless of the locally specific terminology. Further, a new temporal affiliation for Springwells communities is implemented here based on the upper and lower limits of radiocarbon dating for the Strawtown locale in Indiana (the most extensively excavated Springwells site in the study region), ca. A.D. 1160 to 1420.

Alternative Methods for Interpreting Small Datasets

There is no question that the limited numbers of Springwells sites and their associated artifacts have hindered archaeological interpretation for scientists working in the region. This combined with a lack of a comparative Springwells phase culture history assessing both artifact similarity and variability has made it difficult to agree on how to define Springwells. This dissertation adds to the archaeological knowledge base by synthesizing a new comparative framework focusing on the similarities of Springwells stylistic expression encoded in their archaeological ceramics.

The combination of data obtained through traditional archaeological ceramics analyses, and data obtained through computer modeling and simulation, provides enhanced interpretive confidence. This enhanced confidence is derived from the rigor provided by computation and its power to address outcome probability. Computation functions here to alleviate sample-size anxiety accompanying small datasets like those presented in this research.

Figure 2. Location of Springwells sites included in analysis.



Organization of Volume

Theoretical considerations relating to the study of complex systems, cultural transmission, the diffusion of innovations, and various forms of exchange theory are reviewed in Chapter II. The culture history of the Springwells phase and the regional archaeology of selected sites in Michigan, Indiana and Ontario are discussed in Chapter III. The ceramics datasets and the methodology employed to analyze them are presented in Chapter IV. This chapter focuses on categorical stylistic similarities in order to circumvent some of the pitfalls associated with inferential statistics and small sample sizes. A geostatistical analysis then complements the stylistic analysis to form interpretations regarding the spatial distributions of Springwells ceramic motifs. Agent Based Modeling (ABM) techniques are used in Chapter V to simulate Late Prehistoric social interaction and how changes in interactional scenarios affect material culture. Computer simulation augments ceramics analysis and provides a robust and rigorous methodology for interpreting small archaeological datasets. Finally, the study's findings, interpretations and future directions are discussed in Chapter VI. Ultimately, this research simulates how social interaction and integration influence material culture, and then applies these heuristics toward interpreting Springwells cultural processes during the Late Prehistoric period.

CHAPTER II

Theoretical Perspectives

Social scientists have used a variety of approaches to understand the impact of social interaction networks on material culture. First, a historical discussion of notable studies concerning exchange and interaction networks is presented. Second, the works relating to social interaction and information exchange literatures are discussed. Third, these topics are related to the cultural transmission literature and then ultimately tied to a complex systems framework that is the theoretical orientation of this study.

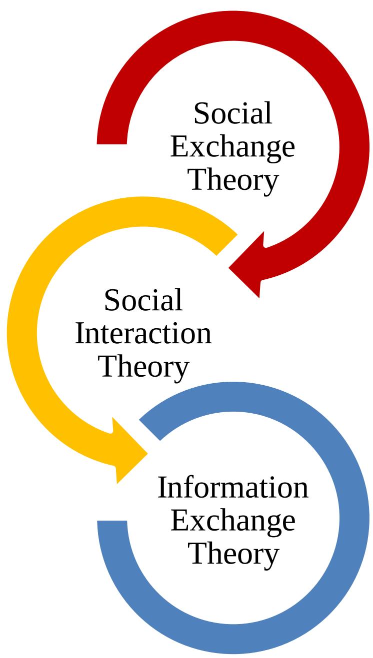
The Interplay between Social Exchange & Social Interaction

To establish working definitions for this discussion, *Social interaction* is defined as communication between people or groups (Stangor 2004:19), and *social exchange* is defined as movements of people or materials between groups (Parkin 1997:430). The study of social interactions both within and between groups has been of great scholarly interest to anthropologists, sociologists and social psychologists, and archaeologists have found social exchange systems worthy of study because these dynamics are reflected and preserved through artifacts present in the material record.

Social exchange and interaction allow people to establish and reinforce social relationships, transcend sociospatial boundaries, and redistribute both materials and information (Wilmsen 1972). These processes are inextricably linked dimensions of sociality (Figure 3), and it has been difficult for researchers to agree on exactly how to study these processes, with some placing analytical emphasis on the procurement and distribution of materials (the formalist approach) and some focusing on social contexts of exchange (the substantivist approach) (Dillian and White 2010; Wilk 1996). They are, in effect, two sides of the same coin; social exchange requires social interaction and social interactions are established and/or maintained through exchanges of material culture.

The research presented here does not focus on social exchange where emphasis is placed on the systems level (Baugh and Ericson 1994; Earle and Ericson 1977). Rather, the central goal is to explain how information moves through a social network starting at the individual level, thus changing and producing multi-scalar effects. Still, to get to that point it is useful to have historical understanding of how interaction and exchange have been studied in order to delineate traditional perspectives from those germane to a complex systems approach.

Figure 3. Theories relating to social exchange and interaction.



Social Exchange Theory

Social exchange theory can trace its origins back to the early twentieth century when Malinowski (1967[1920]) began conducting some of the first systematic research on non-western social exchange systems. Malinowski's description of the Kula exchange in the Trobriand Islands of the South Pacific is one of the most famed anthropological works in history. He describes in detail social relationships embedded in the Kula ritual, and how objects are exchanged in trading networks throughout the islands and circulate in prescribed directions. The Kula ring demonstrates how some small-scale societies engage in trade across great distances, maintaining complex relationships that both facilitate and perpetuate rigid exchange arrangements.

Later, Mauss (2000[1950]) used ethnographic data from cultures in Polynesia, Melanesia and the Pacific Northwest to further explore how individuals within societies are bound together through gift exchange. Mauss is perhaps best known for introducing the concept of reciprocity in exchange theory. He originally described the role of resource redistribution and reciprocity in social relations, and he proposed that exchange is governed by a complex series of obligations between parties. Mauss (2000:39[1950]) describes how the "three obligations: to give, to receive, to reciprocate" perpetuate exchange relationships through social debits and credits.

Sahlins (1972) further refined Mauss's concept of reciprocity by describing three different types that correlate with social distance: generalized, balanced and negative. The closer the social distance, the more generalized exchange, and as social distance increases, so do the chances that one will engage in a negative reciprocal relationship. Familiarity and kinship are the prime variables that influence the nature of exchanges in Sahlins' model. The interplay between social distance, exchange and interaction is an important and recurring theme and will be revisited at several points throughout this dissertation.

As anthropologists were examining exchange processes, researchers from other social sciences were also working to understand the phenomenon. Both sociologists and social psychologists have conducted a great deal of research examining the mechanisms of exchange. Stangor (2004) notes that there have been two main approaches used to study social exchange: group-level and individual-level approaches. The majority of sociologists have been concerned with understanding exchange from the individual's perspective, where anthropologists have been preoccupied with group-level analysis.

Homans (1958) and Emerson (1976) are two of the more influential sociologists that have studied social exchange. Homans was primarily concerned with the individual as the basic unit of analysis. In his model, the exchange of goods is inherently tied to social costs and benefits such as prestige and acceptance. Individuals participating in exchange networks seek to maximize profit as group relationships stabilize at the point of social cost/benefit equilibrium. Emerson's model proposed that exchange should be viewed through the lens of a value-added social process he called productive exchange. During the productive exchange process, individuals integrate themselves into the social network through production, with productive exchange acting as a bridge between the individual and the social spheres.

Taken as a whole, exchange theory has been used to describe how social relations affect the flow of materials through exchange networks (Stangor 2004). The socio-psychological school has been particularly concerned with how group membership rewards individuals for cooperation, and how they tend to maintain relationships that have minimal social costs and maximum social returns. The anthropological school has been generally concerned with how materials move through systems as well as how reciprocal relations, sociocultural context and sources of power function at the systems level.

Social Interaction Theory and Information Exchange Theory

Social interaction theory comes out of the work done by archaeologists in the 1960s and 70's (Deetz 1965; Engelbrecht 1974; Longacre 1970; Whallon 1968) performing what was called "ceramic sociology" (Sackett 1977) that sought to move beyond culture-historical descriptions of artifacts and see the social processes embedded in material culture. Voss and Young (1995:81) interpret that social interaction theory prescribes:

> 1. That the degree of stylistic similarity between communities, households, and individuals will vary inversely with physical and social distance; and 2. That the diversity of styles within a region will diminish with increasing interregional interaction.

Pioneering studies assessing intragroup (Longacre 1964, 1970) similarity and intergroup stylistic homogeneity (Whallon 1968) were executed using expectations derived from this developing theory.

Social interaction theory, however, is not without its detractors (Rice 1987:254; Voss and Young 1995:81). Critiques are based in the theory's inability to account for the social context of learning or for individuals to actively manipulate style, and also for several underlying assumptions regarding the impact of both spatial and social distances on stylistic components (Rice 1987:254) that will be discussed in greater detail in the ceramics analysis presented in Chapter IV. Voss and Young (1995) discuss the history and critique of social interaction theory in detail and note that the widespread acknowledgement of its shortcomings led to an interest incorporating information exchange theory into the study of style.

Information exchange theory states that “information emphasizes the proactive, motivated construction of the self and attended behavior” (Voss and Young 1995;82), and it is this proactive aspect that separates it from social exchange theory. Wobst’s (1977) exploration of style as a medium for information exchange is one such seminal work. He posits that material culture allows individuals to interact with their environment, reducing stress and facilitating predictable exchanges with others. The human capacity for symbolic thought allows for the exchange of energy, matter, and information, with stylistic messaging varying according to social distance. He contends the aforementioned explorations into ceramic sociology have produced little in the way of understanding how style functions within society. Much of the early ceramic sociologists see style represented passively in the material record.

Braun (1977:123) also sees information exchange theory as valuable in understanding social networks primarily because it accounts for the interplay between group membership and individual design as reflected by design elements. Additionally, these behaviors can be modeled through the implementation of ethnographically derived scenarios, which ground interpretations empirically.

The bases for critiques for information exchange theory include Sackett (1985) who rejects the notion that style is primarily active in its application, Hill (1985) who finds multiple aspects regarding the definitions of style ill-defined, and Hantman (1983) who calls into question the use of the information exchange model to account for all stylistic variation (Hegmon 1992).

Cultural Transmission and the Diffusion of Innovations

Anthropological applications of cultural transmission began in the 1980s as researchers in the subfields of psychological and educational anthropology started to consider its potential (Stark et al. 2008b). Cultural transmission (CT) theory differs from the theories discussed above because it focuses on the act of learning as knowledge is transmitted from one person to another (Schönpflug 2008:1), and much of the interest has come from those interested in evolutionary processes and the way in which continuity or change in material culture is produced through conscious choice or stylistic drift (O'Brien 2008; O'Brien and Lyman 2003; O'Brien and Shennan 2010).

Cavalli-Sforza and Feldman (1981) established one of the first models for CT rooted heavily in epidemiological models for genetic transmission. They define the terms through which culture moves between generations from parent to child (vertical transmission), from peer to peer (horizontal transmission), and from senior members of a group to junior members (oblique transmission). They also outline how the diffusion of innovations literature can be used to interpret adoption curves (Cavalli-Sforza and Feldman 1981:29).

Building on Cavalli-Sforza and Feldman's (1981) work on establishing modes of CT, Boyd and Richerson's (1985) work set the stage for contemporary studies by examining the transmission of culture between generations in a framework they called "Dual Inheritance Theory" (Boyd and Richerson 1985; 2005:103) where both culture and genes are transmitted between generations each with vital influence from preceding generations. That is not to say that genes and packets of cultural information travel through societies at the same rates or in the same manner. This phenomenon referred to as "population-level consequences" (Boyd and Richerson 1985:4) means that cultural elements that vary at the individual level die out unless they are acquired and perpetuated at the scale of the population. Variation may arise from multiple trajectories including guided variation, biased transmission, natural selection, frequency-dependent bias and indirect bias (Table 1).

Table 1. Characteristics of varying forms of cultural transmission (Boyd and Richerson 1985).

<table>
<tr><th>Transmission Mode</th><th colspan="2">Characteristics</th></tr>
<tr><td>Guided Variation (GV)</td><td colspan="2">People directly copy one variant and modify to suit individual needs.</td></tr>
<tr><td rowspan="3">Biased Transmission (BT)</td><td>Direct Bias:</td><td>One variant is more appealing after trying all alternatives.</td></tr>
<tr><td>Indirect Bias:</td><td>People directly copy ideal variant from most successful option.</td></tr>
<tr><td>Frequency-Dependent Bias:</td><td>The most popular variant is used by default.</td></tr>
<tr><td>Natural Selection (NS)</td><td colspan="2">Variant best serves needs of population compared to other variants available. NS acts differently than GV or BT. GV increases number of variants possible, BT culls number of variants, NS is an autonomous variable that does not depend on the presence of GV or BT.</td></tr>
</table>

Eerkens and Lipo's (2005) work on CT and the generation of copying errors in material culture is of central importance to archaeologists because they stress the effects of human perception and error on the material record. They model scenarios where vertical, horizontal and oblique transmission modes produce copying errors unique to each process. They also expound upon the range of transmission modes to present additional factors such as prestige, clique consensus and average population values for a specific trait. Using archaeological data obtained from California projectile points and Illinois pottery, the authors simulate variation in copying errors over time. They found that a combination of copying errors and drift limiting processes account for the variation in projectile points for basal thickness and width respectively. Variation in Illinois pottery vessel diameter was attributed to deliberate experimentation.

If one subscribes to the notion that cultural elements are transmitted in manners similar to genetic material then much of the work falling under the CT umbrella may be appealing. There are, however, CT researchers who do not come from the evolutionary school that are finding CT studies useful for interpreting how and why styles emerge and are perpetuated across societies (See Stark et al. 2008a for a diverse collection of works in this vein). These scholars see value in CT studies in relation to social organization, apprenticeship systems and individual learning (Stark et al. 2008b:5).

Tindall's (1976) discussion set the stage for non-quantitative CT studies by defining theoretical and conceptual frameworks. The author is concerned with individual learning, as well as how the "intra-psychic" processes of actors deal with information and communication. His discussion is a polemic directed toward focusing educational anthropologists on their task of developing deductive propositions regarding how people learn. He finds that appropriate theory seeks to explain CT by considering the patterns of exchange, the status and ages of people involved, and the complexity and quantity of information exchange. Bloch (2005) continues with a cognitive approach to CT analysis by piecing together a holistic unifying framework from ethnographic experiences. He argues for the resurgence of generalization in anthropology; a task that CT studies support particularly well.

It may seem that a discussion of non-quantitative, non-evolutionary perspectives may seem unnecessary given the theoretical and methodological quantitative approaches employed in this dissertation. The point, however, is that one need not be an evolutionary anthropologist or archaeologist to find CT studies valuable in the pursuit of understanding culture exchange. The convergence of quantitative and non-quantitative approaches lies in the recognition that CT happens operationally at the scale of the individual; a point illustrated by the employment of Agent Based Modeling later discussed in Chapter V.

Diffusion of Innovation

Diffusion of innovations research is robust and has been developed over decades across a number of disciplines (Rogers 2003) including geography (Brown 1981; Hägerstrand 1967), sociology (Bowers 1937; Tarde 1903[1890]), anthropology (Boas 1911; Kroeber 1940) and marketing (Bass 1969). A particular subset of research known as the Diffusion of Innovations (DI) literature is accepted and applied here and is specifically concerned with how innovation moves through specific channels in social networks (Mahajan and Peterson 1985). DI is different from the other bodies of theory discussed in the social exchange, social interaction, information exchange or cultural transmission sections because it focuses not on informational content or learning processes but how new innovations are adopted.

There are different ways to model adoption patterns of innovations but most include four main components: 1) Innovation 2) Channels of communication 3) Time 4) The social system (Mahajan and Peterson 1985:7; Rogers 2003:11). When graphed, innovation adoption is represented by curves that are represented by shapes that resemble the letters "s" and "r" (Figures 4 and 5). The speed at which something diffuses is referred to as the "rate of adoption" (Rogers 2003:23). S-shaped (Figure 4) curves reflect that initially only a few people adopt an innovation but as time moves forward the innovation becomes more popular and the rate increases until the adoption rate levels off. Rates of adoption associated with R-shaped curves (Figure 5) start with the maximum possible rate of growth and then level off forming a shape that resembles a lower case "r" (Henrich 2001:993).

Henrich (2001) bridged the CT literature with diffusion of innovations research by generating expectations for diffusion curves based on either biased cultural transmission or individual learning. He found that 1) environmental (individual) learning alone does not produce S-shaped adoption curves. 2) S-shaped adoption curves are always produced by biased cultural transmission, and 3) a combination of the two may produce S-curves if bias is the predominate force in the diffusion of new behaviors or ideas. R-shaped curves are produced when adopters arrive at a preference for a perceived cost/benefit over conventional social learning (Henrich 2001:1008).

Figure 4. S-curve adoption pattern

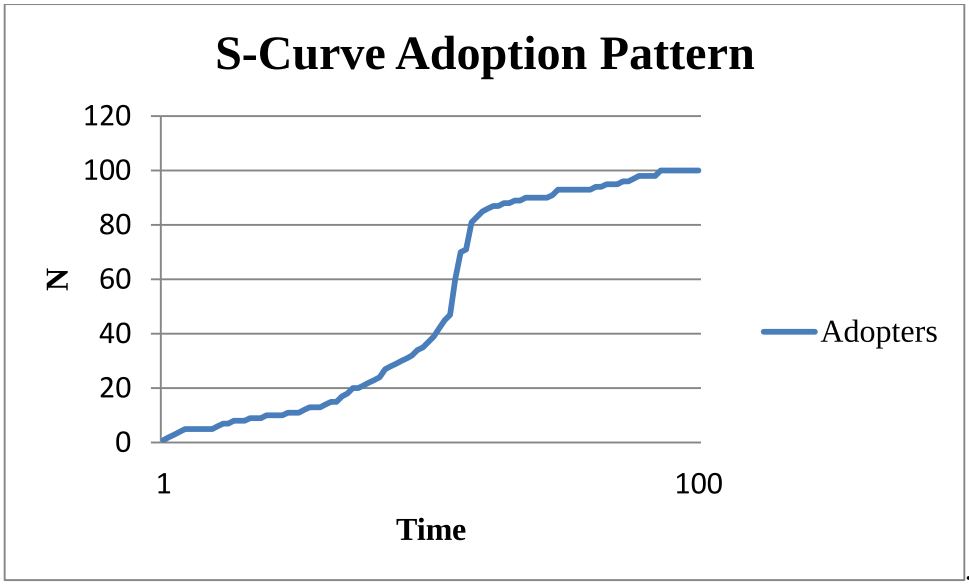
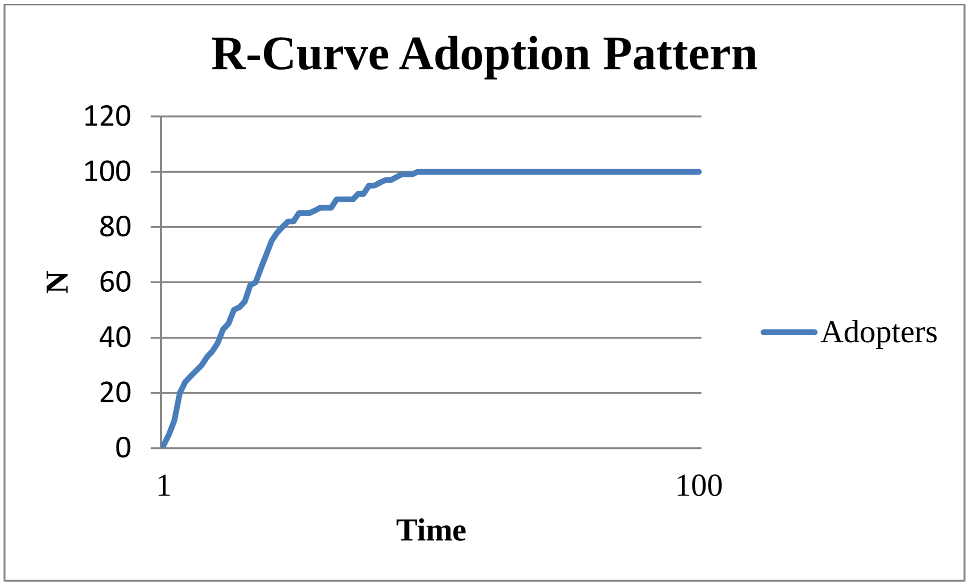


Figure 5. R-curve adoption pattern.



Complex Systems

Interest in complex systems has grown among researchers in recent decades because of its ability to explain emergent properties in both the physical and social realms (Bentley and Maschner 2003a; Byrne 1998; Casti 1994; Holland 1998; Lansing 2006; Messina 2001; Waldrop 1992). It has been used by biologists to examine morphogenesis and homeostasis in multi-cellular organisms (Ross and Arkin 2009), by physicists to understand varying properties of matter at multiple scales (Nicolis and Nicolis 2009), and by economists to explain differential distributions of economic resources (Krugman 1997).

Complexity researchers have sought to understand the world within the context of their respective disciplines but one common thread has tied them together: the notion that physical and social realms are comprised of complex systems. These may be characterized as self-organized, path dependent, and historically contingent systems that exhibit emergent properties (Crawford et al. 2005; O'Sullivan et al. 2006). Complex systems are also irreducible; it is the relationships between entities that define the system and not individual component parts (Casti 1994:171-211;

Manson 2001). Identifying the individual parts within a system is essential for establishing model components, but the emergent properties of that system may only be observed through interactions of those components:

> I emphasize "interactions" because there is a common misconception about reduction: to understand the whole, you analyze a process into atomic parts, and then study these parts in isolation. Such analysis works when the whole can be treated as the sum of the parts, but it does *not* work when the parts interact in less simple ways. For example, we can analyze a complex sound wave, say an instant from the symphony, into its component frequencies, and then reconstruct the whole by adding these components together… However, when the parts interact in less simple ways (as when ants in a colony encounter each other) knowing the behaviors of the isolated parts leaves us a long way from understanding the whole (the colony). The simple notion of reduction-studying the parts and isolation-does not work in such cases. We have to study the interactions as well as the parts (Holland 1998:14).

It should be stressed that the term "complexity," for the purposes of this discussion, refers to a particular scientific approach, and *does not* refer to social complexity in the traditional sense for those who practice anthropology. Complexity does not inherently refer to levels of integration or social organization, but instead refers to an alternate way to think about science in that it does not follow a reductive model. It also provides the researcher with opportunities to pose different kinds of questions than might be asked by traditional scientific approaches.

Complex systems possess at least four key characteristics that allow them to function. First, complex systems are thermodynamically open systems that allow energy and matter to flow both in and out (Bentley and Maschner 2003b:2). Second, as discussed above, complex systems are comprised of constituent entities that interact with one another, either directly or indirectly. Third, complex systems are nonlinear, with both positive and negative feedback loops operating within the system (Holland 1998; Nicolis 1995). The relationships between elements in nonlinear systems are structured in ways that make it extremely difficult to predict changes across scales by calculating inputs and outputs (Beekman and Baden 2005). Fourth, complex systems display emergent properties (Casti 1994; Holland 1998; Wolfram 2002). New properties emerge within the system because interactions between agents are both unique and irreducible:

> The irreducibility of complex phenomena arises because interactions among their constituent elements are nonlinear and their properties nonadditive, so that understanding how interactions `scale up' from local to global behaviour is not straightforward (O'Sullivan et al. 2006:612).

Until this point, this description of complex systems may seem somewhat similar to other systems approaches advanced by archaeologists in the past (Clarke 1968; Doran 1970; Plog 1975). However, the principal difference between complex systems theory and other systems theories, as Bentley and Maschner (2003:2) have stated, is that "complexity theory recognizes that human societies and environments are open systems, far from equilibrium." In fact, in nonlinear complex systems, disequilibrium *precipitates* systemic change. Self-organization and emergent properties allow complex systems to adapt to both external and internal pressures (Manson 2001).

Employing a complex systems approach toward understanding Springwells phase interaction and integration is useful for three primary reasons. First, complex systems approaches focus on how entities *interact* in concert within open systems. Because open systems are amenable to external influences (Messina 2001), emergent properties such as changes in social interaction can occur suddenly and at different scales (Bentley and Maschner 2003a). Studies that employ a complex systems approach focus on the interactions between agents in the system instead of focusing on component parts. Second, complex systems approaches lend themselves particularly well to modeling and simulation. Chapters V and VI elucidate how computer modeling and simulation is used to understand and interpret Late Prehistoric interaction processes within a complexity framework. Third, few archaeological or anthropological studies have combined complex systems approaches and it is not well understood how this experimentation may lead to new and unforeseen interpretations (see Beekman and Baden 2005; Bentley and Maschner 2003b for a more complete review).

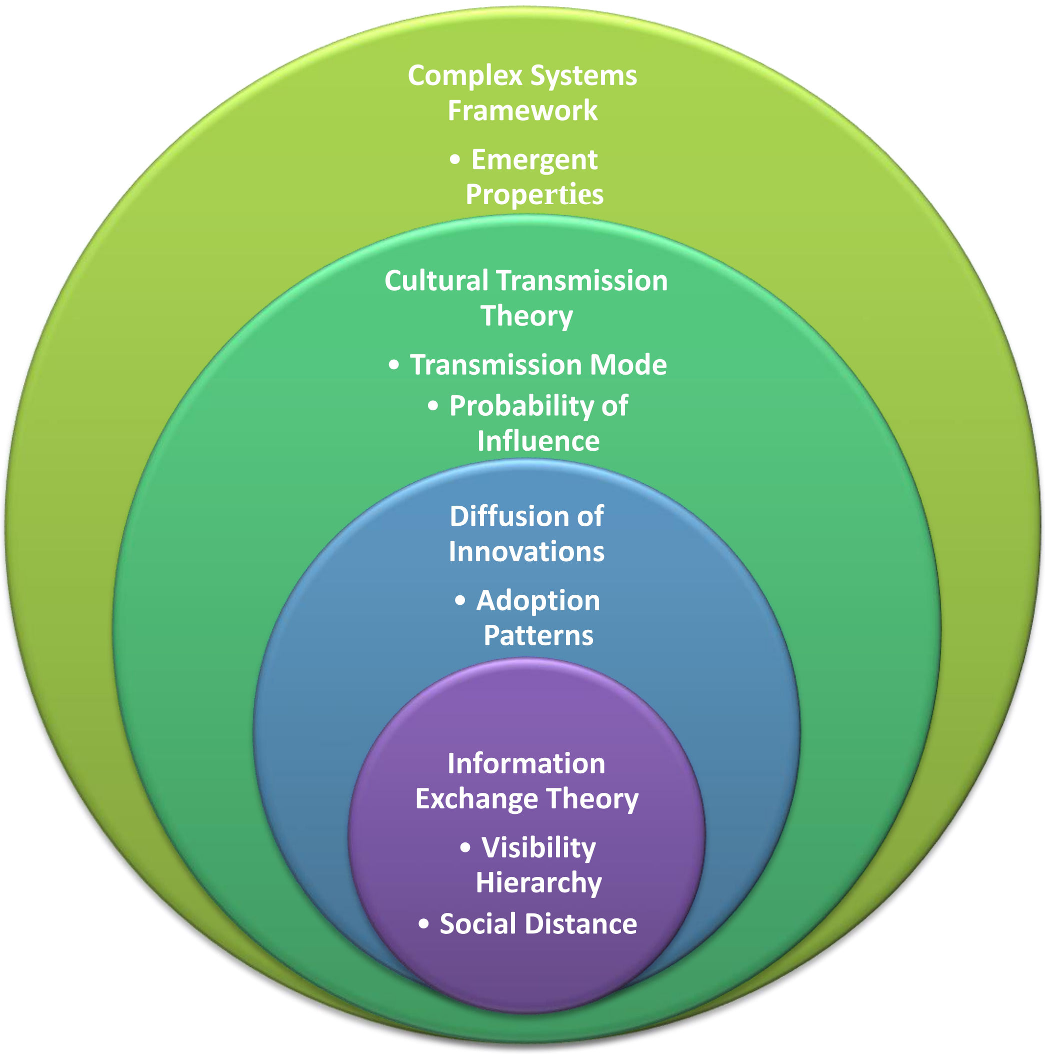
Leveraging Multiple Bodies of Theory

The aforementioned bodies of theory collectively provide a unique capability required for this study because they each address specific dimensions of human behavior necessary to simulate social interaction networks. Some researchers have advocated bringing multiple bodies of theory to bear in concert to answer archaeological questions as research goals grow in scale:

> Given the complexity of human culture and the difficulties in dealing with the archaeological record, the most effective research avoids being confined to a single theoretical approach. Since no two research situations are the same, each requires a unique combination of theoretical approaches to gain the most productive results from the available archaeological data (Sharer and Ashmore 2003:586).

For this dissertation, a nested multi-theoretical approach (Figure 6) informs interpretations of Late Prehistoric Springwells social interaction networks.

Figure 6. Representation of nested multi-theoretical approach



Applying Complex Systems Theory

A complex systems framework is used here to interpret data generated from an Agent Based Model programmed to simulate cultural transmission generated at the scale of the individual. The signatures of these behaviors ultimately become emergent properties of the social network.

Applying Cultural Transmission (CT) Theory

Cultural transmission processes are simulated within an ABM using individual agents who interact under behavioral rules drawn from the CT literature. Stylistic exchange probabilities are then evaluated in relation to specific interactional scenarios generated within the simulation.

Applying Diffusion of Innovations Theory

Model programming and behaviors are captured as output data in excel spreadsheets and interpreted through the diffusion of innovations literature. This literature provides insights into whether the model programming is producing valid results, as well as what the resulting adoption patterns reveal about how agents are interacting and producing system-level characteristics.

Applying Information Exchange Theory

The rules that govern exchange of information between individual agents are constructed from the information exchange theory literature. Information is propagated throughout the social network by simulating the transfer of socially significant information. These information packets are represented as ceramic style categories assigned to agents. One should note that this socially significant information is encoded in the actual Springwells ceramics and analyzed below in Chapter IV.

A Multi-Theoretical Approach

The fusion of nested bodies of theory embedded within this research becomes a means to evaluate statistical probabilities involving the relationships between social context and the transmission of culture. These statistical probabilities then combine with archaeological ceramics analyses to provide a better understanding into Springwells phase interaction and integration across the region.

As funding for archaeological investigations becomes increasingly difficult to procure, archaeologists must find new ways to employ theory, methodology and technique in order to maximize the explanatory potential of existing datasets. Unfortunately, there are often reasons why many datasets residing in existing institutional collections suffer from a lack of analytical treatment. These reasons may include the size, richness or diversity of a particular assemblage, or the geographic distribution of a particular artifact type or attribute of interest. Computational solutions such as social science modeling and simulation and GIS technologies are particularly well suited in assisting with these analytical challenges. It is hoped that more archaeologists will embrace these technologies that hold the potential to add new dimensions to contemporary archaeological interpretation.

CHAPTER III

The Spatial, Temporal and Geographic Contexts for Springwells Communities

If we are to understand how Springwells social networks functioned during the Late Prehistoric period then we need to understand the physical and social geographies in which they interacted. This chapter outlines both the artifact assemblages and geographic locations of selected Springwells sites in Michigan, Indiana and Ontario (Table 2).

Table 2. List of twenty sites included in this study.

Site	*Location*
12H1052	Indiana
Bellamy (Adhm-7)	Ontario
Bruner-Colasanti (AaHq-8)	Ontario
Casassa (20SA1021)	Michigan
Castor Farm (12H3)	Indiana
Dick Site (AaHp-1)	Ontario
E.C. Row (AbHs-7)	Ontario
Fletcher (20BY28)	Michigan
Fort Wayne Mound (20WN1)	Michigan
Gravlin-Tomlinson (20IS300)	Michigan
Haagsma (AeHl-33)	Ontario
Indian Trails (20MR4)	Michigan
Lasalle-Lucier (AbHs-8)	Ontario
Lianh I (AcHo-1)	Ontario
Riviere au Vase (20MB3)	Michigan
Robson Road (AaHa-20)	Ontario
St Mary's Vineyard (20MR33)	Michigan
Strawtown Enclosure (12H883)	Indiana
Taylor Ten (12H987)	Indiana
Wolf (20MB1)	Michigan

The reader should note that this dissertation is not designed to be a comprehensive study of all Springwells archaeological collections. Specifically, permissions were not secured to access several known datasets recovered from northwestern Ohio and are not included in this analysis. Hence, the research presented here uses selected datasets primarily as a platform for a methodological exploration into social science computer simulation. All geospatial analytic and cartographic functions conducted during this study were performed using ESRI ArcGIS 10 Geographic Information Systems (GIS) software (ESRI 2011) or R statistical computing software (Hornk 2012).

Late Prehistoric Material Culture and Chronology

The material culture of the Late Prehistoric period within the area of study has been assigned to the Younge (Fitting 1965, 1975; Greenman 1967) and/or Western Basin Late Woodland (Murphy and Ferris 1990; Stothers and Bechtel 2000) traditions. While the exact nature of what it means to be either "Younge" or "Western Basin" is a matter of contention (Murphy and Ferris 1990; Stothers and Bechtel 2000; Stothers et al. 1994), most archaeologists agree that the people associated with the ceramics, lithics and mortuary program of the Younge/Western Basin Tradition(s) occupied the area surrounding the southern lower Huron and western lower Erie Basins beginning around A.D. 1000 (Brashler et al. 2000; Brashler et al. 1999; Fitting 1975).

The taxonomic construct of the "Younge Tradition" was originally defined by the work of Professor Emerson F. Greenman from excavations at the Younge site (20LP1) in Lapeer County, Michigan in 1935. Greenman interpreted the site as a mortuary center that contained the remains of at least 102 individuals. Three so-called "longhouses" were also present (Fitting 1975; Greenman 1967). The ceramic assemblage was marked exclusively by Riviere Ware ceramics (Fitting 1965), and lithics were represented by both triangular and side-notched points, and other chipped stone tools such as scrapers (Fitting 1965).

Mortuary treatment at Younge was dramatically different from what had been observed at earlier Late Woodland sites in southeastern Michigan. Burials at the site were communal in nature with very few grave goods present. Postmortem treatments such as limited rearticulation or skull perforation were evident (Fitting 1975; Greenman 1967; Halsey 1999). When compared to preceding Wayne Mortuary Tradition sites (Halsey 1976), the Younge site demonstrates that there was a marked change in the way that people organized themselves and interacted during the Late Prehistoric period, as evidenced by a shift away from individual internments characteristic of the Late Woodland Wayne complex toward communal internments (Halsey 1999:234). In addition to changes in mortuary treatment, there were concomitant changes in lithic and ceramic styles throughout the region.

Several researchers have advanced explanations for social change during the Late Prehistoric period. O'Shea (1988) has interpreted changes in mortuary treatment as representing the onset of tribal social organization in the region (discussed below in Chapter VI), postulating that structures present at Younge may have been mortuary-processing facilities used by skilled specialists in caring for the dead. Krakker's (1983) work also models changes in sociocultural systems in southeastern Michigan. Krakker maintains that after A.D. 1300, local communities appear to organize themselves into larger social units such as lineages or clans because of changes in regulatory systems. The subsystems are comprised of local and regional exchanges of energy, information, and matter that act to buffer uncertainty in both the social and physical world. These regulatory subsystems are hierarchically arranged, and these regulators function as buffers against environmental fluctuation. In addition to Krakker, other researchers (Howey 2006; McHale-Milner 1998; O'Shea and McHale-Milner 2002) have argued for more complex egalitarian organization in other parts of the Great Lakes region during this time.

Chronology

Subsequent research eventually established a cultural sequence for Younge Tradition developments (Fitting 1965; Greenman 1939; Halsey 1968). Table 3 below provides a list of Younge Tradition phases and their associated chronologies. It is interesting to note that while Fitting's interpretation of the phase sequence has been in place since the early 1970's, it remains generally accepted in terms of the Late Prehistoric cultural sequence for the region (for most notable exceptions see Stothers and Bechtel 2000; Stothers et al. 1994).

Krakker (1983) noted that interpretations of the Younge Tradition, at the time, were based on ceramic trends as established by Fitting's (1965) work. The Younge phase ceramic sequence begins with the Riviere au Vase ceramic type characterized by globular and elongated vessels that display a variety of surface treatments including cordmarking, fabric impression, stamping, smoothing and roughening. Springwells phase ceramics consist of Macomb series and Springwells Net Impressed varieties. The ceramics representing the final phase of the Younge Tradition, the Wolf phase, are characterized by the appearance of the Parker Festooned type, found in conjunction with Macomb Linear, Vase Corded, Vase Tool Impressed and Springwells Net Impressed ceramics (Fitting 1975).

Table 3. Younge Tradition phase chronology as interpreted by Fitting (1965:149).

Phase	*Temporal Affiliation*
Younge	A.D. 1000-1200
Springwells	A.D. 1200-1400
Wolf	A.D. 1400 +

According to Krakker (1983), Younge phase ceramics become thicker, with higher necks and more complex decoration than earlier ceramics. Decorative treatments include the use of cordmarking, dentate, and plain tool techniques, as well as the application of collars. By A.D.

1200, overall vessel size increases with an increase in smoothed exteriors. Springwells phase ceramics feature linear-decorated collars created with either cord-wrapped tools or push-pull techniques. Wolf phase Parker Festooned ceramics become the final Younge Tradition ceramic type to appear, and have been found with a variety of tempers including shell (Krakker 1983), a technology that has been associated with Mississippian groups to the south (Beld 1993; Payne 1991). Parker Festooned ceramics are easily recognizable due to their dramatic castellated rims and appliqué strips.

Subsequent archaeological research published since the establishment of the original taxonomy has produced a much clearer picture of Springwells phase chronological placement in the Late Prehistoric period. Again, a new temporal affiliation for Springwells communities is used here, and is based on the upper and lower limits of radiocarbon dating for the Strawtown locale in Indiana (the most extensively excavated site in the study region), roughly ca. A.D. 1160 to 1420.

Table 4 and Figure 7 below depict standardized, calibrated radiocarbon dates (n=14) for selected Springwells sites included in this study. Radiocarbon calibration for the comparison was facilitated using the CALIB Radiocarbon Calibration Program version 6.0.1 (Stuiver and Reimer 2011). Significance testing for differences in radiocarbon dates was conducted using CALIB's *test sample significance* feature and revealed that when the Castor Farm dates are extracted from the set, 12 of the 14 dates showed no statistically significant difference between samples (t = 19.03, X^2 = 19.7 [p = .05], df=11). When the Castor Farm dates are included, the samples exhibit statistically significant differences in radiometric samples (t = 40.43, X^2 = 22.4 [p = .05], df=13). The dating derived from the Strawtown Enclosure located adjacent to the

Castor Farm site did not produce statistically significant differences in the dataset. This is probably due to the palimpsest nature of occupations at the Strawtown locale which extend from the Middle/Late Archaic to Historic periods (McCullough et al. 2004). Current interpretations (McCullough et al. 2004:164) place Springwells settlement at the Strawtown locale persisting through the fifteenth century.

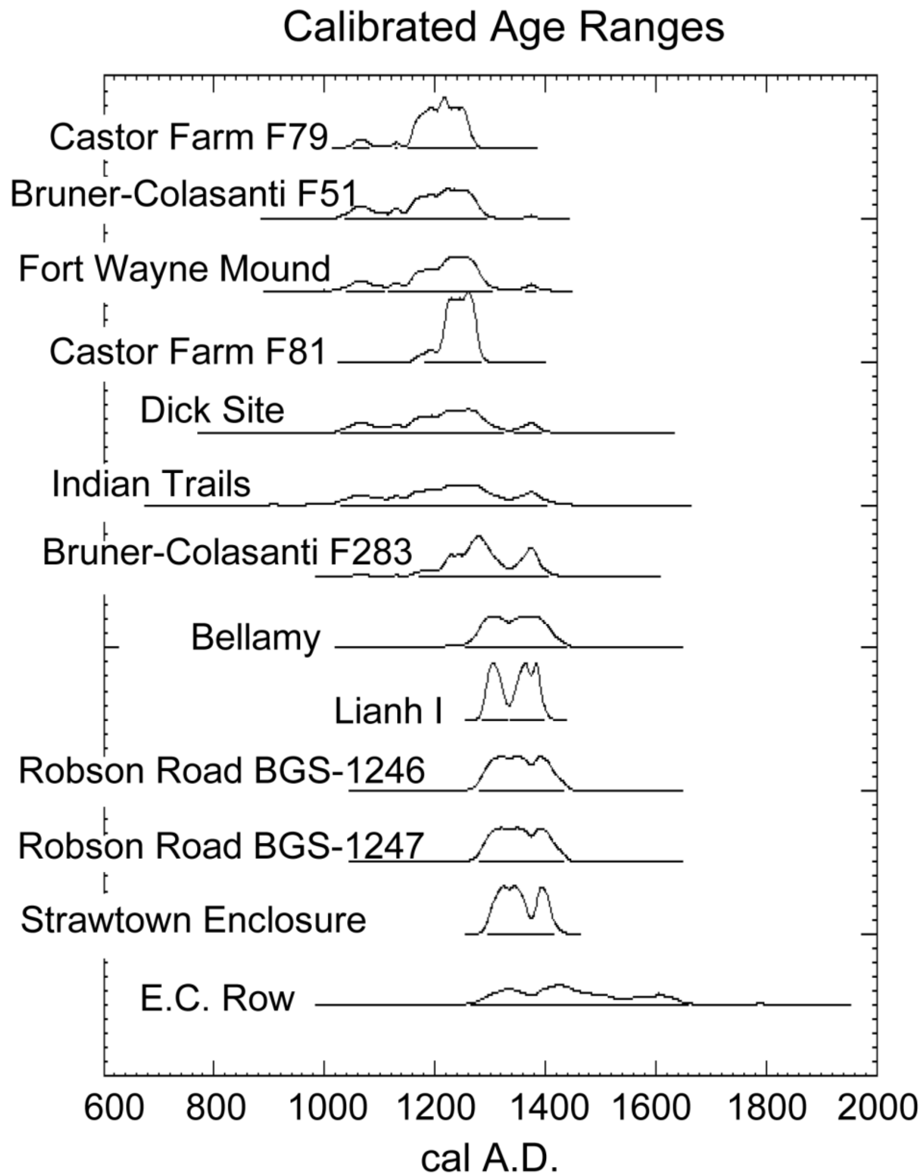
Springwells Social, Political, and Economic Organization

It is important to remember that Springwells social networks developed out of historical relationships that were already in place within the region. Late Prehistoric sites such as Riviere au Vase (Fitting 1965), Casassa (Branstner and Hambacher 1995), and Castor Farm (McCullough and Graham 2010a) all contain Vase series ceramics indicative of earlier Late Prehistoric Younge phase occupations (ca. A.D. 1000-1200) (Fitting 1965:149; Table 3 above). The archaeological evidence indicates that Springwells communities were plugging into social networks that existed across the region prior to the Springwells phase. These networks extended minimally to the beginning of the Late Prehistoric period, but one may imagine that they were in place much earlier. Archaeological data support interpretations that indigenous people often leveraged long distance trade networks within the Great Lakes region; networks that extended back to at least the Late Archaic period (Lovis 1999:113). These historic interaction patterns certainly would have influenced the spatial and social organization of interaction in the study area.

Table 4. Calibrated radiocarbon results for selected Springwells phase sites.

Site	^{14}C *age Yr BP*	*95.4 (2σ) cal age ranges*	*Relative area under distribution*	*Calibration data*
Bellamy (Adhm-7)	630±80	cal A.D. 1256-1438	1	(Reimer et al. 2004)
Bruner-Colasanti (AaHq-8) F51	810±75	cal A.D. 1036-1293	1	(Reimer et al. 2004)
Bruner-Colasanti (AaHq-8) F283	715±75	cal A.D. 1173-1405	1	(Reimer et al. 2004)
Castor Farm (12H3) F79	830±40	cal A.D. 1052-1080	0.04	(Reimer et al. 2004)
		cal A.D. 1129-1132	0.004	(Reimer et al. 2004)
		cal A.D. 1153-1274	0.95	(Reimer et al. 2004)
Castor Farm (12H3) F81	780±40	cal A.D. 1182-1284	1	(Reimer et al. 2004)
Dick Site (AaHp-1)	780±100	cal A.D. 1031-1324	0.92	(Reimer et al. 2004)
		cal A.D. 1345-1393	0.08	(Reimer et al. 2004)
E.C. Row (AbHs-7)	500±125	cal A.D. 1265-1659	1	(Reimer et al. 2004)
Fletcher (20BY28)	785±85	Cal A.D. 1037-1313	.95	(Reimer, et al. 2004)
		Cal A.D. 1357-A.D. 1388	.5	Reimer, et al. 2004)
Fort Wayne Mound (20WN1)	791±75	cal A.D. 1040-1110	0.11	(Reimer et al. 2004)
		cal A.D. 1116-1303	0.87	(Reimer et al. 2004)
		cal A.D.1365-1383	0.02	(Reimer et al. 2004)
Indian Trails (20MR4)	766±117	cal A.D. 1031-1403	1	(Reimer et al. 2004)
Lianh I (AcHo-1)	630±30	cal A.D. 1287-1332	0.41	(Reimer et al. 2004)
		cal A.D. 1337-1398	0.59	(Reimer et al. 2004)
Robson Road (AaHa-20) BGS-1246	600±70	cal A.D. 1280-1432	1	(Reimer et al. 2004)
Robson Road (AaHa-20) BGS-1247	600±70	cal A.D. 1280-1432	1	(Reimer et al. 2004)
Strawtown Enclosure (12H883) F4	590±40	cal A.D. 1296-1415	1	(Reimer et al. 2004)

Figure 7. Multi-sample probability plot comparing calibrated age ranges.



Current interpretations about Late Prehistoric social systems are greatly informed by Krakker's (1983) analysis, which was the first major synthesis of Late Prehistoric cultural processes in the study area since Fitting (1965). Much of the work executed prior to Krakker's research was performed with the purpose of establishing a basic framework of artifact typology and chronology for Younge/Western Basin Tradition sites. Krakker's work was one of the first comprehensive attempts to explain changes in cultural processes during these periods.

Krakker attributes the cultural changes that start during the Younge phase and which persist through the Springwells and Wolf phases to changes in “regulatory subsystems” (Brashler et al. 1999:228-233; Krakker 1983). In Krakker’s model, a change in a lower level subsystem such as the advent of horticultural technology impacts higher level, broader systemic components such as settlement patterns and demography (Krakker 1983:72). He sees a shift toward increased community sizes between A.D. 1000-1300 and concomitant increases in regional interaction more as a function of social distance than geographic distance (Brashler et al. 1999:233). Krakker (1983:428) maintains that some Springwells phase communities (ca. A.D. 1300) were probably comprised of groups of approximately 100 people and that local subgroup identity was reflected through ceramic style. He posits that individual Springwells community size was large enough to suggest that group segmentation was plausible (Krakker 1983:525). Segmentation is thought to operate as a kind of “cellular structure” (Carneiro 2002:51) that both subdivides and unites communities in a manner that allows them to grow in size without fissioning from internal stress. Segmentation may be instituted through a variety of social mechanisms including the establishment of clans, lineages, and age-grades (Carneiro 2002:42).

Murphy and Ferris (1990) view their interpretations of Ontario Springwells communities through the lens of the Western Basin Tradition framework as established by Prahl et al. (1976). They report on several Springwells sites dating between the end of the 11^{th} and 14^{th} centuries A.D. (Murphy and Ferris 1990:228). Increased regional variation in ceramics emerges between A.D. 1200-1300 suggesting that there were existing trade networks linking both Mississippian communities to the south and Iroquoian communities to the east (Murphy and Ferris 1990:229).

Economically, Ontario Springwells groups practiced warm-season aggregation in order to support what authors interpret as increased reliance on cultigens (including maize), at the same time choosing site locations that provide a high degree of resource variability (Murphy and Ferris 1990:244). These warm weather occupation sites also include features such as multiple structures and formalized layouts complete with palisades (Murphy and Ferris 1990:254). Cold weather Ontario Springwells economic strategies featured small group dispersion with resource extraction focusing on faunal and nut resources. Social organization shifted from independent small group organization exhibited in preceding periods toward larger group coalescence for horticultural purposes (Murphy and Ferris 1990:254). Other interpretations of Springwells lifeways share some common ground with Murphy and Ferris in that these communities were not "medium-sized autonomous villages" (Stothers et al. 1994:161), but a component within a settlement system where small hamlets are part of a warm season rotation where people aggregate and then disperse in the fall.

An additional point of debate regarding Springwells culture history is the issue of cultural continuity. Some models contend that Younge/Western Basin communities cease to exist around A.D. 1300 when "Sandusky Tradition" (Brashler et al. 1999:194-211; Stothers and Bechtel 2000; Stothers et al. 1994) radiate out of northern Ohio replacing Springwells Lifeways with succeeding Wolf phase communities. This is a hotly debated proposition and this dissertation is not intended to address the Sandusky Tradition hypothesis directly, however some of the modeling and simulation findings presented later may certainly be applied to this question in future research.

One should note that these aforementioned culture history models were developed at a time when relevant archaeological datasets were small and scarce, and the geographic extent of

Springwells social networks was thought to be much smaller in scale. Recent work by the Indiana University-Purdue University Fort Wayne (IPFW) Archaeological Survey has uncovered a wealth of settlement, subsistence, and material culture data concerning southerly Springwells communities, redefining what we know about local and regional variation in these communities (Arnold et al. 2007; Arnold and McCullough 2009; Mccullough 2009; McCullough 2005, 2008; McCullough and Graham 2010a, b; McCullough et al. 2004). These researchers see the Indiana Springwells expression (designated as the Castor phase) as reflecting relationships with Great Lakes focused Springwells communities. These ties are reflected by shared stylistic elements in materials, particularly with respect to ceramics (a more detailed discussion of these shared ceramic stylistic elements is contained in Chapter IV).

Castor phase groups in central Indiana settled in large village areas of up to four hectares (McCullough and Graham 2010a:158) practicing maize-based and Eastern Agricultural Complex (EAC) starchy/seedy plant horticulture (McCullough and Graham 2010a:163). It appears that Springwells/Castor phase peoples in northeastern Indiana generally conform to the aforementioned horticultural hamlet model aggregating at earthwork enclosures across the landscape (McCullough and Graham 2010a). One notable exception is the Kramer enclosure located in Allen County that demonstrates an extensive occupational history; one that provides evidence for Springwells phase cultural continuity remaining in place until approximately A.D. 1400 (McCullough and Graham 2010a:158; 2010b:247).

Sites Included in this Study

Table 5. Site use summary.

Site	*Springwells Phase Structures*	*Springwells Phase Human Remains*	*Springwells Phase Function*
Bellamy (Adhm-7)	Indeterminate	No	Indeterminate
Bruner-Colasanti (AaHq-8)	Indeterminate	Indeterminate	Indeterminate
Casassa (20SA1021)	TBD	TBD	Aggregation
Dick Site (AaHp-1)	Indeterminate	Indeterminate	Warm-season residential
E.C. Row (AbHs-7)	Palisade and 4 houses	Yes	Warm-season residential
Fletcher (20BY28)	Indeterminate	Indeterminate	Indeterminate
Fort Wayne Mound (20WN1)	Indeterminate	Indeterminate	Aggregation
Gravlin-Tomlinson (20IS300)	No	No	Indeterminate
Haagsma (AeHl-33)	Indeterminate	No	Indeterminate
Indian Trails (20MR4)	Indeterminate	Indeterminate	Indeterminate
Lasalle-Lucier (AbHs-8)	Palisade and houses	Yes	Warm-season residential
Lianh I (AcHo-1)	1 Longhouse	No	Warm-season base camp
Riviere au Vase (20MB3)	Indeterminate	Indeterminate	Aggregation
Robson Road (AaHa-20)	Indeterminate	Indeterminate	Indeterminate
St Mary's Vineyard (20MR33)	Indeterminate	Indeterminate	Indeterminate
Strawtown Locale: Castor Farm (12H3) / Strawtown Enclosure (12H883) / 12H1052 / Taylor Ten (12H987)	Multiple structure types	Yes	Residential village locale with enclosure
Wolf (20MB1)	Indeterminate	Indeterminate	Aggregation

Michigan Sites

CASASSA (20SA1021)

20SA1021 is located in Saginaw County between the Shiawassee River and Bear Creek in St. Charles Township. Discovered during a survey required for the for the installation of a gas pipeline, Casassa is a multicomponent site with evidence of occupations ranging from the Middle Archaic through Late Woodland periods (Branstner and Hambacher 1995). Springwells ceramics recovered include four Macomb Interrupted Linear vessels and 12 Macomb Linear vessels. Some have interpreted the variability of Younge Tradition ceramics recovered from the site to represent a pattern of interactions that reflect a number of groups using the area repeatedly over time as a buffer to ameliorate fluctuating resource stress as needed from year to year (Brashler et al. 1999:219; Brashler and Holman 1985).

Fletcher (20BY28)

20BY28 located on the northwest bank of the Saginaw River in Bay City was excavated intermittently between 1967 and 1987 is the site of multiple archaeological components ranging from the Late Archaic through historic periods (Raviele 2010:90-91). Thirteen Macomb Linear vessels and one Macomb Interrupted Linear vessel represent the Springwells ceramic assemblage. Fletcher is particularly interesting because the ceramics recovered range geographically from the Upper Great Lakes region to southern Ontario (Brashler 1973; Lovis 1990). However, one central problem with assessing a chronological sequence for the site is that it “lacks clear stratification and radiocarbon dates” (Brashler 1978:52).

Fort Wayne Mound (20WN1)

20WN1 is located where the River Rouge meets the Detroit River in the city of Detroit. The Fort Wayne Mound sits on the historic Fort Wayne military reservation and is one of four mounds that comprise the Springwells Mound Group (Halsey 1968). The Aboriginal Research Club of Detroit conducted the excavation that recovered the 20WN1 artifact assemblage in the 1940’s under the direction of Carl Holmquist. Twenty-three human burials were recovered along with grave goods although none of these were directly associated with Springwells phase materials (Fitting and Zurel 1976:221). Sixteen Springwells Net Impressed vessels were recovered along with five Macomb Linear Vessels and one Macomb Interrupted Linear vessel.

As with Fletcher, the nature of the early excavations do not allow for a refined determination on the chronology of the artifacts recovered from the site.

GRAVLIN-TOMLINSON (20IS300)

The Gravlin-Tomlinson site is located in Au Sable Township in Iosco County. Mr. Edward Gravlin, a local resident, along with his grandsons recovered two submerged Macomb vessels from the Au Sable riverbed while rafting. The Gravlin family contacted Dr. William A. Lovis of the Michigan State University Department of Anthropology to enquire about the artifacts. The State of Michigan archaeological site database (ARGUS) indicates that there are several sites reported in this vicinity along the riverbank. The subsequent analysis for one Springwells vessel is discussed in Chapter IV.

INDIAN TRAILS (20MR4)

20MR4 is located on the north bank of Little Swan Creek in Ash Township in Monroe County. A portion of the site was originally excavated in the 1940's by Ralph Patton of the University of Michigan Museum of Anthropology (UMMA). Patton's investigation identified a burial pit containing the remains of at least 18 individuals, six represented as partially rearticulated and the rest as partially cremated bundle burials (Brose and Essenpreis 1973:9; Prahl et al. 1976:269). Ceramics include a local variant of the Springwells Net Impressed type that has been dubbed Indian Trails Linear characterized by "punctation; linear impressions or wide-line incising on either the rim, the collar or both; and often displays a triangular motif on the neck-shoulder area" (Brose and Essenpreis 1973:11). Another local variant dubbed Monroe Impressed Collar that is described as "crude, heavily decorated, generally collard, often castellated" (Brose and Essenpreis 1973:11). None of the ceramics were associated directly with the burials and the provenience for artifact recovery is also unclear (Prahl et al. 1976:269).

A single date for the site was drawn from burial #6 and suggests a date range of A.D. 1184 ± 117. This combined with the stylistic similarities to other Springwells phase pottery types led the authors to assign the ceramics to the Younge Tradition (Brose and Essenpreis 1973:12).

RIVIERE AU VASE (20MB3)

20MB3 is located near Lake St. Clair in Chesterfield Township in Macomb County. It was originally excavated by the University of Michigan under the direction of Professor Greenman in the summers of 1936 and 1937 and also during the spring of 1937 by George I. Quimby. It is from the pottery recovered here that Fitting (1965) establishes his Younge Tradition taxonomy that includes the Macomb and Springwells ceramic types central to this research (see Chapter IV's discussion of ceramic attributes regarding these types). Fitting reports 42 Macomb vessels recovered from this site but he combines all Macomb variants into his total. He also reports three Springwells Net Impressed vessels present at this site. As with Fletcher and the Fort Wayne Mound, the nature of the early excavations do not allow for a refined determination on the chronology of the artifacts recovered from the site and Fitting (1965:94) himself notes the issues relating to artifact distribution and stratigraphy. He offers an interpretation of a two-phase occupation beginning around A.D. 600 and ending around A.D. 1300, with the most intensive phase of use ranging between A.D. 800 and A.D. 1300.

ST MARY'S VINEYARD (20MR33)

20MR33 is located in Monroe Township in Monroe County near the River Raisin. A 1966 surface collection survey was conducted and two 5x5 test pits were excavated to a depth of four feet. Rimsherds from at least one Indian Trails Linear Vessel, one Monroe Impressed Collar vessel, and one Iroquois Linear vessel were recovered (Brose and Essenpreis 1973:23; Prahl et al. 1976:270).

WOLF (20MB1)

20MB1 is located in Chesterfield Township near Lake St. Clair is another site excavated by Professor Greenman in 1936 (Greenman 1939). The excavators uncovered a total of 25 pits containing evidence for carbonized maize but it appears that artifacts (in particular ceramics) were relatively scarce (Fitting and Zurel 1976:253). This is the type-site used to define the Wolf phase which is the phase succeeding the Springwells phase and characterized by the ceramic type know as Parker Festooned (Fitting 1965:140; 1975:158[1970]). There were 14 Macomb vessels and six Springwells Net Impressed vessel recovered from the site.

Ontario Sites

BELLAMY (ADHM-7)

Adhm-7 overlooks the Sydenham River in Camden Township, Kent County. Agricultural plowing had exposed an early nineteenth-century Ojibwa occupation on one side of a bluff, and a Springwells phase occupation complete with at least two intact pits on the other side (Murphy 1987). Excavators recovered rims from four Macomb Interrupted Linear vessels, one Macomb Linear vessel variant, one Iroquois Linear vessel and one miniature vessel (Murphy 1987:21). The stylistic elements of Bellamy ceramics have been interpreted as representing the "ceramic mid-point" (Murphy 1987:17) of the Springwells phase because of their horizontal rim decoration and plain necks.

Lithic materials recovered from the site are limited and included two utilized flakes (Kettle Point and Selkirk cherts), one slate artifact, one bipolar core made of Onondaga chert and associated debitage. Faunal remains consisted of poorly preserved unidentifiable mammal elements and one possible bivalve shell. Floral remains included carbonized corn, nuts and berries. Two uncorrected radiocarbon samples were recovered from the pits but one of them was later considered to be contaminated. The remaining date places the feature within a calibrated range of A. D. 1260-1405 (Murphy 1987:26) and reflects what is generally thought to be a chronological assignment that is solidly Springwells.

Bruner-Colasanti (AaHq-8)

AaHq-8 is located in Gosfield South Township in Essex County. It was relocated and excavated as part of a salvage excavation that was the byproduct of the impending construction of the Highway 3 corridor (Lennox 1982:1). There were 313 features excavated from the site including storage pits and hearths. The majority of lithic material was of local origin and included Selkirk, Kettle Point and Onondaga cherts with one sample representing Pipe Creek chert from Sandusky Bay. Debitage dominated the lithic assemblage, however one Levanna point and four point fragments were also identified (Lennox 1982:22). Sixty-five ceramic vessels were identified with a majority (n=40) assigned to the preceding Younge through the Vase series of ceramics. A subset of seven Macomb Linear and four Springwells Net Impressed vessels were identified relating to the Springwells phase.

Dick Site (AaHp-1)

AaHp-1 is located near the west bank of Sturgeon Creek and two kilometers north of Lake Erie in Mersea Township in Essex County. The site was excavated in 1983 by the University of Windsor under the direction of Peter E.W. Reid. Forty-one Springwells vessels were recovered from the site making it the largest sample of Springwells ceramics recovered in southwestern Ontario (Murphy and Ferris 1990:249). Radiocarbon dates reflect that the site was most intensively used around ca. A.D. 1045-1320 (Murphy and Ferris 1990:227).

E.C. ROW (ABHS-7) / LASALLE-LUCIER (ABHS-8)

AbHs-7 was excavated as a result of transportation development on the E.C. Row-Highway 3 Expressway in 1984. Located in the city of Windsor adjacent to Turkey Creek and the Lasalle-Lucier site (AbHs-8), Lennox and Molto (1995:5) interpreted the site as a warm seasonal settlement. The site contains post molds that indicate the presence of at least four structures, as well as the remains of at least 23 individuals representing all ages and sexes. Chipped stone tools recovered from the site are made from Selkirk, Onondaga, Kettle Point and Bayport cherts. Eight vessels were recovered and identified as "Late" Springwells/ Mixter varieties (Lennox and Molto 1995:31). Excavations performed on the adjacent Lucier site inform much of the interpretation regarding this site.

AbHs-8 is located approximately 150 meters from E.C. Row and the two are considered to be culturally affiliated (Lennox and Molto 1995:26). A combined calibrated date range of A.D. 1310-1515 has been presented for the two sites (Murphy and Ferris 1990:227). The site contained both Younge and Springwells phase occupations, and each was found to be stratigraphically distinct. Postmolds, a palisade and burials were all evident. Five rimsherds were recovered but typology is difficult to ascertain due to the condition of the sherds. Lithics included cores and tool fragments made from a mixture of pebble and Laurel cherts. Maize was also present in feature fill. The site has been interpreted as a warm season settlement for Springwells groups (Lennox and Dodd 1991:50).

HAAGSMA (AEHL-33)

AeHl-33 is located on the west bank of the Sydenham River in the village of Alvinston, Ontario. This site reportedly has both Springwells and Middle Ontario Iroquoian components present (Riddell 1993). At least one longhouse was identified on the site along with 590 overlapping postmolds. The chipped stone assemblage consists of at least 22 projectile points of mixed side-notched and triangular variants with 94% manufactured from Kettle Point chert along with drills and bifaces. The rest of the chipped stone assemblage is made from Selkirk, pebble, or "exotic" cherts. Groundstone tools including one "metate" were also recovered. Thirty-seven rim sherds were classified as Springwells though the majority of ceramics conform to the Iroquois Horizontal type. Riddell (1993) notes that the ceramics present on this site display a blending of both Iroquoian and Springwells design elements.

LIANH I (ACHO-1)

AcHo-1 is located near Rankin Creek in Dover Township in Kent County. The site was first excavated in 1977 because plowing was destroying suspected subsurface features. One longhouse was identified along with several pit features. One radiocarbon date associated with the house structure where most of the Springwells pottery was recovered indicates a corrected date range of A.D. 1300-1405 (Kenyon 1988:12). The lithic assemblage contains diagnostic points made from Onondaga and Kettle Point cherts dating from the Late Archaic through the Late Prehistoric periods. Some Bayport chert is also present in debitage. Two abraders, two celts and one fragment represent the groundstone tool assemblage. Ten Springwells rims were identified along with seven vessels postdating the Springwells assemblage. The site has been interpreted as a "warm weather base camp" (Kenyon 1988:21)

ROBSON ROAD (AAHA-20)

AaHa-20 is located near where Leamington Creek drains into Pigeon Bay in southern Essex County and was first excavated by Peter Reid in 1981, and again in 1987 as a result of impending development (Kenyon et al. 1988). Excavations uncovered a multicomponent site dating from Middle Woodland through the Late Prehistoric periods. At least one-hundred thirtyeight pits were identified with nearly half containing diagnostic artifacts. The lithic assemblage contained one projectile point, two utilized flakes, six biface fragments and debitage all of local cherts. The Springwells assemblage was represented by at least seven rim sherds identified as Springwells ceramics including both linear and net-impressed varieties. One calibrated radiocarbon date associated with the pottery assigns the Springwells occupation to a range of A.D. 1270-1410 (Murphy and Ferris 1990:227). The site is interpreted as part of an undetermined seasonal round and used generally in the warm season.

Indiana Sites

STRAWTOWN LOCALE: CASTOR FARM (12H3) / STRAWTOWN ENCLOSURE (12H883) / 12H1052 / TAYLOR TEN (12H987)

These sites are located within the confines of Strawtown Koteewi Park in Hamilton County near the west fork of the White River. Research at the park has been spearheaded in recent years by the Indiana University-Purdue University at Fort Wayne Archaeological Survey (IPFW-AS) under the direction of Robert G. McCullough. Archaeologists from Ball State University's Archaeological Resources Management Service (BSU-ARMS) had a great deal of involvement with Strawtown area survey and excavation as well.

The archaeological sites located in and around Strawtown Koteewi Park have received a great deal of rigorous research and the radiometric chronology is unusually refined for sites that include Springwells components. This research into Springwells phase sites has proceeded under a somewhat different taxonomic umbrella than that of Michigan or southern Ontario and known as the Castor phase taxonomy.

Castor Farm (12H3) is identified as a large village site containing at least one residential structure as well as a palisade (McCullough and Graham 2010a). At least 332 chipped stone tools have been recovered from the site including 97 hafted bifaces represented by triangular points, a bifurcate point, triangular drills, a bifacial end scraper, humpback knives, a Turkey Tail fragment and a Nodena point (McCullough and Graham 2010a:115). Several ceramic types dating between A.D. 800 and 1300 are represented at the site including shell-tempered Mississippian and Fort Ancient ceramics, Castor series vessels extremely similar in design elements to both Younge and Springwells phase varieties, and earlier Late Woodland Albee phase ceramics.

The Strawtown Enclosure (12H883) is located 200 meters south of 12H3. This enclosure is constructed from a ditch and embankment system. Lithic artifacts recovered include at least 340 chipped stone tools including hafted bifaces represented by triangular points, drills, knives, bifacial end scrapers, a Lost Lake point, a Kirk Corner Notched point, a Lake Erie Bifurcated point, a Saratoga Expanding Stem point, a Merom Expanding Stem point, a Terminal Archaic Barbed Cluster point, a Copena point, and two Nodena points (Arnold and McCullough 2009). Since the enclosure is only 200 meters from 12H3, the ceramics types recovered from here dovetail the Castor Farm varieties (Arnold and McCullough 2009:192).

12H1052 overlaps the Strawtown Enclosure and was investigated in 2003 in the hope of identifying a smaller enclosure mentioned in the historical record. No evidence for such a structure was found, but at least two features were identified along with 1,075 artifacts including 11 ceramic artifacts and 457 chipped stone artifacts (McCullough et al. 2004). Taylor Ten (12H987) was identified by BSU-ARMS as a habitation site and contained at least five features dating to the Early Archaic, Middle Woodland and Late Woodland/Late Prehistoric periods producing “over 3800 ceramic and lithic artifacts” (McCord 2010:79).

CHAPTER IV

Archaeological Ceramics: Background, Datasets and Analyses

Archaeological ceramics studies have been used as a means to detect social identity (Preucel 2006; Rice 1987) and identify cultural processes such as exchange and technological innovation (Orton et al. 1993; Sinopoli 1991). The notion that social interactions between groups are detectible through this medium has also been extensively employed (Brashler 1981; Carr and Neitzel 1995; Deetz 1965; Hill 1985; Longacre 1964; McHale-Milner 1998). As mentioned in Chapter II, there has been a great deal of disagreement as to how much information may actually be decoded through ceramic analysis, but it is generally regarded as one way to answer questions pertaining to group membership and communication. This chapter is concerned primarily with the stylistic identification and geographic distribution of Springwells motifs. The overarching theories relating to social exchange (Emerson 1976; Homans 1958; Mauss 2000[1950]), social interaction (Deetz 1965; Engelbrecht 1974; Longacre 1970; Whallon 1968), and information exchange (Voss and Young 1995; Wobst 1977) theories mentioned in Chapter II are quite varied and useful for informing this study. However, there are other archaeological models relating to social organization and stylistic expression, and some of these are discussed below.

Ceramic Style Exchange as a Proxy for Interaction

Archaeological ceramics are particularly useful for tracing interaction between groups because an individual potter encodes stylistic information that reflects and reinforces group membership during the creation process. Analyzing the exchange of stylistic components is an accepted method to track social interaction (McHale-Milner 1998:150). As such, there are some key examples of archaeologists applying these principles to archaeological ceramics in the Eastern Woodlands of the United States.

Braun and Plog (1982) established a model for the emergence of regional integration in the Midwest at the end of the Middle Woodland Period. In order to do this, they drew on data assembled from both the prehistoric Southwest and the Illinois Valley. The findings were contrary to other models in existence that predicted that during times of local stress groups would exhibit increasingly conflicting behavior. The authors posit that:

1. As social networks become more spatially compact, long distance trade should decrease and regional styles should increasingly diverge.
2. Increasing integration should serve to homogenize styles between and among local groups.
3. Increasing integration should intensify movement of local goods between neighboring groups.

The authors find that social integration is most likely due to the functional development of buffering mechanisms in response to resource fluctuations. One important advantage that Braun and Plog's model had over earlier models was that it incorporated archaeologically testable ceramics criteria.

Plog and Braun (1984) later offer a response to emerging criticism from their aforementioned work to caution that the relationship between stylistic variation and social networks is poorly understood by social scientists. Ethnographic data suggests that "only certain predictable properties of style are consistently subject to deliberate choice and manipulation for social effect, and therefore are subject to stylistic variation" (Plog and Braun 1984:620). This is precisely what makes it possible to analyze and predict stylistic variation in archaeological assemblages. They see social, economic, and religious matters as interconnected, and that there is no single social mechanism presiding over these phenomena. They also argue that increasing tribal regional interaction should result in increasing contact between socially distant groups that are participating in a network. They never suggested that this would involve the dissolution of sub-regional social boundaries as some critiques have suggested. The authors are also interested in how crosscutting sodalities (referred to as societal segmentation) are formalized within a network context, and how the social bonds of groups within a network would involve "social obligations" over a large geographic area. The issue of segmentation is incorporated into the modeling and simulation discussion in Chapter V and is discussed in the interpretations presented in Chapter VI.

Commenting on the development of tribal organization and interaction on the Lower Peninsula of Michigan during the Juntunen phase of the Late Woodland period, O'Shea and McHale-Milner (2002:201) see material culture as particularly responsive to indicating the presence of tribal identification because these social ties are:

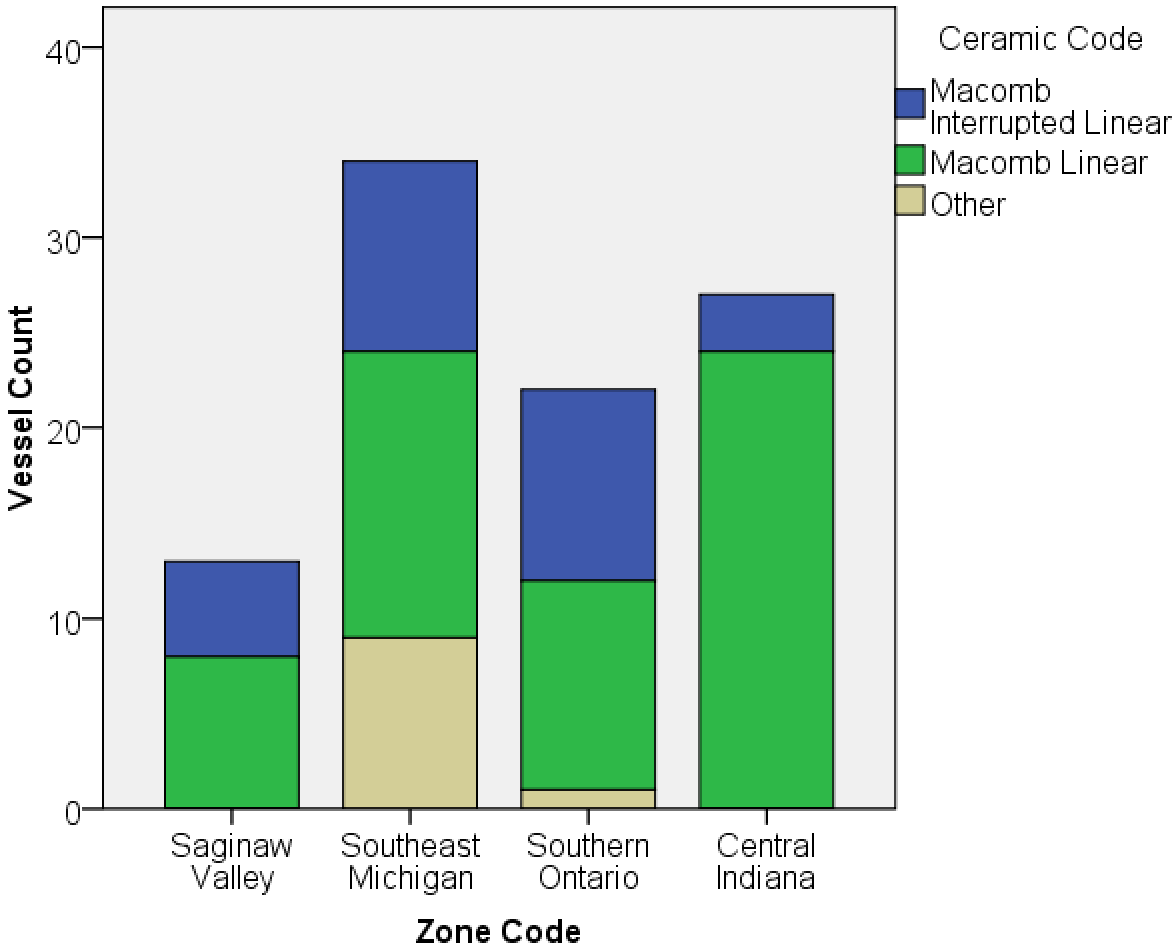
> "a system for predictably organizing population within a landscape over time," and that "material objects, whether personal tool, houses, burials or monuments can all play an important role in establishing identity, asserting rights of ownership and signaling membership in corporate units."

Finally, Rice (Rice 1987:252-254) notes that the use of design elements as a proxy for interaction has been highly criticized for assuming that all social factors influencing stylistic expression such as warfare or structural kinship changes are equally weighted. That said, the analysis presented below assumes that the adoption and propagation of styles through Late Prehistoric indigenous communities reflect membership in social networks that interact with regularity and predictability.

Springwells Ceramics

Original Springwells Ceramics Typology

Figure 8. Original Springwells ceramic types by research locale (Fitting Typology).



The reader should note that while a good faith attempt was made to relocate and analyze all of the ceramics recovered from the sites discussed in Chapter III, this proved to be a very challenging goal. In many cases, only a subset of materials from these sites could be accessed for inclusion in this analysis. Many of these collections have become lost or inaccessible due to institutional restrictions. A profound debt of gratitude is given to the all who granted access to the collections included in this research.

Please recall that the original Springwells phase Younge Tradition ceramic typology (Figure 8 above, Figures 9, 10 , 11 below) was established by Fitting (1965) and consisted of three major varieties: Macomb Linear, Macomb Interrupted Linear, and Springwells Net Impressed ceramics.

MACOMB WARES

Figure 9. Macomb Linear vessel from Riviere au Vase (20MB3).

Macomb Linear ceramics (Figure 9) have coarse sand and grit temper and are defined by horizontal bands surrounding a castellated rim (Fitting 1965:156). These bands are usually created with a stick or other pointed tool, but sometimes they are created using a fabric cord impressed into the clay prior to firing (a variant known as Macomb Linear Corded). Fitting noted that sometimes these bands are interrupted on the corners of the castellation by triangular fields; a trait that will later become important in establishing the revised subtypes discussed later in this chapter.

Figure 10. Macomb Interrupted Linear vessel from the Casassa site (20SA1021).

Macomb Interrupted Linear ceramics (Figure 10) feature the same temper and design motifs except the horizontal bands are created using a technique known as stab-drag (Fitting 1965:157), where a pointed tool is inserted into the clay, dragged across the surface, withdrawn and repeated around the circumference of the rim.

SPRINGWELLS NET IMPRESSED WARES

Figure 11. Springwells Net Impressed rimsherd from the Fort Wayne Mound (20WN1).

Springwells Net Impressed ceramics (Figure 11) as defined by Fitting (Fitting 1965:157) and also discussed by Halsey (1968:127). These vessels are both castellated and non-castellated with coarse grit temper and a cordmarked surface treatment that resembles interlocking net-like patterns near the rim.

MONROE SERIES WARES

Monroe Series wares as defined by Brose and Essenpreis (1973) have been associated with the Springwells phase and therefore are included in this analysis. These wares are represented in this investigation by the Indian Trails Linear and Monroe Impressed Collared varieties.

Figure 12. Indian Trails Linear rimsherd from the Indian Trails site (20MR4).

Indian Trails Linear ceramics (Figure 12) feature coarse grit temper and horizontal bands on the exterior of the castellated rim (Brose and Essenpreis 1973:175). Dating from human remains found at the site place this ceramic variety chronologically at A.D. 1184 ± 117 (Brose and Essenpreis 1973:12). This variety bears a striking resemblance to Springwells Net Impressed ceramics.

Figure 13. Monroe Impressed Collar rimsherd from the St. Mary's Vineyard site (20MR33).

Monroe Impressed Collared (Figure 13) ceramics feature multiple banded horizontal impressions placed below the rim and medium to fine grit tempering. These ceramics are thought to be related to the Macomb Interrupted Linear variety (Brose and Essenpreis 1973:174). A Springwells association for this series was inferred from an Iroquois Linear sherd recovered insitu with the Monroe Impressed Collared sherds (Brose and Essenpreis 1973:23; Prahl et al. 1976:270).

Revised Typology with Stylistic Subgroups

The Fitting typology served as an adequate heuristic to organize a collection of poorly understood Late Prehistoric archaeological materials. As time passed, other researchers developed revised typologies to view these artifacts in a new light (Schneider 2000). One significant revision was developed by researchers at the Indiana University-Purdue University Fort Wayne Archaeological Survey (IPFW-AS) for use in their work in Indiana (Arnold et al. 2007; Arnold and McCullough 2009; Mccullough 2009; McCullough 2005, 2008; McCullough and Graham 2010a, b; McCullough et al. 2004).

IPFW-AS developed a taxonomy where design elements were more finely subdivided than previous classification schemes. For example, instead of simply separating linear decorated ceramics from interrupted linear styles, elements such as truncated horizontal patterning or cording were considered. While the typological system used in this research is inspired by these revised classifications, the stylistic subgroups used here vary from those used by the IPFW-AS in order to specifically reflect the stylistic variation exhibited by the ceramics assemblages incorporated below.

Using a revised typology, the original three Macomb ceramic varieties expand to seven, thus giving a more fine-grained understanding of common design elements. This revised taxonomy, combined with Springwells Net Impressed and Monroe County ceramic types, allows for an expansion to 10 Springwells phase ceramic types used in this ceramic analysis. A comparison between Figure 14 below and Figure 8 above illustrates the increased fidelity of stylistic elements included in the new taxonomy (Table 6). The attributes of these typological categories are discussed in detail in the subsections below. The ceramic vessel is the unit of analysis for this investigation and this serves as a means to normalize varying preservation conditions for ceramics recovered across the study area.

Figure 14. Revised Springwells subgroups by locale.

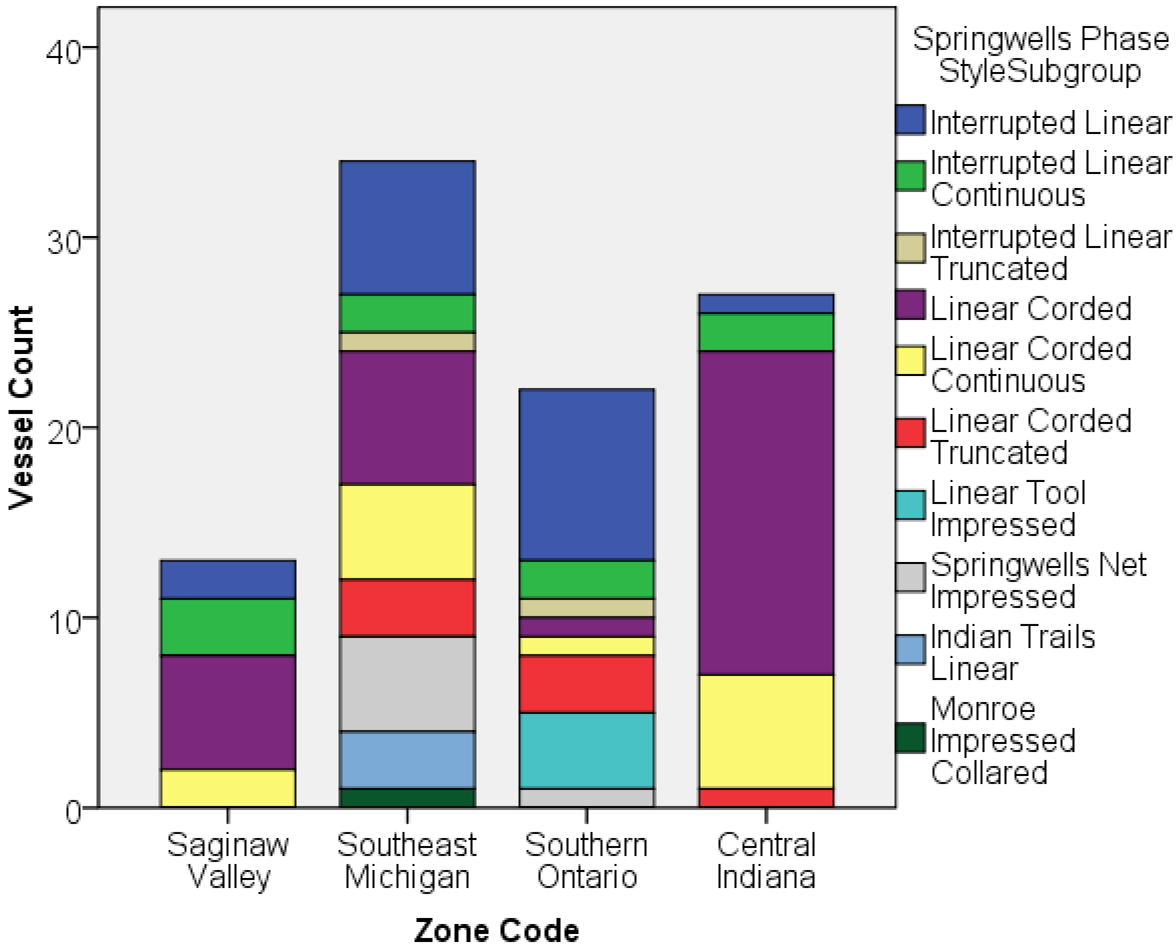


Table 6. Vessel counts by revised stylistic subgroup.

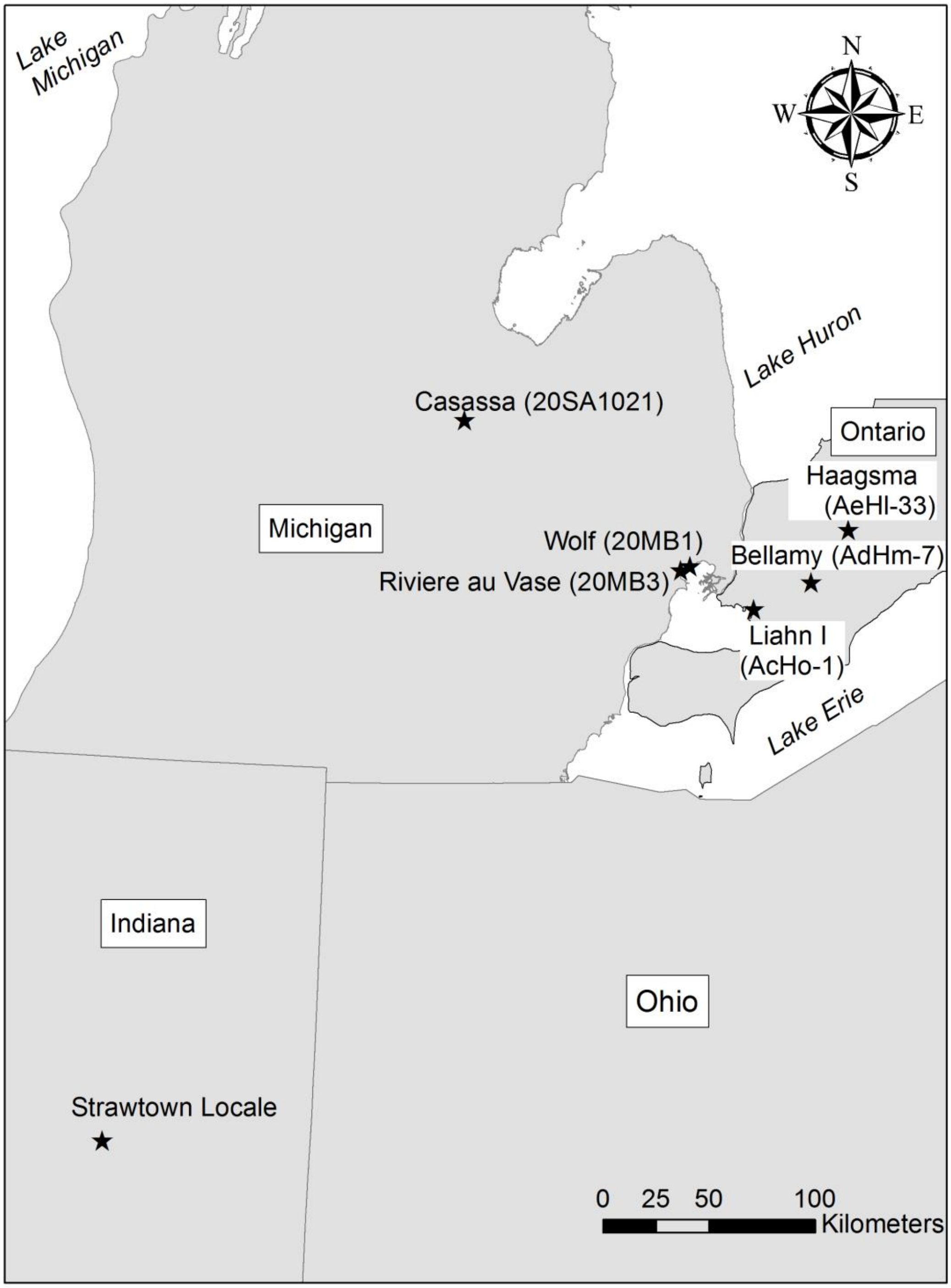
Style Subgroup	*N*
Interrupted Linear	19
Interrupted Linear Continuous	9
Interrupted Linear Truncated	2
Linear Corded	31
Linear Corded Continuous	14
Linear Corded Truncated	7
Linear Tool Impressed	4
Springwells Net Impressed	6
Indian Trails Linear	3
Monroe Impressed Collared	1
Total	96

SUBGROUP 1: INTERRUPTED LINEAR

Figure 15. Interrupted Linear rimsherd from the Bellamy site (AeHl-33).

The *Interrupted Linear subgroup* (Figure 15) accounts for 19.79% (n=19) of the total vessels analyzed. The style conforms to Fitting's (Fitting 1965:157) original description of decorative horizontal rows created below the vessel rim using a stab-drag technique. This particular category is essentially a catchall for interrupted sherds whose damage does not allow for inclusion into a more descriptive stylistic category such as a truncated or continuous style. This subgroup is present at seven of the 20 sites included in this investigation (Figure 16).

Figure 16. Sites with Subgroup 1 ceramics.



SUBGROUP 2: INTERRUPTED LINEAR CONTINUOUS

Figure 17. Interrupted Linear Continuous vessel from the Castor Farm site (12H3).

The *Interrupted Linear Continuous subgroup* (Figure 17) accounts for 9.37% (n=9) of the total vessels analyzed. The style conforms to Fitting's (Fitting 1965:157) original description of decorative horizontal rows created below the vessel rim using a stab-drag technique, and the design remains uninterrupted around the circumference of the vessel. Some vessels from Indiana exhibit a preference for "push-pull" technique rather than the stab-drag technique more common at sites in Michigan (McCullough and Graham 2010a:219). This subgroup is present at seven of the 20 sites included in this investigation (Figure 18).

Figure 18. Sites with Subgroup 2 ceramics

SUBGROUP 3: INTERRUPTED LINEAR TRUNCATED

Figure 19. Interrupted Linear Truncated vessel from the Dick site (AaHp-1).

The *Interrupted Linear Truncated* (Figure 19) subgroup accounts for 2.08% (n=2) of the total vessels analyzed. The style conforms to Fitting's (Fitting 1965:157) original description of decorative horizontal rows created below the vessel rim using a stab-drag technique. However, the horizontal bands are truncated by design fields located generally at castellation points (McCullough and Graham 2010a:219). The vessel above recovered from the Dick site in Essex County, Ontario exhibits a push-pull technique very similar to the vessel shown above (Figure 17) recovered from the Strawtown locale in Indiana. This subgroup is present at two of the 20 sites included in this investigation (Figure 20).

Figure 20. Sites with Subgroup 3 ceramics.

SUBGROUP 4: LINEAR CORDED

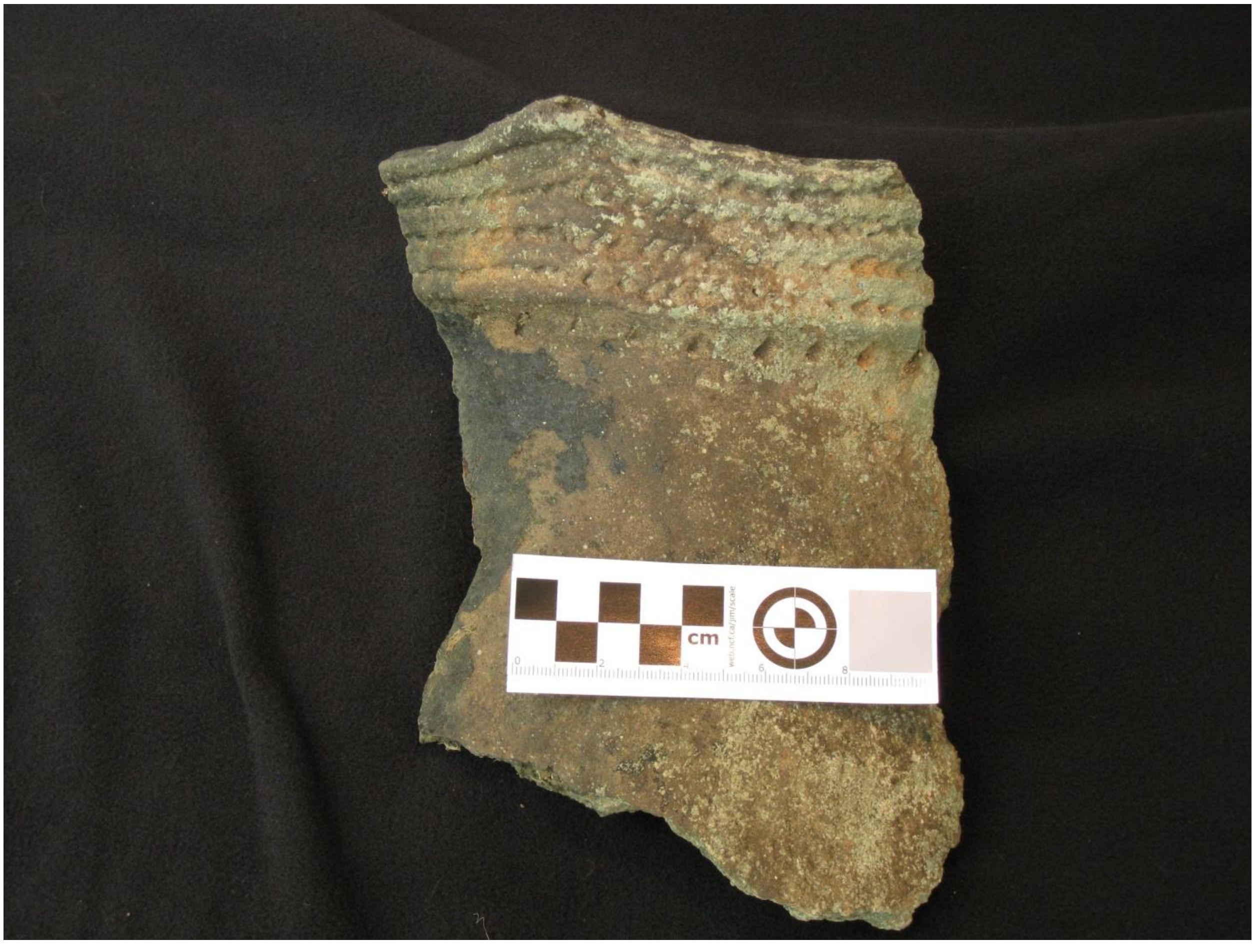
Figure 21. Linear Corded sherd from the Lianh I site (AcHo-1).

The *Linear Corded* subgroup (Figure 21) accounts for 31.29% (n=31) of the total vessels analyzed. The style conforms to Fitting's (1965:157) original description of decorative horizontal rows created below the vessel rim using a either a cordwrapped stick, a knotted cord or a cordwrapped cord. Like the Interrupted Linear type, this particular category is essentially a catchall for corded sherds whose damage does not allow for inclusion into a more descriptive stylistic category such as a truncated or continuous style. This subgroup is present at six of the 20 sites included in this investigation (Figure 22).

Figure 22. Sites with Subgroup 4 ceramics.

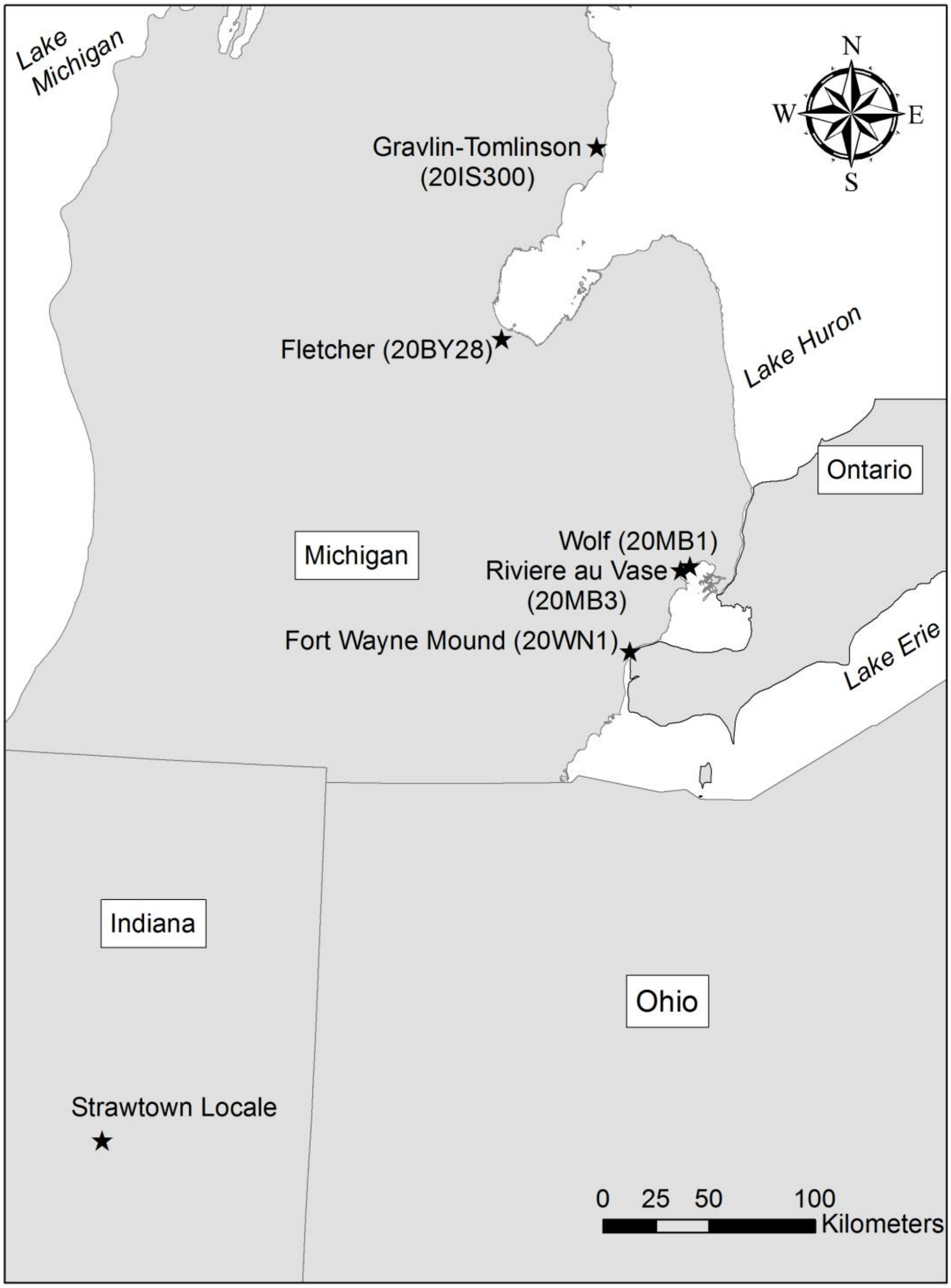
SUBGROUP 5: LINEAR CORDED CONTINUOUS

Figure 23. Linear Corded Continuous vessel from the Gravlin-Tomlinson site.



The *Linear Corded Continuous* subgroup (Figure 23) accounts for 14.58% (n=14) of the total vessels analyzed. The style conforms to Fitting's (1965:157) original description of decorative horizontal rows created below the vessel rim using a either a cordwrapped stick, a knotted cord or a cordwrapped cord and the design remains uninterrupted around the circumference of the vessel. This subgroup is present at six of the 20 sites included in this investigation (Figure 24).

Figure 24. Sites with Subgroup 5 ceramics.

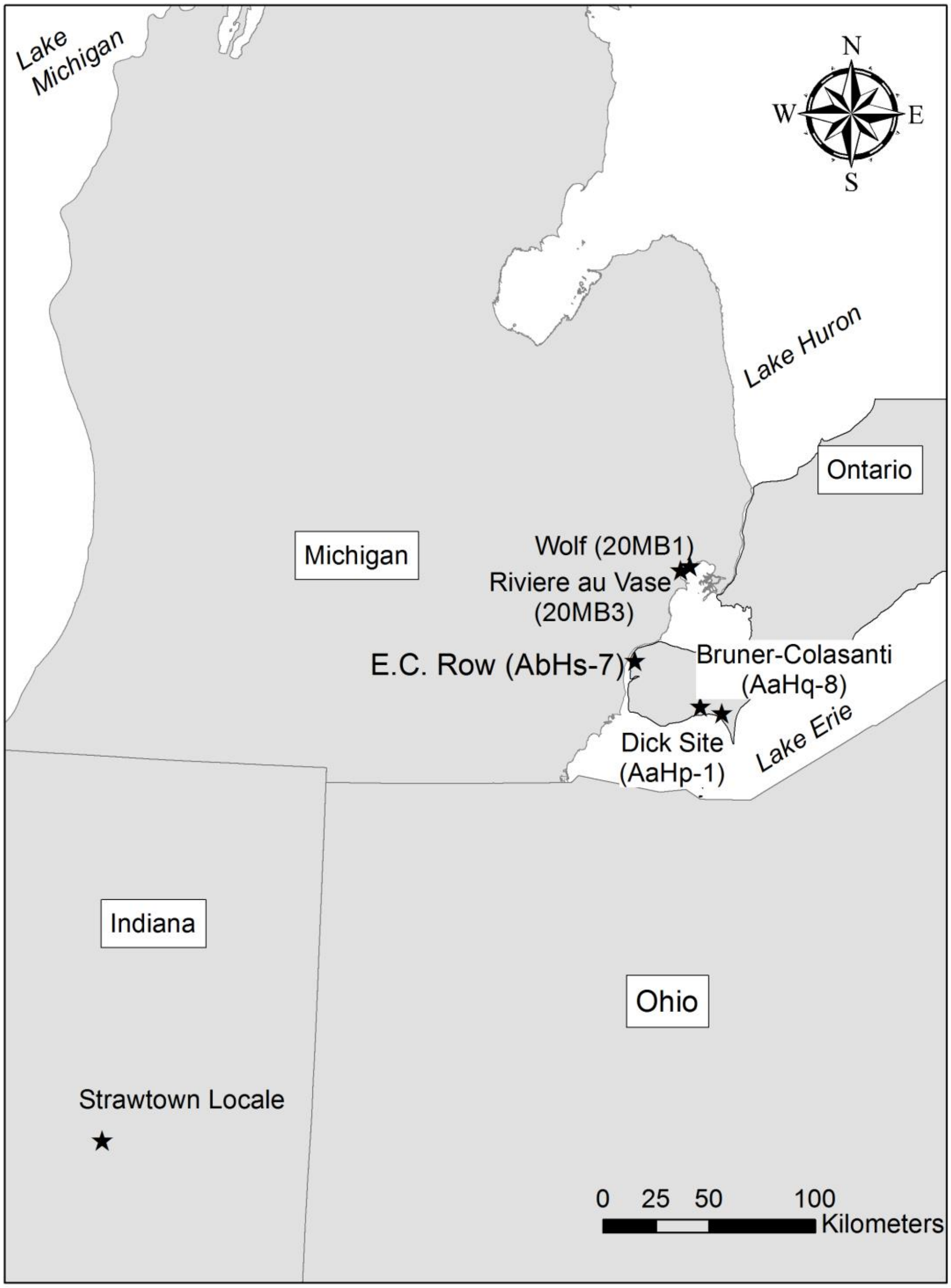


Subgroup 6: Linear Truncated

Figure 25. Linear Corded Truncated vessel from the Dick site (AaHp-1).

The *Linear Corded Truncated* subgroup (Figure 25) accounts for 7.29% (n=7) of the total vessels analyzed. The style conforms to Fitting's (1965:157) original description of decorative horizontal rows created below the vessel rim using a either a cordwrapped stick, a knotted cord or a cordwrapped cord. However, the horizontal bands are truncated by design fields located at generally at castellation points (McCullough and Graham 2010a:219). This subgroup is present at six of the 20 sites included in this investigation (Figure 26).

Figure 26. Sites with Subgroup 6 ceramics.



Subgroup 7: Linear Tool Impressed

Figure 27. Linear Tool Impressed vessel from the Haagsma site (AeHl-33).

The *Linear Tool Impressed* subgroup (Figure 27) accounts for 4.16% (n=4) of the total vessels analyzed. The style conforms to Fitting's (1965:157) original description of decorative horizontal rows created below the vessel rim, however a smooth tool (not a pointed or cordwrapped stick) is used to incise the clay prior to firing. This subgroup is present at three of the 20 sites included in this investigation (Figure 28). All sites are located on the northeastern edge of the study area in Ontario.

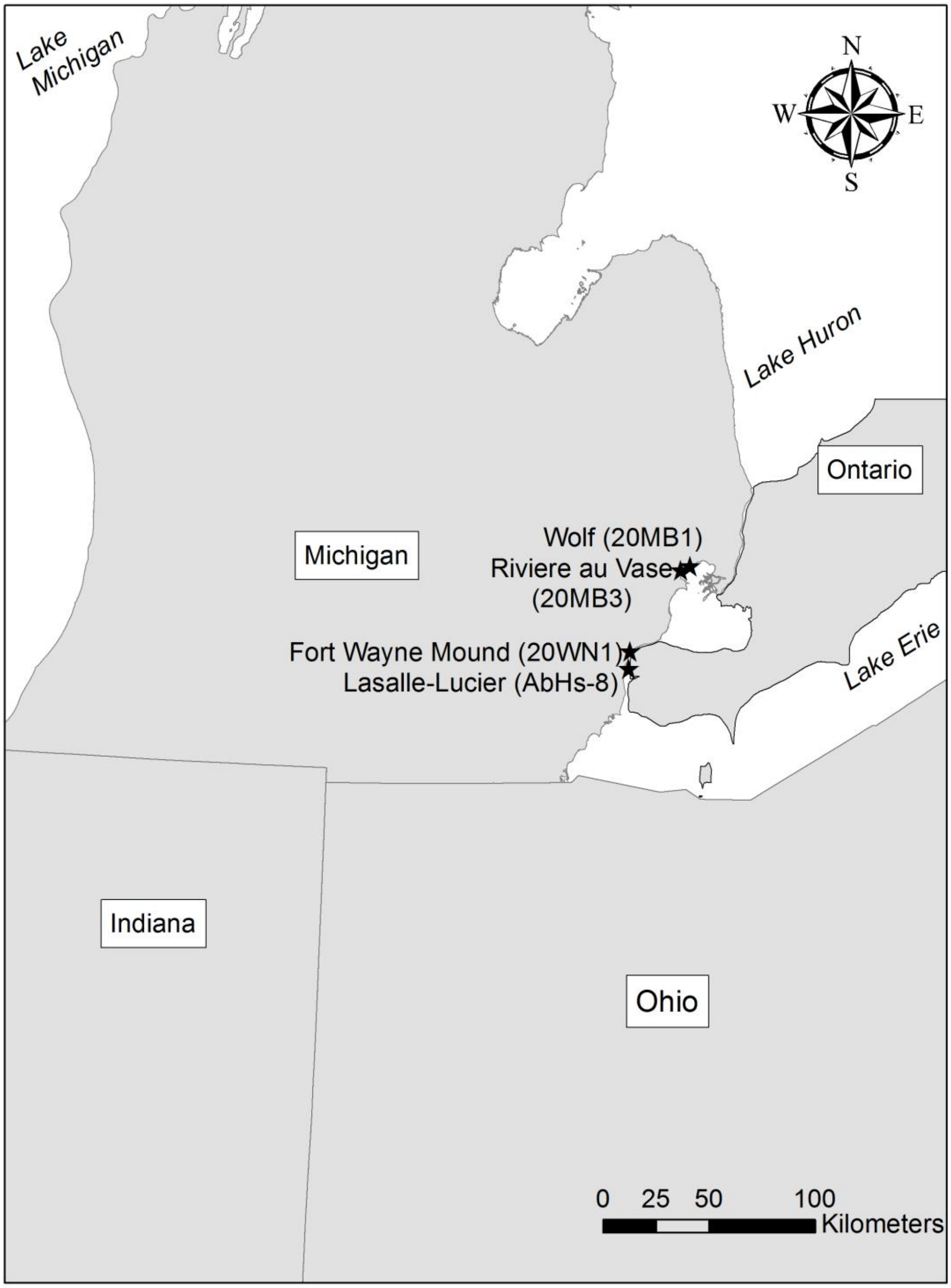
Figure 28. Sites with Subgroup 7 ceramics.

SUBGROUP 8: SPRINGWELLS NET IMPRESSED

Figure 29. Springwells Net Impressed sherd from the Fort Wayne Mound site (20WN1).

Springwells Net Impressed ceramic typology (Figure 29) remains unchanged as defined by Fitting (Fitting 1965:157) and also discussed by Halsey (1968:127). These sherds are both castellated and non-castellated with coarse grit temper and a cordmarked surface treatment that resembles interlocking net-like patterns near the rim. This subgroup accounts for 6.25% (n=6) of the total vessels analyzed and is present at four of the 20 sites included in this investigation (Figure 30).

Figure 30. Sites with Subgroup 8 ceramics.

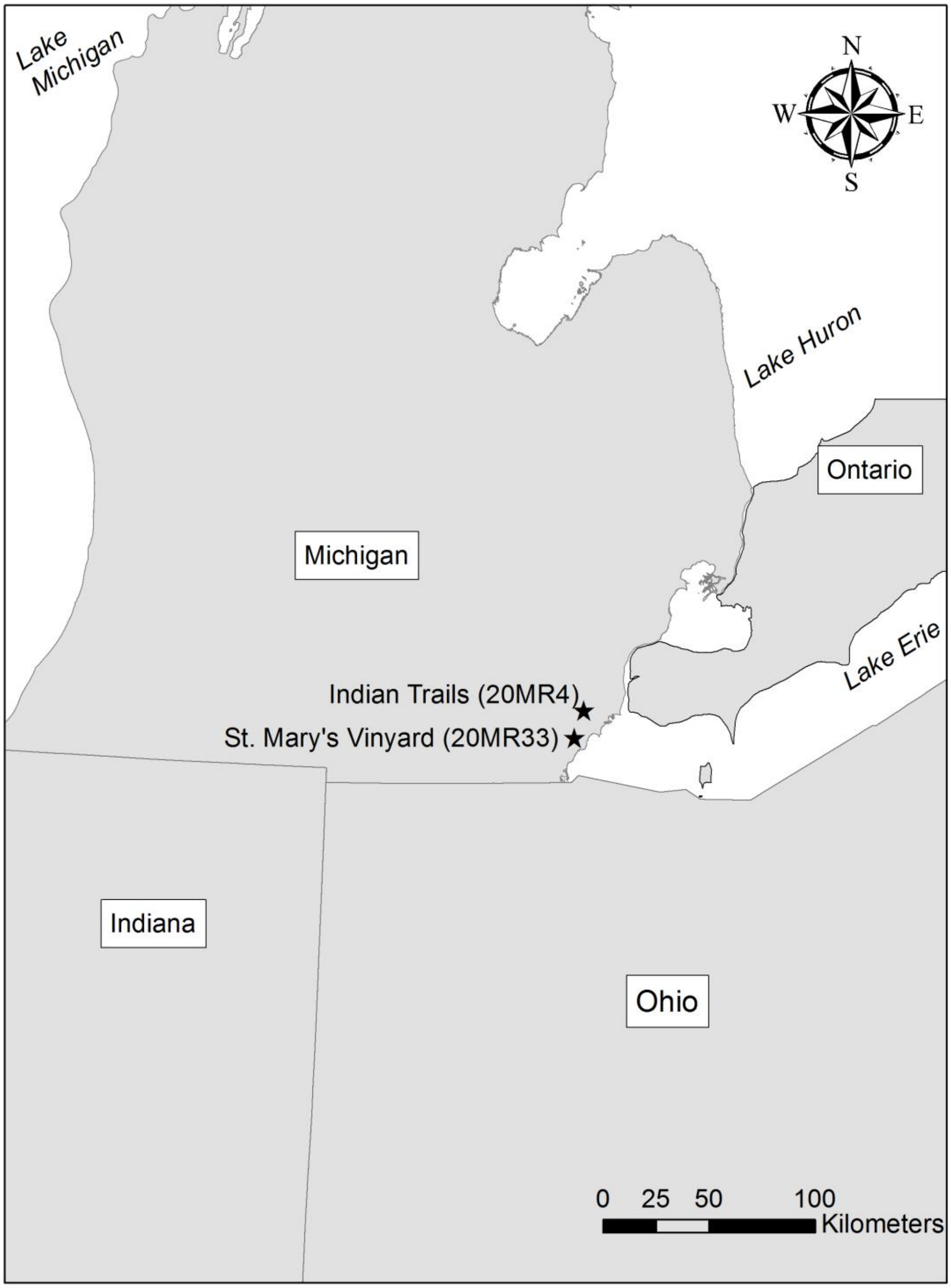


SUBGROUP 9: INDIAN TRAILS LINEAR

Figure 31. Indian Trails Linear vessel from the Indian Trails Site (20MR4).

The *Indian Trails Linear* subgroup (Figure 31) accounts for 3.12% (n=3) of the total vessels analyzed. This ceramic typology remains unchanged as defined by Brose and Essenpreis (1973:175) and features coarse grit temper and horizontal bands on the exterior of the castellated rim. This subgroup is present at two of the 20 sites included in this investigation (Figure 32).

Figure 32. Sites with Subgroup 9 ceramics.

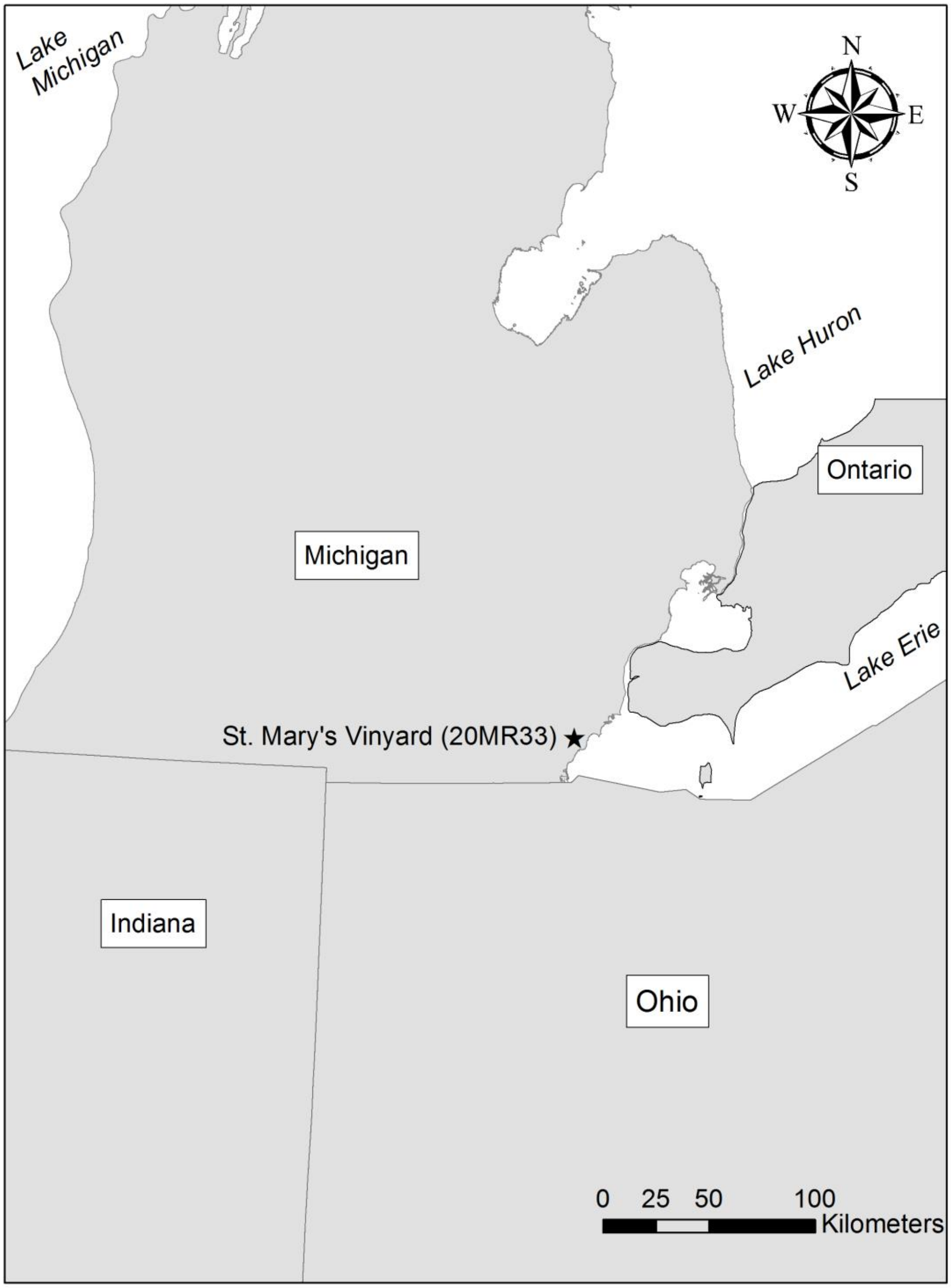


Subgroup 10: Monroe Impressed Collared

Figure 33. Monroe Impressed Collared rimsherd from the St. Mary's Vineyard site (20MR33).

The *Monroe Impressed Collared* subgroup (Figure 33) accounts for 1.04% (n=1) of the total vessels analyzed. This ceramic typology remains unchanged as defined by Brose and Essenpreis (1973:174) and features multiple banded horizontal impressions placed below the rim and medium to fine grit tempering. This subgroup is present at one of the 20 sites included in this investigation (Figure 34).

Figure 34. Sites with Subgroup 10 ceramics.



Analytical Methods

Data Collection

Data were collected from rimsherds representing 96 vessels recovered from 20 sites throughout the study area. The vessels were selected because they conformed to either the original Younge Tradition Springwells phase typology established by Fitting (1965) or the typology established for contemporaneous materials by Brose and Essenpreis (1973) during their Monroe County survey work. Only rimsherds that contained enough measureable stylistic information to associate them positively with the Springwells phase were included in the analysis. Rimsherds needed to have at least one horizontal band characteristic of the Macomb series present, have the "net-impressed" pattern on a collared/castellated Springwells Net Impressed rim present, or have the impressed/collared/castellated rim motif identified in the Monroe County materials.

The collections drawn upon for this investigation are curated at Indiana University-Purdue University Fort Wayne Archaeological Survey Department, The personal collection Gravlin-Tomlinson Family of Oscoda, Michigan, the Michigan State University Department of Anthropology, the Ontario Ministry of Culture-London Office, the University of Michigan Museum of Anthropology, and the University of Windsor Department of Sociology, Anthropology, and Criminology.

As many as 105 metrics were collected for each of the rims depending on the preservation of the ceramics. These metrics included variables such as rim thickness, lip thickness, number of horizontal and vertical bands, surface treatment, temper, and the amount of space between bands. However, it quickly became apparent that because all ceramics were Springwells subtypes and generally contemporaneous, the primary focus of the analysis needed to shift toward understanding shared stylistic themes and their relationships to geographic distributions. This analysis follows that of both Krakker (1983) and Pugh (2010) who each evaluate the relationships between stylistic similarity and spatial proximity.

The hypothesis for the ceramics analysis is the following:

> H1: If social interaction manifests primarily at the sub-regional scale, then Springwells stylistic subgroups will cluster spatially by locale. Alternatively, if interaction manifests routinely at a regional scale, then stylistic subgroups will be more widely dispersed throughout the study area.

Brainerd-Robinson Coefficient Analysis

One way to assess the degree of stylistic similarity across assemblages is to assign a comparative value relating to the types of styles found at each site. Brainerd-Robinson coefficients (Brainerd 1951; Robinson 1951) measure similarity by comparing the relative percentages of standardized categorical variables between artifact assemblages (Pugh 2010:188) on a scale between 0 (least similar) and 200 (most similar). As Pugh (2010:188) has noted, the results of this type of analysis should be viewed as a "comparative statistic" instead of a "test of statistical significance." Pugh (2010:190-192) employed the use of Brainerd-Robinson coefficients to evaluate the similarities between motifs on Oneota ceramic assemblages in the Central Plains region of North America and found little evidence that geographic proximity was related to motif similarity for Western Oneota region. A similar approach was employed here to assess the geographic relationships between these stylistic subgroups. The revised Springwells ceramic subgroups perform the same categorical function as Pugh's Oneota ceramic motifs.

A total for each stylistic subgroup was compiled by site and these totals were then entered numerically into a spreadsheet in Excel 2010. A script (Peeples 2011) developed specifically for use in the R statistical program (Hornk 2012) automatically calculated Brainerd-Robinson coefficients for each site. Table 7 below lists Brainerd-Robinson coefficients for sites based on shared stylistic similarities of ceramic subgroups present at each site.

Table 7. Brainerd-Robinson coefficients for sites and ceramic subgroups.

Sites	*BR Coefficient*
Fletcher, Gravlin-Tomlinson	200
Casassa, Castor Farm	148.15
Haagsma, Lianh I	133.33
Casassa, Riviere au Vase	133.33
Bellamy, Lianh I	133.33
Castor Farm, Riviere au Vase	129.63
↑90^{th} Percentile for similarity ↑	
Fort Wayne Mound, Lasalle-Lucier	120.00
Riviere au Vase, Wolf	106.35
Indian Trails, St. Mary's Vineyard	100.00
Haagsma, Robson Road	100.00
Dick Site, E.C. Row	100.00
Bruner-Colasanti, Fletcher	100.00
Bruner-Colasanti, Gravlin-Tomlinson	100.00
Bellamy, Haagsma	100.00
Lianh I, Wolf	85.71
Haagsma, Wolf	85.71
Bellamy, Wolf	85.71
↑75^{th} Percentile for similarity ↑	
Fort Wayne Mound, Riviere au Vase	84.44
Castor Farm, Fort Wayne Mound	80.00
Lianh I, Riviere au Vase	77.78
Casassa, Lianh I	77.78
Robson Road, Fletcher	66.67
Robson Road, Gravlin-Tomlinson	66.67
Castor Farm, Fletcher	59.26
Castor Farm, Gravlin-Tomlinson	59.26
Fort Wayne Mound, Wolf	57.14
Dick Site, Wolf	57.14
Riviere au Vase, Fletcher	55.56
Riviere au Vase, Gravlin-Tomlinson	55.56
Dick Site, Robson Road	50.00
Dick Site, Fletcher	50.00
Dick Site, Gravlin-Tomlinson	50.00
↑50^{th} Percentile for similarity ↑	

Table 7 (cont'd).

Haagsma, Riviere au Vase	44.44
Dick Site , Riviere au Vase	44.44
Casassa, Haagsma	44.44
Casassa, Wolf	44.44
Bruner-Colasanti, Castor Farm	44.44
Bellamy, Casassa	44.44
Bellamy, Riviere au Vase	44.44
Castor Farm, Wolf	43.39
Castor Farm, Lianh I	40.74
Fort Wayne Mound, Fletcher	40.00
Fort Wayne Mound, Gravlin-Tomlinson	40.00
Casassa, Fort Wayne Mound	40.00
Bruner-Colasanti, Fort Wayne Mound	40.00
Lianh I, Robson Road	33.33
Fort Wayne Mound, Lianh I	33.33
Bruner-Colasanti, Riviere au Vase	33.33
↑25th Percentile for similarity ↑	
Wolf, Fletcher	28.57
Wolf, Gravlin-Tomlinson	28.57
Lasalle-Lucier, Wolf	28.57
E.C. Row, Wolf	28.57
Bruner-Colasanti, Wolf	28.57
Riviere au Vase, Robson Road	22.22
E.C. Row, Riviere au Vase	22.22
Castor Farm, Dick Site	22.22
Casassa, Dick Site	22.22
Casassa, Robson Road	22.22
Casassa, Fletcher	22.22
Casassa, Gravlin-Tomlinson	22.22
Castor Farm, Robson Road	14.81
Lasalle-Lucier, Riviere au Vase	11.11
Castor Farm, E.C. Row	7.41
Castor Farm, Haagsma	7.41
Bellamy, Castor Farm	7.41

Now that stylistic similarity between sites has been assessed, the next step required for interpretation is to determine the relationship between subgroup distributions and geographic space using complementary statistical analysis.

Regression Analysis

An additional hypothesis (H2) tested here is that the distribution of ceramic subgroups is primarily influenced by geographic proximity across the study area. That is to say, the closer the sites in space, the more likely that stylistic subgroupings present between sites will be similar. If this is the case, and in keeping with the first hypothesis presented above, stylistic subgroups should indicate that social interaction manifests primarily at a sub-regional scale.

Euclidean, (straight-line) distance was calculated between sites using ArcGIS 10.0, the values were entered into SPSS 16.0 along with a site-pair's Brainerd-Robinson coefficient, and a linear regression was run between site pairs whose coefficients were greater than zero. Tables 8, 9, and Figure 35 below indicate that there is a very weak association (.027) between Euclidean distance and Brainerd-Robinson coefficients.

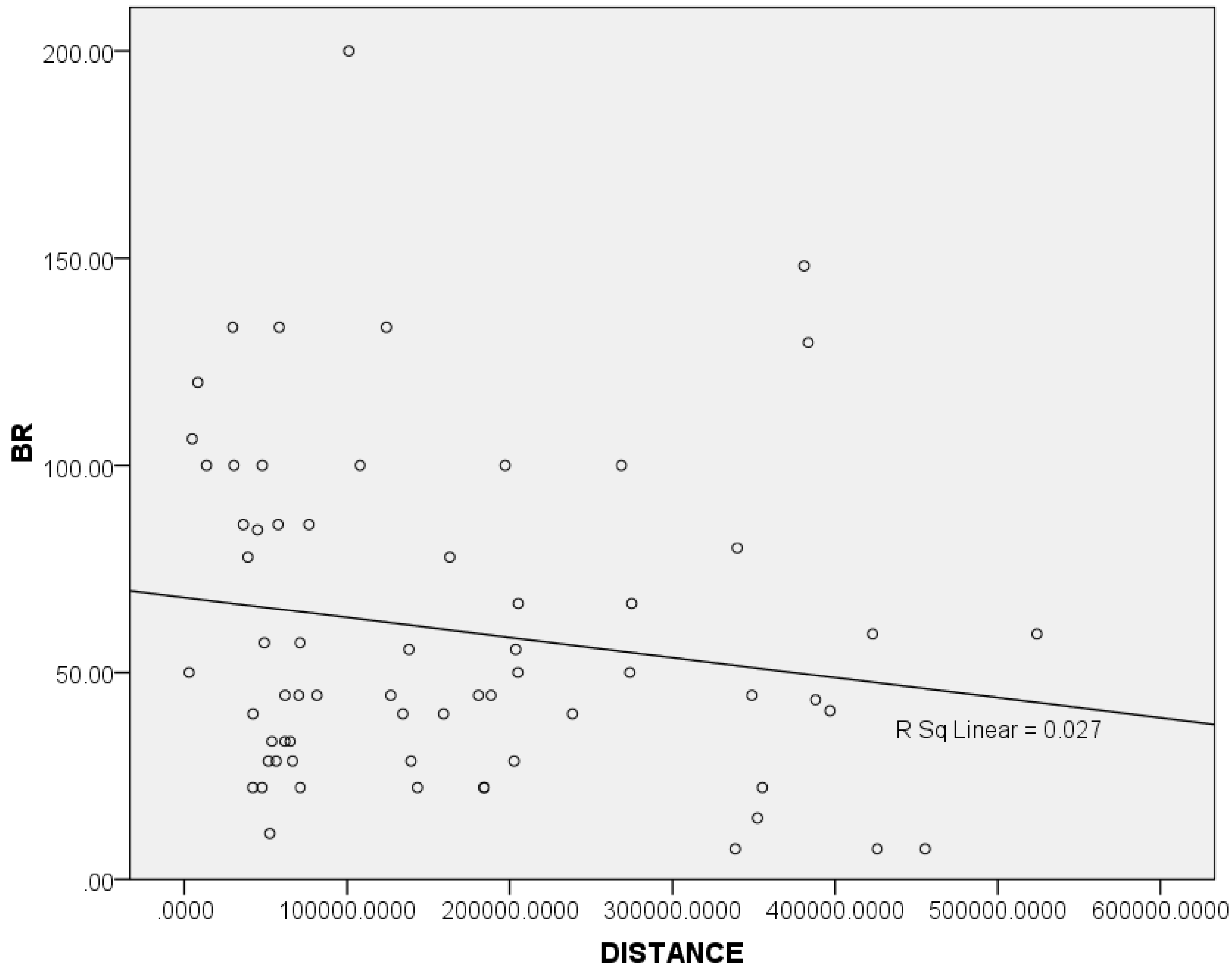
Table 8. Linear regression summary table.

Model Summary				
Model	R	R Square	Adjusted R Square	Standard Error of the Estimate
1	.165	.027	.012	39.585
a. Predictors: (Constant), DISTANCE				
b. Dependent Variable: BR				

Table 9. Residual statistics for linear regression.

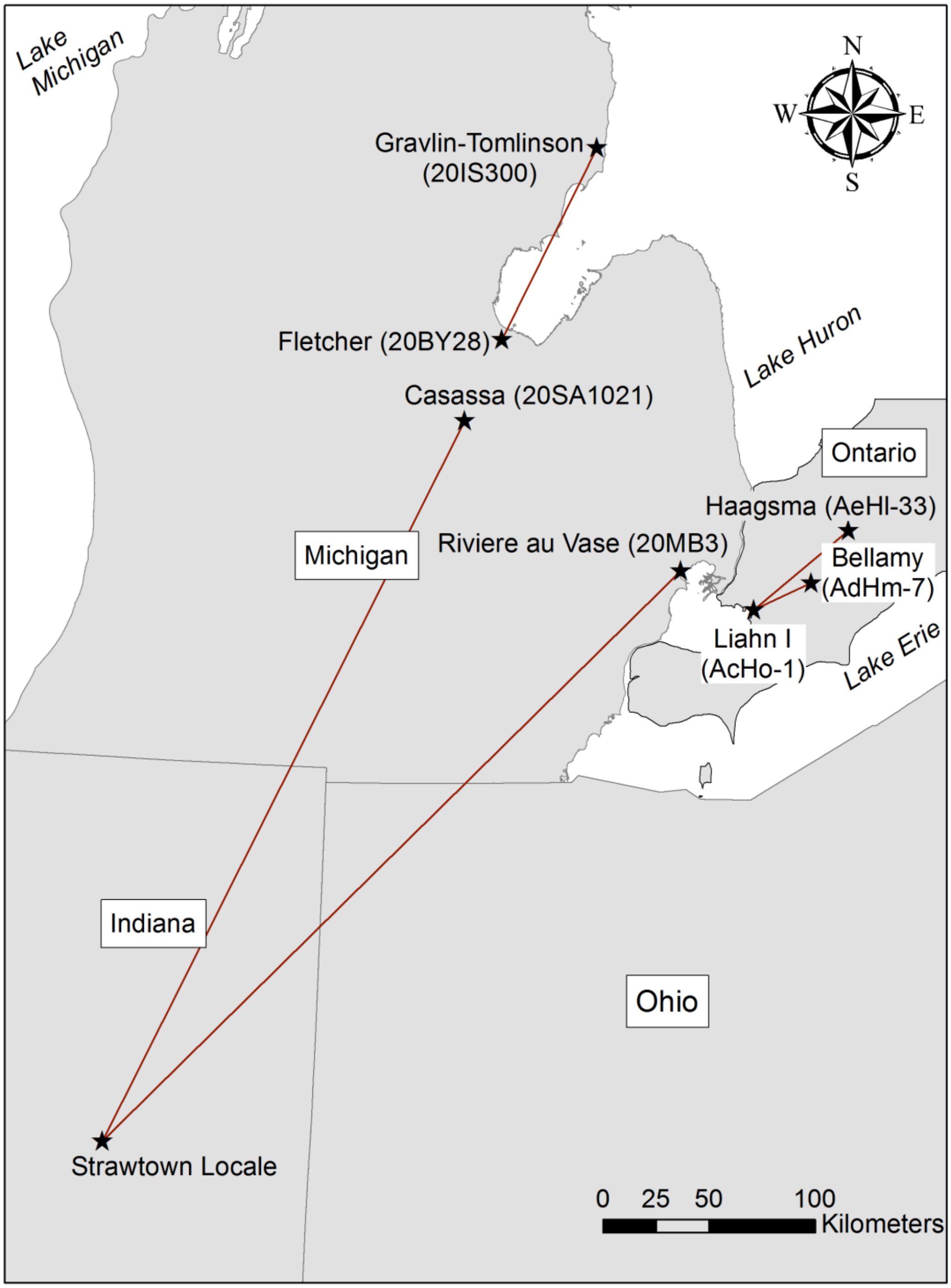
Residuals Statistics				
	Minimum	Maximum	Mean	Standard Deviation
Predicted Value	42.728	67.947	60.157	6.576
Residual	-54.438	136.798	.000	39.275
Std. Predicted Value	-2.650	1.184	.000	1.000
Std. Residual	-1.375	3.456	.000	.992
a. Dependent Variable: BR				

Figure 35. Linear Regression evaluating Euclidean distance and Brainerd-Robinson results.



The interpretation presented here is that while proximity matters somewhat (less than 3%) in terms of subgroup similarity, the overwhelming influence on Brainerd-Robinson coefficients seems to be the result of something other than simple geographic proximity (Figure 36). Pugh (2010:192) attributes similar findings to a combination of social boundaries and chronological factors influencing Western Oneota motif selection. It is likely that these factors are also playing into Springwells stylistic subgroup selection, and alternative explanations are presented later in Chapter VI. Simply stated, the ceramic analysis indicates that interaction manifests routinely at a regional scale as indicated by stylistic subgroups widely dispersed throughout the study area (Figure 36).

Figure 36. Sites sharing a 90th percentile score in terms of Brainerd-Robinson coefficients.



Next Steps: Generative Experimentation and Explanation

At this point in the discussion, it is useful to restate what the ceramics evidence supports about the nature and function of Springwells social networks across the region. We know that:

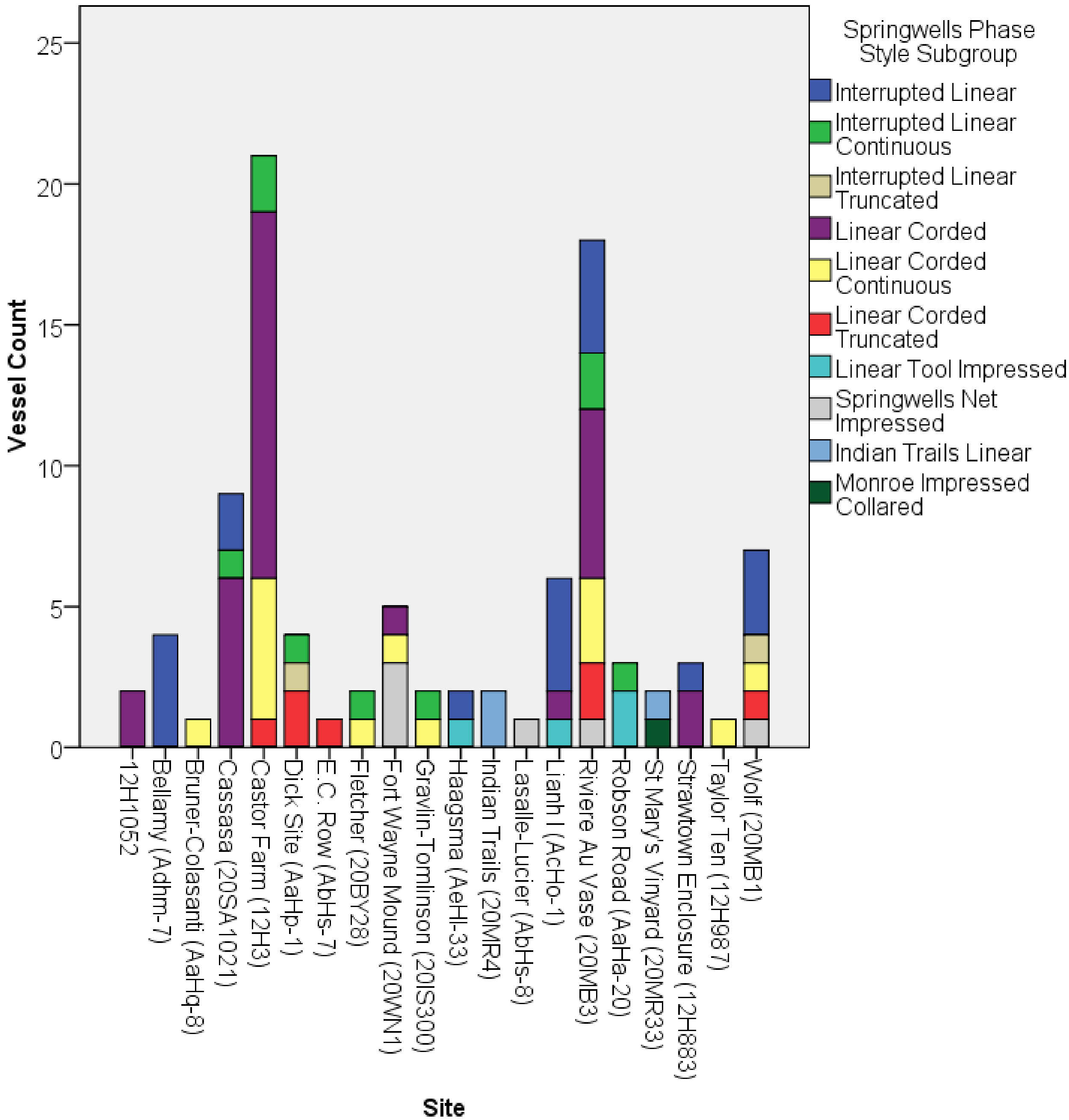
1. Expanding the ceramic subtypes from the original three to 10 allows for a more fine-grained understanding regarding both the similarity and spatial distribution of stylistic motifs across Springwells phase sites in the region (Figure 37).
2. The regression analysis assessing the distribution of styles between sites indicates that Springwells communities interacted at sociospatial scales independent of geographic proximity. As in the case of Castor Farm (central Indiana) and Casassa (Saginaw Valley, Michigan), Brainerd-Robinson scores (BR=148.15) show much higher similarities between sites at greater distances than between many neighboring sites.

We do not know:

1. What social factors account for the lack of influence proximity has on the adoption of stylistic motifs between Springwells communities.
2. What social factors account for the acceleration of stylistic change during the Late Prehistoric period as compared to preceding periods.

In order to move from description to explanation we need to shift our analysis from pattern to process. That is, we may draw upon methodological tools that facilitate a shift from a static snapshot of artifacts to a dynamic, testable, observable process (Epstein 2006; Gilbert and Doran 1994; Gilbert and Troitzsch 2005; Gilbert 2008; Gimblett 2002; Graham 2006; Kohler and Gumerman 2000; Kohler and Leeuw 2007; O'Brien and Shennan 2010; Wolfram 2002). The next chapter does this by drawing upon social science simulation in the form of an Agent Based Model (ABM) to examine how the transmission of stylistic information is influenced by the social context of interaction between participants.

Figure 37. Relative ceramic subtype representation by site.



CHAPTER V

Simulating Springwells Social Interaction through Agent-Based Modeling (ABM)

Agent Based Modeling (ABM) is a computer-based method that allows us to simulate how the interactions of individual components within a system produce emergent phenomena that eventually become hallmark characteristics of a system (Epstein 2006; Gilbert and Troitzsch 2005; Gilbert 2008; Kohler and Gumerman 2000; Kohler and Leeuw 2007; Railsback and Grimm 2012). ABM is noted for its ability to employ "anthropologically plausible" (Dean et al. 1999) rules that influence how agents interact. Moreover, simulation as a method "can be seen as a species of model capable of investigating complex, multifaceted systems, and most importantly, as a means of constructing experimental scenarios that could never normally be observed" (McGlade 2005:558).

With ABM, "Agents" are a specific component of the computer program used to embody social actors (Gilbert 2008:5), and they may collect information about their environment while making decisions about behaviors to engage in as dictated by specific model programming rules (Kohler 2000). One of the main benefits of ABM is that researchers can observe dynamic relationships manifesting between agents at multiple social and spatial scales (Kohler 2000). Assuming proper model conceptualization and implementation, interaction between individual agents produces emergent phenomena that scale-up to the system (the largest, or global) level from behaviors of individual agents (Graham 2006). For the archaeological community, ABM modeling has proven useful to those studying Anasazi culture change in the Southwest (Dean et al. 1999), Roman social interaction in Europe (Graham 2006), and the colonization of Mesolithic islands in what is now modern Scotland (Mithen and Lake 1996).

A separate but related area of interest is the study of cultural transmission (CT), where CT variation has been used to explain how changes in material culture are tied to the social context of interactions (Bentley and Shennan 2003; Eerkens and Lipo 2007). ABM and CT studies may be synergistically combined to simulate the differential flow of information among ethnographically derived scenarios relating to group interactions. Such a model can generate expectations relating to changes in CT and style homogeneity, which may be useful to archaeologists investigating cultural processes in the past.

The simulation processes of interest in this discussion are reasonably straightforward. ABM variables were parameterized along meaningful ranges to reflect changes of group size, frequencies of interaction, and types of communication. Significant changes in patterned interactions should result in concomitant changes in the dimensions of material culture that transmit information relating group identification and cohesion.

This investigation uses the open source ABM package NetLogo 4.1.2 (Wilensky 1999) to satisfy the modeling and simulation needs of this phase of this research. The simulation datasets provide insight into expected rates of change in material culture given changes in interaction. The ability to "rewind the tape" (Dean et al. 1999) and observe social processes under varying conditions should prove to be extremely valuable in terms of how researchers interpret the Springwells phase of the Late Prehistoric period in the Great Lakes region.

Agent Based Modeling and NetLogo

Gilbert and Troitzsch (2005) note that the levels of abstraction and/or detail embedded within an ABM's design greatly affect what questions the model can be programmed to answer. The fewer variables a model contains, the more abstract the model. A modeler aims to construct a design that broadly applies to the questions at hand while simultaneously minimizing operational assumptions (Gilbert and Troitzsch 2005:19). Every time a variable is added to a model, there is the potential for complicating the assessment of relationships between input parameters and output data. These assessments of relationships are commonly referred to as model sensitivity (DeVisser 2010; Santner et al. 2003).

Statistical and mathematical models are often used in the social sciences when the relationships between phenomena being modeled and output measurement have been theoretically established (Gilbert and Troitzsch 2005:16). A “simulation” differs from classical modeling in that it departs from the “mathematical tractability” (Railsback and Grimm 2012:10) of a statistical or mathematical model in favor of incorporating a larger number of elements assumed to be inherent within the respective system. This enhanced complexity facilitates both the manipulation of variables and dynamic experimentation, thus elucidating interactional dynamics between agents occupying a system. One should note that the ABM literature often uses the terms “model” and “simulation” interchangeably. This is probably related to the term “model” embedded within the ABM moniker.

The NetLogo ABM package was created by the Center for Connected Learning and Computer-Based Modeling.at Northwestern University in 1999 (Wilensky 1999). It is a cross-platform ABM specifically designed to model complex systems and their emergent properties. The program provides a user-friendly graphical interface that facilitates a range of applications from classroom demonstrations of simple simulations such as the classic Prisoner’s Dilemma game, to complex simulations of urban sprawl. An active user community collaborates using web-based resources channeled through the NetLogo website (Wilensky 1999).

The world that comprises a NetLogo ABM consists of four major classes: patches, turtles, links and the observer. *Patches* are arranged similarly to a checkerboard. Each stationary patch has an x-y coordinate established in relation to an origin and coordinates increase as one moves right and up. The function they serve in this simulation is to organize the spatial layout of the world. *Turtles* are the agents that move around the world from one patch to another and they are referred to as "persons" in the code below. *Links* are visible or invisible connectors that tie turtles together, but they are not needed or used in this simulation. The *Observer* functions to monitor the actions and entities within the world.

Methods for sending instructions to agents (*commands*) or reporting results (*reporters*) come in two forms: *primitives* and *procedures*. Primitives are predefined commands where the software automatically recognizes how to perform functions embedded within the software. Commands defined by the programmer are called *procedures* and require the programmer to create the code needed to achieve the intended result. Procedures are recognized and executed by the software provided that the programmer has conformed to the terminology and syntax defined in the NetLogo dictionary.

Variables store data values as the program executes. A *global variable* applies to all agents regardless of type, is dictated by the Observer, and all agents may access it. Other types of variables stored in specific types of agents are referred to as *turtle*, *patch* or *link variables* respectively.

Intercommunity Cultural Transmission Model (ICTM)

The purpose of the Intercommunity Cultural Transmission Model (ICTM) presented below (Figures 38-42) is to simulate the exchange of socially meaningful packets of information between communities interacting within a social network. The primary goal is to identify the most likely interactional scenarios that result in differential rates of cultural transmission reflected as ceramic style exchange between communities. The hypothesis tested here is:

> H3: Significant changes in interaction patterns result in concomitant changes in the dimensions of material culture that transmit information relating to group identification and cohesion as represented in the ICTM by stylistic subgroups.

Persons, houses, and aggregation points are the three basic entities that exist within the model, or *world*. Every person has a randomly assigned influence value that represents both the ability to influence others and an individual's susceptibility to outside influence (Mahajan and Peterson 1985; Rogers 2003; Rossman et al. 2008). All persons are candidates for exchange with other communities.

The best way to understand the model is to walk through a single run as the ICTM program executes. The simulation sequentially references seven procedures during each iteration or one model run. These are (in order): setup, assign-segment, go, calculate-influence, exchange, exchange-segmented, calculate-influence and do-plot procedures. The logic, coding, and implementation of each procedure is described here in detail and then presented as formatted NetLogo 4.1.2 code. The reader may refer to the NetLogo User Manual (Wilensky 1999) hereafter for additional background information or technical concerns relating to commands used in this model.

Figure 38. Intercommunity Cultural Transmission Model (ICTM) world.

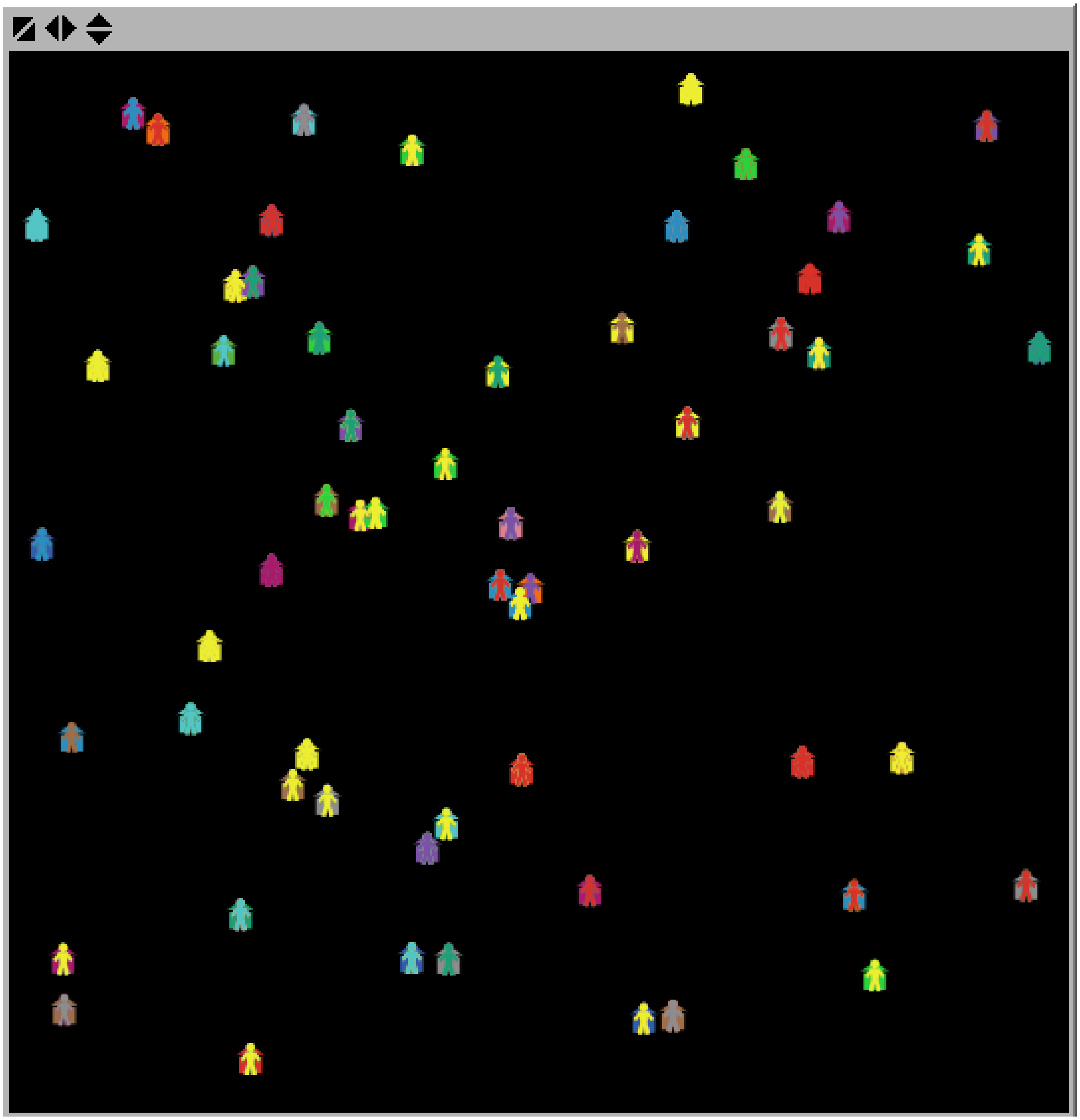


Figure 39. Intercommunity Cultural Transmission Model (ICTM) interfaces.

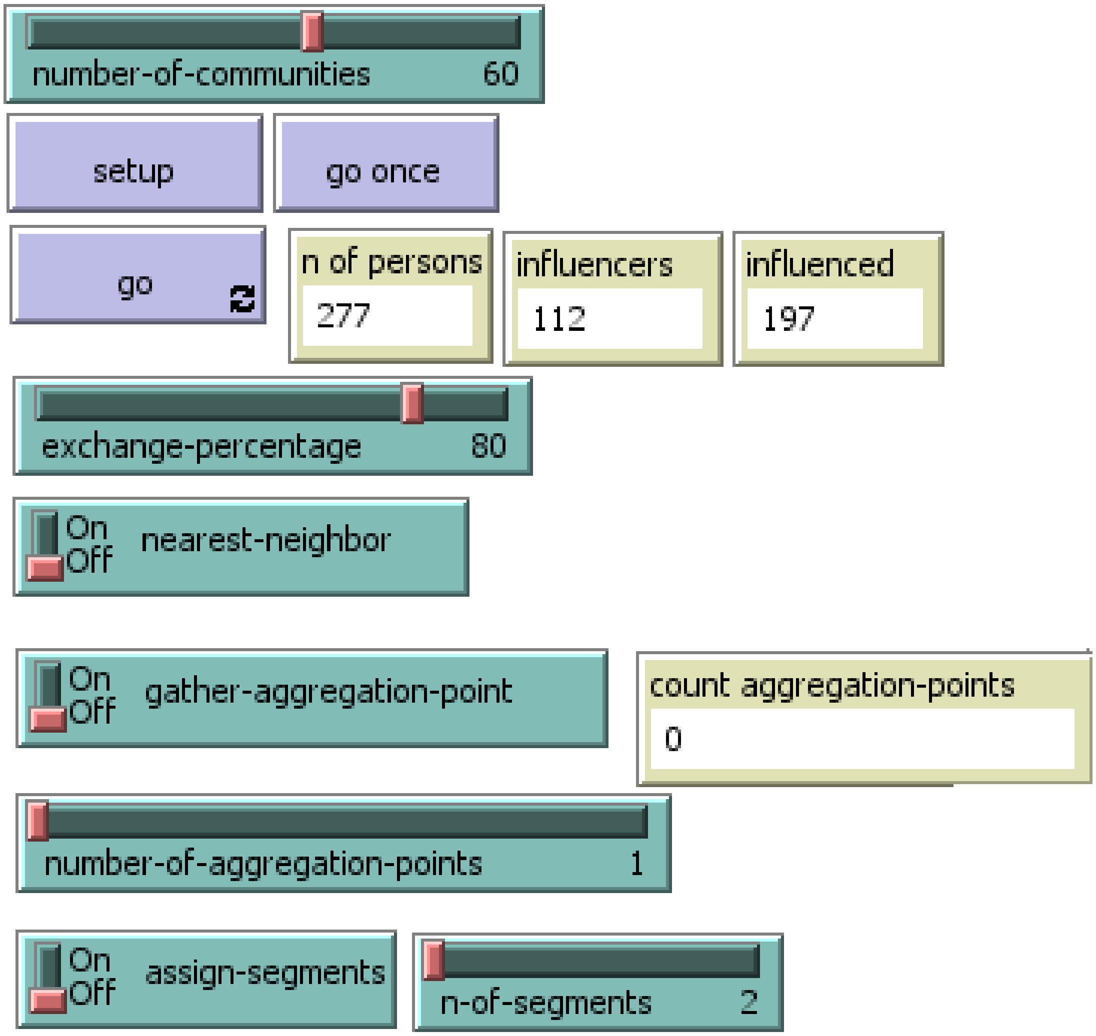


Figure 40. Intercommunity Cultural Transmission Model (ICTM) output.

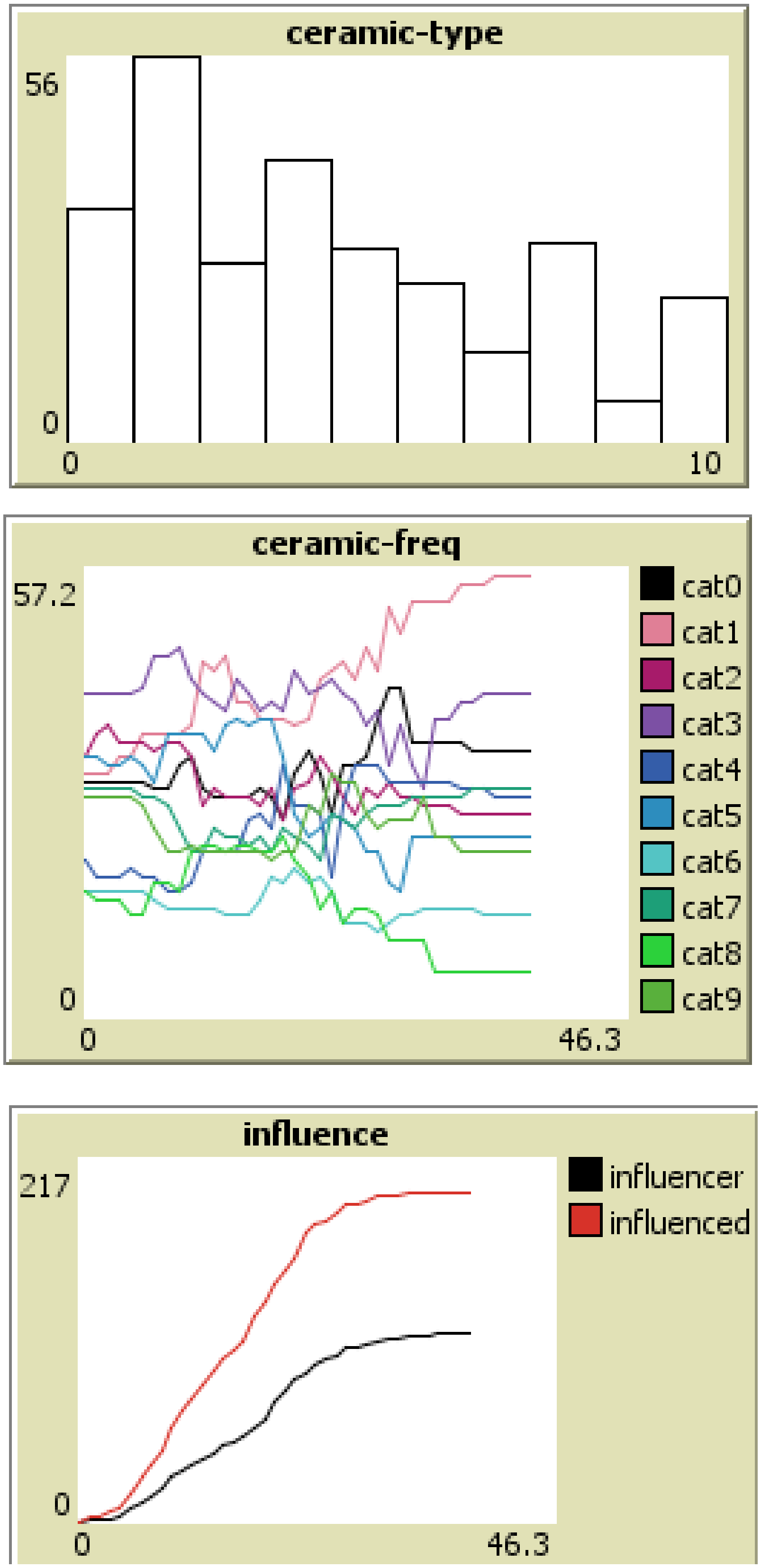
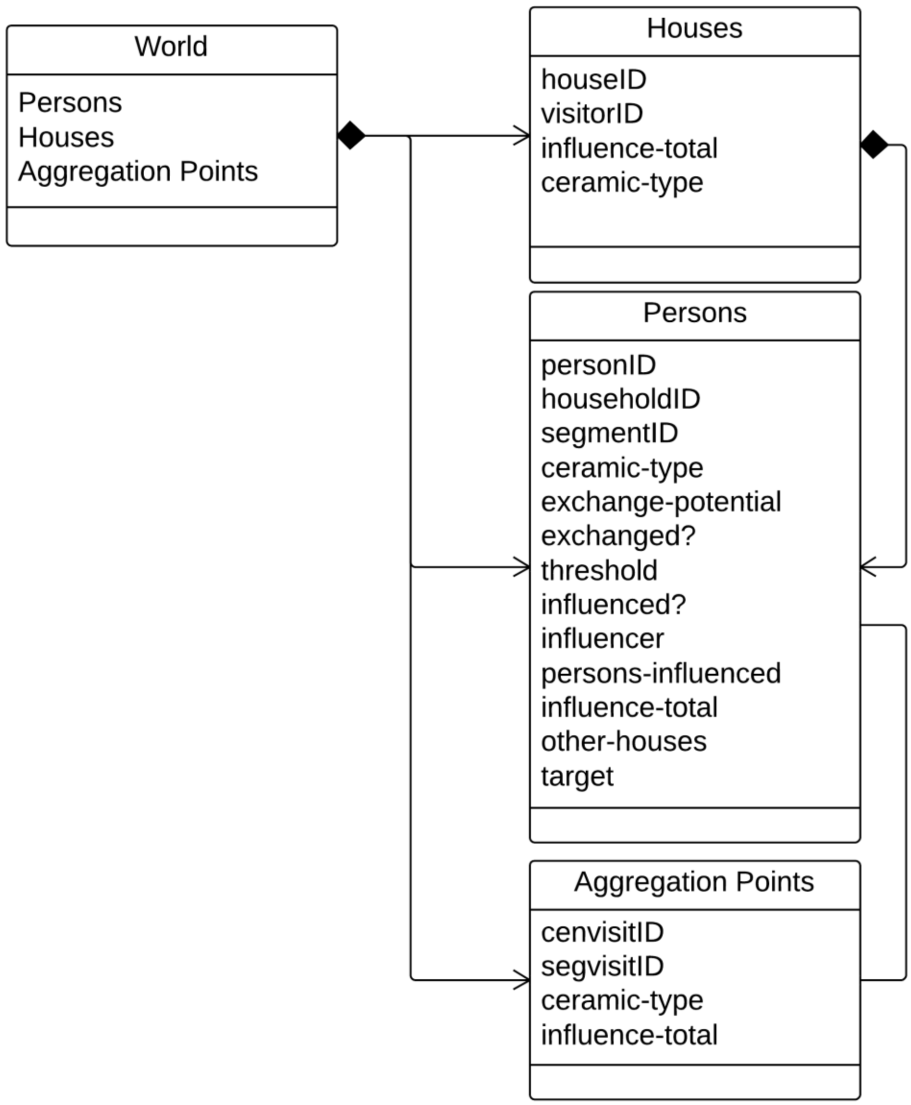


Figure 41. Unified Modeling Language (UML) class diagram for simulation elements.



Variables

As the model initializes communities are set up on the board. Each house has six variables randomly assigned as they are created:

1. HouseID: A unique number assigned to houses at the time of creation.
2. VisitorID: the house records all unique PersonID's present at that moment in time.
3. Influence-total: the sum of influence for all persons located within that community at that particular moment in time.
4. Ceramic-type: a numeric code that represents a particular ceramic style.
5. Next, each house *hatches* a random number of people who inherit some basic information about both themselves and their home communities. These data include:
    a. PersonID: a unique identifier assigned to each person.
    b. HouseholdID: a unique designation for that person's community.
    c. SegmentID- a number randomly assigned that represents a specified number of factional subdivision spanning communities.
    d. Ceramic-type: a numeric code that represents a particular ceramic style. Each person in the community has the same number initially.
    e. Exchange-potential: a random number that determine whether an individual will be exchanged during a trial run.
    f. Exchanged?: a true/false state that indicates whether a person has been selected and exchanged with another community.
    g. Threshold: a random number used to determine whether an individual influences or is influenced by others. This is the amount of influence an agent holds over others during the exchange procedures.
    h. Influenced?: A true/false state that indicates whether a person has been influenced by someone else.
    i. Influencer: the PersonID of the agent who influenced that individual.
    j. Persons-influenced: a record of the PersonID's belonging to the agents who were influenced by that individual.

k. Influence-total: the total number of persons influenced by that agent.
l. Other-houses: the HouseID of other persons in the world.
m. Target: the destination of persons if selected for exchange.

Four variables may be manipulated by the researcher: the number of communities, the percentage of people available for exchange, the type of destination for those exchanged (random community, nearest neighboring community or aggregation point), and whether or not there are intercommunity social subdivisions that crosscut communities (segments). Both the number of aggregation points and the number of segments are modifiable. If the aggregation algorithm is selected all persons selected for exchange will leave their home communities and gather at a common destination. If more than one aggregation point exists then that person's aggregation point is randomly designated. Once the people selected for exchange reach their respective destinations the point records data about those persons present:

6. CentvisitID: the HouseholdID of persons present.
7. SegvisitID: the SegmentID of persons present.
8. Ceramic-type: the ceramic types of persons present
9. Influence-total: the sum of influence for all persons present.

Once a person arrives at the new community, the opportunity for cultural transmission begins. Agents from the target community interact with the new arrivals assessing their levels of influence in relation to themselves. If a new arrival interacts with a local person who has a lower influence threshold then the local person adopts the non-local style. This process is repeated until all local persons have assessed newcomers. If the segmentation parameter described below is selected then the exchange process is the same except only newcomers and locals holding the same segment designation can exchange styles. At this stage in the procedure both influencers and persons influenced are summed, the ceramic types and frequencies recorded, and results routed to output files for statistical post-processing in SPSS.

Parameters

The ICTM has four core parameters that may be adjusted:

1. The number of communities involved in the exchange process.
2. The percentage of people within each community who are eligible for exchange.
3. Segmentation. This represents factioning that crosscuts communities. Members only exchange style with members of the same faction after they reach their destination. This variable may be adjusted to include up to 100 segments.
4. The spatial patterning of the destination for persons selected for exchange. These options include randomized destination, nearest neighbor destination, or a multi-community aggregation point. This variable may be adjusted to include up to 100 aggregation points.

INITIALIZATION AND SETUP PROCEDURE

NetLogo first looks for special instructions in the code that establish special categories of agents known as *breeds*. The ICTM establishes house, persons, and aggregation points as breeds and establishes the aforementioned variables that each breed will store just prior to the setup sequence in the code *(please note that UMI publication requirements specify that the code below is double-spaced and this is not considered a best practice for NetLogo programming):*

```
breed [ houses house ]

houses-own [

 houseID

 visitorID

 influence-total
```

```
  ceramic-type
]
breed [ persons person ]
persons-own [
  personID
  householdID
  segmentID
  ceramic-type
  exchange-potential
  exchanged?
  threshold
  influenced?
  influencer
  persons-influenced
  influence-total
  other-houses
  target
]
breed [ aggregation-points aggregation-point ]
aggregation-points-own [
  cenvisitID
  segvisitID
  ceramic-type
```

```
  influence-total
]
```

NetLogo then looks to the setup procedure as it initializes and creates the world. The communities (represented graphically by individual houses) are created according to the value specified by the number-of-communities slider in the interface. The spatial location for each community is randomly assigned. Each community is also given a unique identifier and a random ceramic type that each person from that community will adopt:

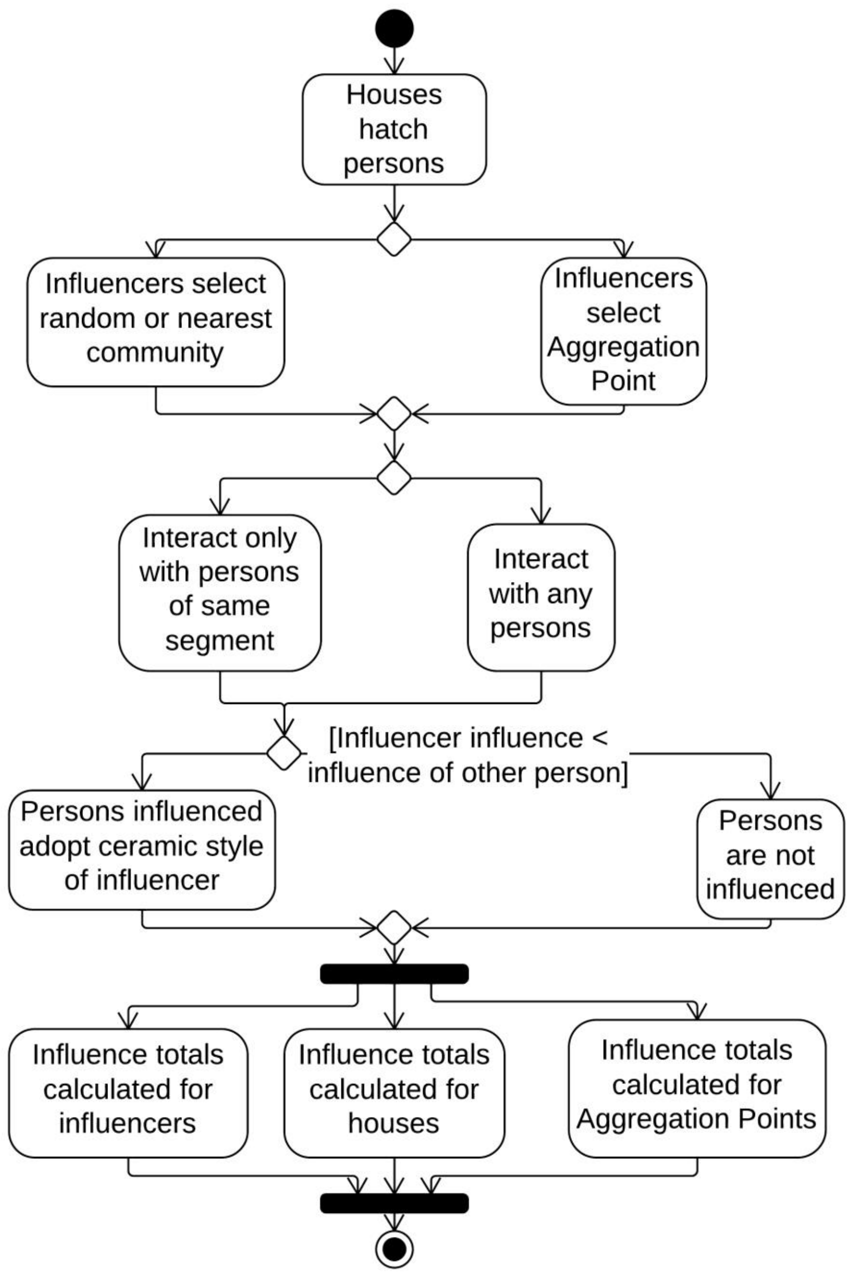
```
to setup
  ca
  set-default-shape houses "house"
  create-houses number-of-communities [
    setxy (random-xcor * 0.95) (random-ycor * 0.95)
    ask houses-here [
      set houseID [ who ] of myself
    ]
    set ceramic-type random 10
  ]
```

Each community then spawns a resident population of people using a random normal distribution averaging five persons per community with a standard deviation of three. This figure may seem low; however, everyone is potentially eligible for exchange depending on the value of a person's exchange-potential variable relative to a random threshold established later in the exchange procedures. In an abstract model, persons exchanged might represent a single gender in a community, which places community population more in line with some estimates of small-scale community demographics in the Great Lakes region contemporaneous with the Springwells phase (O'Shea and McHale-Milner 2002). At this point, persons are made aware of the numerical ID that represents their community affiliation. This allows people to discern between their home communities and other communities in the simulation:

```
ask houses [
 hatch-persons random-normal 5 3 [
  set breed persons set shape "person"
  set size 1
  set target one-of houses
  face target
  set threshold random-normal 50 25
  set influenced? false
  set influencer false
  set persons-influenced
  [
  ]
  set exchange-potential random 100
  set exchanged? false
 ]
 ask persons-here [
  set householdID [houseID] of myself
  set other-houses [householdID] of other persons with [
```

```
      distance myself > 1
    ]
  ]
]
```

Figure 42. Unified Modeling Language (UML) activity diagram for simulation elements.



The next function in the setup procedure involves checking the type of destination for people exchanged. A randomized destination scenario is the default for persons selected for exchange. If an aggregation point is selected for a destination, the point or points are created and distributed randomly in the world. If a nearest neighbor exchange scenario is designated the people will be assigned to a destination closest to their home community as the target. Only one type of exchange scenario is available during a single run:

```
if gather-aggregation-point [
  create-aggregation-points number-of-aggregation-points[
    set shape "circle"
    setxy (random-xcor * 0.95) (random-ycor * 0.95)
    ask persons [
      set target one-of aggregation-points
      face target
    ]
  ]
]
if nearest-neighbor [
  ask persons [
    set target min-one-of (houses with [ distance myself  > 0 ])[ distance myself ]
    face target
  ]
]
```

The model then checks the segmentation parameter to see if a segmentation designation should be assigned to persons. Since segmentation crosscuts all communities, a community may have several factional subdivisions present within it. If this option is selected the next function is to call the *assign-segments* procedure:

```
if assign-segments [
  ask persons [
    assign-segment
  ]
```

The final commands in the setup procedure involve telling people to calculate their influence for the first time, and then plot the results on a variety of graphical interfaces available to the programmer. These commands are repeated during the go procedure and addressed in further detail later in the code explanation:

```
 calculate-influence
 do-plot
end
```

GO PROCEDURE

This procedure sets the simulation into motion. It begins by identifying people who are eligible for exchange. It does this by comparing the random number assigned to each person in the setup procedure to the value of the *exchange-percentage* slider. If the person's exchange potential is less than or equal to the value of the slider that person is selected for exchange. The person is then instructed to move to a new community:

```
to go
 ask persons [
  if distance target > 0 and
  exchange-potential <= exchange-percentage [
   set exchanged? true
   face target
   ifelse distance target < 1 [
    move-to target ]
   [ fd 1 ]
  ]
 ]
```

Communities are instructed to record the unique identifier for people who have newly arrived to its location. This functions primarily as a record keeping operation and has no further operational influence on the simulation:

```
ask houses [
  set visitorID [ who ] of persons-here
]
```

In an aggregated exchange scenario, a similar command is used to record variables for people arriving at the location:

```
ask aggregation-points [
  set cenvisitID [ householdID ] of persons-here
  set cenvisitID remove-duplicates cenvisitID
```

```
  set segvisitID [ segmentID ] of persons-here
  set segvisitID remove-duplicates segvisitID
  set ceramic-type sort remove-duplicates[ ceramic-type ] of persons-here
  set influence-total sum [ threshold ] of persons-here
]
```

The primitive *tick* command is used to advance the clock one time step and move the simulation forward. This is the cue for the people to look around and either influence or be influenced. The *exchange*, *calculate-influence* and *do-plot* procedures are once again invoked:

```
tick
exchange
calculate-influence
do-plot
```

If everyone who has been selected for exchange reaches a destination then the simulation stops:

```
if not any? persons with [
   exchanged? = true and
   distance target > 0 ]
 [ stop ]
end
```

ASSIGN-SEGMENT PROCEDURE

If the assign-segments selector is employed the model will assign a segment randomly to individuals in all communities. The n-of segments slider determines how many segments are available for assignment. Details on how this affects influence are located in the exchange-segmented procedure below:

```
to assign-segment
 ask persons [
  set segmentID random n-of-segments
 ]
end
```

EXCHANGE PROCEDURE

The exchange procedure is where the transmission of culture is simulated. A person first looks to see if the *exchange-segmented* selector is turned on. If it is, then code execution is diverted to the *exchange-segmented* procedure. If it is not, then the program follows the rules contained with this procedure. In the case of the latter, a person first looks for new arrivals whose influence threshold is greater than their own, does not share a similar style, and has reached a final destination. If no one in the community matches those criteria then the exchange process stops. If a person matches the influencer criteria then an exchange will take place with all of those people in the destination community who have lower thresholds. Stochasticity drives this exchange process. An agent can only bring a new style to a destination community if the agent brings a sufficiently high threshold in order for a new style to be adopted by members of the destination community:

```
to exchange
 ask persons [
  ifelse assign-segments [exchange-segmented] [
```

```
    let potential-influencer one-of other persons-here with [
      threshold > [ threshold ] of myself and
    ceramic-type != [ ceramic-type ] of myself and
    exchanged? = true and distance target = 0
    ]
ifelse potential-influencer = nobody [ stop ]
    [ set influencer potential-influencer
      set influenced? true
      set ceramic-type [ceramic-type] of potential-influencer
    ]
  ]
 ]
```

At this time, people who have been exchanged look around to see if anyone has adopted their style in the destination community. If the answer is yes then the influencer records the unique ID of the persons influenced and then sums the total for record keeping purposes.

```
ask persons [
  if any? persons with [ influencer = myself ] [
    set persons-influenced [ who ] of persons with [ influencer = myself ]
    set influencer true
  ]
]
ask persons [
  set influence-total count persons with [ influencer = myself ]
```

```
 ]
end
```

EXCHANGE-SEGMENTED PROCEDURE

This procedure shares the same operations with the aforementioned exchange procedure with the exception that exchange only occurs between members of the same segment at the destination community. All other rules are the same.

```
to exchange-segmented
  ask persons [
    let potential-influencer one-of other persons-here with [
      segmentid = [ segmentid ] of myself and
      threshold > [ threshold]  of myself and
      ceramic-type != [ ceramic-type ] of myself and
      exchanged? = true and distance target = 0
    ]

    ifelse potential-influencer = nobody [ stop ] [
      set influencer potential-influencer
      set influenced? true
      set ceramic-type [ ceramic-type ] of potential-influencer
    ]
  ]
  ask persons [
    if any? persons with [ influencer = myself ] [
```

```
      set persons-influenced [ who ] of persons with [ influencer = myself ]
      set influencer true
    ]
  ]
  ask persons [
    set influence-total
    count persons with [ influencer = myself ]
  ]
end
```

CALCULATE-INFLUENCE PROCEDURE

This procedure tasks the communities with summing the total amount of influence for individuals within that particular community. It serves as a means to compare relative amounts of influence across the world.

```
to calculate-influence
  ask houses [
    set influence-total
    sum [ threshold ] of persons-here
  ]
end
```

DO-PLOT PROCEDURE

This procedure is sends data to the monitor elements embedded within the Graphical User Interface (GUI). The *ceramic-type* histogram helps to visualize the distribution of the 10 ceramic types present during a single model tick. The *ceramic-freq* plot is a line graph embedded in the ICTM interface that displays changes in ceramic-type over time. The *influence* plot displays the sum of both influencers and persons influenced over time. This a line graph embedded in the ICTM interface that displays changes in persons influenced over time. The number of persons influenced is then used to define the curves and therefore the rate of CT taking place during the simulations. Details on how those curves are calculated are discussed in the results section of this chapter.

```
to do-plot
  set-current-plot "ceramic-type"
  set-current-plot-pen "ceramic-type"
  histogram [ceramic-type] of persons
  set-current-plot "ceramic-freq"
  set-current-plot-pen "cat0"
  plot count persons with [ ceramic-type = 0 ]
  set-current-plot-pen "cat1"
  plot count persons with [ ceramic-type = 1 ]
  set-current-plot-pen "cat2"
  plot count persons with [ ceramic-type = 2 ]
  set-current-plot-pen "cat3"
  plot count persons with [ ceramic-type = 3 ]
  set-current-plot-pen "cat4"
  plot count persons with [ ceramic-type = 4 ]
  set-current-plot-pen "cat5"
```

```
  plot count persons with [ ceramic-type = 5 ]
  set-current-plot-pen "cat6"
  plot count persons with [ ceramic-type = 6 ]
  set-current-plot-pen "cat7"
  plot count persons with [ ceramic-type = 7 ]
  set-current-plot-pen "cat8"
  plot count persons with [ ceramic-type = 8 ]
  set-current-plot-pen "cat9"
  plot count persons with [ ceramic-type = 9 ]
  set-current-plot "influence"
  set-current-plot-pen "influencer"
  plot count persons with [ influencer = true ]
  set-current-plot-pen "influenced"
  plot count persons with [ influenced? = true ]
end
```

Space and Time Considerations

It is important to state from the outset that the spatiotemporal aspects of the model do not reflect real-world space or time. While it is possible to integrate geospatial data into NetLogo, this simulation does not attempt to recreate actual geographic space using spatially referenced data. The reason for this is straightforward; the results of the ceramics analysis demonstrate that while spatial distance does matter to a small degree in terms of Springwells style similarity, other factors must be in play. Furthermore, the computer resources needed to create a topologically accurate digital Late Prehistoric landscape and then incorporate that into the ABM at the maximum geographic extent of the study area exceeds NetLogo processing capability. Therefore, the geography influencing the agents occurs in default NetLogo model space.

Model time is also calculated differently than calendric time. Model time is measured through ticks and governed by interactions between agents, and not as calculations representing months or years. One reason for this is the noticeable lack of ethnohistoric documentation to draw upon pertaining to Native kinship, marriage exchange, or intergroup aggregation scheduling in this part of the Midwest. There is no way to accurately determine how many opportunities per week, month or year Springwells people might have had to influence or be influenced. In model time, the clock advances one interval (known as a tick) when all persons who have been exchanged have an opportunity to influence all susceptible persons at the destination.

Model Assessment

Sensitivity Analysis

Sensitivity analysis is the process of evaluating “the extent to which the behavior of the simulation is sensitive to the assumptions which have been made” (Gilbert and Troitzsch 2005:24). During this phase, a modeler is concerned with assessing the degree to which inputs in the model affect outputs. Sensitivity analysis is crucial to understanding whether or not the operating assumptions of the model are reasonable and valid by revealing potential discrepancies in input/output relationships (DeVisser 2010; Railsback and Grimm 2012:291-297). Sensitivity analysis has not been regularly employed in archaeological modeling as opposed to its systematic application across other disciplines. One way to explore a model’s sensitivity is to systematically vary parameters by a specified amount and then observe variations in output. Disproportionate or non-linear relationships between these variables may indicate underlying problems within the model. However, the researcher must also keep in mind that non-linear sensitivity may also indicate an unforeseen legitimate interaction between input and output values, especially when the model in question incorporates continuous environmental data such as elevation or temperature (DeVisser 2010).

Sensitivity analysis for the simulation assessed the effect of varying exchange percentages on the total number of persons influenced during a model run and then constructing a Sensitivity Index (SI) as outlined by Lenhart et al. (2002).

$$\frac{\Delta Y_{\pm i}/Y_D}{2\Delta P_{D\&i}/P_D}$$

The SI above is calculated where *Y* represents the dependent variable output, *P* represents the threshold of the parameter of interest, *i* represents the value of the parameter as it is adjusted above and below the default model, and *D* represents the baseline model value (DeVisser 2010:3; Lenhart et al. 2002:646-647). Table 10 below outlines the classes of sensitivity used to interpret sensitivity analysis results.

Table 10. Categorical classifications for sensitivity (DeVisser 2010; Lenhart et al. 2002).

Sensitivity Index	*Class*	*Sensitivity*
< 0.05	I	Insensitive
0.05 to < 0.20	II	Moderate
0.20 to < 1.00	III	Highly
≥ 1.00	IV	Extremely

The baseline test scenario for the ICTM consisted of 50 communities with a 50% exchange rate. Exchange percentages varied at intervals ranging between 5% and 100% to test the sensitivity specifically associated with exchange parameter change. Each interval was run 100 times and then the mean for persons influenced through cultural transmission was calculated.

The results (Table 11) indicate that this ABM is highly sensitive to adjustments in the exchange parameter when the destination for travelers is randomized. A shift from high to moderate sensitivity at the tail end of the random scenario is attributed to variations in the stochastic nature of destination selection for influencers, and this result does not raise concerns about the explanatory potential of the ICTM moving forward (Joseph P. Messina, personal communication, 2012). Adjustments in exchange percentages in nearest neighbor scenarios result in highly sensitive outcomes at low exchange rates, but eventually trend toward moderate sensitivity and insensitivity at higher exchange rates. This is most likely due to the distributed nature of the social network, where opportunities for an individual to interact with others holding lower influence thresholds are limited because of small-scale interactions manifesting at a local level. Such a scenario effectively acts as a "bottleneck" for threshold diversity, thus limiting influence propagation within the network.

Sensitivity for exchanges with one aggregation point as a destination was highly sensitive regardless of the amount of variation implemented in the exchange parameter. Interpretations for these outcomes are discussed in detail below and they play a powerful role explaining the interplay between Springwells social structure and material culture as interpreted through archaeological data.

The overall results of the sensitivity analysis indicate that space has a pronounced affect on the rate at which CT propagates through a social network, but there is a cut point where influence and the number of vectors transmitting influence diminish. These results are further explored in the section below presenting a more extensive overview and interpretation of the simulation trials.

Table 11. Sensitivity analysis for changes in CT relative to exchange percentages.

Exchange Scenario	*Exchange Percentage*	*Sensitivity Index*
Random	5	0.433
	10	0.317
	20	0.251
	30	0.257
	40	0.257
	50	0.000
	60	0.441
	70	0.211
	80	0.227
	90	0.216
	100	0.162
Nearest Neighbor	5	0.396
	10	0.250
	20	0.271
	30	0.188
	40	0.188
	50	0.000
	60	0.094
	70	0.031
	80	0.063
	90	0.055
	100	0.019
1 Aggregation Point	5	0.494
	10	0.464
	20	0.451
	30	0.287
	40	0.344
	50	0.000
	60	0.619
	70	0.550
	80	0.627
	90	0.682
	100	0.555

Verification

Verification is a process where a simulation is evaluated to ensure it is working as designed (Gilbert and Troitzsch 2005:19; Oreskes et al. 1994). This can be a time consuming process because each procedure in the programming code has to be inspected and its product observed within the context of the model. Many programmers regardless of the software platform refer to this process as "debugging". The verification phase for this simulation is represented by the creation, verification, and subsequent replacement of 39 successive versions of code before arriving at the version used for the experiments presented below. Verification focused on how agents responded as parametric adjustments were introduced. Adjustments were then made to the code as programming flaws were observed.

Validation

Validation consists of evaluating that the components within the model operate in a way that approximates a realistic target behavior (Gilbert and Troitzsch 2005:19; Oreskes et al. 1994). Validation of this simulation is difficult for two reasons. First, the only datasets available to inform how Springwells social networks facilitated cultural transmission are archaeological in nature, and therefore limited because of the relatively small number of known assemblages. It is out of necessity that this simulation is designed with a high level of abstraction and "questions of validity and of verification are hard to distinguish" (Gilbert and Troitzsch 2005:22). Second, as Oreskes et al. (1994) note, validation is difficult if not impossible to achieve in open systems such as social networks because every contingency cannot be accounted for.

It is with these caveats in mind that adoption curves produced by the ICTM serve to validate the model because output data conform to established theory as presented by the diffusion of innovations literature (Mahajan and Peterson 1985; Rogers 2003; Rossman et al. 2008). This research predicts accelerated diffusion patterns will generate R-shaped adoption curves and standard diffusion patterns will generate S-shaped adoption curves. This patterning is discussed in detail below in reference to specific exchange scenarios explored in the ICTM.

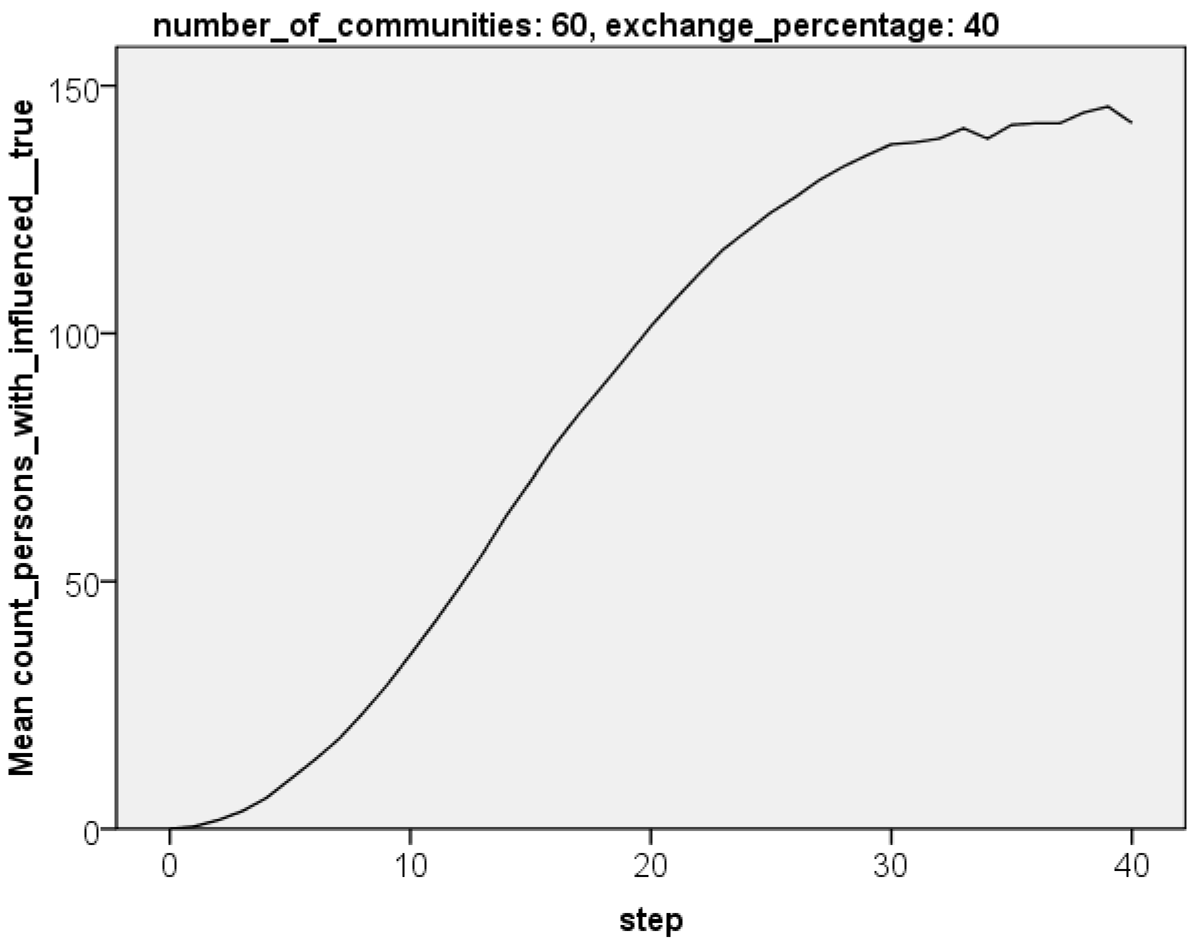
Trials and Results

The simulation results presented here are the product of approximately 700 computer hours of experimentation producing data for 1,040,067 exchange scenarios. NetLogo's BehaviorSpace tool was employed to automate the systematic adjustment of variables for community size, exchange percentage, number of aggregation points and number of segments. These data were exported from the NetLogo environment via comma-separated values tables and then imported into SPSS 16.0 for statistical evaluation.

The number of communities interacting with each other was manipulated in order to assess the effect of population size on cultural transmission. A baseline experiment to assess simple effects of randomized personnel exchange on cultural transmission included community sizes varying in intervals of 5, 10, 20, 40, 60, 80 and 100. Exchange percentages varied in the same intervals for each community size.

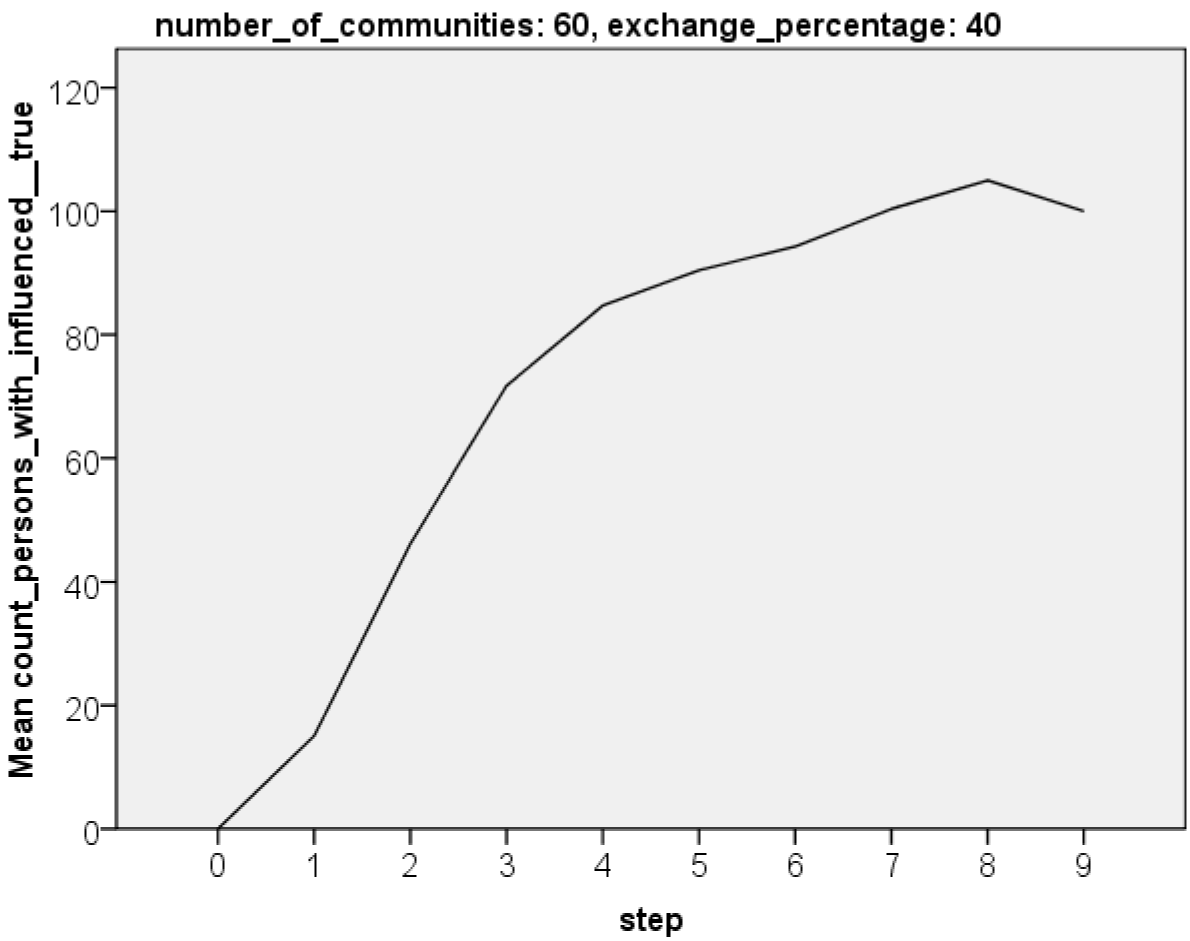
The results indicatethat all exchange scenarios exhibit a logistic, or S-curve in CT exchange between agents in all scenarios *except* those with nearest destination scenarios. Randomized exchange scenarios produced the expected S-shaped adoption curves indicative of standard diffusion patterns (Figure 43) regardless of the degree of additional segmentation (Mahajan and Peterson 1985; Rogers 2003; Rossman et al. 2008). R-shaped adoption curves (Figure 44) were observed in all nearest neighbor exchange scenarios regardless of the degree of additional segmentation.

Figure 43. Representative S-curve for scenarios involving random destination exchange.



Only the scenarios where individuals traveled to the community closest to them resulted in R-curve exchange patterns (Figure 44) indicating faster rates of CT taking place within communities. It is important to note that while Figures 43 and 44 do not appear at first glance to be dramatically different in terms of their curvature, an inspection of the number of steps demonstrates a far more rapid rate of transmission in the nearest destination exchange scenario. These experiments suggest that a nearest destination scenario results in an exchange pattern where a new packet of information propagates through a social network in approximately one-third the time of an equivalent scenario where the destinations are randomized.

Figure 44. Representative R-curve for scenarios involving nearest destination exchange.



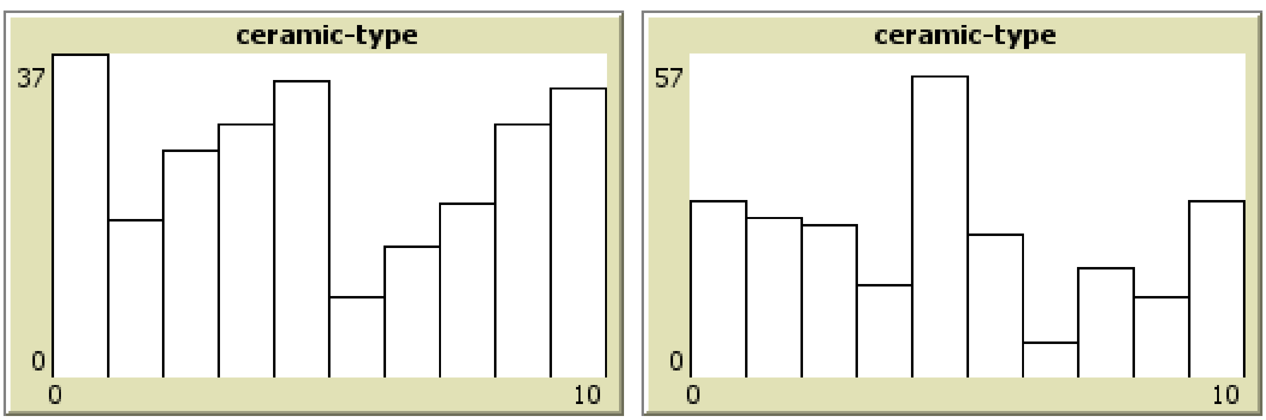
Interpretations

These experiments indicate that different exchange scenarios result in different rates of CT at different spatiotemporal scales. This is consistent with the literature where adoption is based on either regular (S-shaped) or accelerated (R-shaped) diffusion (Mahajan and Peterson 1985; Rogers 2003; Rossman et al. 2008). However, spatial differences affect not only the rate at which information such as ceramic style is exchanged, but also the richness and diversity of style distributed throughout the social network. These variances in transmission result in different signatures at local and regional spatial scales and are dependent on the social context of how people propagate these packets of information through the network. These differences have implications for archaeologists who seek to understand how and why stylistic trends diffuse in fundamentally different ways.

Local Exchange Characteristics

The nearest neighbor scenario is the only exchange pattern to result in R-curve transmission. This transmission signature is independent of the degree of segmentation and analogous to what archaeologists recognize as localized exchange between groups. One interesting effect of this transmission mode is that it has little effect on the richness or diversity of ceramic styles present in the social network as a whole (Figure 45). Nearest neighbor exchange simply functions at an accelerated rate to reshuffle the deck in terms of the number of cases in each style category.

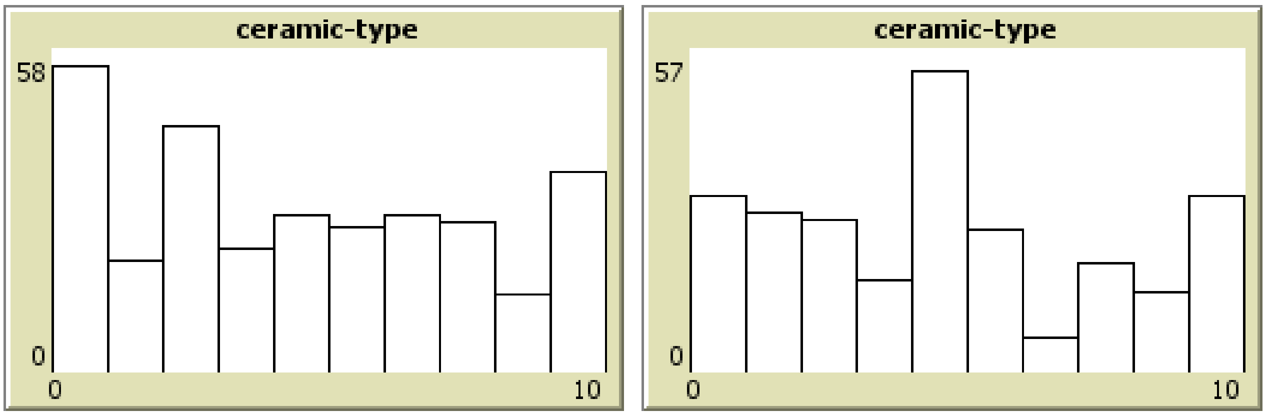
Figure 45. Before (left) and after results of nearest neighbor exchange on ceramic diversity in network.



Regional Exchange Characteristics

Regional exchange is represented in the ICTM through the randomized exchange scenario. S-shaped curves represent this transmission signature regardless of the degree segmentation. Like the nearest neighbor scenario, randomized exchange reshuffles the style deck but has little effect on the richness and diversity of individual types within the network (Figure 46). Segmentation crosscutting communities also has no effect on the propagation of ceramic style in a randomized scenario.

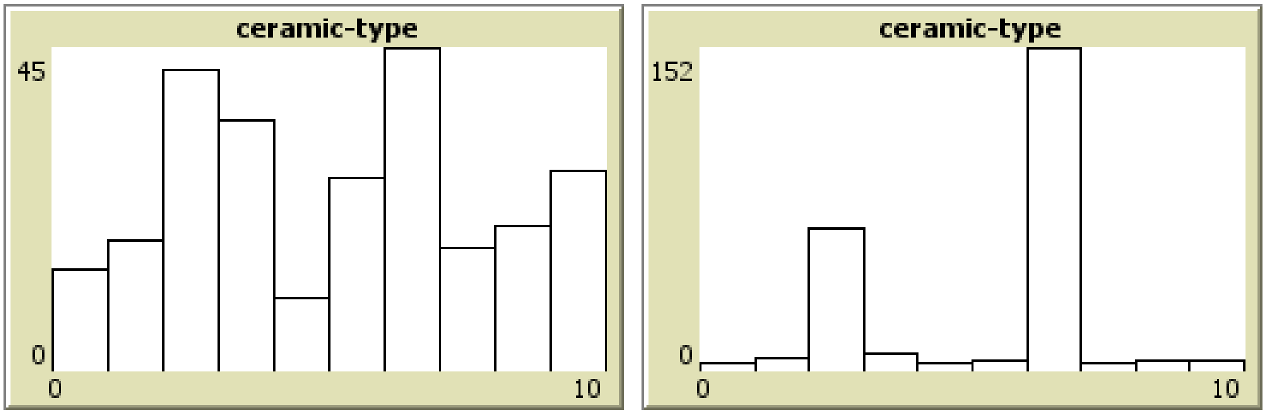
Figure 46. Before (left) and after results of randomized exchange on ceramic diversity in network.



Aggregated Exchange Characteristics

An aggregated context where all members interact and exchange at a specific point on the landscape is the only scenario that affects both stylistic richness and diversity in this simulation (Figure 47). Even though aggregated exchange produces slower adoption rates reflected by S-curves, the dissemination and standardization of new styles only takes place if people come together at an aggregation point. The degree of segmentation has no effect, but the more aggregation points that are added to the scenario, the more diluted the result in terms of limiting stylistic diversity within the network.

Figure 47. Before (left) and after results of aggregated exchange on ceramic diversity in network.



Summary of Simulation Results

The simulation results presented here indicate that the single dominant factor that influences the exchange of style is aggregation. People gathering at a central location is the single most important factor that produces changes in material culture that transmit information relating to group identification and cohesion; in this case the widespread adoption of particular stylistic subgroups. The reader should note that aggregated multi-community interaction is formalized in the region during the Late Prehistoric period, and the implication of these behaviors regarding Springwells communities is specifically addressed in the concluding chapter.

Generally, ceramic styles are remarkably stable in the Great Lakes region until the Younge/Western Basin Tradition appears around A.D. 1000. Prior to that, broad ceramic types remain generally in place for as much as 500 to 1000 years before undergoing major changes in appearance (Fitting 1975; Halsey and Stafford 1999). After A.D. 1000, major stylistic changes occur in ceramics approximately every 200 years. The obvious question to ask is what accounts for such instability in the stylistic repertoire of the potters during the Late Prehistoric? The

ICTM simulation results discussed above provide a lens into the socio-structural changes Late Prehistoric social networks experienced. Chapter VI draws upon both the simulation and ceramic analyses to explore these issues.

CHAPTER VI

Conclusions

Discussion of Results

The relatively small sample size that established the original Younge/Western Basin Tradition typologies in southeastern Michigan has grown in recent years to encompass archaeological datasets far beyond the geographic extent of which Fitting was familiar. While there has been active debate for quite some time on what to call the people who lived in the Great Lakes region between A.D. 1160 to 1420, the research presented here contends that these communities were actively maintaining a long distance social integrative network far more extensive than previously thought. Membership in this Springwells social network is reflected by a shared stylistic grammar encoded in their ceramics.

There have been some very important advances in growing the Springwells archaeological datasets in recent years, particularly with respect the southern extent where Springwells communities existed. The IPFW-AS has been instrumental in this regard and there is an ongoing effort by this organization to push the boundaries of what is currently known about Late Prehistoric lifeways. Unfortunately, archaeological datasets are increasingly poor as one moves to the north and this may be due to several factors including site destruction in the wake of ongoing development. In the absence of new archaeological data in the northern extent of Springwells territory, multiple lines of evidence must be employed in order to form more complete interpretations about this period.

Ceramics Evidence

The ceramics analysis in Chapter IV has revealed that geographic distance has a small influence (<3%) on stylistic similarity at Springwells sites across the study area. However, if distance does not account for the spatial distribution of stylistic subgroups then alternative explanations must be presented. Evidence for social integration between spatially distant communities is presented through stylistic similarities encoded in Springwells ceramics, and these interaction patterns are clarified through Brainerd-Robinson coefficient analysis.

There are three sites in the 90^{th} percentile of similarity (Chapter IV-Figure 36 above, Table 12 below) that may have served as regional integrative aggregation points: Casassa in the Saginaw Valley, Riviere au Vase in southeastern Michigan and the Strawtown locale in Indiana. These sites are among the richest Springwells sites in terms of ceramics and contain evidence that they were socially significant places to gather in larger numbers than many of the other sites. The literature suggests that other sites such as Dick and Fletcher may have functioned in a similar manner but the archaeological context and collections data from the sites cannot support such a claim at this time.

Table 12. Number of vessels by regional integrative aggregation points.

Site	*Number of Vessels per Site*
Casassa	9
Riviere au Vase	18
Strawtown Locale	27

The datasets used in this analysis suggests that that a high level of regional integration was present independent of distance during the Springwells phase. For example, Both Wolf (n=8) and Riviere au Vase (n=18) yielded some of the largest numbers of Springwells vessels known, yet they only shared a Brainerd-Robinson coefficient of 106.35 out of a possible 200 maximum. This is a meaningful piece of data given that these sites are only located approximately five kilometers from each other and one might expect a higher score in terms of similarity. The interpretation presented here is that there were clear differences in terms of which sites were chosen specifically to interact with others regarding matters of regional significance.

Other sites classified in the ninetieth percentile of similarity (Chapter IV-Figure 36 above, Table 13 below) are smaller and spatially clustered by what may be considered sub regions: a tripartite stylistic connection in southern Ontario between Bellamy, Haagsma, and Lianh I, and a shared stylistic connection between Fletcher and Gravlin Tomlinson in the Saginaw Valley. These sites produced fewer archaeological ceramics and they also appear to have less intensive occupations during the Springwells phase as compared to the regional integrative sites.

Table 13. Sub-regional groupings in the 90th percentile of similarity.

Site	*Number of Vessels per Sub-regional Group*
Fletcher/Gravlin-Tomlinson	4
Bellamy/Haagsma/Lianh I	12

The ceramic evidence suggests that there are nested levels of interaction taking place across the study area as reflected through the signaling of stylistic subgroups. This is consistent with information exchange theory, which suggests that stylistic messaging will vary according to social distance. One may be left with the impression that decreasing Brainerd-Robinson similarity means decreases communication between sites. However, it is useful to think about decreasing similarity as a function of group membership signaling between communities at differing levels of social integration.

As communities become more participative in an increasingly interconnected social network, communication needs to occur in more pronounced ways and at multiple levels. This is where the concept of design hierarchies becomes extremely useful, particularly when viewing the dynamic interaction networks of the Late Prehistoric period, a time that was a period of profound social change (Brashler et al. 2000:558) that saw the emergence of tribal sociopolitical integration (Howey 2006; Krakker 1983:525; O'Shea 1988; O'Shea and McHale-Milner 2002) in the Great Lakes region writ large. The phenomenon of emergent tribalization and regional political implications is discussed later in this chapter.

Agent Based Modeling Evidence

The stylistic adoption signatures of both nearest neighbor (R-curve) and randomized exchange patterns (S-curve) in the ICTM validate that the emergent properties of the simulation presented in Chapter V are consistent with the established diffusion of innovations literature. Given that the ABM has effectively been validated, it is now possible to interpret the emergent properties produced by agent behavior in the ICTM.

Three different cultural transmission scenarios were evaluated in this ABM: nearest neighbor exchange, randomized destination exchange, and aggregation point exchange. Simulation results support an interpretation that interaction patterns manifesting in the form of multi-community aggregation account for the rapid consolidation and spread of standardized Springwells ceramic styles in aggregated contexts.

While the nearest neighbor destination was the only scenario that produced R-curve adoption patterns characteristic of rapid diffusion through a network, it did nothing to affect the overall prevalence of a particular style. Nearest neighbor exchange effectively reshuffles the deck in terms of style distributions but does nothing to affect the consolidation of styles throughout a social network. The ICTM behaviors are consistent with the established literature in this regard. This exchange scenario is representative of local exchange characteristics between communities with close spatial relationships.

Randomized destination exchange produces a similar result in terms of style distribution but produces a classic S-curve adoption signature characteristic of standard diffusion through a network. It does nothing to centralize the adoption of styles propagating through that network. The ICTM behaviors are also consistent with the established literature here. This exchange scenario is representative of regional exchange characteristics between communities in a distributed non-aggregated social network. It is arguably the most likely form of interaction for societies exhibiting band-level social organization when considering CT patterning at the regional spatial scale. That is not to say that band-level societies do not aggregate, but the need for regional aggregation and integration signaling is not the same as communities integrated into a tribal organization.

Simulated exchange in aggregated contexts is the only scenario that affects the diversity of styles adopted by participants in a social network. This scenario produces an S-curve adoption pattern, but as people gather, styles are consolidated into one or two predominant subgroups. This is similar to the archaeological ceramics signatures present at the proposed regional integration sites of Casassa, Riviere au Vase and Strawtown. Interestingly, the introduction of segmentation such as that proposed by Krakker (1983:525) during the Springwells phase does not affect the stylistic adoption patterns in this or any other scenario.

The ICTM results validate that it simulates social processes consistent with the established diffusion of innovations literature regarding how ideas or behaviors propagate through a social network. Simulation data combined with data derived from ceramic analysis indicate that Springwells communities were transmitting stylistic information at both local and regional sociospatial scales. These data also indicate that social interaction occurring at a few regional integrative aggregation points afforded the opportunity for dispersed communities to communicate within a context that required the signaling of group identity through shared stylistic expressions incorporated into their ceramics. These results are consistent with other researchers (Brashler et al. 1999; Howey 2006; Krakker 1983; Murphy and Ferris 1990; O'Shea 1988; O'Shea and McHale-Milner 2002; Stothers and Bechtel 2000) who see the Late Prehistoric as a period for increasing social integration throughout the Great Lakes region (Figure 48). The research presented here, particularly with respect to the simulation methodology, provides an alternative approach to explore the most likely scenarios in which people interacted in the absence of more robust archaeological datasets.

Figure 48. Regional Springwells Phase cultural geographies.

Regional Sociopolitics and Springwells Communities

Tribalization

Tribalization has been variously defined historically in anthropology and carries with it a profound ambiguity regarding specific meanings (Ferguson 2000; Fowles 2002; Howey 2006:8; Parkinson 2002). In this discussion the term "tribe" is used as a way to describe an integrative social mechanism that functions to organize groups within a framework of common identity (Ferguson 2000:476) often toward a political end.

As Howey (2006:8) notes, tribal social organization often serves to allow communities to control resources within their territorial area. Tribalization, or the transition moving from small group political organization toward multi-group political integration, carries with it a requirement that people develop "flexible" relationships that allow for buffering uncertainty and risk across the tribal social network (Howey 2006:11; O'Shea and McHale-Milner 2002:200). In other words, integration varies according to the level required to accomplish a particular objective for those concerned (Ferguson 2000:476; O'Shea and McHale-Milner 2002:201). Tribal integration and interaction is known to vary according to situational needs and is facilitated through intertribal relationships with external groups for the purpose of resource diversification (Howey 2006:11; O'Shea and McHale-Milner 2002:200).

The observation that tribal integration often becomes more intense as communities are faced with contact from external political influences (Emerson 1999; Ferguson 2000:476) is of particular interest here when contextualizing life within a regional political framework for Springwells communities. The notion that communities are defined both by what they are and what they are not, is an important one considering how social groups and boundaries operate to form cohesive bonds between members. Barth (1969, 1978) has postulated that identity is central to social organization and it is shaped not only by the individual, but also by interaction with others. This helps provides a framework through which we may better understand how the construction of group identity influences social interactions. Barth maintains that it is the boundaries between groups that actually help define cohesive groups and not just the similarities within the boundaries. The Late Prehistoric Great Lakes region has no shortage of evidence for cultural boundaries from an archaeological standpoint. Viewing these boundaries at a regional scale may help to clarify what Springwells social membership looks like from a cultural geographic perspective.

Late Prehistoric Regional Politics

If we are to understand the nature of interaction taking place within the Springwells social network one needs to understand the sociospatial context that existed at the time. The Late Prehistoric period was an active time for sociopolitical interaction throughout the Midwest. Geospatially, Springwells communities were located in an area that effectively operated as an interaction corridor oriented on the drainages that feed into Lake Erie and Lake Huron. From a geographic perspective (Figure 48 above), they were situated between complex egalitarian maize horticulturalists represented by Fort Ancient cultures to the east, and highly structured maize-fueled Mississippian chiefdoms to the west. Both of these well-defined cultural groups surrounding this interaction corridor kept Springwells social interactions oriented toward other Great Lakes-focused groups.

That is not to say that Late Prehistoric native communities were segregated into mutually exclusive social networks. However, these ties provided a mechanism for Springwells communities to define and reinforce identity particularly in the face of Mississippian & Iroquoian cultural fluorescence throughout the region. To the Northeast, the societies who would come to be known as the Iroquois formed relationships that crossed social boundaries, uniting them into a large-scale political unit (Trigger 1981). In the Central Midwest, Middle Mississippian chiefdoms emerge out of Emergent Mississippian societies (Milner 1998:16). In the Ohio Valley and the Upper Midwest, Upper Mississippian culture typified by Fort Ancient and Oneota societies emerges (Drooker 1997:39-44).

Many Fort Ancient communities engaged in dynamic, overlapping relationships with other Fort Ancient settlements in the region (Cook 2004; Drooker 1997). Separate polities were engaging one another through visitation, intermarriage and alliances. This is represented archaeologically by long-distance exchange items such as copper pendants, beads and gorgets. Fort Ancient communities consisted of different ethnicities that adopted different settlement patterns and economic strategies (Essenpreis 1978). External Northern Ohio interaction with Fort Ancient communities is represented by a two-way flow of ceramics, beads, copper & brass artifacts. Oneota interaction is demonstrated by the presence of marine shell maskettes, disk pipes, and copper badges. Central Mississippi Valley interactions are evidenced by the presence of head pots, lizard effigy vessels and pipes. Upper Mississippian communities probably did not interact with Iroquois communities on a large scale, but iron fitted copper kettles and other artifacts indicate that it may have taken place on occasion. A peer polity model of Fort Ancient interaction depicts autonomous sociopolitical units residing in same geographic region. The exchange of goods is driven by both competition and cooperation (Drooker 1997:3). Upper Mississippian egalitarian social organization is an interesting counterpoint to Middle Mississippian chiefdom models of settlement hierarchy and domination in the prehistoric Midwest. Fort Ancient maize agriculturalists exchanged goods with ranked societies such as the Mississippian chiefdoms on a regular basis (Drooker 1997:328), yet, they chose to remain structured in a non-hierarchical political system. Oneota and Fort Ancient societies appear to have used social interaction more as a means to situate themselves in locales that were more conducive to their economic goals rather than ideological goals (Drooker 1997).

Social interaction was equally important for the Middle Mississippian chiefdoms to both sustain their elite, and maintain their ideology (Pauketat 1997). Organized hierarchically into a blend of simple (single-layered) and complex (multi-level, hierarchical) chiefdoms (Cook 2004:40-41; Milner 1998:2-3), some maintain that Mississippian material culture functioned as a set of shared symbols that some contend was reproduced under direction from a central authority (Pauketat 1997). Others contend that Mississippian sociopolitical organization was a network of autonomous communities interacting within a system of shared ideology (Milner 1998). Regardless of the lack of consensus on the degree of sociopolitical hierarchical centralization, Mississippian cultural expression was widespread throughout the Midwestern United States and archaeological evidence of interaction with other cultures is expansive.

Chronologically, the Mississippian contemporaries of the Springwells phase exhibit large population shifts attributed to social fissioning inherent in complex chiefdoms (Bense 1994). However, Mississippian sociopolitical organization persists in a traditional form up until the early Spanish and French expeditions encounter Native communities as documented in the historic record (Milner 1998:2).

Tribal Development: The Embodiment of a Complex System

It is useful to think of the development of tribal social organization taking place in Younge/Western Basin communities as an example of an emergent complex system. Again, one should note that complexity science does not refer to “complexity” in the sense that the archaeologist is accustomed when referring to levels of social integration. All societies are complex and negotiation within any social network is complicated regardless of organizational form. However, at this point a complex systems approach is employed to address the issue of emerging tribal formation during the Late Prehistoric period. This emergent property is a product of interactions between agents manifesting at a societal scale without direction from a central authority. Consensus between individuals to participate in a multiscalar decision process spanning communities results in a distributed complex adaptive system.

As previously discussed, open systems are amenable to external influences (Cook 2004; Messina 2001) and emergent properties such as changes in social interaction can occur suddenly and at different scales (Bentley and Maschner 2003a). This is certainly the case in the formalization of tribal social structures in the Great Lakes region (Howey 2006; O'Shea and McHale-Milner 2002), as well as generally in the formation of tribal social organization (Blakeslee 2002; Fowles 2002; Parkinson 2002, 2006).

Tribes themselves may be characterized as self-organized, path dependent, and historically contingent systems that exhibit emergent properties (Crawford et al. 2005; O'Sullivan et al. 2006). Tribal formations come out of social relationships that have been historically established, and these participants are bound in terms of language, ancestry, ideology or kinship (O'Shea and McHale-Milner 2002:201).

Tribal participants interact in a manner that requires holistic examination in order to understand the essence of the organizational system. If a hallmark of a complex system is that is irreducible and the relationships between agents define the system (not individual component parts) (Casti 1994:171-211; Manson 2001) then tribes are defined through their aggregate behaviors that result from both internal and external interactions.

Complex systems possess at least four key characteristics that allow them to function. First, complex systems are thermodynamically open systems that allow energy and matter to flow both in and out (Bentley and Maschner 2003b:2). This has been recognized as a fundamental characteristic of Upper Mississippian Fort Ancient tribal social systems (Cook 2004), and arguably, this is a property of all social systems. Second, as discussed above, complex systems are comprised of constituent entities that interact with one another, either directly or indirectly. This is certainly true in the case of tribal societies where it is established that:

> To maintain the integrity and functioning of the larger tribal confederacy, it is necessary to maintain ideological and social mechanisms that will promote the tribal identity beyond the range of the normal, face-to-face or familial connections (O'Shea and McHale-Milner 2002:201).

Third, complex systems are nonlinear, with both positive and negative feedback loops operating within the system (Holland 1998; Nicolis 1995). The relationships between elements in nonlinear systems are structured in ways that make it extremely difficult to predict changes across scales by calculating inputs and outputs (Beekman and Baden 2005). Specifically, we see this property of a complex system exhibited by tribes in that they are "many cycles operating at the same time and at different spatiotemporal scales" (Blakeslee 2002:173). Fourth, complex systems inherently display emergent properties (Casti 1994; Holland 1998; Wolfram 2002) in a decentralized, undirected manner, that is a defining characteristic of the system. Tribal social systems require multi-scalar mechanisms that allow members to self-identify in a manner that asserts both local identity and corporate membership (Howey 2006:16-18; O'Shea and McHale-Milner 2002:201) without permanent centralized sociopolitical direction.

Tribal societies exhibit all of the hallmarks of complex systems as defined by the complexity science literature. The anthropological and archaeological literature suffers from a dearth of scholarship in this regard except for a few seminal efforts (Beekman and Baden 2005; Bentley and Maschner 2003a; Bentley and Maschner 2008; Kohler and Gumerman 2000; Lansing 2006). Perhaps the reason for this gap in the archaeological literature lies in the fact that much of what might be considered complex systems research has been relegated to the neo-cultural evolution school of thought (Bentley and Shennan 2003; Eerkens and Lipo 2005, 2007; Henrich 2001; O'Brien 2008; Read 2002) and considered somewhat unpalatable to those who skew toward the humanistic end of the anthropological analytical spectrum. There is a place for a complex systems approach in anthropological and archaeological research, and this type of approach is capable of engaging both the quantitative (cited above under cultural evolutionists) and humanistic (Bloch 2005; Stark et al. 2008a) aspects of cultural transmission.

Tribal Integrative Centers and Springwells Economies

The Springwells social network that spanned the lower Great Lakes region was one that facilitated interactions along the drainages that connect into the Great Lakes Erie and Huron. This was effectively an interaction corridor situated between two different types of Mississippian societies: Upper Mississippian, complex-egalitarian, horticultural Fort Ancient societies to the east, and Middle Mississippian maize-fueled chiefdoms and Upper Mississippian Oneota egalitarian groups to the west.

Springwells communities interacted along routes that preserve connectivity to the Great Lakes. This Great Lakes connectivity explains the northeastern-southwestern directionality of the Springwells interaction corridor. The known southwesterly extent of the Springwells social network represented by the Strawtown locale was effectively located at a crossroads where interaction with Oneota and Fort Ancient Upper Mississippian groups is represented by ceramic materials recovered in several archaeological contexts (McCullough and Graham 2010a).

The spectrum of settlement and subsistence practices shift from horticultural farmsteads in the northern extent, toward a maize-horticultural village existence in the southern extent. This demonstrated by paleoethnobotanical evidence at the Strawtown locale. The regional archaeology indicates that while northern Springwells communities definitely valued and incorporated maize into their diet, the extent to which their subsistence regimen was dedicated to maize is debated (Hart and Lovis 2013; Hart et al. 2012; Raviele 2010).

Krakker (1983) sees the adoption of horticulture as the primary driver for change in regulatory systems during the Late Prehistoric period in southeastern Michigan. He sees a kind of rippling effect where changes in lower level subsystems such as subsistence activities produce changes in higher-level systems such as ritual activities that function to unite communities in order to buffer risk (Brashler et al. 1999:228). The highest level of this regulatory hierarchy contains systems that affect entire regions such as population density and territorial resource allocation. Krakker (1983) makes a large leap in assuming that Late Prehistoric subsistence was primarily oriented toward maize horticulture. More recent work (Hart et al. 2012; Raviele 2010) indicates there is great variation throughout the Midwest in terms of reliance on maize utilization.

It remains an open question as to how much maize people are reliant upon during the Late Prehistoric period especially given the fact that environmental fluctuations such as the Medieval Warm Period occurring around A.D. 1000 may have generated a great deal of unpredictability into horticultural resource yields (Raviele 2010:144). If that is the case, then it is more appropriate to attribute Late Prehistoric sociopolitical change as a social response to geopolitical conditions within the region rather than a perturbation related to a horticultural subsystem.

Design Hierarchies, Visibility and Symbolic Communication

The discussion presented in Chapter II regarding Information Exchange Theory is particularly relevant to tribal societies who have a requirement to communicate information symbolically at different spatial and social scales. McHale-Milner's (1998) work understanding stylistic elements of Juntunen Late Prehistoric ceramics indicates that the degree of visibility in stylistic elements transmit information in accordance with social distance. In her schema, high visibility design elements such as exterior design patterns on a collar communicate information to a broad audience, where low visibility design elements such as lip shape or tool type communicate information to potters who are in close contact (McHale-Milner 1998:160). She notes that "an active constraint on high-level attributes indicates an attempt to reduce social tensions and ambiguity that plague interaction over great social and geographic distances" (McHale-Milner 1998:161). This is exactly the function that Springwells stylistic subgroups would perform communicating multi-scalar information through symbolic communication in both regional and local contexts.

Summary

This research has examined the nature of Springwells phase sociopolitical organization during the Late Prehistoric period, one small component of the Native American story that we know relatively little about. The ceramic and simulation data support previous interpretations (Krakker 1983; O'Shea 1988) that Springwells phase communities were organized in a form of sociopolitical integration most readily recognized as a loose confederation or interactive network of middle range, tribal societies spanning a broad area.

The interpretation presented here differs from those found in previous work in that it characterizes tribal sociopolitical organization as the embodiment of a complex system. A complexity science approach views the overall characteristics of a system as emergent properties that generate from the scale of the individual and eventually combine with the interactions of other agents at the system level. In this sense, individual Springwells communities interacted at a variety of scales as represented by their ceramic stylistic subgroups, and what archaeologists recognize as Springwells material culture is actually individual behaviors scaling up to the system level. These behaviors are reflected as symbolic communication facilitated through shared stylistic grammar. There is evidence for regional tribal integration occurring at aggregation sites such as Strawtown, Casassa and Riviere au Vase where participants exchanged unifying styles to promote group cohesion across space and time. Sociopolitical integration was accomplished through highly dynamic, decentralized social mechanisms that were constantly in-flux at a variety of social and spatial scales.

Tribes are excellent examples of complex systems in terms of how people organize themselves because they are distributed and decentralized. They emerge out of a need to create and maintain flexible relationships that solve problems as necessary, and then reallocate resources (both human and natural) as needed. Springwells communities had historical ties to each other that served as integrative mechanisms and provided opportunities for both marriage and resource exchange. These social arrangements would have been important in mitigating risk and uncertainty both environmentally and geopolitically.

Springwells tribal interaction and integration is viewed more as a historically contingent social response to political developments in the region rather than a response to changes in subsistence strategies. Previous interpretations (Krakker's in particular) relied heavily on the importance of maize horticulture in Springwells economies. However, access to arable land in the northern extent of Springwells territory as a driver for social change is not yet adequately established. Therefore, a social, and not a subsistence-based explanation for emergent tribal integration during the Late Prehistoric period is presented here.

Looking Forward

Looking forward, more fine-grained modeling and simulation is needed to enhance our understanding of prehistoric population dynamics and demography. It is not clear what emergent phenomena may be observed by perturbing a system in relation to real world birth and mortality rates for hunter-gatherer and horticultural societies. One may also envision when computing power allows for the exploration of spatiotemporally accurate datasets that emulate the actual geophysical environment in which these communities interacted at a regional scale. There is no doubt that realistic pre-settlement physiography and demography models would add much to enhance the fidelity of simulation behavior.

Second, the inclusion of datasets from Ohio as well as new IPFW data excavated since 2010 would greatly add to what we know about the distributions of stylistic subgroups as they are presented here. This discussion has been the most wide-ranging, systematically comparative study pertaining to the Springwells phase, but it is by no means exhaustive. The specific addition of the Springwells ceramics assemblages curated at the University of Toledo would greatly improve our understanding of the level of tribal integration taking place throughout the region. Additionally, the performance of accurate dating studies on ceramic subtypes to reveal precise temporal affiliations would be incredibly helpful to aid in the reconstructing interaction patterns throughout the network.

Finally, increased collaboration between professional archaeologists and amateur collectors with the goal of improved access to private collections would help to complete the Late Prehistoric archaeological picture. This is especially true in the Saginaw Valley, where the author is aware of at least two private collections that house Springwells related materials. Perhaps at some time in the future there may be an enhanced cooperative effort between professional and avocational archaeologists to work synergistically toward a common goal that benefits everyone. It is only through collaboration between interested public, private, and Native stakeholders that we will all gain an enhanced understanding of Native American life in the Great Lakes region of North America

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