March 2015

Materiality and Location: A Geographic Study of Log Home Manufacturing

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Materiality and Location: A Geographic Study of Log Home Manufacturing

A Dissertation Presented

by

JAMES SEDALIA PETERS

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

February 2015

Forestry

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DEDICATION

To my loving parents, the late Dr. James S. Peters, II and Dr. Marie F. Peters.

ACKNOWLEDGMENTS

I thank my academic advisor and committee chair, David T. Damery, for his years of encouragement, support, and guidance. Most important was his early insistence that this dissertation be quantitative with a model to be tested. I thank Richard W. Wilkie, who convinced me that I thought like a geographer, and, more important, advised me throughout the long process of bringing this dissertation to completion. I thank Peggi Clouston for planting the original idea of location analysis as a fruitful approach to studying forest resources. Thanks also go to Risto Suikkari, University of Oulu, who served as an early consultant to the project, and to Jari Heikkilä, University of Oulu, who encouraged me to apply my interest in Finnish wooden towns and massive wood construction to the study of North American log-building. There are too many others at the University of Massachusetts, Amherst, the University of Connecticut, Storrs, the Log Homes Council, the International Log Builders Association, the Great Lakes Log Crafters Association, and at individual log home manufacturing companies for me to thank individually. Collective thanks will have to do.

I must also thank my daughters Llyana and Elizabeth, their families, relatives, and friends who too often saw me missing in action, as I worked to complete what must have seemed like a never-ending project.

ABSTRACT

MATERIALITY AND LOCATION: A GEOGRAPHIC STUDY OF LOG HOME MANUFACTURING

FEBRUARY 2015

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The dissertation presents a material-geographic analysis of the materiality of log home manufacturing and may be the first quantitative application of 'new materiality' concepts. It tests the thesis that log home attributes reveal a manufacturer's geographic region and building culture. A study of human-environment interaction, the research investigated the organization of log home manufacturing in the Eastern Woodlands of North America and illustrates relationships between manufacturers, their perspectives on forest resources and their choices of log conversion (i.e., processing) methods. Data were obtained from secondary sources and by surveying managers of log home manufacturing firms. Methods included hierarchical cluster analysis, spatial analysis using the standard deviational ellipse, a spatial statistic, in GIS, and multinomial logistic regression. The results support the conclusion that log conversion attributes do, in fact, identify manufacturers' regions, their perspectives on their forest resources, and, by extension, their building cultures. Surprisingly, the regions correspond to those originally established by Native Americans hundreds of years ago. A manufacturer's log acquisition methods, distances from timber supplies, timber performance requirements, influences on log conversion methods, and perceptions of market barriers to offering 'green' certified logs were predicted by a manufacturer's log conversion methods. Manufacturers' perspectives on environmental issues and geographic distances from their markets were not. A manufacturer's timber inputs were found to have profound implications. Higher volume manufacturers were more likely to acquire their timber locally or nearby as raw logs and were more likely to produce regionally specific log profiles. Lower volume manufacturers were more likely to acquire their timber as cants from a greater distance and to produce a greater variety of log profiles.

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CHAPTER 1

MATERIALITY AND MATERIAL-GEOGRAPHIC METHODS

> The folk who cut the trees, squared and notched the logs, sawed and mortised the timbers, and split the roof boards possessed an amazing amount of folklore about their tools and materials. They knew how dozens of kinds of Kentucky trees would respond to seasoning, why a dogwood mallet was suitable for striking a froe, and why that froe should be dull. They knew how to make the proper warp for a broadax handle, why a square peg did its work best in a round hole, and what would cause a board to curl. In short, though they lacked modern power tools and materials, and though some could not even read or write, they were well equipped with traditional knowledge and skill.
>
> From Kentucky Folk Architecture[1]

> At first glance, you may think there isn't much difference between one log and another. Seen one tree and you've seen them all, right? Well, you're in for a bit of a surprise. There are more corner styles, profiles and sizes in the modern log home industry than you can shake a stick at. More than 17 tree species are used, each with its own unique physical characteristics. This can include the color of the wood, size (diameter & length), grain pattern, thermal performance and resistance to decay. Plus, logs can be fashioned into a host of different corner styles and profiles, using different crafting and milling techniques… About 90% of all modern log homes built today are milled or manufactured. Using high speed milling machines, harvested trees or squared cants are milled to a specific profile...
>
> From Log Homes Council Buyers Guide[2]

1.1 Introduction

Contemporary North American log homebuilding is something of an unknown territory to academic researchers. This dissertation, a study of log home manufacturing in the eastern temperate forests of North America, was undertaken in an effort to understand the materiality of this sector of the homebuilding industry. It utilizes a material-geographic analytical approach, exploring the materiality of log home manufacturing and testing the thesis that contemporary log homebuilding attributes reveal a manufacturer's geographic region and building culture. In a sense, it is a study of human-environment interaction, exploring how the log homebuilding industry is organized with respect to its forest resources and core woodworking technology.

The results support the conclusion that log conversion (i.e., processing) attributes do, in fact, identify manufacturers' regions and their perspectives on their forest resources. Surprisingly, these are regions that were originally established by Native Americans and are hundreds of years old.

The dissertation demonstrates the efficacy of material-geographic methods. It also presents evidence of the spatial evolution of log homebuilding from 19th Century handcraft methods to early 21st Century industrial production, illustrating that what came before continues to leave its mark. The effects of 'first effective settlement' are no less powerful today for the passing from the scene of the great scholars of American Geography.[3] It is hoped that the dissertation also underscores the logic of place and of local and regional strategies for sustainable resource use and building specification.

Vernacular architecture records our relationships with physical and social environments. Cultural geographers have a history of using correlations between log-building methods and geographic location as diagnostics to ascertain historical settlement patterns.[4] This study is grounded in these methods and extends them in order to gain insight into the organization of contemporary log home manufacturing.

The search for more sustainable housing suggests that this may be time for a new look at North America's log-building traditions. Today, log-building systems provide human shelter successfully in both urban and rural settings just as they have for hundreds of years.[5] The environmental advantages of log building systems have been well documented,[6] and derive from the fact that building logs are less processed than the wood that goes into other wood building systems. Less sawing, kiln drying and other post processing is required, resulting in less particulate matter, VOCs, CO, CO_2, and NOx. No primary processing of the sort required for plywood, veneer, or reconstituted wood products is necessary, further reducing emissions, including CO_2. Log structures can be expected to be environmentally sound, and, in fact, log home manufacturers emphasize their use of sustainable and renewable building materials.

Gertler introduced the concepts of industrial culture and regional cultures of production.[7] Industrial culture is the milieu (i.e., customs, conventions, institutions, networks, etc.) within which industrial production is embedded. Gertler noted that Lundvall addressed the importance of social or cultural context to the success of interactions between the producers of new process technologies and their users,[8] and Granovetter suggested that this interaction "takes place through informal as well as formal mechanisms and is reinforced by shared histories and cultures."[9] As noted by Gertler, the conclusion that systems of innovation and production have become "more social in nature" is now commonplace. Theories of regionalization of innovation, localized learning, and industrial agglomeration have all received significant attention in recent years, and evidence of contemporary regional systems of industrial production and innovation has been widely discussed.

The dissertation presents evidence of relationships between building attributes, geographic location, and building culture.[10] It consists of five chapters. The first chapter introduces the dissertation topic, discusses its theoretical context, presents its rationale, and describes its geographic context. The second chapter presents a qualitative meta-study of research findings of spatial correlation between log-building attributes and geographic location. It also serves as a literature review. The third chapter presents a geographic analysis of contemporary log home manufacturing based on log conversion (i.e., processing) attributes. The fourth chapter presents relationships between log conversion attributes, building culture as evidenced by log home manufacturer perspectives on forest resources, and geographic location. It presents multinomial logistic regression-based tests of the ability of spatially correlated log conversion attributes to predict a manufacturer's: 1) regional location and 2) perspectives on forest resources. The fifth chapter presents conclusions, implications of the findings, and suggestions for future research, and an argument for the development of local and regional building information databases, supply chains, and building standards to reflect the regional character of human-environment interaction.

The remainder of this chapter presents the dissertation's theoretical context and the rationale. It also presents an overview of the Eastern Woodlands, the study area.

1.2 Theoretical Context: Material-Geographic methods, materiality, and building culture

The theoretical basis for using material-geographic study of contemporary vernacular building attributes to understand human-environment interaction can be found in explanations of scientific reasoning and explanation in geography. The use of these methods here reflects the rehabilitation of space and materiality in architecture as well as the broader 'spatial turn' occurring in a number of areas of academic inquiry.[11] Vernacular architecture in late 20th Century North American cultural geography is discussed as a cultural diagnostic. Then, hybridity and the new materiality, concepts that are presently at a leading edge of geographers' conceptualizations of space and spatial relations are discussed. Finally, the identification of communities of building practice from spatially correlated building attributes is discussed along with the use of material performance characteristics to reveal human-environment interaction.

1.2.1 Vernacular architecture, culture, and environment

The literature of scientific reasoning and explanation in geography emphasizes the ordering of spatial variance.[12] Geographic objects are described on the basis of their space-time coordinates and properties (i.e., attributes). As Harvey and Amedeo and Golledge acknowledged, orderings of spatial variance, in themselves, do not explain anything. Nonetheless, they do provide very powerful clues because explanations of spatial variance can be proposed, evaluated, and tested, the approach of the present study. This is also the theoretical framework of late 20th Century cultural geography and many of the classic studies of North American vernacular building. North American cultural geography has an extensive history of material-geographic analysis of vernacular architecture. Typological methods underlie these approaches.[13] Influenced by Carl Sauer and the 'Berkeley School' of cultural geography, which relied heavily on anthropology and viewed buildings as part of the landscape, cultural geographers treated vernacular buildings as anthropological artifacts and analyzed their attributes for correlation with location or place.[14] That is, building attributes were used as typological descriptors to categorize buildings, building systems and sub-systems, as well as individual building components. In this way, typologies of material culture were developed and evaluated for spatial correlation.

Findings of such studies are illustrated in the second chapter of the dissertation, a meta-study of geographies of log building in eastern North America. Forty-two studies containing 167 individual findings of correlation between log-building attributes and location were identified. These correlations involved 22 individual building attributes, of which about one-third were explicitly ecological and about one-third explicitly cultural. The most frequently cited attributes were house type, corner notch type, tree species used, and log profile. Most findings dated from the 18th and 19th Centuries, reflecting researchers' keen interest in early European settlement of North America.

Although this type of study has been criticized for describing rather than explaining patterns of building as well as for a lack of sophistication with respect to social theory,[15] these methods can be adapted to apply in contemporary research. The first criticism resulted from the nature of geographic analysis. The second can be addressed by actor-network theory and other non-representational theories, as will be discussed.

Because scholars of vernacular architecture have tended to define their subjects as historical or, in non-western contexts, as indigenous, it is first necessary to recognize contemporary vernacular buildings and hybrids of traditional and modern buildings as legitimate subjects of vernacular study.[16] This requires recognizing these building types as authentic artifacts of living traditions, representing continuing trial and error processes through which their builders adapt to local climatic, cultural, technological, and resource contexts.

1.2.2 Hybridity and the new materiality

Conventional approaches to materiality address the aesthetic, engineering, economic, and environmental performance of materials.[17] Architects, in particular, have been concerned with the role of materials as determinants of form.[18] Architects have also been concerned with concepts of honesty in the use of materials, primarily developed in the arts and crafts and modern movements.[19] In the last few years, the interrelationships of the material, the social, the temporal, and the spatial have become topics of interest in a number of fields in addition to architecture.[20] At the core of this relational understanding of materiality are actor-network theory (ANT) and other non-representational theories (NRT) that blur functional distinctions between the natural (or material) and the social.[21]

Often portrayed as a theoretical rediscovery of space and place, ANT treats space and place as processes or as relational rather than static containers.[22] From this perspective place is the sum of all of the relationships that determine what that place is. Vernacular buildings are negotiated assemblages of building attributes with sociotechnical syntaxes.[23] They are representations of relationships as well as actants in those relationships.

ANT was first applied in science and technology studies.[24] ANT views technical objects (i.e., technologies, buildings and other assemblages of material culture) as simultaneously embodying sets of relations between heterogeneous elements (i.e., hybridity). It conceptualizes a constant interaction (i.e., performance) between the natural (or material) and the social, as all sorts of ‘actants,’ human and nonhuman, participate in constructing and maintaining the network of relationships that is the object.[25] Human behavior shapes objects, and objects shape human behavior. Meskell expressed this as "a material lifeworld that is conceived and constructed by us, yet equally shaping human experience in daily praxis."[26]

The advantage of this conceptual approach is that, rather than viewing buildings as influenced by the power of abstractions such as culture or environment, buildings are viewed as being influenced by the power of concrete behaviors. Building components, for example, are seen as interacting simultaneously with each other, with humans, and with non-human actors (e.g., temperature, moisture, plants, animals, and insects). Thus vernacular buildings can be conceived of as more than a collection of components put together by builders, and they are what Law has referred to as "system sensitive" in the sense that the various roles necessary to make the system function take precedence over individual component performances.[27] This approach accommodates modern-traditional hybrids and renders irrelevant the conflict between environment and culture, so prevalent in work influenced by the Berkeley School.

1.2.3 Communities of practice, building materials, and performance

ANT/NRT-based methods of empirical investigation have yet to be developed. Multiple kinds of space and human knowledge operating simultaneously, as well as the representation of relational space, have proven difficult concepts to operationalize.[28] However, as is discussed below, ANT/NRT offers a theoretical framework for attribute-based spatial analysis of contemporary, hybrid vernacular buildings. The foundational ANT/NRT concept of things moving together in networks with the power to make stable or durable spaces can be applied to conceptualizing communities of building practice in ways that link building attributes, place, and builder perspectives.

Vernacular builders employing the same methods in the same place (i.e., region) can be assumed to belong to a community of practice, although Amin and Roberts argue that different types of knowledge (e.g., craft or task-based, epistemic or high creativity, professional, and virtual) may have different spatial consequences.[29] Our concern here is with craft or task-based knowledge or, in Thrift's typology, practical knowledge.[30] Given the influence of first effective settlement, tradition, and the trial and error nature of vernacular learning, groups encountered in vernacular contexts can be expected to conform with respect to their 'rule systems' for building.[31] Thus, spatially correlated building attributes and correlations between building attributes and builder perspectives are evidence of a community of practice. From an ANT/NRT perspective, spatially correlated building attributes represent place-associated stabilities in the networks of relationships that are a building's performance. The association of spatially correlated building attributes with specific ethnic groups is not required for theoretically grounding group membership claims, as had often been assumed by cultural geographers.

Builders can be expected to belong to multiple communities of practice. However, attributes that differentiate with respect to their use of materials and their associated techniques are the most revealing because they indicate resource-based patterns of human-environment interaction. Material inputs (i.e., producer perspective) and outputs (i.e., consumer perspective) are tangible, but the metrics of their physical, economic, and technical characteristics are often qualitative or abstract. For example, in a study of industrial lumber manufacturers, Eastin et al. used a set of 16 characteristics to describe softwood lumber.[32] Similarly, in a study of the wood product specification preferences of U.S. architects, Wagner and Hansen used 14 characteristics to describe wood products.[33] Such characteristics are the basis of material selection, correspond to ANT/NRT performances, and represent interactions that impact building design. These embedded performances may also constitute the specifics of human-environment interaction.

The thesis of the dissertation is that building attributes reveal building culture. This thesis was tested on the log conversion (i.e., processing) attributes of log homebuilding. The thesis can be accepted if correlations are found between building attributes and location or between building attributes and builder perspectives. It is assumed that shared locations and shared perspectives are indications of communities of practice.

1.3 Rationale: The importance of embedded knowledge to managing human-environment interaction

The ecological lessons of our vernacular building heritage and universal, science-based metrics of environmental impact (e.g., greenhouse gas emissions, carbon sequestration) have roles to play,[34] but the most compelling path to sustainability begins with understandings of the shared local and regional practices of ecosystem/culture interaction. These shared practices are embedded in localities and regions. Advocates of green building practices have too often favored an anti-modern environmentalism, emphasizing literal application of traditional (i.e., preindustrial) building methods, or a modern environmentalism emphasizing technical means, universal methods, and/or harmonized standards for sustainability.[35] The sustainability claims behind these approaches have been referred to as “vernacular/regional determinism” and “technological determinism,” respectively.[36] Both approaches are flawed. Anti-modern approaches fail to address contemporary life styles, systems of production, and cultural meanings, and by commoditizing building materials and ignoring tacit environmental knowledge, modern environmentalism fails to address relationships between local and regional cultures and ecosystems.[37]

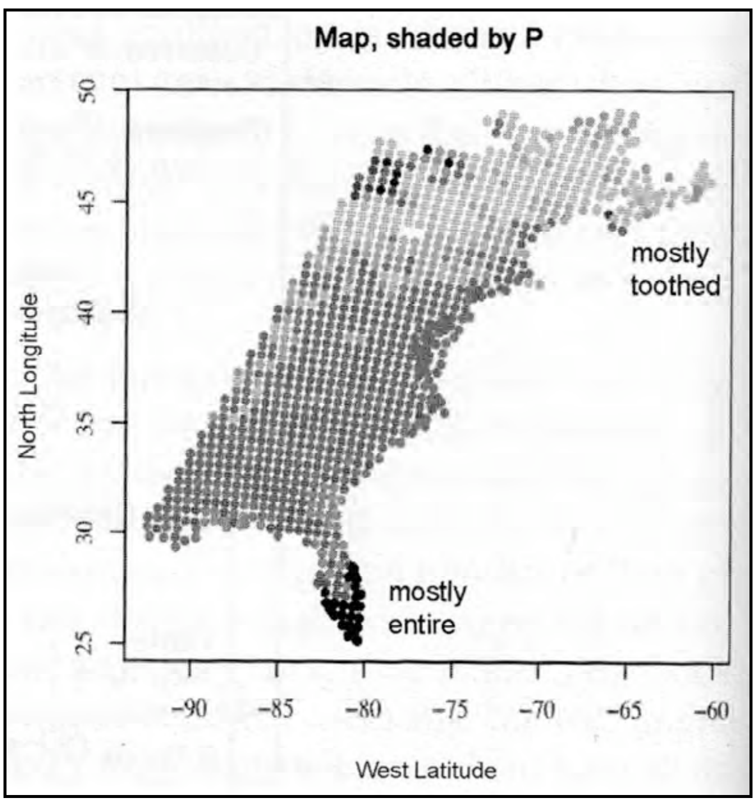
By viewing buildings as material-semiotic assemblages,[38] communities of building practice can be identified.[39] Strategic thinking about reconfiguring building design and production to build more sustainably can also be facilitated.[40] Because environmental knowledge is a situated knowledge, sustainable building efforts require an understanding of situated human-environment interaction.

American cultural geography has provided a basis for applying material-geographic methods to identify communities of building practice from spatially correlated building attributes. Relational conceptions of space, including hybridity and the new materiality, provide a basis for applying these methods to contemporary building. Applying such methods, this study tested if such methods are, in fact, effective for identifying differences in contemporary building culture.

1.4 The Eastern Woodlands

The geographic context of the study is the Eastern Woodlands. Extending from the Gulf of Mexico north to the Canadian Maritime provinces and the Great Lakes Basin, the Eastern Woodlands are best described as the eastern, temperate forests of North America. This biome occupies a climatic niche governed by mean annual temperatures ranging between about 2^0 C and 18^0 C and by mean annual precipitation ranging between about 60 cm and 240 cm. Its forest zones are mixed evergreen boreal/deciduous temperate (north), deciduous temperate (central), and mixed deciduous temperate/evergreen warm temperate (south).

The Eastern Woodlands can be divided into ten ecoregion provinces that vary on a north-south gradient, confounded by elevation, aspect, soil type, and disturbance history and regime.[41] Individual Eastern Woodlands forests are deciduous, evergreen, or mixed. Deciduous forests occupy areas with high summer precipitation and low winter temperatures.



Proportion (P) of tree species with "entire" (non-toothed) leaves reflects the temperature gradient

Figure 1.1: Climate and tree species distribution (Adams)[42]

Evergreen forests occupy areas with dry summers and warm winters. Evergreens can also occupy sites that would be deciduous, were it not for deficits of nutrients or water.[43] Cyclical climatic fluctuations result in significant cyclical fluctuations in primary productivity. As a consequence, the Eastern Woodlands offer plant and animal populations a distinctive set of challenges and opportunities. The shared human adaptations to these environments contribute significantly to the region's coherence as a unit of study.

Figure 1.2: Ecoregion provinces of the Eastern Woodlands (based on Bailey)[44]

Sub-regional cultural boundaries have remained fairly constant from the immediate pre-Columbian period to the present. It is fair to say that Europeans migrated into cultural regions that had already been established by Native Americans.[45]

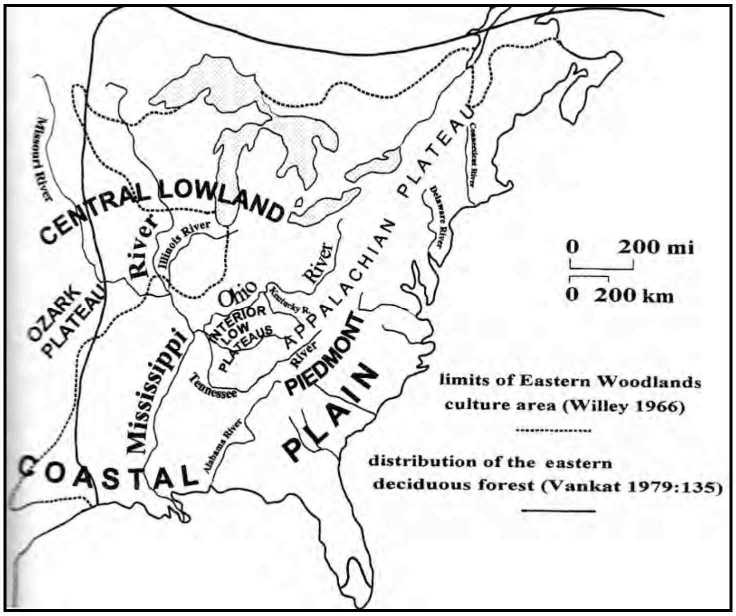


Figure 1.2: Pre-European Eastern Woodlands culture area (Gremillion)

The core cultural sub-regions in which European log-building traditions took root can be broadly categorized as the Upland North (northern Appalachian Plateau), the Upland South (southern Appalachian Plateau), the Lowland South (southern coastal plain), and the Great Lakes Basin. There are also ecotone areas in between with mixed characteristics. Climate and ecological history have been the primary determinants of the forest resources available to builders. Climate, culture, and available resources have been the primary determinants of building design.

The only coherent body of scientific research on North American log building was produced in the American Geography project. Nearly everything else on the subject is a single isolated study, anecdotal, or a case study. Starting with Fred Kniffen in the 1930s and culminating with Terry Jordan in the late 1980s, Kniffen, Jordan, Wilbur

Zelinsky, and other cultural geographers studied pre-1850 log building as a guide to early European settlement patterns of North America.[46]

Starting in about 1600, European settlers started to move west from cultural hearths along the Atlantic coast, transforming the landscape to support European systems of agricultural exploitation.[47] At about the same time, Swedes and Finns of New Sweden in the Delaware Valley (NJ, PA) introduced European log-building methods. These methods traveled west into the forested frontier as the predominant homebuilding method, especially in areas without access to sawmills. At the time of initial European settlement, forest cover was nearly 100%. European settlers replaced trees with farmland, primarily at the expense of oak and beech, species typically occupying productive mesic sites. As by-products, logs for homes and firewood and charcoal were produced for residential, commercial, and semi-industrial purposes. The first sawmill was established near York, Maine in 1623.

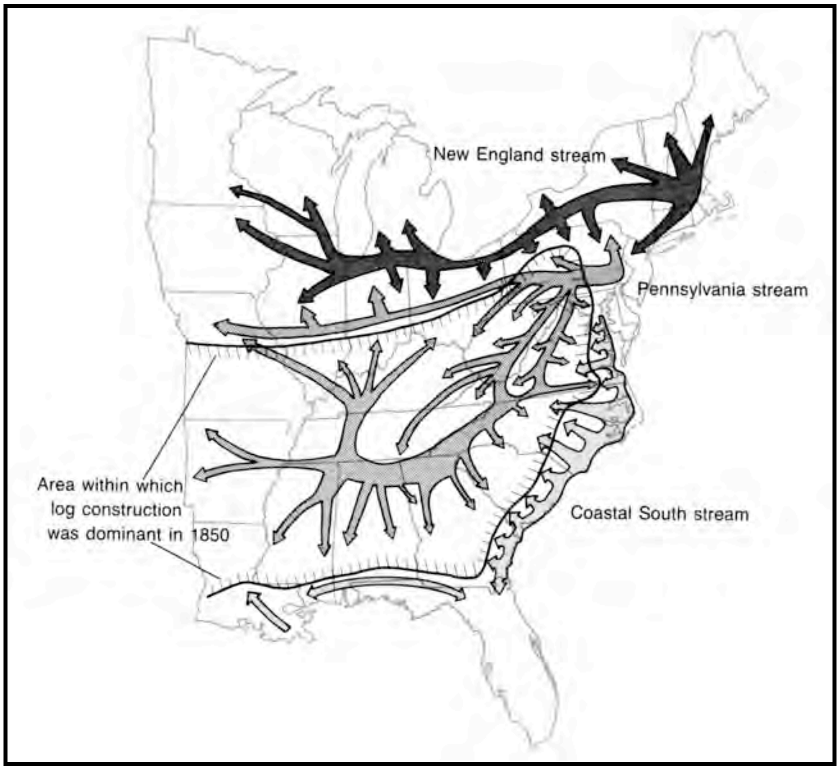


Figure 1.3: Routes of diffusion of European building methods (Carver)[48]

Most scholars agree that Finns and Swedes, building in the Delaware Valley, brought the first European tradition log-building methods to North America. From this start in what is often referred to as the cultural hearth area of America, log-building methods were carried south through the Appalachian Plateau and then up into the Midwest. See Figure 1.3. Before industrialization, log homes were common in all of the cultural regions[49] of eastern North America except for the Lowland North (i.e., northern Atlantic coast). In all of the other regions (i.e., Upland South, Lowland South, Upland North, and the Great Lakes Basin) log homes prevailed until the coming of the railroads. Today, log home manufacturing operations are still found in all of these regions.

After about 1800, lumbering was restricted to areas where agriculture was difficult, but it was conducted on a massive scale. Lumber production became mechanized and moved into the Great Lakes Basin. Old-growth forest was cut at a rapid rate. Lumber production peaked about 1890 and dropped to a much smaller scale by 1920, as the industry moved to Old-growth areas in the Pacific Northwest and to plantation forestry in the Southeast.[50] Over time, nearly all of the land was cut over. Forest cover fell below 50% and in some areas below 30%. Ultimately, less than 1% of old-growth forest remained. Since the mid 19th Century, forest cover has substantially returned as a result of a reduction in agricultural land use and a smaller forest products industry.[51] Industrial manufacturers now produce about 90% of log homes. Manufacturing operations are thought to be located in proximity to forest resource inputs.[52]

Endnotes

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[2] Log Homes Council. Buyers Guide: "Choosing the right building materials for your dream home." Assessed December 24, 2010, http://loghomes.org/log-profiles--corner-styles-70.

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[13] Defined by Adams and Adams as systems of types. “A typology is a conceptual system made by partitioning a specified field of entities into a comprehensive set of mutually exclusive types, according to a set of common criteria dictated by the purpose of the typologist. Within any typology, each type is a category created by the typologist, into which he can place discrete entities having specific identifying characteristics, to distinguish them from entities having other characteristics, in a way that is meaningful to the purpose of the typology.” Classificatory methods are tools. They are neither predictive nor explanatory, as they do not involve intrinsic understandings. Adams, William Y. and Ernest W. Adams, Archaeological Typology and Practical Reality: A Dialectical Approach to Artifact Classification and Sorting (Cambridge: Cambridge University Press, 1991), p. 325.

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CHAPTER 2
A META-STUDY OF SPATIALLY CORRELATED ATTRIBUTES

A log cabin, sketched by Mr. Tidball in a Creek Indian community in 1791

> Housing even considered alone is a basic fact of human geography. It reflects cultural heritage, current fashion, functional needs, and the positive and negative aspects of noncultural environment. These relationships are more easily appreciated for a simpler era when plant and animal husbandry were dominant pursuits, but are no less true today.[1]

> The experience waiting to be collected from traditional buildings is a heritage we cannot afford to lose. It contains... a sort of gene pool of knowledge about design in harmony with climate and with natural environment, knowledge that could alter the mind-set of our modern globalistic architecture and building technology.[2]

2.1 Introduction

Vernacular architectures record our relationships with physical and social environments. Late 20th Century American cultural geographers were able to use correlations between building method and geographic location to ascertain historical settlement patterns, most often by looking at the details of log construction. This chapter serves as a literature review. It describes a search of the academic literature for findings of correlation between log-building attributes and location in the study region. It also describes a qualitative meta-study of the findings offered by that literature.

Although a number of studies of traditional buildings have integrated the findings of earlier work, there have been no systematic evaluations of that literature. Somewhat surprisingly, keyword searches of a range of databases and publications identified no systematic literature reviews.[3] Only a handful of systematic reviews of geographic studies of any sort were identified.[4]

The primary goals of the meta-study were to synthesize and assess a fragmented knowledge of spatial correlations of log-building technology in North America's eastern temperate forests and, in particular, to identify spatially correlated building attributes and attribute categories that have been documented by previous research and the resulting conclusions about regions. The Paterson, *et al*. approach to qualitative meta-study (i.e., meta-data-analysis, meta-method, and meta-theory, leading to meta-synthesis) was employed to address the findings, methods, theoretical bases, and contradictions and complexities of the selected studies.[5] The results were used to inform the dissertation's study of contemporary log-building methods.[6] Data collection focused on four key questions:

- What first and second-order spatial variation in log-building methods were observed, and what log-building attributes were the bases of these spatial variations (i.e., correlations)?[7]
- What attributes were explicitly environmental or cultural?
- What research methods were used to produce a study's findings?
- What theories did the studies propose to explain their findings?

Forty-two studies with 167 findings of correlations between log-building attributes and location and were identified and classified by attribute type, geographic scale, date, and analytical approach.

After a brief contextual discussion of cultural geography and vernacular building, the rest of this chapter discusses the methods of the meta-study and its findings. The chapter concludes with the case for log conversion (i.e., processing) attributes as valid bases for log-building typologies and the suggestion that building standards intended to protect and enhance ecosystem functioning should probably be designed to operate at sub-regional or state/provincial scales.

2.2 Cultural geography and vernacular building

For some time it has been understood that vernacular buildings record our relationships with physical and social environments[8] and that they hold ecological lessons for building today.[9]

Traditional knowledge of building materials was based on understandings of nature and of the uses of natural materials.[10] As a consequence, studies of traditional buildings constitute a resource of knowledge not only of building materials and techniques, but of human-environment interaction as well. Much of what we know about North America's traditional building heritage is the work of cultural geographers, folklorists, and historians. Because cultural geographers, in particular, were interested in the characteristics of regions and places, they used the characteristics of building technology, especially log-building technology,[11] to document early European settlement patterns in North America.[12] For example see Figure 2.1 in which Kniffen and Glassie present the locations where various corner notch types were found.

Figure 2.1: Early distribution of corner notch types in eastern N. America (Kniffen and Glassie)[13]

Today, we have access to a variety of studies describing the areal differentiation of traditional building technologies, and, as a result, we have a variety of insights into buildings as responses to culture, technology, resources, and the environment. During the pioneer period, the time period covered by most of these studies, houses were built with locally sourced materials, building techniques were simple and required no materials unavailable at or near the building site. Logs were a by-product of clearing land for cultivation. As a general rule, log was the preferred European homebuilding method except in New England, in areas settled by New Englanders, and on the southern coastal plain. Log was the predominant homebuilding method, as late as the early 20th Century, in areas where sawmills had not been established, transport of milled lumber was too difficult, or milled lumber was too expensive to be used as the primary building material.

2.3 Qualitative meta-study methods

Qualitative meta-study is second-order analysis that synthesizes the results of prior studies and also seeks to reflect upon the research processes involved.[14] It is an interpretive constructivist approach, consisting of a qualitative examination of the theory, method, and data analysis of existing studies, leading to a synthesis.[15] The steps of meta-analysis are:

- Formulating a research question
- Selection and appraisal of primary research
- Meta-data-analysis
- Meta-method
- Meta-theory
- Meta-synthesis
- Disseminating the findings

The research question guiding the meta-study was: *What does research on log building in the Eastern Woodlands tell us about relationships between building method (i.e., building attributes) and geographic location*? The theoretical framework is based in the literature of scientific reasoning and explanation in geography, emphasizing the ordering of spatial variance and describing geographic objects on the basis of their space-time coordinates and attributes.[16]

Study candidates were identified primarily through keyword searches of various databases and by reviewing bibliographies.[17] Studies were selected for review if they included a finding of spatial variation on the basis of a log-building attribute.[18] Fifty-four studies were selected for review. Of these, forty-two (42) described explicit and robust, spatially correlated building attributes. These studies identified 167 individual spatial correlations. The studies were evaluated with respect to their researcher credentials (i.e., sponsors and researcher disciplines), problem statements (i.e., research questions), research purposes (i.e., study objectives), theoretical frameworks (i.e., study types, key concepts, and assumptions), study limitations (i.e., geographic and temporal extents), data collection (including data collection procedures), data analysis, and conclusions. In order to provide consistency, one person reviewed, coded, and evaluated all of the studies.

The *meta-data-analysis* consisted of compiling the studies' findings of spatial correlation. The correlations were described by attribute, location, geographic scale, temporal extent, geographic location/building attribute relationship, and whether there was an explicit cultural or ecological context. *Meta-method* addressed the rigor and epistemological soundness of the methods used in the selected studies and was used to compare findings. *Meta-theory* assessed the underlying structures on which the studies were grounded, identifying research design strategies and major cognitive paradigms. Finally, *Meta-synthesis* brought together the ideas and findings taken up in the meta-data-analysis, meta-method, and meta-theory phases of the meta-study, including contradictions and complexities in the studies' theories and findings.

2.4 Meta-study results

2.4.1 Meta-data-analysis

Typically, studies of larger geographic entities (i.e., regions) identified explicit areal variation of log-building attributes. Studies of smaller geographic entities (i.e., landscapes, counties) most often identified attributes that were considered typical or predominant in the geographic area under study without discussing geographic context.[19] Studies of mid-sized geographic entities (i.e., sub-regions, states/provinces) took both approaches.

The spatial correlations involved 63 geographic entities at multiple geographic scales (see Table 2.1). These correlations involved 22 building attributes (see Table 2.2). About one-third of the 167 spatial correlations were explicitly ecologically related. Of these, about 40 percent were at state/province scale, and about 30 percent were at sub-regional scale. Regional and county scale correlations were both greater than 10 percent. Environmental factors included climate, the presence of tree species preferred for log building, and the presence of specialized materials such as stones suitable for foundations, clay or moss suitable for chinking, and lime for mortar. About one-third of correlations were explicitly cultural. Of these about 30 percent were at sub-regional scale, about 25 percent at county scale, and about 20 percent at state/province scale. Regional scale and multi-regional scale correlations were both about 10 percent. Log-building traditions (i.e., craft knowledge) possessed by ethnic or cultural groups and house types associated with ethnic or cultural groups were the cultural factors most often cited.

Table 2.1: Geographic entities with spatially correlated log-building attributes

(1) Landscapes	(2) Counties	(3) States/Provinces	(4) Sub-Regions	(5) Regions	(6) Multi-Regions
Montreal (QC)	Keweenaw Peninsula (MI)	Newfoundland	St. Lawrence Valley	Appalachia	Eastern USA
Augusta Township (ON)	St. Louis Co. (MN)	Ontario	Lake Superior	Upland South	Midland Culture area
Jamestown 1st (VA)	Cumberland Co. (PA)	NY (Adirondacks)	Mississippi Valley	The South	Great Lakes & Mississippi Valley
	Dubois Co. (IN)	NJ (Southwest)	E. PA; W. Appalachian Valleys; Valley of VA		
	Jersey Co. (IL)	PA (Eastern)	Mountains of MD, VA		
	Blount Co. (TN)	OH	E. of Blue Ridge; esp. VA Piedmont		
	Overton Co. (TN)	IN (South)	SW-VA; NW-NC; NE-TN		
	Independence Co. (AR)	VA	North Appalachia		
	Medina Co. (TX)	VA (South) & NC	North & Central Appalachia		
	New Braunfels Co. (TX)	NC (Western Piedmont)	Northern South Appalachia		
		TN (East & Middle)	S. Appalachia		
		MO (Little Dixie)	Western VA and KY		
		GA	Ohio and upper OH Valley		
		AL	OH Valley, mountain South		
		AL (North)	from TN Valley N to KY (Cent.), IL (South), IN, & OH		
		LA	from TN Valley, S.E. to GA; S. to AL; S.W. to MS & LA; W. to AR & MO		
		TX	Ozarks and Ouachitas		
		TX (Central)	The South (S.&E. of fall the line)		
		TX (East)	Oak-Pine Flatlands (The South)		
		TX (German Settled)	Southeastern pine forest		
		TX (Hill Country)	Southern coastal plain		
			Inner Gulf Coastal Plain		
			Interior Deep South		

The most frequently cited spatially correlated log-building attributes were house type, corner notch type, tree species, log profile, chinking, corner notch/log profile combination, roof structure, chimney material, and foundation material, and wall type. These ten attributes accounted for nearly 90 percent of the correlations.

Table 2.2: Spatially correlated log-building attributes

	#		#
Log Conversion		*Building Systems*	
corner notch	34	Additions:	
corner notch/log profile	8	porches	2
log profile	13	sheds	1
tree species	21	Floors:	
		floor material	2
General Construction		Foundations:	
chimney placement	3	foundation material	6
craftsmanship (level)	2	Heating:	
door placement	2	chimney material	7
floor area	1	heating fixtures	1
house type	38	Roofs:	
pen shape	1	roof material	2
		roof structure	7
		Walls:	
		chinking	9
		connections	1
		log length	1
		wall type	5

Overall, spatial correlations were cited most frequently at state/province scale (about 35 percent). County, sub-regional, and regional scales each constituted about 20 percent of the correlations. This demonstrates a relatively greater interest in state/provincial studies. It is not evidence that spatial correlations occurred more often at state/provincial scale.

Figure 2.2 presents the relative frequencies, denoted by the size of the circles, of the 167 spatially correlated attributes by type, geographic scale, and time period. The prominence of log conversion attributes, sub-region and state/provincial scales, early settlement time periods is clear.

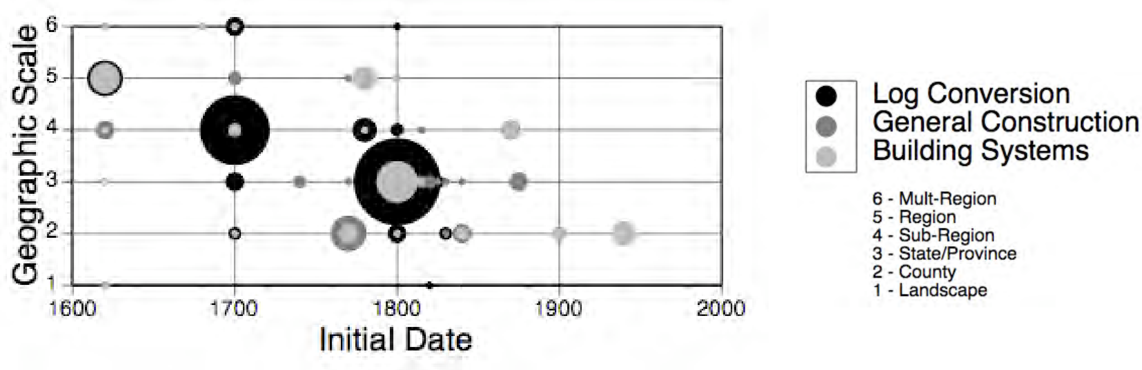


Figure 2.2: All attributes

About one-half of the spatial correlations involved log conversion (i.e., processing) attributes (corner notch, corner notch/log profile combination, log profile, and tree species), directly relating them to the forest resource. General construction and building system attributes correlated more evenly across geographic scales. House type[20] constituted a majority of the general construction attributes and about one-quarter of the spatial correlations, overall. A majority of the correlations were identified by studies covering the 18th and 19th Centuries, reflecting researchers' keen interest in early European occupation.[21]

Log conversion attributes correlated primarily at the sub-regional and state/province scales as a result of the fact that corner notch type, a key indicator in several studies, correlated most frequently at these scales. Other log conversion attributes were fairly evenly distributed. A few studies addressed the question of whether or not corner notch types correlated statistically with the tree species used. These studies' conclusions were contradictory.

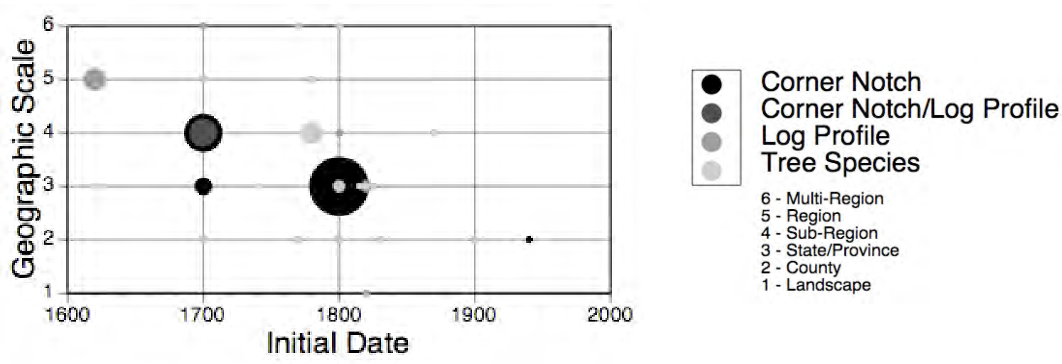


Figure 2.3: Log conversion attributes

Figure 2.3 presents the relative frequencies; again denoted by the size of the circles, of the 76 spatially correlated log conversion attributes by conversion type, geographic scale, and time period.   Tree species utilization correlations were found from multi-region to county scales. At multi-regional scale (eastern USA), eastern white pine, yellow poplar, and oak were identified as common, typical or predominant. At regional scale (e.g., Upland South), Black locust was identified as the most desirable. Yellow poplar was predominant in the early years. Later, oak was predominant. Finally, mixtures of oak, chestnut, poplar, and pine were predominant. At sub-regional scales, pine (Lake Superior), cypress (Mississippi Valley), oak and hickory (Ozarks and Ouachitas), oak (southern oak-pine flatlands), and pine (southeastern pine forest) were considered the most desirable. At state/province scales, Eastern white pine (Ontario), oak and cedar (southwestern New Jersey), oak, cedar, and pine (Texas), oak and pine (Georgia), and white oak ("Little Dixie", MO) were referred to as common, preferred or predominant.

Figure 2.4 presents the relative frequencies of the 47 spatially correlated general construction attributes by type, geographic scale, and time period. Most often these were spatially correlated house types. The earliest house-type correlations were related to the specific ethnic sources of the pioneers and their construction types (e.g., Fenno-Scandinavian log house, British frontier blockhouse), as were many correlations from later settlement periods (e.g., Yankee, German, Slavic, Scandinavian). About one-half of the house-type correlations were at the state/province scale, with the reminder fairly evenly distributed across the other scales. At multi-regional and regional scales, double pen and single pen house types were common, as were 1-1/2 story houses.

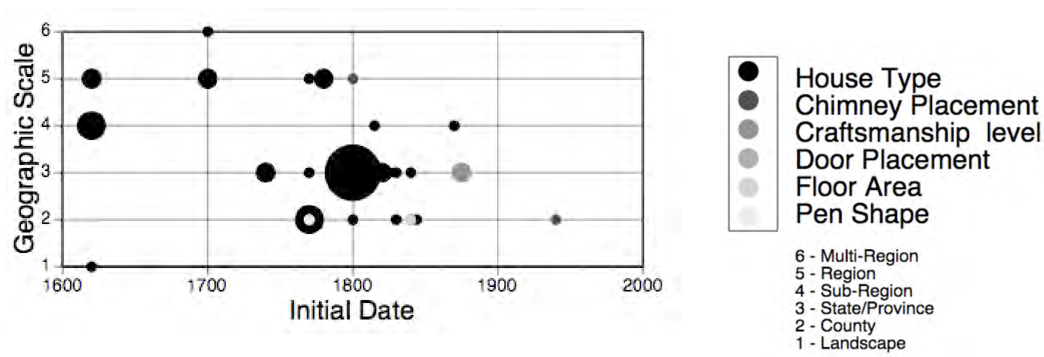


Figure 2.4: General construction attributes

At sub-region scales, the two-room, single-story house was cited as the most popular. Nordic pair, 1-1/2 story, and 2-story houses were common in the Lake Superior area. English, German, and French plan houses were typical in the Ohio and the upper Ohio Valley. The saddlebag house type was common in the Ohio Valley and the mountain South. The Cumberland house type was common at the southern end of the Upland South, and the dogtrot house was common in the inner Gulf coastal plain.

With the exception of foundation and house addition attributes, which were concentrated at the sub-regional and county scales respectively, building system correlations were fairly evenly distributed across geographic scales.

2.4.2 Meta-method

The studies were published from 1936 to 2004 with a median publication date of 1978. Geographers authored about one-half of the studies. Anthropologists, architects, architecture historians, folklorists, and historians authored the other half. About two-thirds of the studies were published in academic journals. Of these, about one-third were geography journals, about one-third were folklore journals, and about one-third were architecture, vernacular architecture, history, historic preservation, or anthropology journals.

About one-half of the studies identified sponsors. Of these about 70% were authored by geographers. The researchers' universities and state and provincial historical societies were the most frequently cited sponsors. The National Endowment for the Humanities and the National Science Foundation provided support for multiple studies.

The academic disciplines of the authors had methodological consequences. Geographers tended to be primarily concerned with spatial questions, especially the geographical diffusion of building technology, which was used as a marker for the diffusion of cultures and populations. Combinations of surveys and field observation were used to establish patterns of the spatial deployment of building attributes. Having established the facts on the ground, the geographers used these facts to identify the cultures that produced them and to delineate their spatial extents. The anthropologists and folklorists also tended to use combinations of surveys and field observation. However, their research objectives were somewhat different, often beginning with a focus on a specific cultural group rather than on a geographic area. The historians and architectural historians tended to emphasize historical documents as data sources. Architects and folklorists tended to focus on field observation, describing example buildings.

About one-half of the studies' problem statements or research questions involved description or documentation of built structures, usually houses, but sometimes barns and other building types. Typically, these studies employed surveys and/or field observation. Although only a handful of the studies systematically presented the researchers' data and data analysis, the fits between research methods and conclusions all appeared to be sound. Where survey and/or observational data were the basis for findings regarding the utilization of specific building techniques, the studies seemed straightforward and based on the survey and/or observational data. The conclusions, regarding the sources of building techniques and therefore, the environmental and cultural influences on the builders, in all cases seemed logical as well. However, the conclusions were not always in agreement. Researchers disagreed regarding specific European antecedents of log-building methods, although the authors of more recent studies agree that the principal source of log-building technology in North America was Northern Europe.

2.4.3 Meta-theory

By far the most frequent concept underlying these studies was that folk practices provide evidence of cultural diffusion and reveal cultural processes. Construction details are assumed to provide evidence of cultural occupancy and cultural practice. A few studies tempered this view with the notion that this was not always true, suggesting that, even in early North America, European craftsmen were capable with a broad range of building techniques and were therefore capable of responding to their environmental circumstances with construction methods from multiple traditions. From this perspective, selections of corner notch, log profile, and wall type were primarily determined by the requirements of climate, building site, and the available tree species. Although only a few researchers addressed this specific question, the disagreement is illustrated by the fact that researchers found both that corner notch type did and did not correlate with tree species utilization.

Ultimately, these differing views were at the root of disagreements as to whether environment or culture was more strongly determinative of building attributes. These concepts are less contradictory than they might appear. Jordan suggested that four hypotheses, developed in 'traditional' cultural geography, explain cultural production in early European North America.[22] These hypotheses were 'first effective settlement',[23] 'cultural simplification',[24] 'syncretism', and 'cultural preadaptation'.[25] First effective settlement posits that the first group able to successfully establish itself is of crucial significance for later social and cultural developments, even if those developments involves settlement by new groups. Zelinsky suggested how this worked:

> Whenever an empty territory undergoes settlement, or an earlier population is dislodged by invaders, the specific characteristics of the first group able to effect a viable, self-perpetuating society are of crucial significance for the later social and cultural geography of the area, no matter how tiny the initial band of settlers may have been.... Thus, in terms of lasting impact, the activities of a few hundred, or even a few score, initial colonizers can mean much more for the cultural geography of a place than the contributions of tens of thousands of new immigrants a few generations later. (p. 13-14)

Cultural simplification posits that Europeans established drastically simplified versions of European society in early North America. Syncretism posits that American building culture resulted from the blending of multiple European traditions. Cultural pre-adaptation posits that the European groups that successfully colonized North America were pre-adapted for success, especially Swedes and Finns by their experience in forests and Scotch-Irish, who had generations of experience in contested environments. Thus, the first successful European building cultures can be viewed as pre-adapted for success. Subsequent building efforts were heavily influenced by those building cultures. Over time, North Americans integrated multiple building methods based on the advantages that those methods provided, rather than adhering to individual European building traditions. Over time, construction details continued to reveal culture and provide evidence of cultural occupancy. However, building culture was evolving and becoming more and more adapted to North American conditions.

2.4.4 Meta-Synthesis

Ecosystems exist at a range of scales from small, localized areas to large biomes at continental scale and ultimately, to the biosphere itself, with smaller ecosystems nested within larger ecosystems. The studies of Eastern Woodland log building identified spatial correlations across a broad range of geographic scales. To the extent that the correlations reflect environmental influences, we can assume that like ecosystems, smaller scale correlations are nested within larger scale correlations.

Our interpretation of these spatial correlations is that the regions of European-American building culture were well established by the end of the 18th Century.

Subsequently, post-pioneer developments brought both sub-regional syntheses and new European implants, the latter principally occurring at local scales.[26] Jordan mapped this model of log-building regions in Texas, identifying 'Upland South' (Hill Country) and 'Lowland South' (East Texas) regions, ecotone areas of mixed characteristics, and individual German dominated counties. This model can be extended and, with the addition of the 'Great Lakes Basin' and 'Upland North',[27] fits historical spatial correlation data for the entire Eastern Woodlands.

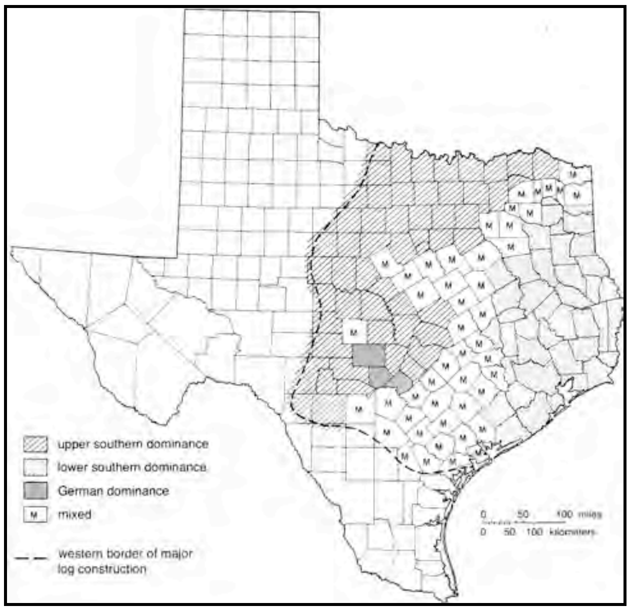


Figure 2.5: Texas log building cultural areas (Jordan)[28]

2.5 Conclusion

The history of European tradition log building in North America has evolved through ten identifiable, sometimes overlapping phases: first European contact, the forested frontier, early settlement, the backwoods, the arts and crafts movement, the national parks movement, early manufacturing, modern manufacturing, the modern handcraft movement, and high environmental performance log building. The first four phases are documented by the studies evaluated here. Native American log building has evolved both separately and within European traditions.

Several conclusions are important for the present study. Perhaps, most important, the cited studies identified spatially correlated building attributes as markers for the environmental and cultural influences to which log buildings have responded. Cultural and environmental factors interact extensively as bases of differentiation of building attributes. Regions identified by spatially correlated building attributes are areas of shared solutions to the problems of culture/environment interaction.

Although spatial correlations were cited at all geographic scales, the majority were at state/province and county scales. About 70 percent of the explicitly ecology-related correlations were at sub-region and state/province scales. About 75 percent of the explicitly culture-related correlations were at sub-region to county scales.

The geographic model of building culture and deployment of log-building technology implied by Jordan's study of Texas log building appears to fit the meta-study findings. However well these findings explain historical patterns of building in the Eastern Woodlands, it remains to be demonstrated that this model, consisting of the 'Upland South', 'Lowland South', 'Great Lakes Basin', and 'Upland North', fits the spatial expression of contemporary industrial log-building cultures. 'Classic' American geographic theory suggests that it will.

Endnotes

[1] Kniffen, Fred, "Folk housing: key to diffusion," Annals of the Association of American Geographers Vol. 55, No. 4 (1965): p 549-577.

[2] Woolston G, "Sustainable architecture in Finland," Earthwatch Vol. 14, No. 4 (1994): p. 65-73.

[3] Keywords included meta-analysis, meta-study, research synthesis, systematic review, and literature review combined with geography and vernacular architecture. Data bases included EBSCOhost Academic Search Premier, Google Scholar, Informaworld Taylor & Francis Group Current Collection, JSTOR, and Wiley Interscience. Individual publications included Annals of the Association of American Geographers, Area, The Geographical Journal, Historical Geography, Journal of Cultural Geography, Perspectives in Vernacular Architecture, Professional Geographer, Progress in Human Geography, Progress in Physical Geography, and Vernacular Architecture.

[4] Glasmeier A, Farrigan T, "Understanding community forestry: a qualitative meta-study of the concept, the process, and its potential for poverty alleviation in the United States case" The Geographic Journal Vol. 171 no. 1 (2005): 56-69, a model for this analysis, is a notable example.

[5] Paterson, Barbara L., Sally E. Thorne, Connie Canam, and Carol Jillings, Meta-Study of Qualitative Health Research: A Practical Guide to Meta-Analysis and Meta-Synthesis (Thousand Oaks, CA: Sage Publications, 2001).

[6] See Adams, William Y. and Ernest W. Adams, Archaeological Typology and Practical Reality: A Dialectical Approach to Artifact Classification and Sorting (Cambridge: Cambridge University Press, 1991); Dunnell, Robert C. 1971. Systematics in Prehistory (New York: Free Press, 1971); and Dunnell, Robert C, "Methodological issues in Americanist artifact classification," in Schiffer, Michael B. (ed.), Advances in Archaeological Method and Theory, Vol. 9 (1986) p. 149-207.

[7] First-order spatial variation occurs when observations of a phenomenon vary from place to place due to underlying properties of the local environment. Second-order spatial variation occurs when there are local interaction effects. In practice, it is often difficult to distinguish between the two. See O'Sullivan, David, David J. Unwin, Geographic Information Analysis (Hoboken, NJ: John Wiley & Sons, Inc., 2002).

[8] Henderson, Martha L., "Maintaining vernacular architecture on the Mescalero Apache reservation", Journal of Cultural Geography Vol. 13, No. 1 (1992): p. 15-28 and Noble, Allen G., Traditional Buildings: A Global Survey of Structural Forms and Cultural Functions (London: I.B. Tauris, 2007).

[9] Pearson David, In Search of Natural Architecture (New York: Abbeville Press, 1994).

[10] Larsen, Knut E. and Nils Marsein, Conservation of Historic Timber Structures: An Ecological Approach (Oxford: Butterworth-Heinemann, 2000).

[11] Log-building because in most of North America log structures were the first building efforts by Europeans. Log building and timber frame building are the two European building traditions that were implanted in eastern North America. Subsequent developments in homebuilding, balloon frame and western light frame construction, involved industrialized methods.

[12] Jordan Terry, "Presidential Address: Preadaptation and European colonization in rural North America", Annals of the Association of American Geographers Vol. 79, No. 4 (1989): p. 489-500.

[13] Kniffen, Fred B. and Henry Glassie, 1966. "Building in wood in the Eastern United States: a time-place perspective," Geographical Review Vol. 56, No. 1 (1966): p. 41-66.

[14] Zhao, Shanyang, "Metatheory, Metamethod, Meta-Data-Analysis: What, Why, and How?" Sociological Perspectives Vol. 34, No. 3 (1991): p. 377-390.

[15] Paterson, *et al*. (2001).

[16] Harvey, David, Explanation in Geography (New York: St. Martin's Press, 1969); Amedeo, Douglas and Reginald G. Golledge, An Introduction to Scientific Reasoning in Geography (New York: John Wiley & Sons, 1975).

[17] Keywords included 'log', 'log house', 'log cabin', 'log structure', and 'log building' combined with 'geography', 'architecture', 'vernacular architecture', and 'folk architecture'. Data bases included EBSCOhost Academic Search Premier, Google, Google Scholar, Informaworld Taylor & Francis Group Current Collection, JSTOR, ProQuest Dissertations and Theses, USDA Forest Service publications and Wiley Interscience. Individual publications included Annals of the Association of American Geographers, Bulletin of the Association for Preservation Technology, Canadian Geographer, Canadian Geographical Journal, The Geographical Journal, Geographical Review, Historical Geography, Journal of Cultural Geography, The Journal of Geography, Perspectives in Vernacular Architecture, Professional Geographer, Progress in Human Geography, Vernacular Architecture, and Winterthur Portfolio.

[18] For examinations of North American log-building attributes and typologies see: Kniffen, Fred B. and Henry Glassie, 1966. "Building in wood in the Eastern United States: a time-place perspective," Geographical Review Vol. 56, No. 1 (1966): p. 41-66; Jordan, Terry G., American Log buildings: An Old World Heritage (Chapel Hill: The University of North Carolina Press, 1985); and Wilson Mary, "Log cabin technology and typology", in Log Cabin Studies, USDA Forest Service, Intermountain Region (1984), p. 1-22.

[19] An approach that introduces the modifiable areal unit problem (MAUP) and the resulting possibility of arbitrary results. Fotheringham A, Wong D W S, 1991, "The

modifiable areal unit problem in multivariate statistical analysis" Environment and Planning A Vol. 23 No. 7 (1991): p. 1025 – 1044.

[20] It should be noted that, although log construction often has its own terminology for house type, house type is usually considered to be independent of construction technique.

[21] It should be noted that findings regarding the very earliest European occupation (i.e., 17th Century) appear to be dominated by correlations involving large geographic entities (i.e., multi-region, region, sub-region). This probably results from the fact that artifacts and data from this era are rare, with a very limited number of cases being broadly generalized.

[22] Jordan (1985)

[23] Kniffen (1965); Zelinsky, Wilbur, The Cultural Geography of the United States, (Englewood Cliffs, NJ: Prentice-Hall, 1973).

[24] Harris R C, "The simplification of Europe overseas", Annals of the Association of American Geographers Vol. 67 No.4 (1977): p. 469-483.

[25] Zelinsky (1973)

[26] Jordan, Terry G., Texas Log Buildings: A Folk Architecture. (Austin, TX: University of Texas Press, 1978); Kaups, Matti, "Finnish log houses in the Upper Middle West: 1890-1920," Journal of Cultural Geography Vol. 3, No. 2 (1983): p. 2-26.

[27] Notable for the absence of strong log-building traditions beyond the area of initial 17th Century North American introduction in the Delaware Valley.

[28] Jordan (1978)

CHAPTER 3

A GEOGRAPHY OF LOG CONVERSION

The walls are composed of horizontally stacked logs that are both the exterior facade and the interior walls. The logs are machined to fit together with tongue and grooves. The logs are mechanically fastened together and sealed with caulk between each log. The logs are notched to fit together at corners. Windows and door rough openings are cut out of the log wall.[1]

3.1 Introduction

Buildings and the built-environment are products of complex systems of interaction between culture and environment. Knowledge of the environment, building methods and tools, building materials, end-uses, and socially acceptable outcomes are all required to build. Building solutions are repeated, communicated across multiple generations, and become embedded in places or regions as communities of practice made up of clients, end-users, architects, engineers, contractors, tradesmen, bankers, insurers, building officials, planning officials, suppliers, manufacturers etc.

In recent years, the notion of regional systems of innovation and production has become commonplace within the literature.[2] Theories of geography of innovation, localized learning, and industrial agglomeration have all received significant attention. Evidence of contemporary, regional (local) systems of industrial production has also been discussed.[3] The suggested sources of regional effects are varied. Regions have been discussed as settings or environments for problem solving,[4] and it has been observed that spatial proximity facilitates the exchange of detailed technical information through learning-by-doing,[5] user-producer interaction,[6] and a "variety of other sources, including employees, suppliers, customers and public bodies."[7] To identify industrial regions is to identify communities of shared industrial culture based on shared knowledge of problems and solutions.[8] In this study the shared knowledge of problems and solutions is how to convert (i.e., process) and use logs in log home manufacturing.

There are more than a half-million log homes in the United States, and in recent years log building has been a growing segment of the custom home market. Prior to the financial crisis of 2007-2008, over 25,000 log houses were constructed per year.[9] About ninety percent were factory made,[10] but handcraft log builders appear to represent an important repository of log building knowledge.[11] Studies of forest products industries have suggested a pattern of resource-oriented location by special-product sawmill operations and regional preferences for residential building materials.[12] Anecdotal reports suggest that log home manufacturers are either handcraft log builders who have made the transition to higher volume industrial production or sawmill operators who decided to produce a specialized log building product. Despite a lifestyle oriented popular press (e.g., Log Homes Illustrated, Log Home Living, Custom Wood Homes) and a small technical press (e.g., Joiners' Quarterly) that cover log-building topics, there has been little research on the industry or how it is organized. However, not surprisingly, owners and managers of log home manufacturing firms seem very well informed with respect to industry issues, organization, economics, market conditions, and technology.

Historically, geographic methods of identifying regions were subjective, but contemporary researchers have striven to be more empirical, employing a variety of multivariate methods.[13]

3.2 Methods

The study employed a spatial-taxonomic (i.e., spatial statistics and cluster analysis) method to analyze the geography of log home manufacturing based on log conversion (i.e., processing) methods.

3.2.1 Data

Seventy-two (72) Eastern Woodlands log home manufacturers were identified. Applying Jordan's regionalization, these manufacturers were located in the Upland South, Upland North, Great Lakes Basin, and Lowland South. None were located in the Lowland North or in the cultural hearth area of eastern Pennsylvania and the Delaware Valley. Most were located in core regions, corresponding to combinations of Bailey's ecoregion provinces.[14] A few manufacturers were located in adjacent ecotone areas. See Figures 3.1 and 1.2.

Figure 3.1: Core Eastern Woodlands cultural regions

Upland South

- Central Appalachian broadleaf forest – coniferous forest
- Eastern broadleaf forest (continental)
- Ozark broadleaf forest
- Ouachita mixed forest

Lowland South

- Outer coastal plain mixed

Upland North

- Adirondack - New England mixed forest

Great Lakes Basin

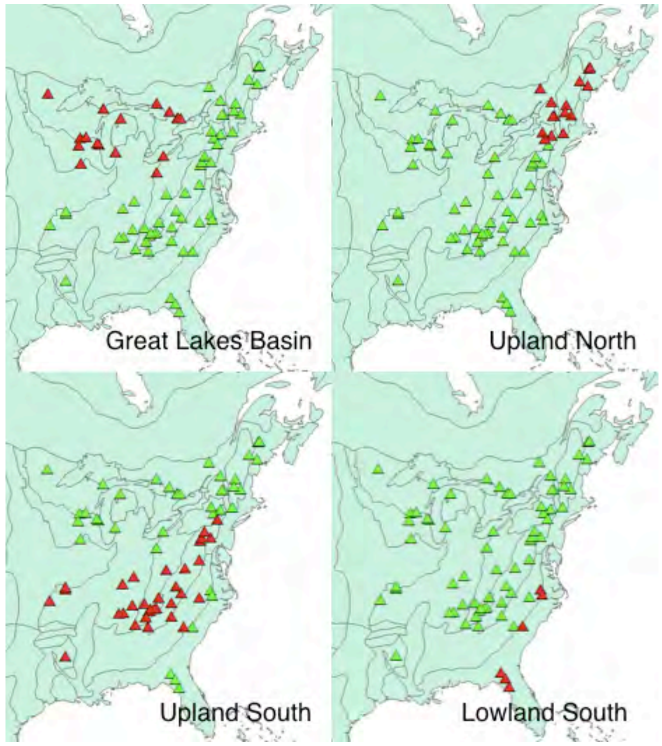
- Laurentian mixed forest

Manufacturers were identified through the popular press, the Log Homes Council membership directory, online guides, and Internet searches for manufacturer websites. These secondary sources[15] also provided data on individual manufacturers with respect to location (i.e., postal code),[16] cumulative production volume, log conversion attributes (i.e., tree species used, log treatment, log type, log profile, horizontal log surfaces, and corner notch type), and product certification (i.e., grade, LEED, Energy Star, and FSC). Complete data was achieved by telephoning the handful of manufacturers with missing data.

A little less than half of Eastern Woodlands manufacturers were located in the Upland South. These manufacturers accounted for about one-half of total cumulative log home production. The Upland North accounted for about 22% of manufacturers and about 35% of cumulative production. The rest was divided between the Great Lakes Basin and the Lowland South locations. See Figure 3.2.

Table 3.1: Manufacturers by Region

	Upland South	Lowland South	Great Lakes	Upland North	Total
manufacturers	33	6	17	16	72
% manufacturers	45.8%	8.3%	23.6%	22.2%	100%
% cumulative production	50.9%	5.6%	8.1%	35.4%	100%



▲ = within region ▲ = outside of region

Figure 3.2: Log home manufacturer locations by region

Tree species utilization data showed that twenty tree species are used to produce building logs. Eastern white pine (EWP) was used by 63 of the 72 manufacturers. Eastern white pine is abundant, relatively inexpensive, is available in longer lengths, machines well, and is attractive. Thirty-three used Western red cedar, which is decay resistant, is available in longer lengths and larger diameters, and is attractive. Twenty-three used Northern white cedar, which is durable and attractive. Fifteen used Douglas fir, which is strong, is easy to machine, is attractive, and is very dimensionally stable. Thirteen used cypress, which is the most decay resistant. It is also more expensive and requires specialized processing. Twelve used Red pine, is available in longer lengths, has moderately high shrinkage, but is dimensionally stable once dried. Eleven used

Lodgepole pine, which is straight grained with narrow growth rings and easy to work. Ten used Engelmann spruce, which is lightweight and has low shrinkage. Treating eastern tree species individually and grouping western tree species together in one category permitted condensation of the tree species data. Logs that were sourced from the Intermountain or Pacific Northwest would probably not influence eastern manufacturer location. Given the variety of tree species used and the fact that only Eastern white pine is used by a majority of manufacturers, it was concluded that tree species was a good candidate for differentiating between manufacturers. See Table 3.2.

Table 3.2: Tree species frequencies (>10%; n=72)

	Eastern white pine	Red pine	Lodgepole pine	Western red cedar	White cedar	Douglas fir	Englemann spruce
manufacturers	63	12	11	33	23	15	10
% manufacturers	88%	17%	15%	46%	32%	21%	14%

Dimensional stability requires that logs be dried to the average moisture content that they will encounter in service. As a result, climate is a consideration. Drying time required depends on tree species and the climate at manufacturer's location. Different moisture contents are recommended for damp, warm coastal areas compared to the rest of the study area. Log treatment data showed that most manufacturers employed both air-drying and kiln-drying techniques. See Table 3.3. A small number of manufacturers used standing dead trees, which have dried and are therefore naturally dimensionally stable. Only the use of preservative was a candidate for differentiating manufacturers. It was concluded that log treatment would not be a good candidate to spatially differentiate different types of manufacturers.

Table 3.3: Log treatment type frequency (n=72)

	air dry	kiln dry	preservative	standing dead trees
manufacturers	50	48	24	9
% manufacturers	69%	67%	33%	13%

Log type data showed that almost half of manufacturers produce three out of four log types. See Table 3.4. Nearly all manufacturers produced full logs. Hand crafted logs are full logs that have been hand crafted for aesthetic reasons. Half log is used as siding on conventional stick built homes, presenting the appearance of log homes. Log type would not be a likely candidate to spatially differentiate different types of manufacturers.

Table 3.4: Log type frequency (n=72)

	full log	hand crafted log	half log	laminated log
manufacturers	69	47	32	9
% manufacturers	96%	65%	44%	13%

Log profile data showed that almost half of manufacturers used four log profile types. See Table 3.5. The choice of log profile is based on tradition, aesthetics, and function. Individual log profiles are associated with specific log building traditions. Square and rectangular profiles probably first came into wide use in climates where siding was needed to improve the performance of the wall. Later, square and rectangular profiles were considered more appropriate for villages and towns. Round profiles were associated with rural locations. Swedish cope also marked a functional improvement on wall performance with respect to water and air infiltration. D-log is a recently developed aesthetic choice intended to give a rustic exterior appearance and a more functional flat interior wall. See Figure 3.3. Today, log profile is primarily an aesthetic choice. Sometimes it is based on customer preferences. In other cases the manufacturer has decided that certain log profiles are most consistent with their log home designs. Log profile type did not seem to be a likely candidate to spatially differentiate different types of manufacturers.

Table 3.5: Log profile type frequency (n=72)

	square log	D-log	round log	Swedish cope
manufacturers	68	59	52	27
% manufacturers	94%	82%	72%	38%

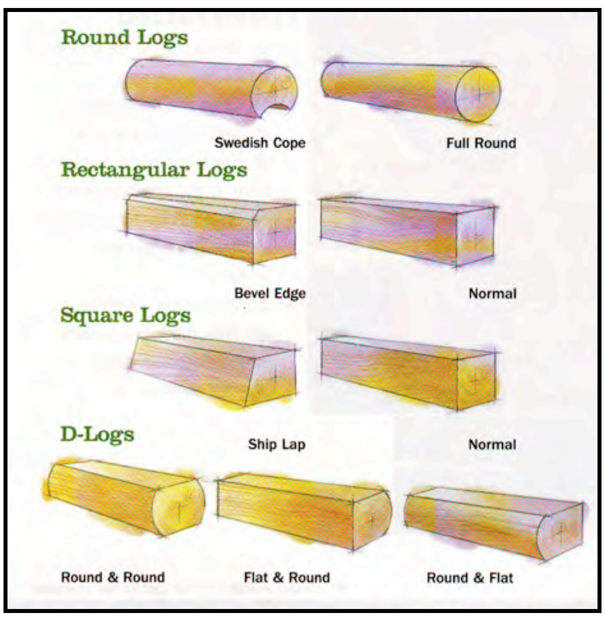


Figure 3.3: Examples of log profiles (Log Home Living)[17]

Horizontal log surface design (see Figure 3.4) has consequences for water, air, and dust infiltration. Double and triple tongue-and-groove give the best performance. Flat on flat and full round, the most historically accurate, are the poorest performing, although chinking compounds are much better performing today. Flat with spline groove is an older approach, developed before sawing T&G became feasible. Swedish cope, round logs also perform well. Horizontal log surface data exhibited a good spread. See Table 3.6. Multiple horizontal surface types were employed, but only two of the types (i.e., T&G) were employed by a majority of manufacturers. Horizontal log surface type seemed a good candidate to spatially differentiate different types of manufacturers.

Table 3.6: Horizontal surface type frequency (n=72)

	T&G (double+)	T&G (single)	Swedish cope	full round	flat on flat	flat w/ spline groove
manufacturers	46	37	24	23	16	15
% manufacturers	64%	51%	33%	32%	22%	21%

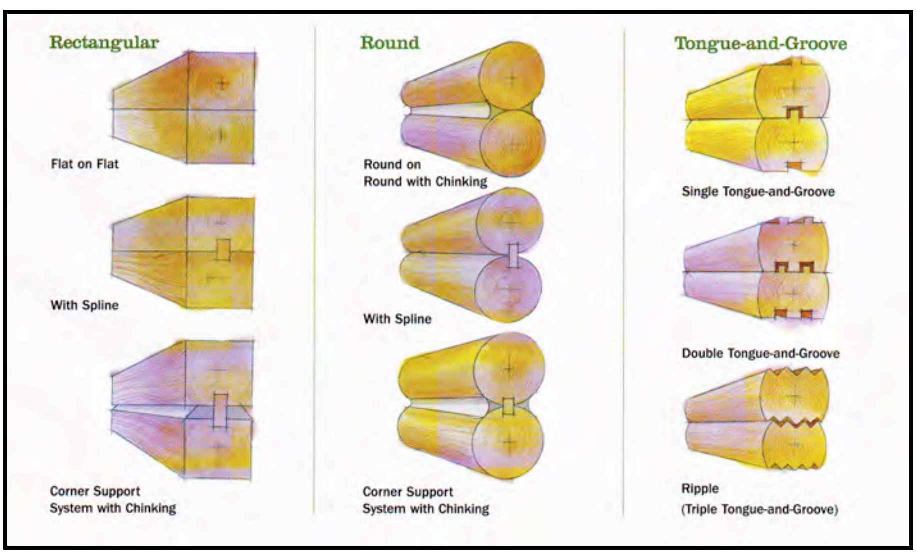
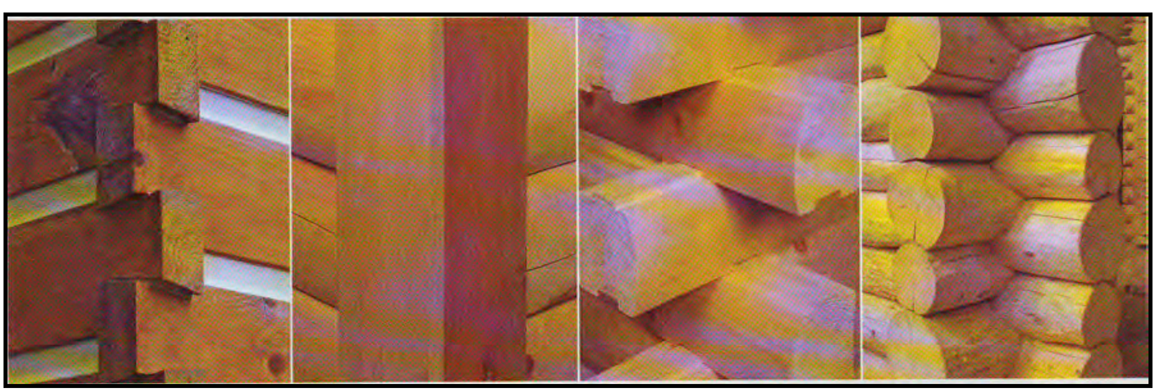


Figure 3.4: Examples of horizontal log surfaces (Log Home Living)[18]

A variety of corner notches are produced. See Figure 3.5. Corner notches must perform functionally in several ways. Most importantly, they must shed water to keep it out of the joint itself. They must also be tight and keep out the wind. They must perform structurally to resist the structural loads transferred to the corner notch through the log as well as be roll resistant and self-locking. Historically, corner notches were markers for the building traditions that produced the houses. Today, corner notches are more a matter of customer preference. Corner notch type data showed that about half of the manufacturers produced 2/3 of the corner notch types. See Table 3.7. The rest produced fewer types suggesting that corner notch type might spatially differentiate different types of manufacturers.

Table 3.7: Corner notch type frequency (n=72)

	saddle	butt & pass	dovetail	corner post butt & pass	interlock	notch & pass
manufacturers	50	49	51	36	32	16
% manufacturers	69%	68%	71%	50%	44%	22%



Dovetail Corner post Butt-and-pass Saddle

Figure 3.5: Examples of corner notches (<u>Log Home Living</u>)[19]

Initial assessment of the log conversion data suggested that three of the five log conversion attributes showed good potential for spatially differentiating different types of log home manufacturers. Pearson chi-square tests of independence (cross-tabulations) indicated that several log conversion attribute clusters were correlated. See Table 3.8. Tree species were correlated with log treatment type and horizontal surface, log type was correlated with log treatment, log profile, and horizontal surface, and horizontal surface was correlated with log profile and corner notch.

Table 3.8: Log conversion clusters: Pearson Chi Square Tests of Independence (n=72; test statistic < .100)

SIGNIFICANCE LEVEL

	tree species	log treatment	log type	log profile	horiz. surface	corner notch
tree species		0.013			0.095	
log treatment			0.019			
log type				0.079	0.034	
log profile					0.000	
horiz. surface						0.008
corner notch						

Pearson chi-square tests of independence also indicated that log profile and, perhaps log type were correlated with cultural region. Log profile was correlated with cumulative, log home production. See Appendix 1, Table 1.

3.2.2 Categorization

Geographic studies have often used pre-defined spatial variables, just as log home manufacturers have been described as being located in Eastern Woodlands regions in this study. However, such assignments introduce the modifiable areal unit problem (MAUP), and, therefore, the possibility of arbitrary results.[20] As a result, regions cannot be assumed. They must be proven. This is one reason why this study undertook the identification and mapping of Eastern Woodlands regions based on log conversion attributes. There was a problem, however. Unlike the individual examples of handcraft log homebuilding studied by cultural geographers where only one conversion method was used in each dwelling, individual log home manufacturers produce a variety of products using a variety of log conversion attributes.

Log conversion attribute data were converted to binomial format,[21] and hierarchical cluster analysis was performed to categorize like-type log manufacturers on the basis of their log conversion attributes.[22] Hierarchical cluster analyses were performed[23] using squared Euclidian distance and Ward's linkage.[24]

To some extent cluster analysis is subjective. The analyst must choose the level of the cluster dendrogram at which to draw clusters. When the clusters of like-type cases have too few members to be useful, a higher level in the dendrogram can be chosen to increase the number of cases in a cluster. However, the resulting clusters are less alike. The clusters that were chosen for use in the analysis are presented in the next section (i.e., § 3.2.3).

Chi-square tests of independence were performed on contingency tables formed from the clusters that resulted from the cluster analysis. Considerable correlation was found between clusters. See Appendix 1, Table 1.

3.2.3 Spatial analysis

The standard deviational ellipse (SDE), a spatial statistic, was chosen to test the conversion clusters for spatial correlation in a geographic information system (GIS) environment.[25] Sometimes referred to as a centrographic method,[26] the standard deviational ellipse is available in the ArcGIS spatial statistics toolbox. The SDE is a visualization tool that shows the spatial spread of a set of point locations. It captures the directional bias of a geographic phenomenon having a point distribution by presenting an elliptical polygon (centered on the mean center of the point locations) and two standard distances (long and short axes), representing the spread of the points in the chosen number of standard distances.[27] Standard distance is the spatial analogy to standard deviation in classical statistics and indicates how locations or points deviate from the mean center or spatial mean.[28] The long axis corresponds to the direction with the maximum spread of points. The short axis is perpendicular to the long axis. The two axes can be thought of as x and y axes in the Cartesian coordinate system.[29] Multiple ellipses can be mapped, permitting areas of intersection or union to be observed. Importantly, the area delimited by a SDE is inherent in the data and is not arbitrary,[30] and, unlike measurements of spatial autocorrelation (e.g., Geary's ratio and Moran's I index), the SDE is mapped directly in geographic space, and the points can be weighted.

In this study SDEs were used to areally differentiate clusters of like-type log conversion attributes by mapping their core distributions. SDEs in which at least two of the clusters were non-overlapping were interpreted as differentiating the clusters spatially. SDEs in which at least two of the clusters were at least half non-overlapping were interpreted as spatially correlated but not spatially differentiated. All other attribute clusters were interpreted as being neither spatially differentiated nor spatially correlated. Where one interpretation began and another ended was a subjective judgment. In this study the goal was to identify spatially differentiating log conversion attributes. Therefore, SDEs were interpreted considering that goal. Where at least two attribute clusters were completely non-overlapping, no judgment was required. These cases were spatially differentiated. However, attributes with no spatially non-overlapping clusters, but at least two nearly non-overlapping clusters, were considered to be functionally differentiating. Log conversion attributes were spatially differentiating or functionally differentiating would be the focus of further analysis. Non-differentiated, spatially correlated attributes were noted, but were not necessarily the focus of further analysis.

The location of each log home manufacturer was mapped in ArcGIS. Weighting each location point by the cumulative log home production of that manufacturer, the standard deviational ellipse (SDE) tool was used to map the log conversion attribute clusters.

3.3 Results

Tree species used is a spatially differentiating log conversion attribute. Like the eastern forests, tree species utilization clusters are differentiated along a general

North/South gradient. See Figure 3.6. Not surprisingly given the geographic nature of tree species ranges, all six clusters are spatially correlated. Clusters SP2 (Cypress), SP3 (Cypress, western species, and EWP), & SP5 (EWP, Red pine, White cedar, and western species) differentiate from each other, exhibiting no spatial overlap. Cluster SP1 (EWP, other) differentiates from Cluster SP2, and Cluster SP6 (EWP, white cedar, and western species) differentiates from Clusters SP2 and SP3. Cluster SP4 (EWP) is differentiated from Cluster SP2. Although there is considerable overlap in the middle, the species utilization clusters generally appear to correspond to cultural regions.

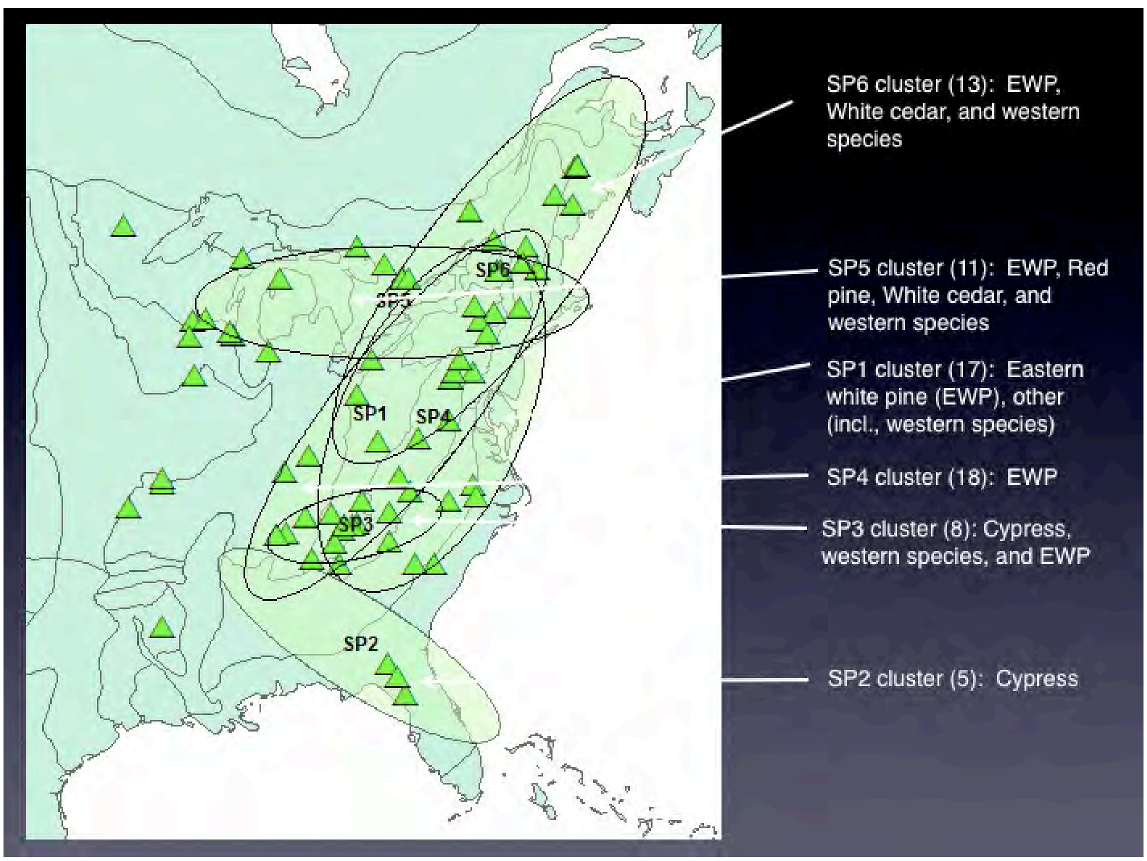


Figure 3.6: Tree species clusters (SDEs; n=72)

Log treatment is a spatially differentiating log conversion attribute. However, only Clusters TR1 (Standing dead trees and other) and TR4 (Air dry) are spatially differentiated (from each other). Five of the six log treatment clusters are somewhat spatially correlated. Except for TR2, the clusters are only partly overlapping with each other, and there is more overlap in the south than in the north. See Figure 3.7.

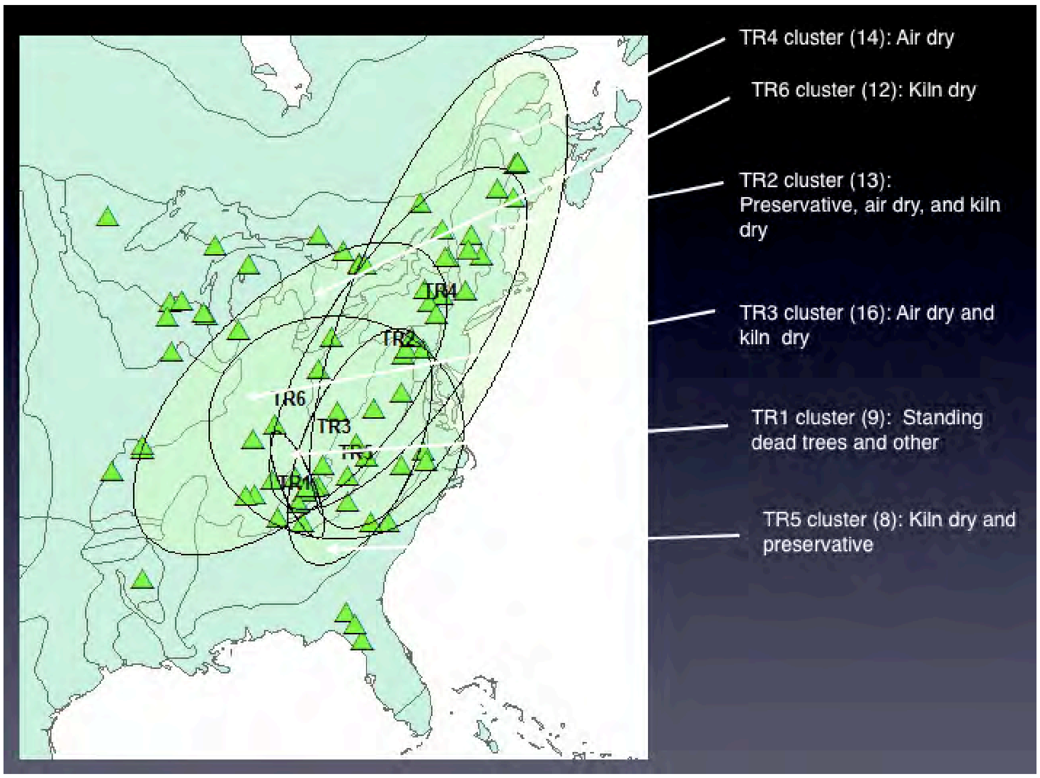


Figure 3.7: Log treatment clusters (SDEs; n=72)

Log type is not a spatially differentiating log conversion attribute. All of the log type clusters are spatially correlated to some extent, but they also all overlap each other. There is more overlap in the middle where all of the clusters overlap than in the north or south. See Figure 3.8.

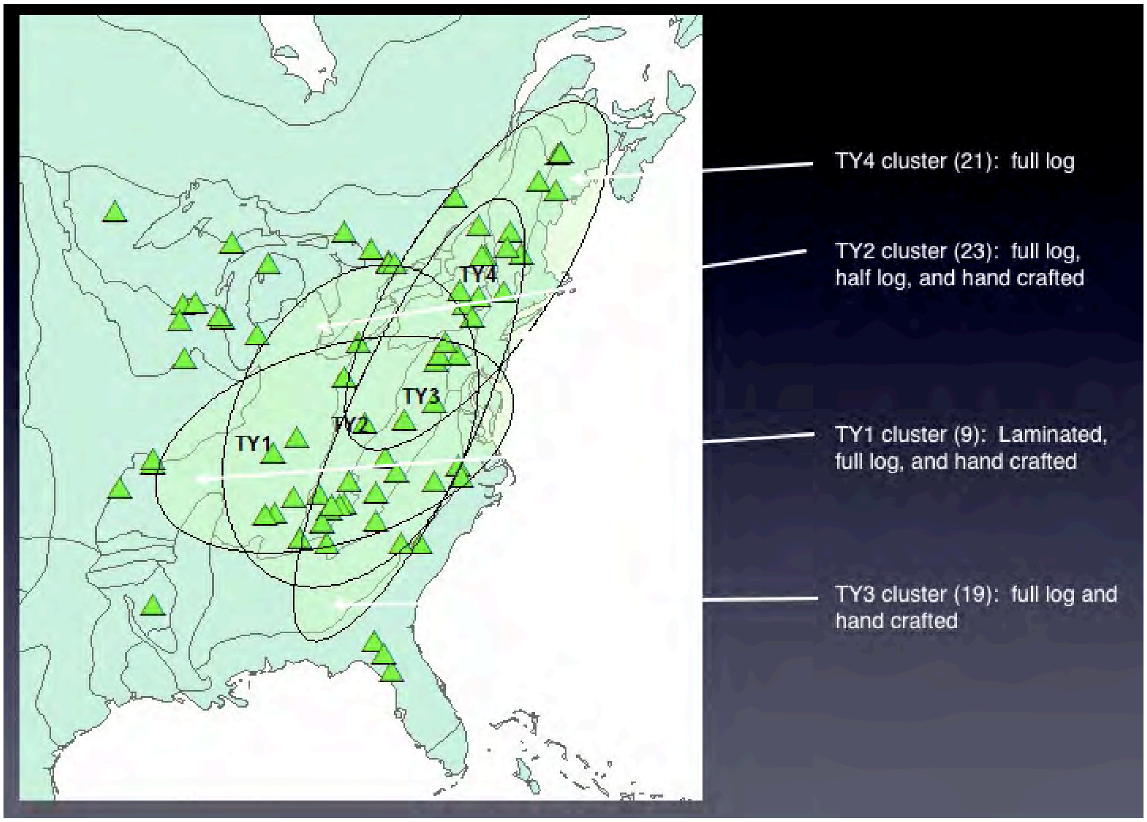


Figure 3.8: Log type clusters (SDEs; n=72)

Log profile is not a spatially differentiating log conversion attribute. All of the clusters overlap, although two of the four log profile type clusters (LP1 and LP3) exhibit spatial correlation. See Figure 3.9.

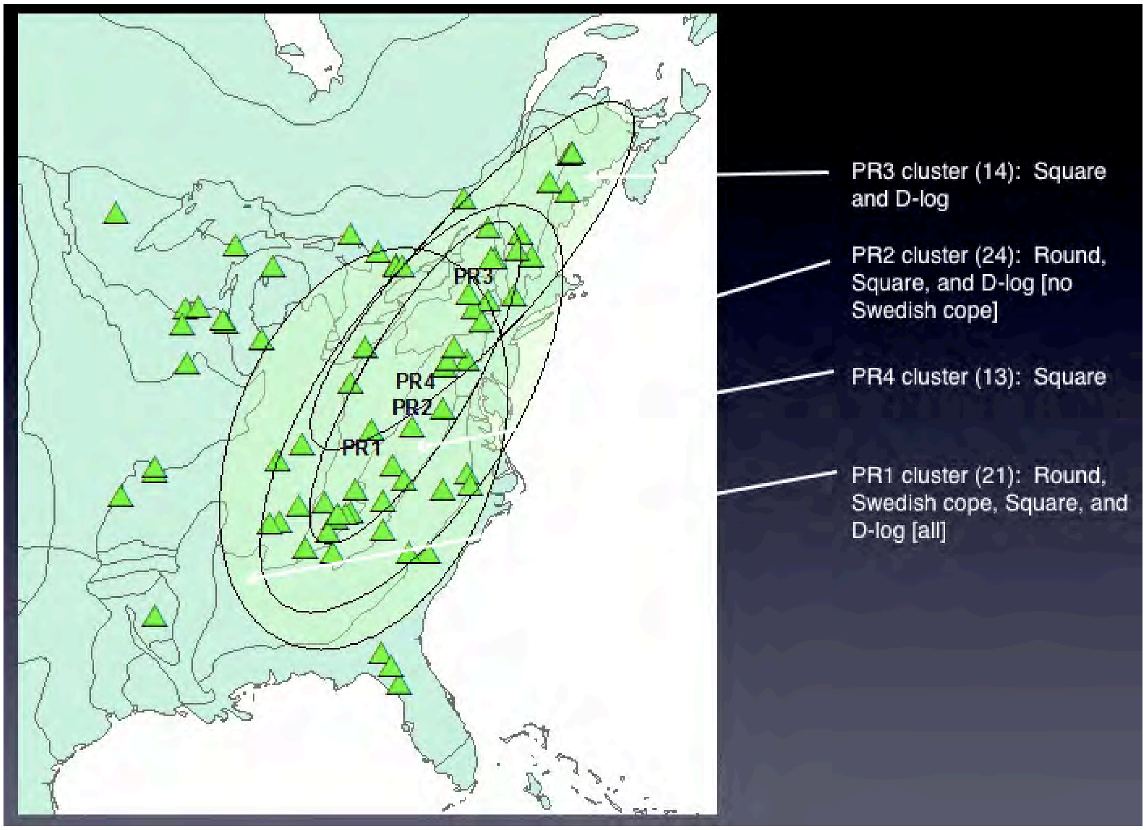


Figure 3.9: Log profile clusters (SDEs; n=72)

Horizontal log surface is a spatially differentiating log conversion attribute. Cluster HS4 (flat w/ spline groove) is differentiated from clusters HS2 (T&G single, T&G double+, Swedish cope) and HS3 (T&G single). Cluster HS5 (T&G double+) is mostly differentiated from clusters HS2 and HS3. All of the horizontal surface type clusters exhibit spatial correlation. See Figure 3.10.

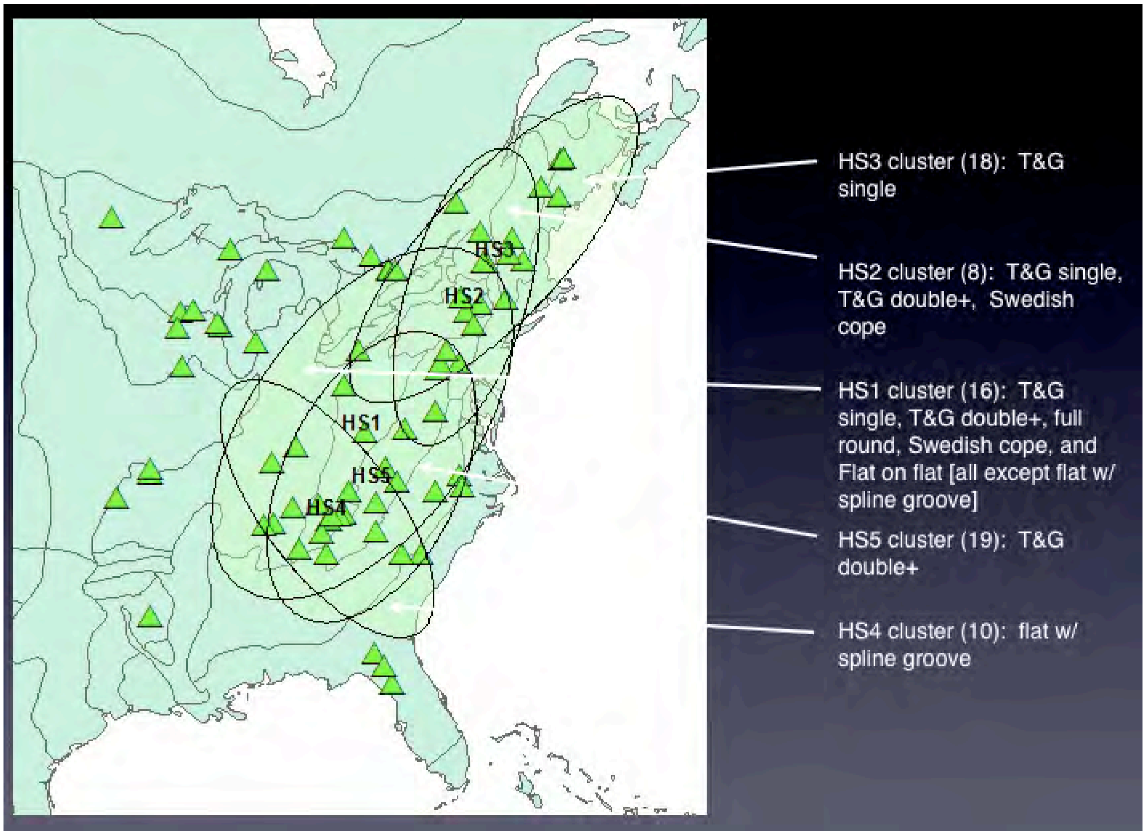


Figure 3.10: Horizontal surface clusters (SDEs; n=72)

Corner notch type is a spatially differentiating log conversion attribute. Cluster CN4 (butt&pass, and corner post B&P) only overlaps Cluster CN3 (saddle, dovetail, butt&pass, and corner post B&P) and Cluster CN2 (saddle, dovetail, and butt&pass) slightly. As a result, Cluster CN4 is substantially differentiated from Clusters CN3 and CN2. See Figure 3.11.

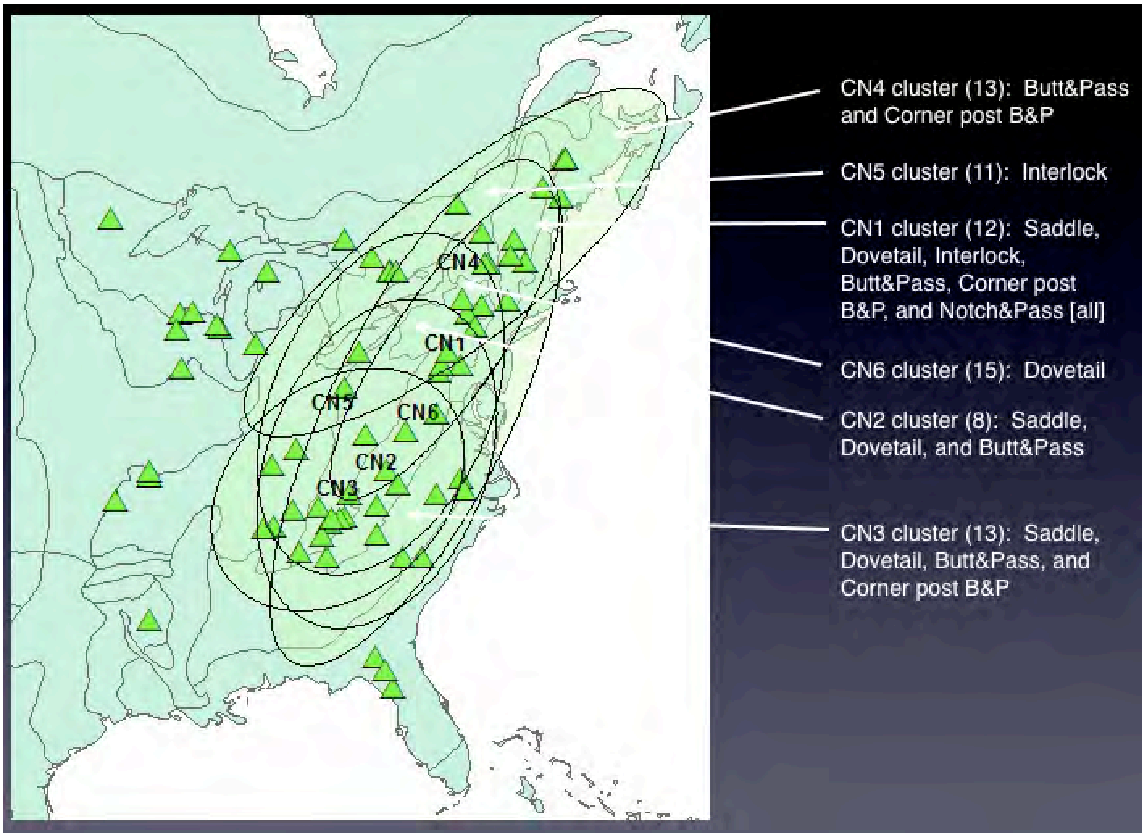


Figure 3.11: Corner notch type clusters (SDEs; n=72)

3.4 Conclusion

Four log conversion attributes exhibited spatial differentiation. As anticipated from the assessment of the frequencies of individual spatially differentiating log conversion attributes, the SDEs exhibit the most spatial differentiation with respect to tree species utilization and horizontal log surface. The following SDEs exhibited spatial differentiation:

- *Tree species utilization*: SP1 (EWP, other), SP2 (Cypress), SP3 (Cypress, western species, and EWP), SP4 (EWP), SP5 (EWP, Red pine, White cedar, and western species), SP6 (EWP, white cedar, and western species)

- *Log treatment type*: TR1 (Standing dead trees and other), TR4 (Air dry),
- *Log type*: none
- *Log profile type*: none
- *Horizontal log surface type*: HS2 (T&G single, T&G double+, Swedish cope), HS3 (T&G single), HS4 (flat w/ spline groove), HS5 (T&G double+)
- *Corner notch type*: Cluster CN3 (saddle, dovetail, butt&pass, and corner post butt&pass) and Cluster CN4 (butt&pass and corner post butt&pass)

Taken together, the six log conversion attributes differentiated along a north/south gradient like the eastern temperate forests themselves. This generally took the form of southern clusters, northern clusters, and multiple overlapping clusters in between. A few clusters were east/west oriented. Spatially differentiated log attribute clusters generally appeared to differentiate along culture region lines. There were several differentiations between the Southern clusters (i.e., Upland South and Lowland South) and the Northern clusters (i.e., Upland North and Great Lakes Basin). Only the tree species utilization clusters provided clear differentiation between the Upland and Lowland South. The tree species utilization clusters also partially differentiated between the Upland North and the Great Lakes Basin.

Individual spatial correlations (i.e., tree species utilization, log treatment, horizontal log surface, and corner notch type) were expected to provide a geographic guide to differences in building culture. All four attributes are strongly influenced by environmental factors, tree species by climate and ecology; log treatment by tree species used, climate, and building site conditions; horizontal log surface and corner notch type by tree species used and climate. Log type and log profile may identify differences in building culture. However, their geography alone does not appear to be a factor.

Table 3.9: Differentiating clusters and Eastern Woodlands regions

Region	Tree species	Log treatment	Horizontal log surface	Corner notch
Upland South	SP1, SP3	TR4, TR5	HS4, HS5	CN3
Lowland South	SP2	-	-	-
Upland North	SP6	TR4	HS2, HS3	CN4
Great Lakes Basin	SP5	-	-	CN4

The next and final step (see Chapter 4) was to investigate possible correlations between log conversion attributes and manufacturer perspectives.

Endnotes

[1] Having promised anonymity to survey (see Chapter 4) participants, the photo and quote are not identified.

[2] Gertler, Meric S., Manufacturing Culture: The Institutional Geography of Industrial Practice (New York: Oxford University Press, 2004).

[3] Malecki, E. J., "Creating and sustaining competitiveness: local knowledge and economic geography" in Bryson, John R., Peter W. Daniels, Nick Henry, and Jane Pollard (eds.), Knowledge, Space, Economy (London: Routledge, 2000); Hilpert, U. (ed.), Regionalisation of Globalised Innovation: Locations for Advanced Industrial Development and Disparities in Participation (London: Routledge, 2003); Preissl, B. and L. Solimene, The Dynamics of Clusters and Innovation: Beyond Systems and Networks (Heidelberg: Physica-Verlag, 2003).

[4] Hambrick, D. C, "An empirical typology of mature industrial-product environments," Academy of Management Journal Vol. 26, No. 2 (1983): p. 213-230; Lefebvre, H, The Production of Space (Oxford: Blackwell, 1991).

[5] Arrow, K. J., "The economic implications of learning by doing," Review of Economic Studies Vol. 29, No. 3 (1962): p. 155-173; Von Hippel, E. and M. Tyre, "The mechanics of learning by doing: problem discovery during process machine use," Technology and Culture Vol. 37, No. 2 1996): p. 312-329.

[6] Gertler (2004); Von Hippel, E. and M. Tyre, "The mechanics of learning by doing: problem discovery during process machine use," Technology and Culture Vol. 37, No. 2 (1996): p. 312-329; Storper, M. and R. Salais, Worlds of Production: The Action Frameworks of the Economy (Cambridge, MA: Harvard University Press, 1997).

[7] Cooke, P. and K. Morgan, The Associational Economy (Oxford: Oxford University Press, 1998).

[8] Gertler (2004).

[9] Log Homes Council (LHC). Website www.loghomes.org accessed 8/15/11.

[10] National Association of Home Builders (NAHB). 2006. Website www.nahb.org (accessed 8/15/11).

[11] International Log Builders' Association (ILBA). 2006. Website www.logassociation.org (accessed 8/15/11); Great Lakes Log Crafters Association (GLLCA). 2006. Website www.gllca.org (accessed 9/3/11).

[12] Polzin, P. E. 1994. "Spatial distribution of wood products industries," Journal of Forestry Vol. 92, No. 5 (1994): p. 38-42; Damery, David T. and Paul Fisette. 2001. "Decision making in the purchase of siding: a survey of architects contractors, and homeowners in the U.S. Northeast," Forest Products Journal Vol. 51, No. 7/8 (2001): p. 29-36.

[13] Hargrove, W. W. and F. M. Hoffman, "Using multivariate clustering to characterize ecoregion borders," Computing in Science and Engineering Vol. 1 (1999): p. 18–25.

[14] Bailey, Robert G., "Description of the Ecoregions of the United States," USDA, Forest Service (1995), http://www.fs.fed.us/land/ecosysmgmt/index.html, accessed 8/7/2013.

[15] The original plan was to obtain all primary data, and there was a significant effort to reach log home manufacturers, including presenting at a Log Homes Council annual meeting and meeting individually with Log Homes Council members and staff. However, participation was extremely low due to the length of the survey. As a result it was decided to use secondary data sources to the extent possible and only survey to obtain data on manufacturer perspectives.

[16] Postal codes were translated into geographic coordinates. See Appendix1, Figure1.

[17] "2009 Annual Buyer's Guide," Log Home Living (2008): p. 34.

[18] "2011 Annual Buyer's Guide," Log Home Living (2010): p. 46.

[19] "2009 Annual Buyer's Guide," Log Home Living (2008): p. 35.

[20] Fotheringham, A. S. and D. W. S. Wong, "The modifiable areal unit problem in multivariate statistical analysis," Environment and Planning Vol. 23 (1991): p. 1025-1044; Wong, D. W.S. and J. Lee, Statistical Analysis of Geographic Information with ArcView GIS® and ArcGIS® (Hoboken, NJ:John Wiley Sons, Inc., 2005).

[21] The species data were tested with the non-parametric, binomial test procedure. The test measures the likelihood that a random process could have produced the observed frequency of a binomial variable. This variable was found not to be random. Cox, D.R. and E.J. Snell, Analysis of Binary Data (London: Chapman and Hall, 1989).

[22] Anderberg, M. R., Cluster Analysis for Applications (New York: Academic Press, 1973); McGarigal, K., S. Cushman and S. Stafford, Multivariate Statistics for Wildlife and Ecology Research (New York: Springer, 2000).

[23] Using the IBM SPSS (version 20) statistical software package.

[24] Ward's linkage minimizes within group distance.

[25] Isaacs, E. H. and R. M. Srivastava, An Introduction to Applied Geostatistics (New York: Oxford University Press, 1989); Bailey, T. C. and A. C. Gatrell, Interactive Spatial Data Analysis (Harlow, England: Prentice Hall, 1995).

[26] Greene, R. "Poverty concentration measures and the urban underclass," Economic Geography Vol. 67, No. 3 (1991): p. 240-252.

[27] The ellipse is idealized. What distinguishes it from a circle, for example, is the ellipse's ability to capture directional bias.

[28] Wong and Lee (2005).

[29] Wong and Lee (2005); Mitchell, A., The ESRI® Guide to GIS Analysis, Volume 2: Spatial Measurements & Statistics (Redlands, CA: ESRI Press, 2005).

[30] Lefever, D. W., "Measuring geographic concentration by means of the standard deviational ellipse," The American Journal of Sociology Vol. 32, No. 1 (1926): p. 88-94.

CHAPTER 4

MANUFACTURERS, BUILDING ATTRIBUTES, REGIONS, AND CULTURE

> If tradition is seen not as a blind handing down of habits and objects but as part of a process in which what has come before has the ability to teach, then the concept takes on a more dynamic meaning.
>
> Howard Davis, The Culture of Building[1]

4.1 Introduction

The first chapter discussed why spatially correlated building attributes were of interest and proposed a test of whether or not spatially correlated attributes could identify contemporary log-building culture. The second chapter presented an analysis of spatially correlated log building attributes and observed that historically such attributes have included log conversion attributes such as tree species, log profile, and, especially, corner notch type. The third chapter described the data that was obtained on contemporary log home manufacturers' log conversion methods and how those data were manipulated and analyzed to identify spatially correlated log conversion attributes. The analysis identified tree species used, log treatment (i.e., drying, use of preservatives), horizontal log surfaces (i.e., tongue & groove, Swedish cope, flat on flat), and corner notch type (i.e., saddle, dovetail, butt & pass) as spatially correlated. With the spatially correlated log conversion attributes identified; the ability of those and other log conversion attributes to predict building culture could be tested. This chapter presents those tests and their results.

The tests consisted of determining the ability of the spatially correlated attributes to identify the cultural regions and operating perspectives of log home manufacturers. Cultural regions identified by Jordan, Kniffen, and Zelinsky were used in the test.[2] Data on manufacturers' operating perspectives on forest resources was obtained by survey.

4.2 Methods

4.2.1 Data

Data on manufacturer perspectives was obtained via telephone survey. See Appendix 2. Owners or general managers of log home manufacturers were asked to answer the following questions. All of the questions, except for question #4 (influences on log conversion methods), were assessed using five-point Likert scales.

1. PROCUREMENT TYPE: About how much of your timber procurement for building logs is acquired via each of the following methods? (i.e., raw roundwood picked up in the field, raw roundwood delivered to the mill, cants, sawn lumber, glulam logs)
2. PROCUREMENT DISTANCE: About how much of your company's timber supply for building logs is typically procured from the following distances? (i.e., locally, relatively nearby, w/in region, w/in eastern North America, w/in North America)
3. TIMBER PERFORMANCE: How influential to your to company's choice of tree species to process into building logs were the following timber characteristics? (i.e., narrow growth rings, straight grain orientation, absence of knots, uniform color, rot/insect

resistance, environmentally sustainable, accepts preservative/stain, machinability, availability in longer lengths, availability in larger diameters, appearance, mechanical strength, durability, dimensional stability, price, price stability, reliability of supply, local availability of supply, regional availability of supply)

4. INFLUENCES ON LOG CONVERSION METHODS: Which of the following are major influences (i.e., tree species, environment, regional/cultural traditions, customer preferences) on your company's choices of log conversion methods (i.e., log treatment, log type, log profile, horizontal surface type, corner notch type)?

5. COMPANY ENVIRONMENTAL PREFORMANCE: How representative of your company's attitudes toward environmental issues are each of the following statements? (i.e., adequate performance now, science and technology will provide ways to improve performance, company emphasizes use of renewable materials, company reducing use of virgin building materials, company emphasizes use of natural materials and traditional building methods)

6. MARKET BARRIERS TO OFFERING 'GREEN' CERTIFIED LOGS: Rate each of the following potential market barriers in terms of how much influence it has been on your company's decision on whether or not to offer 'green' certified building logs. (i.e., credibility of certification schemes, supply of certified wood, established contracts and supplier relationships, market demand, customer willingness to pay more, technical requirements e.g., chain of custody)

7. DISTANCE FROM CUSTOMERS: Approximately how much of your company's log home production is sold to customers at the following distances? (i.e., locally, relatively nearby, w/in region, w/in eastern North America, w/in North America)

An attempt was made to contact all of the log home manufacturers in eastern North America. Thirty-eight (38) of the seventy-two (72) manufacturers participated in the survey. Although the participation rate, 52.7%, was good, it was a small sample. The total number of cases was small, and there were not enough cases for some variables to be fully evaluated. These were Lowland South manufacturers, tree species clusters SP2 and SP3, corner notch type cluster CN2, horizontal log surface type cluster HS2, and log treatment cluster TR1. There appeared to be some non-response bias.[3] Manufacturers located in the Upland North cultural region were overrepresented. Manufacturers located in the Upland South and Lowland South were underrepresented.[4] See Appendix 1, Table 3. Because the analysis grouped survey results into clusters of like-type manufacturers, did not use frequencies to compare clusters, and only employed quantitative data on cumulative log home production volume, this non-response bias was not considered significant.

Survey results are presented in Appendix 1, Tables 4 – 10.

4.2.2 Categorization

Manufacturer data were converted to binomial format, and hierarchical cluster analysis was performed[5] to categorize like-type manufacturers, on the basis of the survey questions.[6] The cluster analyses used squared Euclidian distance and Ward's linkage.[7]

As was discussed in the previous chapter, to some extent cluster analysis is subjective. The analyst must choose the level of the cluster dendrogram at which to draw clusters. When the clusters of like-type cases have too few members to be useful, a higher level in the dendrogram can be chosen to increase the number of cases in a cluster. However, the result is that the members of the clusters become less alike.

Chi-square tests of independence were performed on contingency tables formed from the clusters. Only the log conversion influences and market barriers clusters were found to be to be correlated (significance level= 0.057).

- Log procurement type responses separated into clusters distinguished by acquisition of: 1) cants only; 2) all types except glulam, majority cants; 3) all types, no majority.

- Procurement distance responses separated into clusters distinguished by acquisition from: 1) local areas (i.e., w/in 100 mi.); 2) nearby areas (i.e., w/in 200 – 300 mi.) mostly w/ none local; 3) North America (i.e., Pacific Northwest); 4) nearby areas mostly w/ some at all other distances, including local.

- Timber performance characteristics responses separated into clusters distinguished by: 1) high importance scores on local and regional availability, moderate importance scores on the other characteristics; 2) high importance scores on all characteristics except for average scores on local and regional availability; and 3) low importance scores on all characteristics except for average scores on local and regional availability.

- Log conversion attribute (i.e., log treatment, log type, log profile, horizontal log surface, and corner notch type)[8] influence responses separated into clusters distinguished by: 1) strong influence by all four factors (i.e., tree species used, environmental performance, tradition, customer preferences); 2) moderately strong influence except for low influence on log profile and corner notch type (strong influence by customer preferences only); 3) generally low influence by all factors except for strong influence of tree species on log treatment, customer preferences on log type, and environmental performance on horizontal log surface; 4) low to moderate influence of all factors except for strong influence by customer preferences; 5) strong influence by tradition and customer preferences, otherwise low influence.

- Environmental perspective responses separated into clusters distinguished by: 1) high scores on adequacy of current policies, use of renewable materials, and emphasis on natural materials and low scores on recycling; 2) low scores on adequacy of current policies, high scores on use of renewable materials and emphasis on natural materials, and moderate scores on recycling; 3) moderate scores on all factors, 4) high scores on all factors except for moderate scores on recycling, and 5) high scores on all factors.

- Market barriers to 'green' certification responses separated into clusters distinguished by: 1) low scores for all factors except for moderate scores on lack of customer demand; 2) low to moderate scores on all factors except for high scores on established supplier relationships; 3) high scores on all factors; 4) low to moderate scores on all factors except for high scores on customer demand, customer willingness to pay more, and technical issues.

- Market distance responses separated into clusters distinguished by: 1) about one-half of production sold to customers within the region and about one-half sold at greater distances; 2) nearly all production sold to local and nearby customers; 3) nearly all production sold at various distances within the region; 4) some production sold at all distances.

4.2.3 Analysis

Multinomial logistic regression (also referred to as multiple logistic regression) was chosen to test the ability of the spatially correlated and non-correlated log conversion attributes to predict log home manufacturers': 1) regional location and 2) perspectives on forest resources.

Regression modeling is a method for quantifying the relationship between a dependent variable and one or more independent, predictive variables. Usually a set of candidate predictive variables is derived based on a proposed conceptual model of the relationship. These variables are then tested with an ordinary least squares or maximum likelihood based general linear model (GLM). Coefficients are estimated for the predictor variables, and the results are evaluated based on some specified statistical performance. Logistic regression is a GLM that models binary, categorical response variables using log-likelihood methods.

Multinomial logistic regression (MLR) is an extension of logistic regression, allowing discrete outcomes. Dependent variables are non-metric. Independent variables may be dichotomous, nominal (i.e., categorical), ordinal, or metric. Metric independent variables are referred to as covariates.

MLR models take the following form:[9]

$$g(\chi) = \beta_0 + \beta_1 \chi_{i1} + \beta_2 \chi_{i2} + \ldots + \beta_p \chi_{ip}$$

where $g(\chi)$ is the natural log of the odds ratio $y_i = 1$ versus $y_i = 0$
β_0 is the intercept constant
β_1 is the partial regression coefficient for χ_1, holding the remaining

predictors constant
β_2 is the partial regression coefficient for χ_2, holding the remaining predictors constant

MLR analysis, using SPSS (Version 20), was performed for multiple outcomes relating to log home manufacturer regional location and perspectives on timber resources with log conversion attributes and cumulative log home production as predictors. Combinations of log conversion attributes and cumulative production volume were tested for their ability to predict regional location. Combinations of log conversion attributes, cumulative production volume, and region were tested[10] for their ability to predict manufacturer relationships to their timber resources.

The potential problem of results biased by (multi)collinearity was addressed by avoiding the use of combinations of independent variables that exhibited correlation on Chi-square tests of independence. There was no way to avoid consequences arising from the small number of cases.[11] Nearly all of the initial MLR model runs generated warnings indicating "too many cells (i.e., dependent variable levels by subpopulations) with zero frequencies" and "singularities in the Hessian matrix" had been encountered. Many parameter estimates were out of acceptable ranges.[12] For example, standard error estimates were often greater than 2, indicating possible (multi)collinearity. As a consequence, the initial model results were invalid. Three procedures were undertaken to reduce the number of number of independent variables:

- Categorical variables were transformed into discrete variables,
- Variable categories with few occurrences were removed,

- Variable categories with few occurrences were combined with adjacent variables in cluster analysis dendrograms to create new variable categories with greater occurrences.

Finally, variables were introduced one at a time to evaluate model results in order to avoid introducing too many independent variables. Models with warnings of "too many cells (i.e., dependent variable levels by sub-populations) with zero frequencies" were flagged and discarded if competing models were available without such warnings.

Model variables, accuracies, and proportional by chance accuracy test results are presented below along with findings based on parameter estimates. The parameter estimates are presented in tables in Appendix 1.

4.3 Findings

Cultural regions: Multinomial logistical regression models were simplified by transforming categorical dependent and independent variables into discrete variables, by removing the single Lowland South case, and by combining and dropping independent variables. As a result, valid models were obtained for the three remaining regions and for a regionalization that combined the Upland North and Great Lakes Basin together as a single region. Although the MLR models generally produced results that were consistent with the results of the spatial analyses presented in Chapter 3, it should be noted that the cases in the MLR analyses were not weighted by production volume (i.e., homes_000).

Tree species clusters SP1a (EWP and other, including western)[13] and SP5a (SP5: EWP, Red pine, White cedar, western species; SP6: EWP, White cedar, western species)[14] predicted manufacturers' locations in the Upland South cultural region, with a

91.7% accuracy rate and 77.1% overall. The proportional by chance accuracy criteria was 68.7%. The criterion for classification accuracy was satisfied.[15] See Table 4.1. Combinations of a) SP1a, SP5a, TY1a (TY1 and TY2) and TY3a (TY3 and TY4) and b) SP1a, SP5a, PR1, PR2, and PR3a (PR3 and PR4) also yielded valid models.[16]

A MLR model's parameter estimates explain the working of the model with respect to the prediction of the dependent variable from the independent variables. This is the likelihood of the state of an independent variable resulting in a given state of the dependent variable. In this particular model, inspection of the parameter estimates indicated that belonging to tree species clusters SP1a or SP5a reduced the likelihood of a manufacturer being located in the Upland South.[17] However, SP5a had a much greater impact. These findings are consistent with the spatial analysis presented in Chapter 3 and result from the fact that the Upland South is outside of the species ranges of Red pine and White cedar. See Appendix 1, Table 13.

Table 4.1: MLR Upland South region prediction model

	dependent variable	independent variable 1	independent variable 2	independent variable 3	independent variable 4	covariate
1	Upland South Region	tree species (SP1a)	tree species (SP5a)	-	-	-

	likelihood ratio test chi-square (sig)	classification % correct	Upland South % correct	other region
1	0.001	77.1%	91.7%	69.6%

SP1a (SP1: EWP and other, including western), SP5a (SP5: EWP, Red pine, White cedar, western species; SP6: EWP, White cedar, western species), CN1a (CN1: all;

CN2: saddle, dovetail, butt&pass; CN3: saddle, dovetail, butt&pass, corner post butt&pass), and CN5a (CN5: interlock; and CN6: dovetail)[18] predicted manufacturers' locations in the Upland North cultural region, with a 46.2% accuracy rate but predicted 'not Upland North region' with 90.9% accuracy, resulting in 74.3% accuracy overall. This model was slightly outside of the chi-square significance threshold (≤.10). The proportional by chance accuracy criteria was 66.7%. The criterion for classification accuracy was satisfied. See Table 4.2. No other combinations of independent variables yielded valid results.

Inspection of parameter estimates indicated that belonging to tree species cluster SP1a or SP5a about equally increased the likelihood of a manufacturer being located in the Upland North.[19] Belonging to corner notch type cluster CN1a or CN5a reduced the likelihood of a manufacturer being located in the Upland North.[20] Belonging to CN5a had greater effect. The specialized corner notches of CN5a (i.e., interlock, dovetail) were more likely to be produced in the Upland South. See Appendix 1, Table 14.

Table 4.2: MLR Upland North region prediction model

	dependent variable	independent variable 1	independent variable 2	independent variable 3	independent variable 4	covariate
1	Upland North Region	tree species (SP1a)	tree species (SP5a)	corner notch (CN1a)	corner notch (CN5a)	–

	likelihood ratio test chi-square (sig)	classification % correct	Upland North % correct	other region
1	0.109	74.3%	46.2%	90.9%

Tree species clusters SP1 (EWP and other, including western), SP4 (EWP), and SP5 (EWP, Red pine, White cedar, western species) predicted manufacturers' locations in the Great Lakes Basin cultural region, with a 70.0% accuracy rate and predicted not Great Lakes Basin region with 88.0% accuracy, resulting in 82.9% accuracy overall. The proportional by chance accuracy criteria was 73.9%. The criterion for classification accuracy was satisfied. See Table 4.3. No other combinations of independent variables yielded valid results.

Inspection of parameter estimates indicated that belonging to tree species cluster SP1 (EWP and other, including western) or SP4 (EWP) equally reduced the likelihood of a manufacturer being located in the Great Lakes Basin. Belonging to SP5 (EWP, Red pine, White cedar, western species) increased the likelihood of a manufacturer being located in the Great Lakes Basin and had a greater effect. This finding reflects the fact that Red pine and white cedar species ranges substantially cover the Great Lakes Basin but not the Upland South. See Appendix 1, Table 15.

Table 4.3: MLR Great Lakes Basin region prediction model

	dependent variable	independent variable 1	independent variable 2	independent variable 3	independent variable 4	covariate
1	Great Lakes Basin	tree species (SP1)	tree species (SP4)	tree species (SP6)	-	-

	likelihood ratio test chi-square (sig)	classification % correct	Great Lakes Basin % correct	other region % correct
1	0.01	82.9%	70.0%	88.0%

The performance of the Upland North MLR model suggested a model that did not require differentiation between the Upland North and the Great Lakes Basin regions. When these regions were combined, resulting in a two-region scheme (i.e., North and Upland South), a valid model was obtained with SP1a (SP1: EWP and other, including western) and SP5a (SP5: EWP, Red pine, White cedar, western species; SP6: EWP, White cedar, western species) as independent variables. Tree species clusters predicted manufacturers' locations in the Upland South and North cultural regions, with 90.1% and 69.6% accuracy, respectively, resulting in 71.1% accuracy overall, something of a performance improvement over the Upland North model. The proportional by chance accuracy criteria was 68.7%. The criterion for classification accuracy was satisfied. See Table 4.4.

Inspection of the parameter estimates indicated that belonging to tree species clusters S1a or SP5a reduced the likelihood of a manufacturer being located in the Upland South compared to SP4. SP5a had much greater effect. This finding reflects the fact that Red pine and white cedar species ranges substantially cover the Upland North and Great Lakes Basin but not the Upland South. See Appendix 1, Table 16.

Table 4.4: MLR two region prediction model

	dependent variable	independent variable 1	independent variable 2	independent variable 3	independent variable 4	covariate
1	Upland South	tree species (SP1a)	tree species (SP5a)	-	-	-

	likelihood ratio test chi-square (sig)	classification % correct	Upland South % correct	North % correct
1	0.001	77.1%	91.7%	69.6%

That tree species is a predictor comes as no surprise. Tree species have geographic ranges, which vary with climate, latitude and solar aspect, and soils. How the independent variable, corner notch type type, functions geographically in this contemporary context is an open question. Historically, corner notches were associated with cultural (i.e., ethnic) groups' log-building techniques and, as a result, exhibited regional associations based on ethnic settlement patterns. These patterns may persist as regional traditions and be expressed as customer choice. Corner notch selections are also responses to climate in that they must perform adequately to shed water and minimize air infiltration.

Log procurement type: Log procurement type cluster membership (i.e., PT1-cants only, PT2-all types except glulam w/ majority cants, PT3-all types w/ no majority) was consolidated into PT1a (PT1 and PT2) and not PT1a (PT3), representing cants only/mostly cants and mostly other sources, respectively. Independent variables, SP1 (EWP and other, including western species), SP4 (EWP only), and SP5 (EWP, Red pine, White cedar, western species), and covariate, homes_000 (cumulative log home production), predicted manufacturers' procurement type cluster membership. PT1a (cants) membership was predicted with 91.7% accuracy, not PT1a (all types) membership with 54.5% accuracy, resulting in 80.0% accuracy overall. The proportional by chance accuracy criteria was 71.1%. The criterion for classification accuracy was satisfied. See Table 4.5. No other combinations of independent variables yielded valid results.

Inspection of the parameter estimates indicated that belonging to SP1 (EWP and other, including western species), SP4 (EWP only), or SP5 (EWP, Red pine, White cedar, western species) increased the likelihood of belonging to PT1a (mostly cants), while greater production volume reduced the likelihood of belonging to PT1a. Belonging to SP4 had greater impact than belonging to SP5 or SP1. Belonging to SP5 had greater impact than belonging to SP1. See Appendix 1, Table 17.

Table 4.5: MLR procurement type prediction model

	dependent variable	independent variable 1	independent variable 2	independent variable 3	independent variable 4	covariate
1	procurement type (PT1a)	tree species (SP1)	tree species (SP4)	tree species (SP5)	-	homes_000

	likelihood ratio test chi-square (sig)	classification % correct	PT1a (PT1, PT2) % correct	not PT1a (PT3) % correct
1	0.066	80.0%	91.7%	54.5%

The role of tree species is fairly straightforward. A manufacturer's location affects the availability of suitable timber. Out of region tree species are acquired as cants or milled timber. Higher volume manufacturers were less likely to acquire their timber supplies this way. They are more likely to process raw logs.

Log procurement distance: Procurement distance cluster membership (i.e., PD1- local, PD2- mostly nearby w/ none local; PD3- North America, PD4- mostly nearby w/ some at all other distances) was consolidated to PD1a (PD1 and PD2) and not PD1a (PD3 and PD4), representing local/nearby and all distances, respectively. SP1a (SP1: EWP and other, including western), SP5a (SP5: EWP, Red pine, White cedar, western species; SP6: EWP, White cedar, western species), PR1 (all), PR2 (all except Swedish cope), and PR3a (PR3: square, D-log; PR4: square) predicted manufacturers' membership in procurement distance cluster PD1a (mostly local and nearby) with 82.6% accuracy, not

PD1a (North America and mostly nearby with some at all distances) membership with 58.3% accuracy, resulting in 74.1% accuracy overall. The proportional by chance accuracy criteria was 68.7%. The criterion for accuracy was satisfied. See Table 4.6.

Inspection of the parameter estimates indicated that cluster PR3a was not a factor. Membership in SP1a and SP5a both reduced the likelihood of a manufacturer being a member of cluster PD1a (local and nearby). Membership in clusters PR1 (all profiles) and PR2 (all profiles except Swedish cope) increased the likelihood of being a member of cluster PD1a. See Appendix 1, Table 18.

Table 4.6: MLR procurement distance prediction model

	dependent variable	independent variable 1	independent variable 2	independent variable 3	independent variable 4	independent variable 5
1	procurement distance (PD1a)	tree species (SP1a)	tree species (SP5a)	log profile (PR1)	log profile (PR2)	log profile (PR3a)

	likelihood ratio test chi-square (sig)	classification % correct	PTD1a % correct	not PD1a % correct
1	0.078	74.3%	82.6%	58.3%

The role of tree species was that manufacturers using out of region species and a greater number of species were less likely to procure their timber locally or from nearby, paralleling the effects of cants vs. raw logs. Similarly, manufacturers specializing in the production of square log profiles were more likely to acquire their timber at a greater distance than those manufacturers that produced all or nearly all of the log profile types.

Timber performance: Timber performance cluster membership (i.e., TP1- high importance scores on local and regional availability and moderate scores on the other characteristics, TP2- high importance scores on all characteristics except for average scores on local and regional availability, and TP3- low importance scores on all characteristics except for average scores on local and regional availability) was consolidated into TP1a (TP1, TP2) and not TP1a (TP3), representing higher performance requirements and lower performance requirements, respectively. Cluster membership was predicted by SP1 (EWP and other, including western species), SP4 (EWP only), SP6 (EWP, White cedar, western species), TY2 (full log, half log, handcrafted log), TY3 (full log, handcrafted log), and TY4 (full log only) with 92.6% accuracy (TP1a) and 75.0% accuracy (not TP1a), resulting in 88.6% accuracy overall. The proportional by chance accuracy criteria was 80.9%. The criterion for accuracy was satisfied. See Table 4.7.

Inspection of parameter estimates indicated that membership in cluster SP1 (EWP and other, including western species) increased the odds of belonging to TP1 (higher performance), while belonging to clusters SP4 (EWP only) or SP6 (EWP, White cedar, western species) reduced the odds of belonging to TP1, with SP6 having a greater effect. Membership in clusters TY2 (full log, half log, handcrafted log), TY3 (full log, handcrafted log), or TY4 (full log only) all increased the likelihood of belonging to TP1, with TY4 having a greater effect than TY3 or TY2, which had about equal effect. See Appendix1, Table 19. Thus, manufacturers using EWP and other, including western species were more likely to require higher timber performance, while manufacturers using EWP only or EWP, White cedar, and western species were more likely to require lesser performance. Manufacturers producing full logs only were more likely to require higher timber performance than those producing full log, half log, and handcrafted log, which in turn were more likely to require higher timber performance that manufacturers producing full log and handcrafted log. It was unclear why this would be so. It was suggested that the presence of handcrafted log in both log type clusters, requiring lesser timber performance, might indicate the presence of a ‘rustic’ aesthetic, having less concern with timber imperfections.

Table 4.7: MLR timber performance prediction model

	dependent variable	independent variable 1	independent variable 2	independent variable 3	independent variable 4	independent variable 5	independent variable 6
1	timber performance (TP1a)	tree species (SP1)	tree species (SP4)	tree species (SP6)	log type (TY2)	log type (TY3)	log type (TY4)

	liklihood ratio test chi-square (sig)	classification % correct	TP1a % correct	not TP1a % correct
1	0.076	88.6%	92.6%	75.0%

Log conversion influences: Log conversion influences cluster membership (i.e., CI1-strong influence, CI2- moderately strong influence w/ exceptions, CI3-generally low influence w/ exceptions, CI4- low to moderate influence w/ exceptions, CI5-strong influence by tradition and customer preferences, otherwise low influence) was consolidated into CI1a (CI1, CI2) and not CI1a (CI3, CI4, CI5), corresponding to greatly influenced and less influenced, respectively.

CI1a (greatly influenced) cluster membership was predicted by SP1a (SP1 only: EWP and other, including western species) and SP5a (SP5: EWP, Red pine, White cedar, western species; SP6: EWP, White cedar, western species) with 46.2% accuracy and not CI1a (less influenced) cluster membership with 86.2% accuracy, resulting in 71.4% accuracy overall. The proportional by chance accuracy criteria was 66.7%. The criterion for classification accuracy was satisfied. See Table 4.8. Independent variables, SP1a, SP5a, CN1a, and CN5a and SP1a, SP5a, PR1, PR2 and PR3a also yielded valid results.

Inspection of parameter estimates indicated that belonging to tree species clusters SP1a (SP1 only: EWP and other, including western species) or SP5a (SP5: EWP, Red pine, White cedar, western species; SP6: EWP, White cedar, western species) increased the odds of belonging to cluster CI1a (more influences) rather that not cluster CI1a (less influences).[21] SP5a had a somewhat greater effect. Thus, manufacturers belonging to clusters SP1a and SP5a acquired a greater variety of tree species. This may result in more influences and a greater number of product choices. See Appendix 1, Table 20.

Table 4.8: MLR log conversion influences prediction model

	dependent variable	independent variable 1	independent variable 2	independent variable 3	independent variable 4	covariate
1	log conversion influences (CI1a)	tree species (SP1a)	tree species (SP5a)	-	-	-

	likelihood ratio test chi-square (sig)	classification % correct	CI1a % correct	not CI1a % correct
1	0.095	71.4%	46.2%	86.4%

Environmental perspective: Environmental perspective cluster membership (i.e., EP1- high scores on adequacy, renewable materials, and natural materials, low scores on recycling, EP2- low scores on adequacy, high scores on renewable materials and natural materials, and moderate scores on recycling, EP3- moderate scores on all factors, EP4- high scores except moderate scores on recycling, and EP5- high scores on all) was consolidated into EP1a (EP1, EP2, EP3) and not EP1a (EP4, EP5), representing moderate and high environmental performance, respectively. However, no statistically significant MLR models were found.[22] Either manufacturers' environmental perspectives were confounded by the level of generalization required by the limited number of cases available for MLR analysis or manufacturers' environmental perspectives have not yet been sufficiently aligned with their operations to correlate with those operations.

Market barriers: Market barrier cluster membership (MB1- low scores except lack of customer demand (moderate), MB2- low to moderate scores except for established supplier relationships (high), MB3- high scores, MB4- low to moderate scores except for high customer demand, customer willingness to pay more, and technical issues) was consolidated into MB1a (MB1, MB2) and not MB1a (MB3, MB4), representing less concern with market barriers and more concern with market barriers, respectively.

MB1a cluster membership was predicted by SP1a (SP1 only: EWP and other, including western species), SP5a (SP5: EWP, Red pine, White cedar, western species; SP6: EWP, White cedar, western species), CN1a (CN1: all; CN2: saddle, dovetail, butt&pass; CN3: saddle, dovetail, butt&pass, corner post butt&pass), and CN5a (CN5: interlock; and CN6: dovetail) with 78.6% accuracy and not MB1a cluster membership with 81.0% accuracy, resulting in 80.0% accuracy overall. The proportional by chance accuracy criteria was 65.0%. The criterion for classification accuracy was satisfied. See Table 4.9. In addition, other combinations of independent variables SP1a, SP5a, CN1a, CN5a, PR1, PR2, PR3a, TY1a, and TY3a also yielded valid results.

Inspection of parameter estimates indicated that belonging to tree species cluster SP1a reduced the odds of belonging to cluster MB1a (less concern with market barriers), belonging to species cluster SP5a increased the odds of belonging to cluster MB1a, and belonging to CN1a (most corner notch types) or CN5a (specialized corner notch types) both increased the odds of belonging to MB1a, although belonging to CN5a had greater effect. See Appendix 1, Table 21. Interpretation of these results was unclear. If, as suggested above, SP1a represents broader technical capabilities, it may explain the lack of concern with market barriers by manufacturers belonging to this cluster. However, the reverse may be true with respect to corner notch type. Here, more specialized producers of corner notch types had less concern with market barriers.

Table 4.9: MLR market barrier perception prediction model

	dependent variable	independent variable 1	independent variable 2	independent variable 3	independent variable 4	covariate
1	market barriers (MB1a)	tree species (SP1a)	tree species (SP5a)	corner notch (CN1a)	corner notch (CN5a)	-

	likelihood ratio test chi-square (sig)	classification % correct	MB1a % correct	not MB1a % correct
1	0.019	80.0%	78.6%	81.0%

Market distance: Market distance cluster membership (MD1- half of production sold within the region, half sold at greater distances, MD2- nearly all production sold locally and nearby, MD3- all production sold at various distances within the region, MD4- some production sold at all distances) was consolidated into MD1 and not MD1 (MD2, MD3, MD4), representing mostly regional and greater distances and mostly nearby, respectively. However no valid MLR models were found.

4.4 Conclusion

Survey data was obtained on log home manufacturers' perspectives on forest resources. Hierarchical cluster analysis of that data was used to group manufacturers into like-types clusters of log procurement type, log procurement distance, timber performance requirements, log conversion influences (i.e., tree species, environment, tradition, and customer preferences), environmental perspective, perspective on market barriers to offering 'green' certified (e.g., FSC), and market distance. Multinomial logistic regression was used to test non-correlated combinations log conversion (i.e., tree species, log treatment, log type, log profile, horizontal log surface, and corner notch type) and other (i.e., region, cumulative production) attributes for their ability to predict manufactures' cultural regions and memberships in forest resource perspective clusters. A combination of the independent variables, tree species, log type, log profile, and corner notch type predicted cultural region location with 71%-77% accuracy rates overall. Except for environmental perspective and market distance combinations of the same independent variables along with cumulative log home production predicted membership in forest resource perspective clusters with 71%-89% accuracy rates. The fact that environmental perspectives were not predicted was a surprise and suggests a question for future research. For whatever reason, it seems that manufacturers' environmental perspectives are not grounded in the nature of their timber resources, their timber processing choices, or their regional locations. That distance to markets could not be predicted was less of a surprise. No model relating market distance to log conversion attributes, production volume, or region had been suggested.

Spatially correlated and non-correlated log conversion attributes predicted log home manufacturers' perspectives on forest resources, thereby supporting the proposition that log conversion attributes identify contemporary building culture. Because spatially correlated log conversion attributes, tree species and corner notch type, predicted manufacturers' cultural region, it is also reasonable to conclude that manufacturers' forest resource orientations are deeply rooted regionally and, therefore, culturally.

Interestingly, tree species are primarily an environmental factor and corner notch type is primarily a cultural factor, illustrating the interactions between environment and culture that shape the production of human shelter. Tree species play a major role in the prediction of log home manufacturer perspectives on forest resources. Broad conclusions concerning how log home manufacturing is organized with respect to tree species and other log conversion methods are as follows:

- A manufacturer's location affects the availability of suitable timber, and out of region tree species were acquired as cants or milled lumber. Higher volume manufacturers were more likely to acquire their timber supplies locally (i.e., within about 100 miles) or nearby (i.e., within about 200-300 miles) as raw logs.
- Manufacturers that acquired their timber supplies at greater distances were more likely to produce a greater number of log profiles while manufacturers that acquired their timber supplies locally and nearby were more likely to produce a more limited set of log profiles, associated with their regional location.
- Manufacturers using EWP and other, including western species (SP1) were more likely to require higher timber performance, presumably acquiring more

of their timber supplies from greater distances and in the form of cants or milled lumber.

- Manufacturers using EWP only (SP4) or EWP, White cedar, and western species (SP6) were more likely to require lesser performance, presumably because their timber supplies were more likely to be acquired locally and nearby and in the form of raw logs.

- Manufacturers producing full logs only were more likely to require higher timber performance than those producing full logs, half logs, and handcrafted logs, which in turn were more likely to require higher timber performance than manufacturers producing full logs and handcrafted logs. Perhaps, this is because the production of handcrafted logs indicates more of a 'rustic' orientation and, as a result, less concern with imperfections in timber supplies.

- Manufacturers acquiring a greater number of tree species also indicated more external influences on their log conversion methods.

- Manufacturers' environmental perspectives could not be correlated with log conversion attributes or region, suggesting that environmental perspectives have more to do with the attitudes of management than with firms' production factors or operating environments.

- Manufacturers acquiring a greater diversity of tree species as well as those producing more specialized, regional corner notch types were less concerned with market barriers to offering 'green' certified logs, suggesting the existence of two industry segments, the former experienced enough to have overcome these market barriers, the latter so traditional as to not have considered offering 'green' certified logs.

- Manufacturers' distances to their customers could not be correlated with log conversion attributes or region, suggesting that the extent of a manufacturers' market has little to do with production factors or operating environment.

Given these findings, it is reasonable to conclude that factors that find physical expression in the building product are essential to identifying the influences that determine the character of that product. This is the 'new materiality'. Eastern Woodlands log home manufacturing is very much shaped by manufacturers' relationships to their timber supplies, and these relationships find their way into production processes and products. Most importantly, there are separate sets of consequences associated with a manufacturer's distance from its timber supplies. Higher volume manufacturers were more likely to acquire their timber supplies locally or nearby suggesting that higher volume log home manufacturers can invest in economies of scale in timber acquisition and processing that are unavailable to lower volume log home manufacturers. However, lower volume log home manufacturers can capture economies of scale by acquiring their timber supplies (i.e., as cants or milled lumber) from high volume sawmills. Manufacturers acquiring their timber supplies locally or nearby were more likely to produce log profiles associated with their regional traditions.

The regional scheme implicitly developed by Jordan, Kniffen, and Zelinsky (i.e., Upland South, Lowland South, Upland North, and Great Lakes Basin) was validated. The fact that these regions were identified on the basis of building attributes dating from the 18th and 19th Centuries is well worth considering. Regions are powerful, long lasting influences on culture and society.

Endnotes

[1] Davis, Howard, The Culture of Building (New York: Oxford University Press, 1999): p. 17.

[2] Kniffen, Fred B, "Folk housing: key to diffusion," Annals of the Association of American Geographers Vol. 55, No. 4 (1965): p. 549-577; Kniffen, Fred B. and Henry

Glassie, 1966. "Building in wood in the Eastern United States: a time-place perspective," Geographical Review Vol. 56, No. 1 (1966): p. 41-66; Zelinsky, Wilbur, The Cultural Geography of the United States (Englewood Cliffs, NJ: Prentice-Hall, 1973); Jordan, Terry G., Texas Log Buildings: A Folk Architecture (Austin, TX: University of Texas Press, 1978); Jordan, Terry G., American Log buildings: An Old World Heritage (Chapel Hill: The University of North Carolina Press, 1985).

[3] Dillman, Don A., Mail and Internet Surveys: The Tailored Design Method (New York: John Wiley and Sons, 2000); Armstrong, J. Scott and Terry S. Overton, "Estimating nonresponse bias in mail surveys," Journal of Marketing Research Vol. 14, No. 3 (1977).

[4] The surveyor identified himself as being from the Building and Construction Technology Program at the University of Massachusetts, Amherst.

[5] Using the IBM SPSS (version 20) statistical software package.

[6] Anderberg, M. R., Cluster Analysis for Applications (New York: Academic Press, 1973); McGarigal, K., S. Cushman and S. Stafford, Multivariate Statistics for Wildlife and Ecology Research (New York: Springer, 2000).

[7] Ward's linkage minimizes within group distance. Other distance and linkage parameters were tested, and cluster membership was found to be stable.

[8] Tree species used was not included because it was an influencing factor.

[9] Quinn, Gerry P. and Michael J. Keough, Experimental Design and Data Analysis for Biologists (Cambridge: Cambridge University Press, 2002). Tabachnick, Barbara G., Using Multivariate Statistics (Needham Heights, MA: Allyn & Bacon, 2001).

[10] Using 0.10 level of significance.

[11] The suggested minimum number of cases per independent variable is 10. Hosmer, David W., and Stanley Lemeshow, Applied logistic regression (New York: Wiley, 2000). Bull, S.B., Greenwood, C.M.T., Hauck, W.W., "Jackknife bias reduction for polychotomous logistic regression. Statistics in Medicine Vol. 16 (1997): 545–560 found that studies indicate that, when the ratio of the number of observations to the number of parameters is less than 10, the MLEs are likely to be inflated in magnitude.

[12] For interpretation of the estimated parameters see: Tarling, Roger, Statistical Modelling for Social Researchers (Abington, Oxon: Routledge, 2009). See Chapter 6, Multinomial logistic regression for multinomial response variables, p. 77-87 for SPSS examples.

[13] SP2 and SP3 cases were removed from the analysis due to too few cases.

[14] SP4 (EWP only) did not need to be explicitly specified in the model. SP1a = 0 and SP5a = 0 was the equivalent of SP4 = 1.

[15] The criteria was 1.25 times the proportional accuracy rate (PAR). The PAR is computed by squaring and summing the proportion of each 'case processing summary' group in SPSS.

[16] No problems with the variables themselves (i.e., warnings indicating "too many cells with zero frequencies" or "singularities in the Hessian matrix" or with significance of the chi-square likelihood ratio test of the model fit.

[17] Implicitly compared to belonging to SP4 (EWP; i.e., Sp1a=0; SP5a=0).

[18] CN4 did not need to be explicitly specified in the model. CN1a = 0 and CN5a = 0 was the equivalent of CN4 = 1.

[19] Implicitly compared to belonging to SP4 (EWP).

[20] Implicitly compared to CN4 (butt&pass, corner post).

[21] Implicitly compared to SP4 (EWP only).

[22] When five individual environmental perspective models were constructed with five dichotomous dependent variables (i.e., EP1, EP2, EP3, EP4, and EP5), three statistically significant models were found. However, all of these models were very accurate (e.g., 100%) predicting not cluster membership and very inaccurate (e.g., 0%) predicting cluster membership. These models used combinations of tree species, cultural region, and cumulative production.

CHAPTER 5

MATERIALITY: HYBRIDITY OF NATURE AND CULTURE

… these hybrid, part social/part natural—yet deeply historical and thus produced—objects/subjects are intermediaries that embody and express nature *and* society and weave networks of infinite liminal spaces. - Erik Swyngedouw[1]

Studies of material culture have long been part of 'traditional' readings of cultural geography… (*including*) Kniffen's careful charting of the transformation of natural objects into regionally distinctive groupings of cultural artifacts and vernacular building styles… Far from globalization resulting in a homogeneous world with no social or cultural differentiation, there is mounting evidence of the continued significance of local contexts of consumption as well as increasingly complex geographies of production that defy description in terms of a unilinear process of globalization. - Peter Jackson[2]

5.1 Introduction

Relying on material-geographic methods, the dissertation has presented an analysis of log home manufacturing in North America's Eastern Woodlands grounded in the materiality of log home production methods. Chapter 1 discussed the theoretical context within which material-geographic methods were applied, and presented an overview of the Eastern Woodlands, the geographic context of the study. Chapter 2 presented an evaluation of previous applications of material-geographic methods to Eastern Woodlands log building. Conducted in a diverse set of social science contexts, these studies found that log conversion attributes, such as tree species used, log profile, and corner notch type were spatially correlated. Chapter 3 presented a geographic analysis of contemporary log conversion attributes. It showed that tree species used, log treatment type, horizontal log surface type and corner notch type were sufficiently spatially correlated to differentiate log home manufacturers. Chapter 4 presented multinomial logistic regression (MLR) models testing spatially correlated and non-spatially correlated log conversion attributes for their ability to predict manufacturers' regions and perspectives on forest resources. Combinations of tree species used and corner notch type were shown to predict cultural region. Combinations of tree species used, log type, log profile, corner notch type, and log home production volume were shown to predict manufacturer perspectives on their forest resources.

In what may be the first quantitative application of 'new materiality' concepts, the thesis of the dissertation was proved. Spatially correlated log conversion attributes do, in fact, reveal contemporary log home manufacturers' regions, their perspectives on forest resources, and, by extension, their building cultures. Equally important, this material-geographic examination of log home manufacturing revealed essential location-based relationships between manufacturers and their material supplies, production processes, and products.

What follows discusses implications of these findings, suggestions for future research, and the need for local and regional building information databases, supply chains, and building standards.

5.2 Implications

The study has demonstrated the efficacy of material-geographic methods of investigation. It identified a number of important contemporary relationships between log home manufacturing, log home building methods, and manufacturers' perspectives on their timber resources. Although current social theory, especially actor-network theory (ANT), the 'new materiality', and the ability to conduct computation-intensive statistical and spatial analysis make the methods of mid-20th century American geography appear archaic, scholars like Fred Kniffen, Henry Glassie, Wilbur Zelinsky, and Terry Jordan provided an conceptual platform, which made this work possible. They pioneered the application of material-geographic methods in American cultural geography and found evidence of cultural regions that this study found to be relevant today.

Although log homebuilders have the option of acquiring their logs at great distances, and some do, it appears that the spatial evolution of log homebuilding methods from 19th Century handcraft methods to early 21st Century industrial production has not been great. Manufactured log home continue to reveal their regional origins. What came before continues to leave its mark. The effects of 'first effective settlement' continue to exercise their hold today. Considering Gremillion's finding that sub-regional cultural boundaries in the Eastern Woodlands have remained fairly constant from the immediate pre-Columbian period to the present,[3] this should not be surprising. It is fair to say that Europeans migrated into cultural regions that had already been established by Native

Americans. These regions exist today for the log home manufacturing and probably for other natural resource-based production.

Perspectives provided by actor-network theory and the 'new materiality' made these findings understandable. Answers to questions of what has changed and how are probably impossible to innumerate. Did the trees change? Yes. Did the climate change? It is changing. Did the insects change? Their ranges are changing. Have the saws changed? Yes. Have chinking materials changed? Yes. Has what people consider a proper house changed? No question. All of these things have changed, but whatever has changed has had to continue to work within the system made up of the other natural, technological, and social elements that make up a log house. Whatever has changed and whatever has remained the same, the fact that the regions have been stable, has important implications for understanding change processes. New elements must successfully integrate into a system. Old elements must continue to integrate by keeping up with the changes in a system.

5.3 Future research

Areas for future research include geographic analysis of log home manufacturing in the Intermountain West and the Pacific Northwest, both of which have living Native American log-building cultures that have existed for hundreds of years. Similarly, there are log home manufacturers in northern Europe to be studied. The meta-study described in Chapter 2 identified house type as extensively spatially correlated. As with log conversion attributes, a conceptual basis exists for geographic study of contemporary Eastern Woodlands house types. Indeed, material-geographic studies of any contemporary building culture could serve to support sustainable building practice by identifying the processes and relationships operating in that culture.

5.4 Regional building standards development

The challenges of environmental conservation and renewal cannot be answered by universal solutions. However, they can be answered locally and regionally, one place at a time, by addressing the unique natural, cultural, and historical features of each of these places. This requires development of local and regional building information databases, supply chains, and building standards to reflect the regional character of human-environment interaction. Policy too can be place-based if the regional building culture is sufficiently understood.

Advocates of green building practices have, typically, favored an anti-modern environmentalism, emphasizing literal application of traditional (i.e., preindustrial) building methods, or a modern environmentalism emphasizing technical means, universal methods,[4] and harmonized standards for sustainability.[5] However, the anti-modern approach fails to address contemporary life styles, systems of production, and cultural meanings. The modern approach, primarily as a result of the commoditization of building materials, fails to address impacts relationships with and impacts on local and regional ecosystems. To date, little attention has been paid to bioregional sourcing and its eco-cultural implications. "Most people just talk about 'local sourcing' without going much further."[6] Without appropriately local or regional building standards and codes and without well-developed local and regional supply chains, bioregionally based materials and product information databases, or well-tested models of eco-cultural synthesis,[7] many of the requirements necessary to build sustainably are simply lacking.

Despite the emergence of environmental geography with its focus on human-environment interaction and despite the development of multiple environmental discourses[8] and definitions of sustainable architecture,[9] the regional thread of North American cultural geography pioneered by Kniffen and developed by Zelinsky, Newton, and Jordan and material-geographic methods have not been taken up for application to issues of industrial organization, sustainability or ecological modernization. Identification of processes and relationships operating in regional building cultures should be used to guide sustainability efforts.

Endnotes

[1] Swyngedouw, Erik(1999) “Modernity and Hybridity: Nature, Regeneracionismo, and the Production of the Spanish Waterscape, 1890-1930”, Annals of the Association of American Geographers Vol. 89, No. 3, (1999): p. 445.

[2] Jackson, Peter, “Rematerializing social and cultural geography”, Social & Cultural Geography Vol. 1, No. 1 (2000): p. 9.

[3] Gremillion, Kristen J., “Eastern Woodlands overview”, in Minnis, Paul E. (ed.), People and Plants in Ancient Eastern North America, (Washington, DC: Smithsonian Books, 2003), p. 17-49.

[4] Hagan, Susannah, “The good, the bad and the juggled: the new ethics of building materials,” The Journal of Architecture Vol. 3 (1998): p. 107-115.

[5] Stevenson, Fionn and Jonathan Ball, “Sustainability and materiality: the bioregional and cultural challenges to evaluation,” Local Environment Vol. 3, No. 1 (1998): p. 191-209.

[6] Stevenson, Fionn, 2010. Personal communication.

[7] Kohler, Niklaus, “Cultural issues for a sustainable built environment,” In Cole, Raymond J. and Richard Lorch (eds.), Buildings, Culture and Environment: Informing Local and Global Practices (Oxford: Blackwell Publishing, 2003), p. 83-108.

[8] Dryzek, John S, The Politics of the Earth: Environmental Discourses (Oxford: Oxford University Press, 2005); Hajer, Maarten A., The Politics of Environmental Discourse: Ecological Modernization and the Policy Process (Oxford: Oxford University Press, 1995).

[9] Canizaro, Vincent and Kim Tanzer, “Introduction (Environmental architectures and sustainability: a taxonomy of tactics,” Journal of Architectural Education Vol. 60, No. 4 (2007): p. 4-14; Guy, Simon and Steven A. Moore, “Sustainable architecture and the pluralist imagination,” Journal of Architectural Education Vol. 60, No. 4 (2007): p. 15-23; Guy, Simon and Graham Farmer, “Reinterpreting sustainable architecture: the place of technology,” Journal of Architectural Education Vol. 54, No. 3 (2001) p. 140-148.

APPENDIX 1

FIGURES AND TABLES

1. File names: gpsvisualizer.xls; log long-lat_b.xls; 1344426680-06047.txt; postcodes1.txt
   Source: http://www.gpsvisualizer.com
   Source documentation: uses own database (seemingly derived from Yahoo and Google services)

2. File names: zipgps.db; zipcodeDB.xls
   Source: http://www.mrwadlo.com
   Source documentation: uses own database (no sources cited)

3. File names: zipcode.csv
   Source: http://www.boutell.com/zipcodes/
   Source documentation: see erle_doc.txt

4. File names: US.txt; CA.txt
   Source: http://www.geonames.org
   Source documentation: see About GeoNames.pdf
   Other: WGS84; USA source is U.S. Geological Survey Geographic Names Information System (http://geonames.usgs.gov/index.html); CA source is GeoBase (www.geobase.ca), overseen by overseen by the Canadian Council on Geomatics (CCOG);

Figure 1: Sources of geographic coordinates

Table 1: Significance levels of log conversion clusters, Pearson Chi Square Tests of Independence (n=72; test statistic < .100)

	species	log treatment	log type	log profile	horizontal log surface	corner notch type
Region	0.000		[0.107]	0.050		
Homes (000)				0.014		

Table 2: Certification data (n=72)

	Graded logs	Energy Star certified	LEED certified	FSC certified
manufacturers	48	6	1	7
% manufacturers	67%	8%	1%	10%

Table 3: Non-response bias assessment

	Upland South	Lowland South	Great Lakes	Upland North
manufacturers (n=72)	31	6	19	16
% of mfr.	43.1%	8.3%	26.4%	22.2%
production (000)	143.0	15.5	24.3	97.5
% of production	51.9%	5.6%	8.8%	35.4%
survey participants (n=38)	12	2	11	13
% of participants	31.6%	5.3%	28.9%	34.2%
participant production (000)	60.5	10	15.06	90.5
% of participant production	34.4%	5.7%	8.6%	51.4%

Table 4: Share of log procurement by type (1-5; n=38)

(procurement type)	mean	std dev
field	1.29	0.927
mill	1.58	1.154
cants	3.63	1.699
sawn lumber	1.50	1.247
glulam	1.11	0.649

Table 5: Share of log procurement by cumulative distance (1-5; n=38)

(procurement distance)	mean	std dev
local (< 100 mi.)	3.11	1.556
nearby (< 200-300 mi.)	4.29	1.113
region (~ 500 mi.)	4.63	0.913
e. N. Am.	4.71	0.867
N. Am.	5.00	0.000

Table 6: Influence on timber choice (1-5; n=38)

(timber performance)	mean	std dev
tight growth rings	2.55	1.465
straight grain	3.16	1.443
absence of knots	2.26	1.228
uniform color	2.53	1.409
rot/insect resistence	3.32	1.579
sustainable	3.79	1.189
preservative/stain	4.00	1.273
machinability	4.11	1.158
longer lengths	3.76	1.125
larger diameters	3.29	1.160
appearance	4.16	1.197
mechanical strength	3.45	1.179
durability	3.92	2.239
dimensional stability	4.18	0.982
price	3.79	1.044
price stability	3.58	1.154
reliability of supply	4.47	0.725
local supply	3.55	1.465
regional supply	3.76	1.422

Table 7: Influences on log conversion choices (%; n=38)

	tree species	environmental performance	cultural or regional tradition	customer preferences
log treatment	74%	55%	42%	76%
log type	50%	34%	47%	87%
log profile	37%	21%	39%	87%
horizontal surfaces	29%	55%	42%	71%
corner notch	24%	34%	39%	79%

Table 8: Manufacturers' environmental perspectives (1-5; n=38)

	mean	std dev
adequate now	3.24	1.125
science & technology	3.26	1.267
renewable	4.39	0.916
recycling	2.45	1.389
natural materials	3.66	1.072

Table 9: Manufacturers' perceptions of market barriers (1-5; n=38)

	mean	std dev
credibility	2.29	1,271
supply	2.61	1,552
supplier relationships	3.00	1,525
no demand	3.47	1,428
willingness to pay	3.58	1,553
technical problems	3.24	1,584

Table 10: Cumulative Market Distance (1-5; n=38)

(market distance)	mean	std dev
local (< 100 mi.)	2.21	0.935
nearby (< 200-300 mi.)	3.26	0.921
region (~ 500 mi.)	3.92	0.818
e. N. Am.	4.39	0.679
N. Am.	4.87	0.343

Table 11: Log conversion attributes clusters vs. manufacturer perspective clusters Pearson chi square test of independence (n=38; test statistic < .100)

SIGNIFICANCE LEVEL	procurement type	procure distance	timber perform	conv influence	environment	mkt barriers	mkt distance
tree species							
log treatment							
log type			0.022			0.031	
log profile						[0.105]	
horiz. surface			0.047				
corner notch				0.052			

Table 12: Significance levels of region and volume vs. manufacturer clusters Pearson chi square test of independence (n=38; test statistic < .100)

	procurement type	procurement distance	timber performance	conversion influences	environment	market barriers	market distance
Region							
Homes (000)	0.080	0.077					

Table 13: Upland South region prediction model: parameter estimates

Parameter Estimates

Upland South[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	90% Confidence ... Lower Bound	90% Confidence ... Upper Bound
0	Intercept	3.243	1.419	5.225	1	.022			
	[SP1a=0]	-.470	.975	.233	1	.630	.625	.126	3.106
	[SP1a=1]	0[b]	.	.	0	.	.	.	.
	[SP5a=0]	-3.466	1.250	7.687	1	.006	.031	.004	.244
	[SP5a=1]	0[b]	.	.	0	.	.	.	.

a. The reference category is: 1.

b. This parameter is set to zero because it is redundant.

Table 14: Upland North region prediction model: parameter estimates

Parameter Estimates

Upland North[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	90% Confidence ... Lower Bound	90% Confidence ... Upper Bound
0	Intercept	2.122	1.746	1.476	1	.224			
	[SP1a=0]	.723	1.151	.394	1	.530	2.060	.310	13.680
	[SP1a=1]	0[b]	.	.	0	.	.	.	.
	[SP5a=0]	.790	1.028	.591	1	.442	2.204	.406	11.947
	[SP5a=1]	0[b]	.	.	0	.	.	.	.
	[CN1a=0]	-1.658	1.051	2.486	1	.115	.191	.034	1.074
	[CN1a=1]	0[b]	.	.	0	.	.	.	.
	[CN5a=0]	-2.408	1.076	5.011	1	.025	.090	.015	.528
	[CN5a=1]	0[b]	.	.	0	.	.	.	.

a. The reference category is: 1.

b. This parameter is set to zero because it is redundant.

Table 15: Great Lakes Basin region prediction model: parameter estimates

Parameter Estimates

Great Lakes[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	90% Confidence ... Lower Bound	90% Confidence ... Upper Bound
0	Intercept	-.272	2.719	.010	1	.920			
	[SP1=0]	-.288	1.514	.036	1	.849	.750	.062	9.046
	[SP1=1]	0[b]	.	.	0	.	.	.	.
	[SP4=0]	-.288	1.514	.036	1	.849	.750	.062	9.046
	[SP4=1]	0[b]	.	.	0	.	.	.	.
	[SP5=0]	2.639	1.282	4.239	1	.039	14.000	1.700	115.276
	[SP5=1]	0[b]	.	.	0	.	.	.	.
	[SP6=0]	0[b]	.	.	0	.	.	.	.
	[SP6=1]	0[b]	.	.	0	.	.	.	.

a. The reference category is: 1.

b. This parameter is set to zero because it is redundant.

Table 16: 2-region prediction model: parameter estimates

Parameter Estimates

Region A[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	90% Confidence ... Lower Bound	90% Confidence ... Upper Bound
0	Intercept	3.243	1.419	5.225	1	.022			
	[SP1a=0]	-.470	.975	.233	1	.630	.625	.126	3.106
	[SP1a=1]	0[b]	.	.	0	.	.	.	.
	[SP5a=0]	-3.466	1.250	7.687	1	.006	.031	.004	.244
	[SP5a=1]	0[b]	.	.	0	.	.	.	.

a. The reference category is: 1.

b. This parameter is set to zero because it is redundant.

Table 17: Procurement type prediction model: parameter estimates

Parameter Estimates

PT1a[a]		B	Std. Error	Wald	df	Sig.	Exp(B)
0	Intercept	-1.784	2.397	.554	1	.457	
	homes_000	-.346	.205	2.848	1	.091	.707
	[SP1=0]	1.610	1.428	1.271	1	.260	5.002
	[SP1=1]	0[b]	.	.	0	.	.
	[SP4=0]	.379	1.196	.100	1	.751	1.461
	[SP4=1]	0[b]	.	.	0	.	.
	[SP5=0]	.865	1.154	.561	1	.454	2.375
	[SP5=1]	0[b]	.	.	0	.	.

Parameter Estimates

PT1a[a]		90% Confidence Interval for Exp (B)	
		Lower Bound	Upper Bound
0	Intercept		
	homes_000	.505	.991
	[SP1=0]	.478	52.374
	[SP1=1]	.	.
	[SP4=0]	.204	10.455
	[SP4=1]	.	.
	[SP5=0]	.356	15.861
	[SP5=1]	.	.

Table 18: Procurement distance prediction model: parameter estimates

Parameter Estimates

PD1a[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	90% Confidence ... Lower Bound	90% Confidence ... Upper Bound
0	Intercept	-.473	1.808	.069	1	.793			
	[SP1a=0]	-2.554	1.326	3.710	1	.054	.078	.009	.689
	[SP1a=1]	0[b]	.	.	0	.	.	.	.
	[SP5a=0]	-1.975	1.257	2.469	1	.116	.139	.018	1.097
	[SP5a=1]	0[b]	.	.	0	.	.	.	.
	[PR1=0]	1.928	1.277	2.278	1	.131	6.874	.841	56.185
	[PR1=1]	0[b]	.	.	0	.	.	.	.
	[PR2=0]	1.472	.908	2.627	1	.105	4.360	.978	19.428
	[PR2=1]	0[b]	.	.	0	.	.	.	.
	[PR3a=0]	0[b]	.	.	0	.	.	.	.
	[PR3a=1]	0[b]	.	.	0	.	.	.	.

a. The reference category is: 1.

b. This parameter is set to zero because it is redundant.

Table 19: Timber performance prediction model: parameter estimates

Parameter Estimates

TP1a[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	90% Confidence ... Lower Bound	90% Confidence ... Upper Bound
0	Intercept	-6.701	5.487	1.491	1	.222			
	[SP1=0]	.523	1.788	.085	1	.770	1.686	.089	31.920
	[SP1=1]	0[b]	.	.	0	.	.	.	.
	[SP4=0]	-.126	1.725	.005	1	.942	.882	.052	15.061
	[SP4=1]	0[b]	.	.	0	.	.	.	.
	[SP6=0]	-2.682	1.385	3.747	1	.053	.068	.007	.668
	[SP6=1]	0[b]	.	.	0	.	.	.	.
	[SP5=0]	0[b]	.	.	0	.	.	.	.
	[SP5=1]	0[b]	.	.	0	.	.	.	.
	[TY2=0]	3.055	1.871	2.668	1	.102	21.228	.979	460.456
	[TY2=1]	0[b]	.	.	0	.	.	.	.
	[TY3=0]	2.686	1.713	2.457	1	.117	14.674	.876	245.785
	[TY3=1]	0[b]	.	.	0	.	.	.	.
	[TY4=0]	4.043	1.922	4.425	1	.035	56.993	2.415	1345.289
	[TY4=1]	0[b]	.	.	0	.	.	.	.

a. The reference category is: 1.

b. This parameter is set to zero because it is redundant.

Table 20: Log conversion influence prediction model: parameter estimates

Parameter Estimates

Cl1a[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	90% Confidence ... Lower Bound	90% Confidence ... Upper Bound
0	Intercept	2.565	1.152	4.958	1	.026			
	[SP1a=0]	-1.386	1.000	1.922	1	.166	.250	.048	1.295
	[SP1a=1]	0[b]	.	.	0	.	.	.	.
	[SP5a=0]	-1.872	.909	4.237	1	.040	.154	.034	.687
	[SP5a=1]	0[b]	.	.	0	.	.	.	.

a. The reference category is: 1.

b. This parameter is set to zero because it is redundant.

Table 21: Market barrier prediction model: parameter estimates

Parameter Estimates

MB1a[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	90% Confidence ... Lower Bound	90% Confidence ... Upper Bound
0	Intercept	-2.973	2.088	2.028	1	.154			
	[SP1a=0]	-.829	1.161	.510	1	.475	.436	.065	2.944
	[SP1a=1]	0[b]	.	.	0	.	.	.	.
	[SP5a=0]	1.672	1.063	2.476	1	.116	5.324	.927	30.582
	[SP5a=1]	0[b]	.	.	0	.	.	.	.
	[CN1a=0]	1.979	1.332	2.207	1	.137	7.237	.809	64.753
	[CN1a=1]	0[b]	.	.	0	.	.	.	.
	[CN5a=0]	3.493	1.405	6.179	1	.013	32.891	3.260	331.871
	[CN5a=1]	0[b]	.	.	0	.	.	.	.

a. The reference category is: 1.

b. This parameter is set to zero because it is redundant.

APPENDIX 2

LOG HOME MANUFACTURER SURVEY

Hello, this is *Jim Peters <jspeters@eco.umass.edu> from the Building and Construction Technology Program at the University of Massachusetts, Amherst. I would like to ask you some questions for a LOG HOME MANUFACTURER STUDY we are doing. We are studying influences on log conversion methods in the eastern USA and CA. It should take about 10 minutes, if you are willing to answer my questions. Your responses will be confidential. Data will be aggregated to maintain your company's anonymity, and if you like, we will send you a copy of the results when they become available. Can you give me about 10-15 minutes to answer my questions, now or at another more convenient time? (Information about this project can be found at http://blogs.umass.edu/jspeters).*

Let me get your contact information.

Name: ____________________	Title: ____________________
Telephone: ____________________	Email: ____________________
Company: ____________________	Address1: ____________________
Address2: ____________________	Town: ____________________
State (Prov): ____________________	Postal code: ____________________

***(If not available now*) Would it be convenient for me to call you again, or would you prefer to answer my questions online?** *[ ] online* *[ ] telephone*
***(If telephone)* Date & Time** ____

***(If online)* I will email the URL and the password to you shortly and then follow up with you in a few days. [https://www.surveymonkey.com/s/FJPDCWC *] [logmfr]*.**

1. About how much of your timber procurement for building logs is acquired via each of the following methods? From 1-5, from none to all: (1***) none or almost none*** [<10%], (2) ***some*** [10%-1/3], (3) ***about half*** [1/3-2/3], (4) ***most*** [2/3-90%], or (5) ***all or nearly all*** [>90%].

a.	Raw roundwood picked up in the field:	1	2	3	4	5
b.	Raw roundwood delivered to the mill:	1	2	3	4	5
c.	Cants:	1	2	3	4	5
d.	Sawn lumber:	1	2	3	4	5
e.	Glulam logs:	1	2	3	4	5

2. About how much of your company's timber supply for building logs is typically procured from the following distances? From 1-5, from none to all: (1***) none or almost none*** [<10%], (2) ***some*** [10%-1/3], (3) ***about half*** [1/3-2/3], (4) ***most*** [2/3-90%], or (5) ***all or nearly all*** [>90%].

a.	Locally (w/in ~100 mi.)?	1	2	3	4	5
b.	Relatively nearby (w/in ~200/300 mi.)?	1	2	3	4	5
c.	Within your region (w/in ~500 mi.)?	1	2	3	4	5
d.	Within the eastern North America?	1	2	3	4	5
e.	Within North America?	1	2	3	4	5

3. ***** How influential to your to company's choice of tree species to process into building logs (i.e., walls) were the following timber characteristics? From 1-5, from not at all to extremely influential: (1) *not at all influential*, (2) *somewhat influential*, (3) *influential*, (4) *very influential*, and (5) *extremely influential* (the determining factor).

Timber characteristics	**Not Influential**	**Somewhat Influential**	**Influential**	**Very Influential**	**Extremely Influential**
Timber quality					
Narrow (or tight) growth rings	1	2	3	4	5
Straight grain orientation	1	2	3	4	5
Absence of knots	1	2	3	4	5
Uniform color	1	2	3	4	5
Rot/insect resistance	1	2	3	4	5
Environmentally sustainable	1	2	3	4	5
Manufacturing properties					
Accepts preservative/stain	1	2	3	4	5
Machinability	1	2	3	4	5
Availability in longer lengths	1	2	3	4	5
Availability in larger diameters	1	2	3	4	5
Appearance (e.g., rustic)	1	2	3	4	5
Mechanical properties					
Mechanical strength	1	2	3	4	5
Durability	1	2	3	4	5
Dimensional stability	1	2	3	4	5
Econ/Price characteristics					
Price	1	2	3	4	5
Price stability	1	2	3	4	5
Reliability of supply	1	2	3	4	5
Local availability of supply	1	2	3	4	5
Regional availability of supply	1	2	3	4	5

4. Which of the following (i.e., tree species used, environmental performance, regional/cultural traditions, customer preferences) are major influences on your company's choices of log conversion methods? (Multiple answers per row accepted.)

Conversion methods	**Tree species used**	**Environmental performance (climate, insects, rot)**	**Regional/Cultural traditions**	**Customer preferences**
Log treatment (e.g., dry, preserve)	____	____	____	____
Log type (e.g., 1/2-log, glulam)	____	____	____	____
Log profile (e.g., D-log, SE cope)	____	____	____	____
Horizontal surface (e.g., T&G)	____	____	____	____
Corner notch type (e.g., dovetail)	____	____	____	____

5. *How representative of your company's attitudes toward environmental issues are each of the following statements? From 1-5, from not to all representative to exactly representative: (1) not at all representative, (2) somewhat representative, (3) representative, (4) very representative, or (5) exactly representative.

   a. Our company has no need to improve its environmental performance. We have adequate performance now: 1 2 3 4 5

   a. Our company expects that science and technology will provide us ways to improve our company's environmental performance: 1 2 3 4 5

   b. Our company emphasizes the use of renewable materials: 1 2 3 4 5

   c. Our company is reducing its use of virgin building materials through reuse and recycling: 1 2 3 4 5

   a. Our company believes that chemical pollution from synthetic building materials is the key issue. We emphasize the use of natural materials, traditional building methods, and organic treatments and 1 2 3 4 5

6. ***Rate each of the following potential market barriers in terms of how much influence it has been on your company's decision on whether or not to offer *green certified* building logs. From 1-5, from not at all influential to extremely influential: (1) not at all influential, (2) somewhat influential, (3) influential, (4) very influential, (5) extremely influential, the determining factor.

   a. Lack of credibility of certification schemes: 1 2 3 4 5

   b. Lack of supply of certified wood: 1 2 3 4 5

   c. Established contracts and supplier relationships: 1 2 3 4 5

   d. No clear market demand: 1 2 3 4 5

   e. Insufficient customer willingness to pay more: 1 2 3 4 5

   f. Difficulties or cost of meeting technical requirements (e.g., chain of custody):
   1 2 3 4 5

7. Approximately how much of your company's log home production is sold to customers at the following distances? From 1-5, from almost none to nearly all: (1***) none or almost none*** [<10%], (2) ***some*** [10%-1/3], (3) ***about half*** [1/3-2/3], (4) ***most*** [2/3-90%], or (5) ***all or nearly all*** [>90%]:

   a. Locally (w/in ~100 mi.)? 1 2 3 4 5
   b. Relatively nearby (w/in ~200/300 mi.)? 1 2 3 4 5
   c. Within your region (w/in ~500 mi.)? 1 2 3 4 5
   d. Within the eastern North America? 1 2 3 4 5
   e. Within North America? 1 2 3 4 5

THANK YOU, WE ARE FINISHED! I appreciate your willingness to participate. Do you want us to send you a copy of the results of this study? [ ] yes [ ] no

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