THE EGOCENTRIC MAP PERSPECTIVE IN THEMATIC CHOROPLETH MAPS

by

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A THESIS

Presented to the Department of Geography
and the Graduate School of the University of Oregon
in partial fulfillment of the requirements
for the degree of
Master of Arts

September 2010

"The Egocentric Map Perspective in Thematic Choropleth Maps," a thesis prepared by Matthew E. Millett in partial fulfillment of the requirements for the Master of Arts degree in the Department of Geography. This thesis has been approved and accepted by:

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23 August 2010
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An Abstract of the Thesis of

Matthew E. Millett for the degree of Master of Arts

in the Department of Geography to be taken September 2010

Title: THE EGOCENTRIC MAP PERSPECTIVE IN THEMATIC CHOROPLETH MAPS

Approved: ______________________________
Dr. Amy Lobben

Choropleth maps are a popular way of depicting spatial data. The map communication model, which theorizes that geographic information is transmitted from the cartographer to the map user via a map, suggests that cartographers are responsible for clearly conveying spatial data in a way all map users can understand. Map users, however, come from different places and may harbor certain regional biases. This thesis investigates whether map users tend to focus on data patterns within their home regions during the visual-search and decision-making processes when reading classed choropleth maps, thereby exhibiting an egocentric map behavior. Seventy-one subjects took a computer-based test asking them to identify various phenomena on a series of choropleth maps of the lower 48 states. The results show a weak positive effect of egocentric map behavior; subjects who lived in a particular state longer were slightly more likely to choose states nearby their home region.

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ACKNOWLEDGMENTS

In addition to my committee members Amy Lobben and Dan Gavin, I would like to thank Derek Miller, Robert Pickett, Lindsay Naylor, Nick Martinelli, René Kladzyk, Tom Ptak, and Alexandra Marcus for their ideas and assistance. The completion of this thesis, however, would not have been possible without the loving support of Antra Renault.

This thesis is dedicated to Calvin, Camilla, and Marigold.

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CHAPTER I

INTRODUCTION

Since the adoption of cartography as a communication science in the 1960s, researchers in the cartographic community have frequently focused their efforts on improving production and symbolization methods in order to facilitate the communication of spatial information from the cartographer to the map reader (MacEachren 1995). The academic literature is replete with such research, from Flannery's investigation on the perception of graduated symbols in 1956 to Jenks' 1967 study on data classification to Harrower and Brewer's research on color schemes in 2003. More recently, however, researchers have begun to investigate another component to map communication – how map readers contextualize what they are viewing based on their own experiences and sensibilities.

This thesis contributes to the more-recent map-use investigations by focusing on how map readers' individual perspectives influence the exploration and decision-making tasks associated with viewing quantitative and qualitative classed thematic choropleth maps. To that end, the following research questions were posed:

• Do map readers exhibit egocentric map behavior during the visual-search and decision-making processes when viewing classed thematic choropleth maps of the United States?

• Do variables such as age, sex, and prior geographic knowledge significantly affect how such maps are read and discerned?

Maps are ubiquitous. Not only are they found in traditional places like atlases, textbooks, and newspapers, but more and more they are appearing in digital format on portable devices such as car-navigation systems, cellular telephones, laptops and netbooks (Peterson 2008). Understanding *how* maps are read is essential. Local decisions in both the public and private sectors are influenced by the spatial and cartographic perceptions of a few key people (Gould 1973).

In Chapter II, a review of selected literature researching and discussing map cognition, map communication and egocentric map perspectives reveals that while numerous articles and books have been published on map cognition and communication, relatively little has been investigated with regard to egocentric map behavior save for the efforts of Saarinen (1999), Gould and White (1986), and Gould (1975). Among other things, their research found that people from different places view and think about the world in different manners, and they have different sets of guidelines from which they derive certain preferences for places. These are the ideas that inspired this research.

The methods used to investigate the research questions is discussed in Chapter III. The research questions were investigated through the design and implementation of a computer-based map-reading task and map quiz, and a paper-based demographic survey administered to a group of participants recruited from the University of Oregon.

Chapter IV details how the data were analyzed and reports the results of the analysis. Independent variables including age, sex, major, home state, and quiz score were related to the dependent variable – the participants' locational choices in the computer-based map-reading task – with some promising but nonetheless mixed results.

Lastly, Chapter V offers concluding remarks, and discusses the how the results might relate to previous cartographic and behavioral research.

CHAPTER II

MAP COMMUNICATION, MAP COGNITION, AND EGOCENTRIC MAP BEHAVIOR

Because this research is concerned with behavior associated with reading thematic choropleth maps, it is necessary to discuss: 1) How maps have been generally considered historically and how they communicate spatial information (map communication); 2) How people encode and decode spatial information acquired from maps (map cognition); and 3) The ways map readers form cognitive or mental maps and how their frame of reference may affect their spatial knowledge acquisition when viewing maps of familiar and unfamiliar regions (egocentric map behavior).

Map Communication

According to Muehrcke (1998), "a map has many ingredients of a painting or a poem" (p. 17). Up until the middle of the 20th century, maps were mostly thought of in this light – judged on their artistic and aesthetic qualities. How maps communicated spatial information to the reader was not usually considered (Lloyd 2000). A 1526 map from a Turkish sea atlas shows a detailed view of the city of Constantinople – complete with mosques, homes, walls, other buildings, and trees (Figure 1, Brown 1949) while Nicolas Germanus' work, created circa 1460 and based on Ptolemy's *Geographia*, depicts

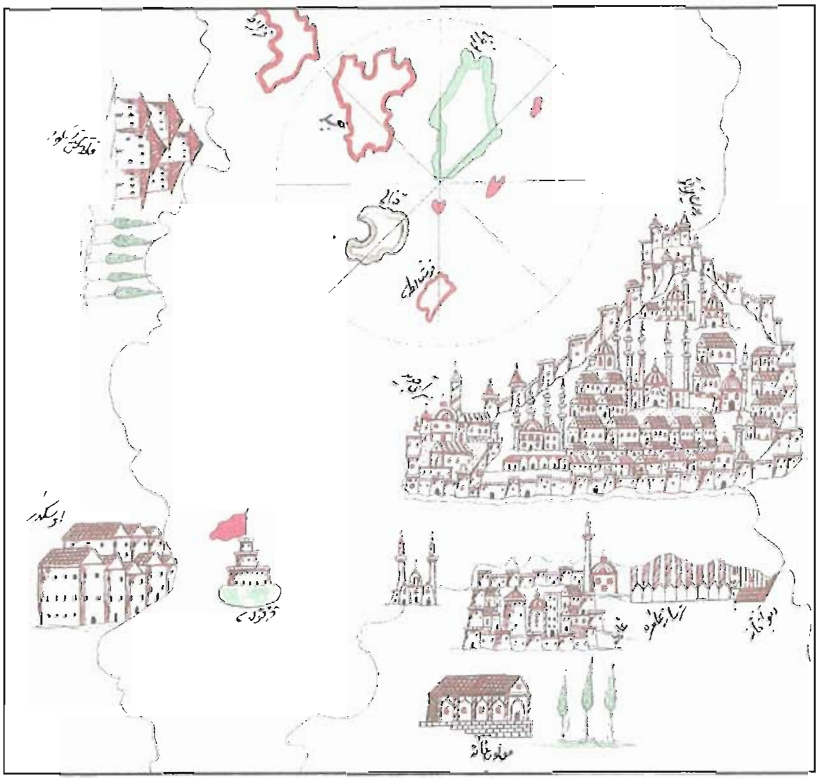


Figure 1. City of Constantinople, 1526 (Brown 1949).

the known world with such artistic embellishments as cherubic faces representing the 12 winds (Virga 2007). These images are more impressionistic representations rather than the functional maps we are now used to seeing.

Two developments in the latter half of the 20th century, however, had a major effect on how maps are considered (MacEachren 1995). First was the publication of Robinson's seminal work "The Look of Maps" in 1952. In his book, Robinson called on researchers to scientifically study and develop principles and practices that encourage good cartographic design with the goal of improving the overall map communication process. Robinson believed that maps should be functional and logically designed to serve some useful purpose (Robinson et al. 1995, Robinson 1952). What resulted was a plethora of studies in symbolization and design which looked at objective methods for depicting spatial information and relationships on maps; some studies were also linked to psychophysical research in psychology (Montello 2002, MacEachren 1995, Gilmartin 1981). The second important development, according to MacEachren (1995), was the adoption of the idea of cartography as a communication science.

The Communication Process

The idea of maps as communication devices developed in the 1960s (MacEachren 1995). Board's (1967) "Map-Model Cycle" (Figure 2) is a flow diagram – albeit a rather

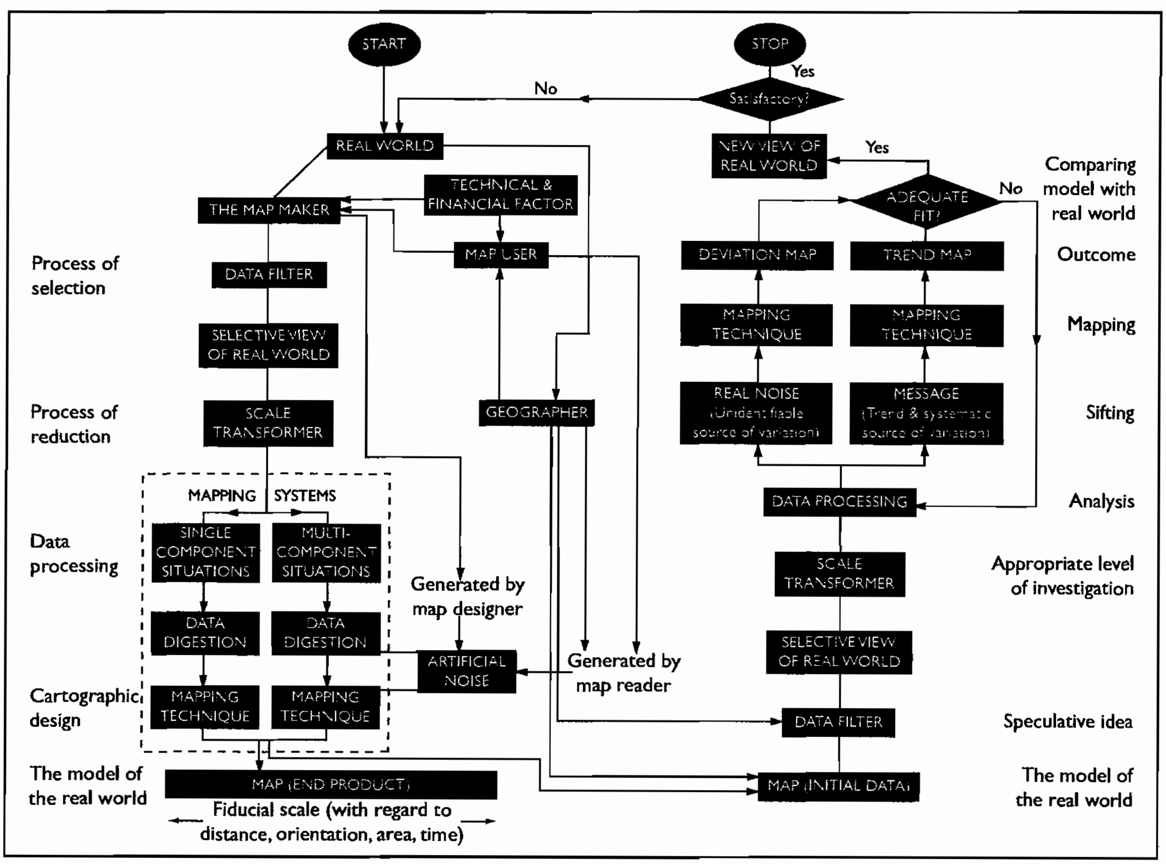


Figure 2. The Map-Model Cycle (Based on Board 1967).

complicated one – depicting the process of how spatial information in the "real" world is relayed by the cartographer through the processes of data selection, scale reduction, and cartographic design, to the map reader where it is then filtered, digested, and more or less learned and understood (Figure 3).

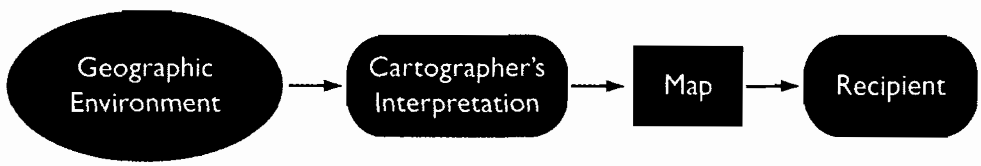


Figure 3. The Map Communication Model (Based on MacEachren 1995).

Essentially, certain spatial information is collected and gathered by and transmitted from the mapmaker to the map reader via the map; the spatial information and patterns encoded in the map by the cartographer are then decoded and stored by the map reader in the form of a mental or cognitive map (Lloyd 2000, MacEachren 1995, Board and Taylor 1977, Board 1967).

Fearing (1953) noted four basic components of human communication in which all problems of communication lie (as cited in Dent 1972):

- The communicator (the sender of the message)
- The interpreter (the message's receiver)
- The communication content (the information needed to be communicated)
- The communication situation (the need to communicate or be communicated to)

Relating it to cartography, Dent (1972) describes the communicator as the mapmaker, the interpreter as the map reader, the communication content as the map, and the communication situation as assumed since it is clear that information is being communicated via the map. However, successful communication can only occur through mutual comprehension of words and symbols (Fearing 1953 as cited in Dent 1972); understanding occurs when the map reader is able to assign meaning to what he or she is viewing (Dent 1972).

Though Robinson himself never explicitly proposed a communication model for cartography, MacEachren (1995) argues that it is clear that Robinson believed that maps must have a pre-determined purpose and that some particular map knowledge is to be *discerned* from it by the map reader, not necessarily *constructed* by the map reader.

MacEachren (1995) raises three objections to treating maps simply as communication devices. First, there are many ways people read and use maps – e.g., finding a location, navigating, determining land ownership, etc. – and all map readers are not alike. As Balchin (1972) found (as cited in Board and Taylor 1977), it is possible that we are not all born map readers. In addition, some maps – such as topographic maps, for example – may have no explicit theme or topic at all and are therefore difficult to objectively study, while others may communicate information other than what the cartographer originally intended. The cartographic message is often not explicit and can be formed only in the map reader's mind (Dent 1999, Dent 1972). (Board and Taylor (1977) note that although mapmakers cannot consciously incorporate more information into a map than what they are already aware of, map readers may gain further spatial knowledge through the process of induction.) The map message can also be intentionally or unintentionally manipulated by the cartographer to send a distorted representation of reality (Monmonier 1996). Second, the communication model has no ability to recognize the importance of art and aesthetics in cartography. And third, how can one objectively study maps if there are those who believe that maps do not objectively represent the real world?

Geographers should be concerned with how spatial information is coded, stored, reconstructed and processed in memory (MacEachren 1995, Lloyd 1982, Gilmartin 1981). Further study on spatial decision-making requires that the cartographic community understand how people build and employ cognitive structures (Lloyd 1982). It is necessary, therefore, to examine how map readers construct, process, store and recall spatial information acquired from maps in their own minds. Determining map effectiveness has relevance for anyone using thematic maps in a classroom situation for teaching, or to illustrate their results in a research paper (MacEachren 1995, MacEachren 1982, Gilmartin 1981).

Board and Taylor (1977) assert that it is wrong to state that a map contains no information not put into it when it was made. Map readers do not necessarily share the mapmaker's knowledge of cartographic language and symbols. It is important, therefore, for cartographers to be more aware of map readers' requirements. Understanding the entire cartographic process from both the cartographer's and the map reader's points of view is key (Lloyd and Steinke 1977).

Map Cognition

Map cognition – a term coined by Tolman (1948) in his study of rats and their navigation of mazes – is the *process* in which an individual "acquires, codes, stores, recalls, and decodes information about the relative locations and attributes of phenomena" in his or her spatial environment (Downs and Stea 1973, p. 9). Eysenck et al. (1972, as cited by Gilmartin 1981) described several cognitive processes including perception, discovery, recognition, imaging, judging, memorizing, learning, and speech. Cognitive maps may contain information about location and attributes (MacEachren 1991), each of which are theorized to be stored in separate parts of the brain (Levine et al. 1985 as cited in Rittschof and Kulhavy 1998).

Research based on understanding how maps are read and recalled could be more relevant than perceptual research on symbol detection, discrimination, and interpretation (MacEachren 1991). However, it is important to understand that such a process is not observable directly, rather conclusions must be drawn based on results which are observable (Olson 1977).

Map Reading and Visual Search

Map reading involves *searching for* and *identifying* regions, symbols, themes, text, and the geographical order or hierarchy of elements on the page (Bertin 1983). Identification is concerned with matching symbols with the legend, discerning patterns, and assessing the map's internal structure; it is often achieved through the recognition of map features, shapes, and spatial organizations (Morrison 1974 as cited in Board and Taylor 1977). But the way maps are read and understood, and the level of spatial knowledge individuals possess varies considerably from reader to reader (Lobben 2004, Gould and White 1986, Gould 1973). Expertise, culture, sex, age, ethnicity, socioeconomic status, and other variables could affect one's map-reading ability (Slocum et al. 2001).

Map readers use specific map-reading strategies to complete map-reading tasks, and each map reader's individual abilities may dictate which strategies he or she may employ (Lobben 2004). Concerning the investigation of an egocentric map perspective, several processes – including visual search, visual attention and orienting – may come into play.

Visual search (Figure 4) involves the active scanning of an environment (such as a map) for some particular object (the target) while filtering out extraneous features called distracters (Trick and Enns 1998). Visual search is a fundamental activity in map reading (Lloyd 1977). Visual attention, or where the map reader is looking, begins as a kind of spotlight of a certain diameter – one with a wide range of field with a low resolution – and then narrows into a smaller range of field with a high resolution; there is thus a narrowing of attention over time (Humphreys and Bruce 1995). Orienting is simply

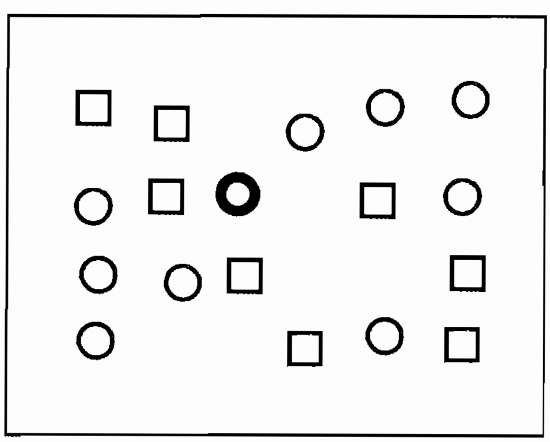


Figure 4. Visual search example with one target and 17 distracters (Based on Trick and Enns 1998).

aligning one's attention with information stored in his or her memory (Posner 1980). For example, a map reader might search for a familiar spot on a map – say, a well-known intersection – to get his or her bearings.

All of these processes are the beginning steps in the formation of map readers' mental maps.

Mental Maps

Mental maps – the spatial information and patterns encoded in the map by the cartographer, and then decoded and stored by the map reader – are in essence a reference system used by the brain (Board and Taylor 1977).

People's mental maps are formed not only by direct experience in their environment, but also by images from books, radio, television, newspapers, and the Internet (Peterson 2008, Bryant and Tversky 1999, Rittschof and Kulhavy 1998, Kulhavy and Stock 1994, Gould and White 1986). Recent technological changes even allow almost anyone to make maps (Krygier and Wood 2005) and spatial language by itself can also be converted into a mental image (Bryant and Tversky 1999). When a mental image is formed by studying a tangible map (paper or digital), information about the map's structures (directional relationships between locations) and features (visual information such as the distribution of ink or pixels themselves and other visual variables) are represented in the mental map image (Rittschof and Kulhavy 1998). Physical and cultural landscapes, climate, social attitudes, language, etc., may also be represented in one's mental map (Gould and White 1986). People's behavior often reflects images they have formed from the social and physical environment they perceive rather than the true environment (Gould 1975).

Lynch (1960) suggests that navigators or wayfinders form and understand their mental maps through paths (such as roads and sidewalks), edges (boundaries), districts (regions), nodes (focal points), and landmarks (readily identifiable objects). Golledge and Spector (1978), on the other hand, postulate that wayfinders construct their mental maps by encoding familiar locations, features, areas, and landmarks as anchor points, which are then used to organize and recall other spatial information. New locations are learned and imposed on the mental map based on their relative locations to the original anchor points (Figure 5).

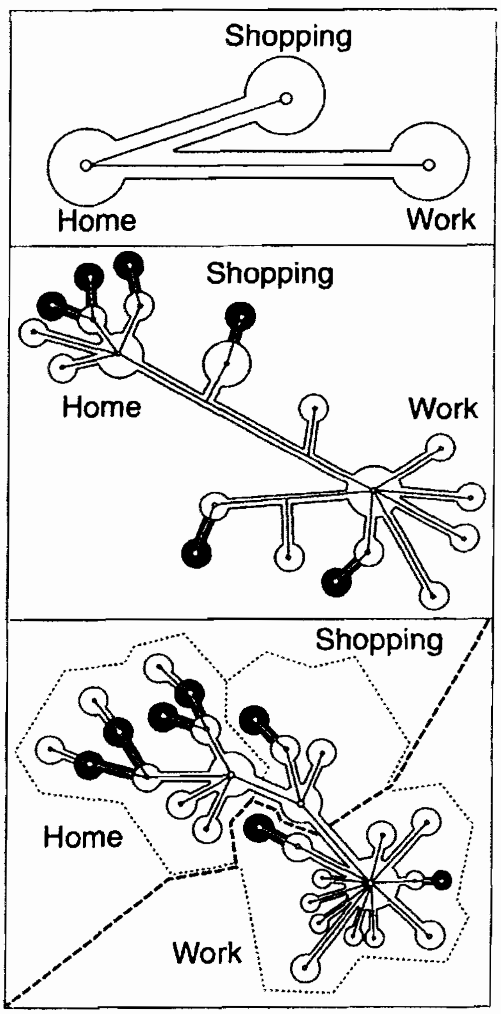


Figure 5. Anchor points may aid in the formation of mental maps (Golledge 1999).

Just as in tangible maps, however, not all the aspects of the environment are represented in mental maps, rather, the spatial information is schematized (Tversky 2000) and reduced into a simpler, more organized form (Kosslyn and Pomerantz 1977) or stored as abstract constructs (Dent 1999). In any case, mental maps affect our spatial behavior and decision-making abilities (Dent 1999, Golledge 1999, Thorndyke and Stasz 1980, Gould 1975). Images of maps, then, could have behavioral effects similar to the reading of tangible maps and mental maps may in fact be functionally equivalent to tangible maps in form if not in content (Kosslyn and Pomerantz 1977 as cited in Lloyd 1982).

Mental maps extend beyond map readers' knowledge of spatial relationships and contain social and environmental knowledge as well. This additional information encoded by map readers shapes their individual attitudes toward the world and affects their decision-making behavior (Kitchin 1994, Gould 1973).

Map readers come from different places and may have their own opinions about other parts of the world. They might also have an emotional attachment to where they live and thus tend to exaggerate about their home towns. This emotional attachment could wane with distance, and faraway places might often receive less consideration (Gould and White 1986). Their map knowledge, therefore, may have great influence on their map behavior.

Map Knowledge

Kulhavy and Stock (1996) discuss two kinds of map knowledge: general and specific. In Western society, general map knowledge develops at an early age due to an exposure to the maps in books, newspapers, magazines and on television, phones, and the Internet (Peterson 2008, Kulhavy and Stock 1996). General map knowledge includes the ability to understand aerial photographs, recognize symbols on maps, have a general understanding of distance and direction, and so forth. Essentially, general map knowledge encompasses all abilities to perceive images as "map-like" (Kulhavy and Stock 1996, p. 124).

In addition to general map knowledge, however, map readers learn varying degrees of specific map knowledge, and thus have greater or lesser degrees of familiarity with particular maps. These differences influence the way map readers construct mental images after viewing maps, and further map reading is in turn influenced by information already encoded in memory (Kulhavy and Stock 1996). Familiar shapes encountered on maps can be encoded into memory into what Lloyd (1994) terms as prototypes. Prototypes represent a category of an object stored in the map reader's memory as an abstraction, and that abstraction captures those features that are typical of the object. Lloyd's study found that the more often participants were exposed to maps with prototypical characteristics, the more often they learned and used spatial prototypes. Golledge (2002) suggests that geographic knowledge levels change considerably when people are exposed to fundamental geographic principles such as "location, place, connectivity, interaction, distribution, pattern, hierarchy, distance, direction, orientation, reference frame, geographic association, scale, region and geographic representation" (p. 10). It is therefore possible that map readers with a great deal of exposure to maps and geographical concepts may perform differently in map-reading tasks than those who have not received such exposure.

Egocentric Map Behavior

Few studies have addressed the question central to this research, that is the idea that map readers view small-scale thematic choropleth maps through the lens of their home regions and thus exhibit an egocentric map behavior.

Saarinen's (1999) study asked participants from around the globe to sketch a map of the world on a blank piece of paper. The results indicated a strong propensity for drawing European-centered maps, and Europe's relative size was often greatly exaggerated in comparison to the rest of the world; more European place names were also included. Saarinen attributes this phenomenon to the prevalence of Eurocentric world maps and textbooks, and the Eurocentric instruction of world history and geography. In addition, he discovered that participants' home areas were often drawn in much greater detail while less space was devoted to distant or unknown places.

Though Gould (1975) and Gould and White's (1986) studies focused on participants' *preferences* for certain places, they were nonetheless able to conclude that people in certain regions appear to share their spatial images; their mental maps seem to be very similar.

Whether or not map readers exhibit egocentric map behavior, it is possible that numerous cultural and locational factors may affect people's map-reading and mental-map-building abilities.

CHAPTER III

METHODS AND PROCEDURES

In order to determine the existence of an egocentric map perspective by map readers, an experiment investigating the use of thematic classed choropleth maps of the coterminous United States was designed and administered. The ubiquity of thematic choropleth maps made them a good choice for the experiment since participants would have likely already been familiar with these maps. Participants were recruited both in person and via e-mail from classes and e-mail lists at the University of Oregon and then asked to perform a map-reading task on a laptop computer which consisted of 35 thematic choropleth maps. On each map, participants were asked to read a statement about a particular phenomenon, identify the location where that phenomenon was occurring, and click the target with the mouse. After viewing all 35 maps, a map quiz asking participants to identify each of the lower 48 states was administered. Last, participants were asked to fill out a short demographic survey.

Thematic Choropleth Maps

Thematic choropleth maps capture a single distribution or relationship and depict that distribution or relationship by manipulating the visual variables of hue, value, and chroma to represent a particular quantity within an enumeration unit such as a country, state or county (Robinson 1995). The use of such maps is widespread because they can be made to represent almost any phenomenon visible or invisible, and they can easily depict spatial patterns and relationships (Tyner 1992). Government agencies such as the U.S. Census Bureau, and newspapers, magazines, television, and the Internet all make extensive use of thematic choropleth maps (Harrower and Brewer 2003, Monmonier 1989), therefore they were used to test egocentric map behavior due to their inherent familiarity.

Factors such as visual complexity and amount of information presented influence map effectiveness (MacEachren 1982), thus it was important make the maps simple and efficient for the reader to understand. Graphical excellence, as Tufte (2001) calls it, minimizes the burden on a map reader's working memory. The intent of the research, after all, is to examine egocentrism in map use, so it was important to limit any distractions introduced from overly detailed or complicated maps. Bertin (1983) sums it up simply: Understanding means simplifying.

Test Instrument

To construct a test instrument that effectively investigated how map readers from different places and with different levels of geographical place-name knowledge view the same thematic classed choropleth maps, several factors were considered: 1) The duration of the test (i.e., it had to be long enough to gather sufficient data to draw conclusions, but short enough to prevent unnecessary participant fatigue); 2) The visual variables of shape, size, value, and hue as they pertained to state polygons; 3) The effect of Oregon's location in the lower 48 states and its relatively long distance away from other states; 4) Map readers' pre-conceived notions of geographical phenomena and previously learned ideas about states and regions; 5) Participants' choices (which had to be easily captured, stored and output for later analysis).

Map-Reading Task

Because of perceptual limitations, fewer classes are better when specific information for particular locations is needed to be portrayed (MacEachren 1982). Bertin (1983) suggests that between three and seven categories is optimal, while Tyner (1992) prefers four to 10 classes. In order to keep as few classes as possible without running the risk of over-generalizing, a four-class qualitative color scheme was chosen for the map-reading task.

To keep the duration of the map-reading task relatively short but also have a variety of hues from which to choose for filling the different enumeration units, the binomial coefficient equation (Figure 6) was used to calculate the ideal number of

$$\binom{n}{k} = \frac{n!}{k!\,(n-k)!}$$

Where $n = 7$ (number of total colors) and $k = 4$ (number of colors needed for each map)

$$\binom{7}{4} = \frac{7!}{4!\,(7-4)!} = \frac{7*6*5*4*3*2*1}{4*3*2*1(3*2*1)} = \frac{5040}{144} = 35$$

		$k = 4$
	5	5
	6	7
$n = 7$	15	35
	8	70
	9	126

Figure 6. Binomial coefficient equation and results.

maps. Seven hues for a four-class scheme yielded 35 total maps. Eight hues would have produced too many maps while six would have yielded too few. Hues for the qualitative color scheme were based on those recommended on ColorBrewer.org (Brewer 2010).

A series of 35 qualitative choropleth maps were therefore created for the map-reading task, 18 of which depicted four classes of phenomena with states as enumeration units, and 17 of which depicted similar phenomena with concentric rings of county clusters as enumeration units. After creating the county cluster maps, however, it was determined that the maps appeared to look more quantitative in nature; it did not seem logical for qualitative phenomena to occur in such a pattern, so the data and color schemes were changed to reflect quantitative phenomena.

Each map contained several states in a target category (determined by hue for the state maps and value for the county cluster maps) from which participants were asked to choose a location. Since it was likely that many participants recruited for the experiment would be from Oregon, targets were created in numerous different locations on the maps.

Qualitative/State Maps

To achieve an even distribution of states and county clusters near and far from Oregon, a distance scheme was created. States were divided into state zones which corresponded to how many states away a particular state was from Oregon (Figure 7). For example, map readers using Oregon to orient themselves must visually cross through four states to reach any of the states in State Zone 4 (Minnesota, Iowa, Missouri, Kansas, Oklahoma or Texas).

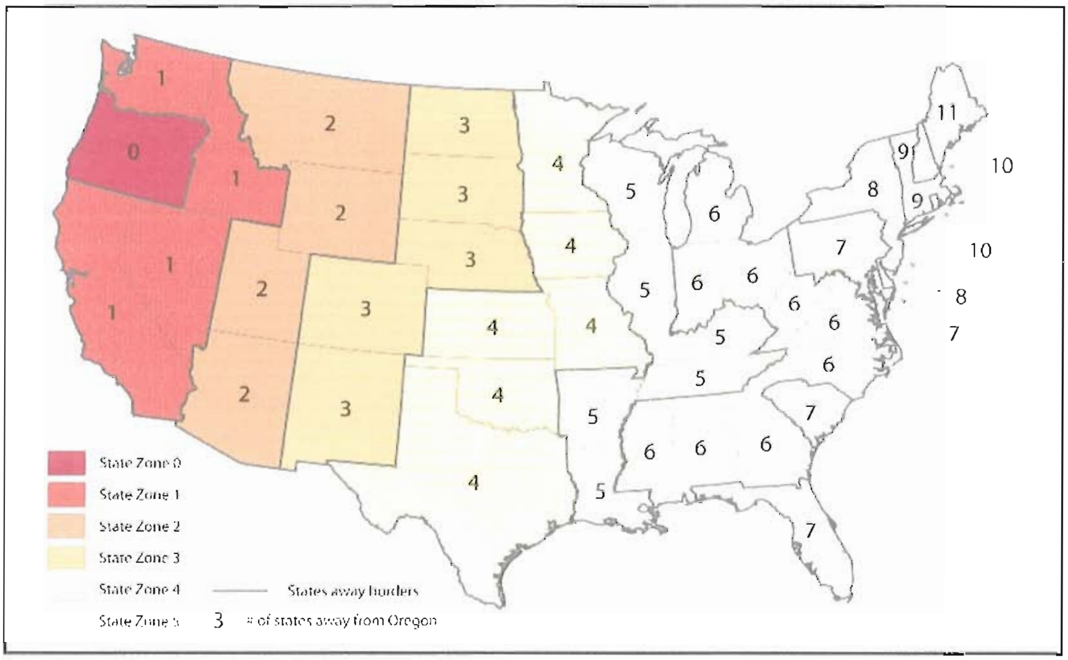


Figure 7. State zones for qualitative/state maps.

This admittedly complicated scheme was designed to ensure that no states (other than Oregon) were either over- or under-represented. The idea was to weight the maps with more target states farther west and closer to Oregon. The distribution of target states was further enhanced by keeping the number of target states per zone relatively equal in the state zones that actually contained target states. The randomization process also ensured that no state was either over- or under-represented in non-target categories as well. So for each qualitative/state map, Oregon was either in the target category or not in the target category, and some randomly selected combination of states from different state zones were also in the target category. (See Appendix A for all maps in the experiment.)

Since states eastward of State Zone 4 are smaller and farther away from Oregon, and to make the scheme easier to use, State Zones 5-11 were compressed into one large zone simply called State Zone 5. States were randomly assigned a "1," a "2," a "3" or a "4," with a "1" being the target category and the others being non-target categories. (See Appendix B, Table B-1, Table B-2, and Table B-3, for map-by-map breakdowns of zone and color schemes, and category assignments for each state.)

Oregon was in the target category in nine of the 18 qualitative/state maps. In four of those nine, Oregon was paired up with a target state in State Zone 1 – Nevada (Appendix A, Figure A-7), California (Appendix A, Figure A-11), Idaho (Appendix A, Figure A-23), and Washington (Appendix A, Figure A-35). In each of these maps, there was at least one randomly selected target state in each zone eastward of State Zone 2, with a few zones claiming two or three randomly selected target states; only one state was present in State Zone 1 in each of the four maps.

In two of the nine maps, Oregon was paired up with a target state in State Zone 2 – Montana (Appendix A, Figure A-15) and Wyoming (Appendix A, Figure A-32). In these two maps, no target state was present in Zone 1, rather the target states were randomly distributed throughout State Zone 3 and eastward; only one target state was present in State Zone 2.

This process continued with Oregon being paired up once with a State Zone 3 target (Colorado, Appendix A, Figure A-26), once with a State Zone 4 target (Kansas, Appendix A, Figure A-5), and once with a State Zone 5 target (Tennessee, Appendix A, Figure A-30). No target state (other than Oregon) was present anywhere westward of the aforementioned target states in State Zone 3, State Zone 4 and State Zone 5.

This same zonal scheme was applied to nine other maps in which Oregon was not in the target category. Four of the maps featured a State Zone 1 state as the most westward target state (California (Appendix A, Figure A-34), Washington (Appendix A, Figure A-1), Nevada (Appendix A, Figure A-18), and Idaho (Appendix A, Figure A-28)); two maps had a State Zone 2 target state as the most westward (Utah (Appendix A, Figure A-14) and Arizona (Appendix A, Figure A-17)); and there was one map each for State Zone 3, State Zone 4 and State Zone 5 with a similar scheme. (The most westward target states were South Dakota for State Zone 3 (Appendix A, Figure A-13), Oklahoma for State Zone 4 (Appendix A, Figure A-20), and Illinois for State Zone 5 (Appendix A, Figure A-3)).

Although a random qualitative color scheme of four hues (picked randomly from seven qualitative color choices) were assigned to each map, the schemes were designed so that no one hue appeared more times as either the target or non-target categories. The order of the legends was also randomized to make sure that the target category was not always appearing first in the legend. Thus, hues were evenly represented in terms of what they represented (target or non-target states) and where they were placed in the legends (first, second, third or fourth positions).

Quantitative/County-cluster Maps

For the quantitative/county-cluster maps, 14 county clusters of roughly the same size and shape were created in order to minimize those visual variables during the decision-making process (Figure 8). Each county cluster was comprised of three rings:

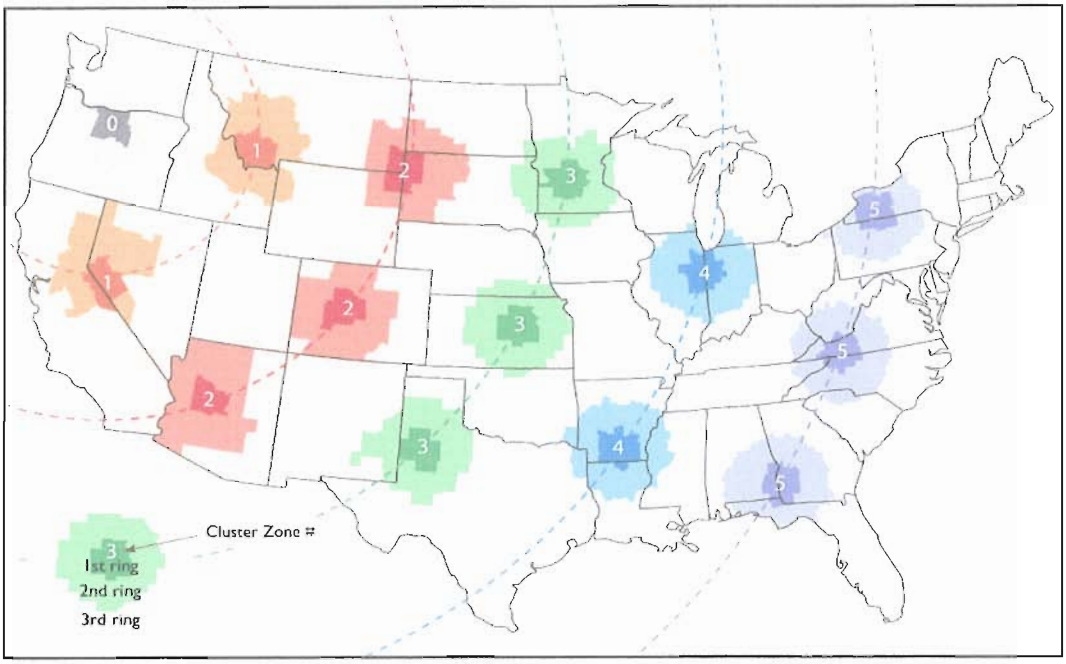


Figure 8. Cluster zones for quantitative/county-cluster maps.

the first ring (or core ring) was the smallest with a diameter of roughly 30 pixels but was designed to represent the greatest amount of a particular phenomenon. The second ring, located just outside the core, had a total diameter of 70 pixels and represented the second-greatest amount of the same phenomenon. And the third ring had a 110-pixel diameter and represented the third-highest value of the phenomenon. Everything outside of the three-ring clusters was considered to have the lowest value of the phenomenon. One county cluster was placed in north central Oregon, and 13 others were placed at regular distance intervals from its center. Each concentric zone was 135 pixels away from the Oregon cluster and were placed as follows:

- Cluster Zone 1 (135 pixels away from Oregon cluster): Montana and Nevada
- Cluster Zone 2 (270 pixels away): Arizona, Colorado, and South Dakota

- Cluster Zone 3 (405 pixels away): Kansas, Minnesota, and Texas
- Cluster Zone 4 (540 pixels away): Arkansas and Illinois
- Cluster Zone 5 (675 pixels away): Georgia, New York, and Virginia

The distance of 135 pixels was chosen in order to allow for proper spacing between each zone and to ensure that the entire map was covered.

Each of the 17 county-cluster maps contained a total of three county clusters, chosen at random, with nine of the maps featuring the Oregon cluster in the target and eight of them with no Oregon cluster. The schemes featured different combinations of clusters in nearby and faraway zones.

Nine of the 17 county-cluster maps had the Oregon cluster in the target category; of those, three maps contained a cluster from Cluster Zone 1, two contained a cluster from Cluster Zone 2, two contained a cluster from Cluster Zone 3, and one contained a cluster from Cluster Zone 4 as the next-most westward cluster on the map.

In the other eight county-cluster maps in which the Oregon cluster was not in the target category, five of the maps contained a cluster from Cluster Zone 1, two contained a cluster from Cluster Zone 2, and one contained a cluster from Cluster Zone 3 as the most westward cluster on the map. Again, just as with the qualitative/state maps, the idea was to weight the maps with more target states farther west and closer to the Oregon cluster.

Five different graduated-color ramps of four classes each were used, each based on changes in value (from light to dark). They were: red, blue, orange, green and violet and based on colors retrieved from ColorBrewer.org (Brewer 2010). Each color ramp was randomly assigned to each map with red and orange used four times each, and blue, green and violet used three times each.

Which ring participants were asked to choose was also randomized. Six times, participants were asked to identify phenomena in the first ring, while target phenomena was placed in the second and third rings five times each. (See Appendix B, Table B-4, for a map-by-map breakdown of county-cluster locations, color schemes and target-ring assignments.)

Fictitious Phenomena

In order to eliminate the possibility of participants equating particular states or regions with certain activities (such as Iowa = corn production, or Michigan = car manufacturing), it was necessary to generate fictitious phenomena for the themes of each map. For example, if participants were shown a four-classed qualitative choropleth map of the coterminous U.S. depicting predominant crop production in each state (the choices could be wheat, corn, soybeans and cotton) and asked to choose a state in which cotton production is predominant, participants might choose states they think are major cotton producers (states in the South, for instance), instead of choosing states they see depicting high cotton production on the map. Using fictitious preferences for the state maps worked well with the qualitative color schemes, while depicting varying degrees of fictitious phenomena worked better with the qualitative county-cluster maps (Appendix B, Table B-5 and Table B-6). The color schemes, decision statements (e.g., "Click a region with the highest degree of preference for belt sanders" or "Click a state with a preference for satin gowns"), legend order, and phenomena degree were all randomized. Careful consideration was given to the topics of the decision statements to make sure that the phenomena were not easily connectable to any particular states or regions. The topics, in fact, bordered on the inane in order to ensure that participants would simply read the maps rather than try to draw on previous knowledge or suspicions about certain places.

Map Quiz

U.S. state-name knowledge was tested through the creation of a computerized map quiz designed to follow the map-reading task. The quiz map was the same size as those in the map-reading task, and each state was shaded with the same hue (light blue). After a brief instructional screen, participants were shown a map of the lower 48 states with a statement asking them to identify a particular state. They were instructed to click the location of the state in the statement to move on to the next screen. All 48 states were included in the quiz and were placed in random order. The color and size of the map was the same for each question.

Test Construction

Using a U.S. base map from ESRI with an equal-area projection, the national, state and county borders were all simplified in ArcMap 9.3 for easier reading, smaller file sizes and faster rendering time. A base map of state borders only was exported to Adobe Illustrator where each state polygon was converted into a separate movie clip. This was done so that actions could be applied to them once they were exported to Adobe Flash.

The same base map was copied and exported to Illustrator for the creation of the 18 qualitative/state map images. Once the color schemes (and thus the category assignments for each of the state maps) were applied, the images were saved as portable network graphics (PNGs) for importation into Flash. The process was repeated for the 17 county-cluster maps, though instead of applying colors to each state, three of 14 different county clusters were placed in their proper locations on the map and given their proper graduated color ramp. These images were also saved as PNGs.

The states-only base map was then exported to Flash where the alpha (or transparency) was set to zero, rendering it invisible. Using ActionScript 3, actions designed to measure what was clicked on (including both the state name and the XY pixel coordinate) were created so the participants' mouse clicks could be stored and captured for later analysis. One by one, the state and county-cluster PNGs were imported onto the Flash timeline in their previously determined randomized order, all appearing directly over the invisible states-only map layer with the mouse-click-capture actions applied to it. This invisible mesh overlay was created so that actions would not have to be reapplied to each of the 35 maps, thereby reducing file size and allowing for the application to run more smoothly. File size was further reduced by using PNGs rather than filling in all of the hues in Flash itself. One single map and set of actions was created for the quiz, and only the text changed from frame to frame.

ActionScript 3 code captured each participant's data into a text file. Data included which states were clicked on during the map-reading task, and the corresponding XY pixel location of that click (the origin was a point just northwest of the state Washington

– X values grew larger with eastward mouse movement; Y values grew larger with southward mouse movement).

Survey

The final part of the test instrument was a short demographic survey (Appendix C). It was originally intended to be administered via computer, but time constraints and programming difficulties made it untenable. The alternative, then, was to administer it on paper and input the data into a spreadsheet manually. Participants were asked to identify their age, sex, country of citizenship, major or degree, current occupation, and to list the all the places they had lived (including the years they had lived there and the duration of their stay). Lastly, participants were asked to identify one state they would consider to be their "home state."

Participants and Recruitment

Seventy-five students from the University of Oregon were recruited via e-mail or in person for the experiment (Appendix D); each signed a consent form (Appendix E) and was paid $10 for his or her participation. Participation was open to anyone over 18 who was not colorblind. People who are colorblind, which constitutes 11 percent of the population (Krygier and Wood 2005), were excluded because it would not be possible for them to discern differences between greens and reds, two colors which were used in various combinations in the experiment (Krygier and Wood 2005, Brewer et al. 1997).

A colorblind-friendly scheme was not possible due to the number of maps and color combinations needed to effectively investigate the research questions.

Test Procedure

Following their signed consent, participants were assigned three-digit random identification numbers for privacy, and the consent forms with their identifying numbers (and names and signatures) were kept in a secure location. The consent forms were the only materials, then, that contained both the participants' names and their identification numbers. Identification numbers were then used on all subsequent testing materials, including the survey. Each of the text files exported from Flash was given the participant's corresponding three-digit identifications number as well.

Each participant took the computer portion of the experiment on the same laptop computer at the same desk in the Spatial and Map Cognition Research Lab at the University of Oregon. The order of the images for the map-reading task and the map-quiz task were the same for everyone. Following the computer-based test, which took participants between 10 and 20 minutes to complete, a paper survey with the corresponding identification number already attached was completed on a nearby table. It took participants between five and 10 minutes to fill out the survey. Once participants were done with the computer-based test, the data window capturing the state names and XY locations of his or her mouse clicks in Flash was first saved to a text file, then to a Microsoft Excel spreadsheet. All of the data were eventually copied into a master spreadsheet for later analysis.

CHAPTER IV

ANALYSIS AND RESULTS

Analysis of the data collected from the map-reading task, map quiz, and survey was completed using linear regression models to ascertain how the various dependent and independent variables related. A t-test was administered in order to determine which participants were Oregonians and which ones were not was statistically similar, as well as to determine whether the results from the map-reading task were statistically different between Oregonians and non-Oregonians.

A total of 75 people participated in the experiment, however, the results of four of them were not considered in the final analysis because they reported their citizenship to foreign countries in the survey. Since the map-reading task was focused on U.S. states and the quiz portion of the test focused on U.S. state-name knowledge, it did not seem appropriate to include their data in the analysis.

Independent Variables

Four of the five independent variables used in the analysis were extracted from the survey data: age, sex, major, and home state. The participants were relatively young (the mean age was 22 and 92 percent of the sample was 25 years or younger), majority male (59 percent), and came from several different areas of study. Geographers, which included those who reported geography or GIS as their major, made up 32 percent of the sample. Of the non-geographers, 35 percent were business, business administration, economics, accounting or marketing majors.

Participants were asked to identify all of the different states or countries they had lived in and to report the duration they had spent in each place; they were also asked to identify one home state. The time spent in Oregon was calculated as a percentage by taking the number of years they lived in each place and dividing by their age. Thus time became the independent variable "percent of life lived in Oregon."

Thirty-seven participants (52 percent) lived in Oregon more than half of their lives – 65 percent of whom reported Oregon as the only state they had ever lived in. However, 44 participants (62 percent) chose Oregon as their home state. For the seven people who reported Oregon as their home state but actually lived in the state less than half of their lives, their collective mean time in Oregon was only 15 percent. It was thus necessary to determine which method to use for determining who was an Oregonian and who was a non-Oregonian for the statistical comparison – self-reported home state or percent of life lived in Oregon.

If individual attitudes are shaped by the types of maps to which people are exposed as suggested by Kitchin (1994) and Gould (1973), it is not unreasonable to assume that where a person actually grew up is more important than with what state a person identifies.

A series of t-tests (Table 1) using the independent variables of age, sex and major was performed in order to ensure that deriving the independent variable of percent of life lived in Oregon was statistically indistinguishable from the self-reported independent variable of home state. Equal variances in each t-test were confirmed through a corresponding series of F-tests. In comparing the samples of self-reported Oregonians and the derived subset of those participants who reported living in Oregon more than half of their lives, the results clearly show that the means of age, sex and major are all indeed statistically indistinguishable. Thus, percent of life lived in Oregon was used as the independent variable for home state.

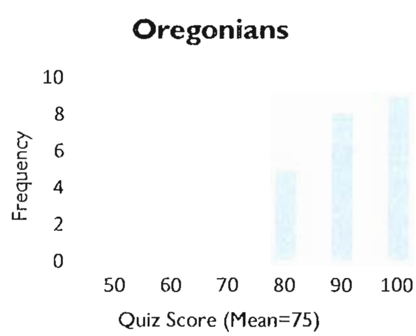
Table 1. Comparing self-reported and calculated measures of home state.

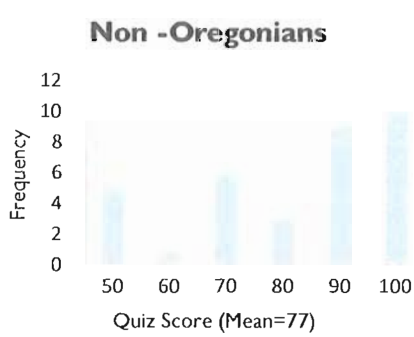
t-tests (assuming equal variances)	AGE		SEX (1 = male)		MAJOR (1 = geog.)	
	OR (rep)	*OR (pct)*	*OR (rep)*	*OR (pct)*	*OR (rep)*	*OR (pct)*
Mean	21.818	20.459	0.568	0.595	0.273	0.216
Variance	37.082	5.644	0.251	0.248	0.203	0.174
Observations	44	37	44	37	44	37
Pooled Variance	22.756		0.250		0.190	
Hypothesized Mean Diff.	0		0		0	
df	79		79		79	
t Stat	1.277		-0.237		0.581	
P(T<=t) one-tail	0.103		0.407		0.281	
t Critical one-tail	1.664		1.664		1.664	
P(T<=t) two-tail	0.205		0.813		0.563	
t Critical two-tail	1.990		1.990		1.990	

OR (rep) = Oregonians (self-reported by participant)
OR (pct) = Oregonians (calculated as percentage of life lived in Oregon)
Since P > .05, the null hypothesis that the means are equal is accepted for all variables

The last independent variable came from the second part of the computer portion of the experiment: the 48-state map quiz. Participants were scored based on the percentage of correct answers. In reviewing the results, a problem of lag time was discovered with the Flash interface. Some participants apparently clicked a state more than once when the frame refused to advance. Unfortunately, their second mouse-click was recorded on the subsequent frame, thereby registering an erroneous result in the data output file. These obvious double-clicks (and in a few cases, triple-clicks), were disregarded and the percentage of correct answers was adjusted accordingly; only 0.85 percent of all of the quiz frames were disregarded.

The overall mean score for the map quiz was 76 percent correct. When divided into two groups, Oregonians and non-Oregonians performed slightly differently but the difference was not significant (Figure 9). Oregonians had no trouble locating states along the West Coast (Washington, Oregon and California), in central west and northern Plains (Idaho, Nevada, Utah, Montana, North Dakota, and South Dakota), and those with unique, jutting shapes along the edges of the map (Texas, Florida, and Maine). They faltered, however, with many states in the central part of the country (particularly





t-Test: Two-Sample Assuming Equal Variances

Quiz scores	*OR*	*NOR*
Mean	74.626	77.353
Variance	388.628	288.538
Observations	37	34
Pooled Variance	340.759	
Hypothesized mean diff.	0	
df	69	
t Stat	-0.622	
P(T<=t) one-tail	0.268	
t Critical one-tail	1.667	
P(T<=t) two-tail	0.536	
t Critical two-tail	1.995	

OR = Oregonians
NOR = Non-Oregonians

Figure 9. Distribution of quiz scores and correpsonding t-test.

Arkansas, Indiana, and Missouri), and confused Colorado and Wyoming, and, to a lesser degree, Arizona and New Mexico (Figure 10).

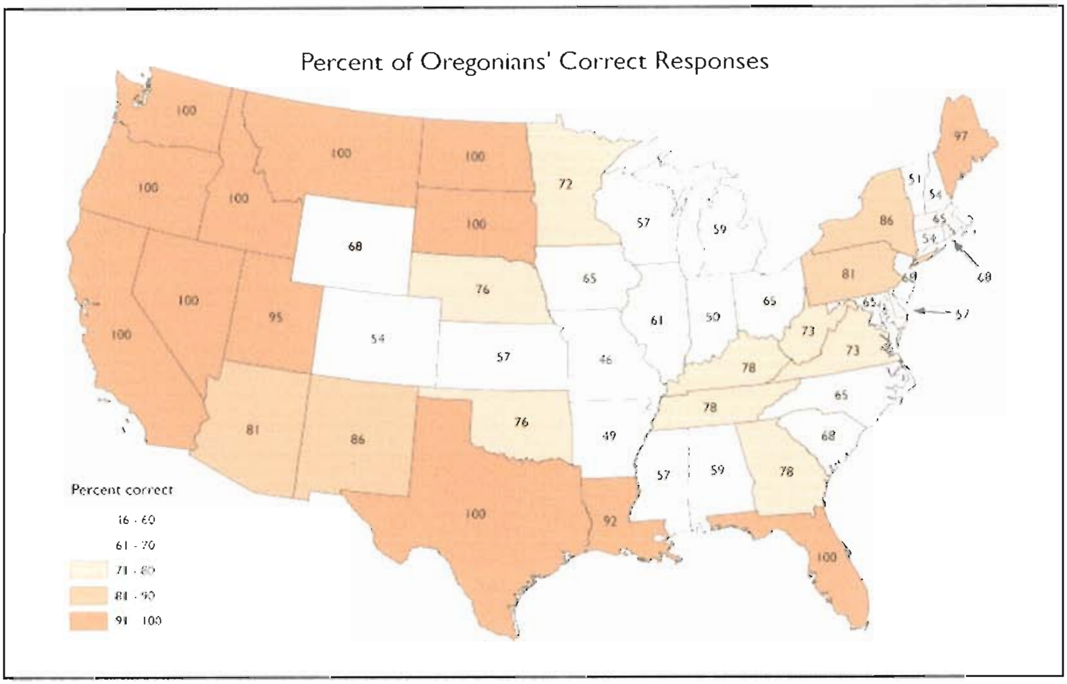


Figure 10. Oregonians' quiz scores.

Non-Oregonians' state-by-state knowledge was similar, but as a group they had a better grasp on the difference between Colorado and Wyoming, and Arizona and New Mexico. They also performed better with states in the central part of the country (Figure 11).

In comparing Oregonians' and non-Oregonians' quiz scores (Figure 12), it is apparent that Oregonians had a slightly better understanding of the states bordering Canada from Washington to North Dakota, and in particular had higher scores for Pennsylvania (a mean score of 8 percent better), Iowa (9 percent) and, curiously, Kentucky (15 percent). Non-Oregonians, on the other hand, had a greater understanding

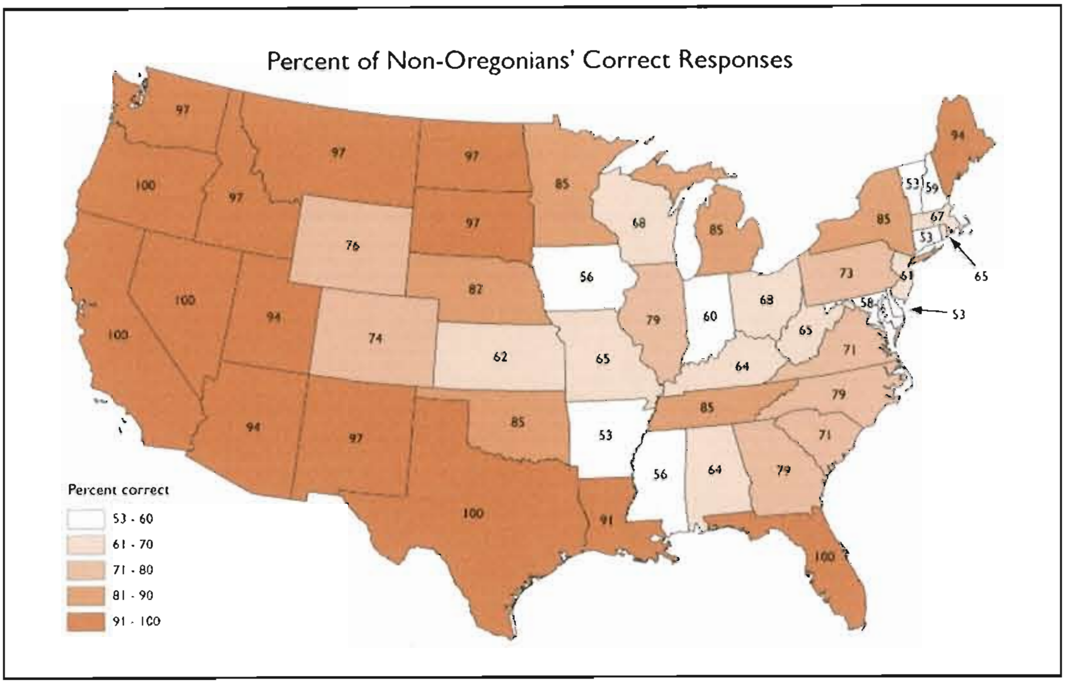


Figure 11. Non-Oregonians' quiz scores.

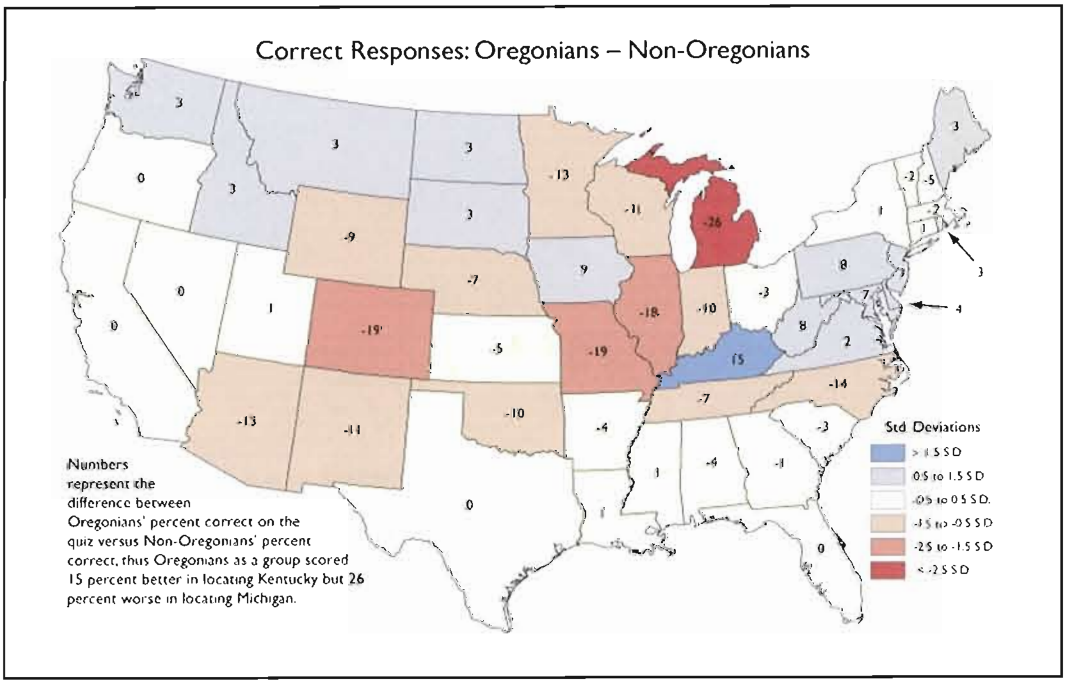


Figure 12. Comparing Oregonians' and non-Oregonians' quiz scores.

of the Midwest, the central Plains, and the Southwest, and particularly Illinois (a mean score of 18 percent better), Missouri (19 percent), and Michigan (26 percent). Both groups had a relatively equal understanding of the West, the Southeast, and the Mid-Atlantic states.

Dependent Variables

Two dependent variables were used for analysis – mean pixel distance from each participants' selection to the Oregon state or county-cluster centroid, and the number of times each participant selected Oregon when it was in the target category.

Mean Pixel Distance

To determine the mean pixel distance to Oregon from states or county-clusters selected during the map-reading task, the centroid of each polygon was determined using the pixel grid (Figure 13 and Figure 14). The XY coordinates were then used to determine a Euclidian distance for each of the 35 maps in the map-reading task (Table 2 and Table 3).

As was the case with the map quiz, a small number of erroneous clicks recorded due to the lag issue in the Flash application were discarded. A number of incorrect selections resulting from clicking on states county clusters that were not in the target category were also removed from analysis. These made up only 1.2 percent of the total clicks in the map-reading task.

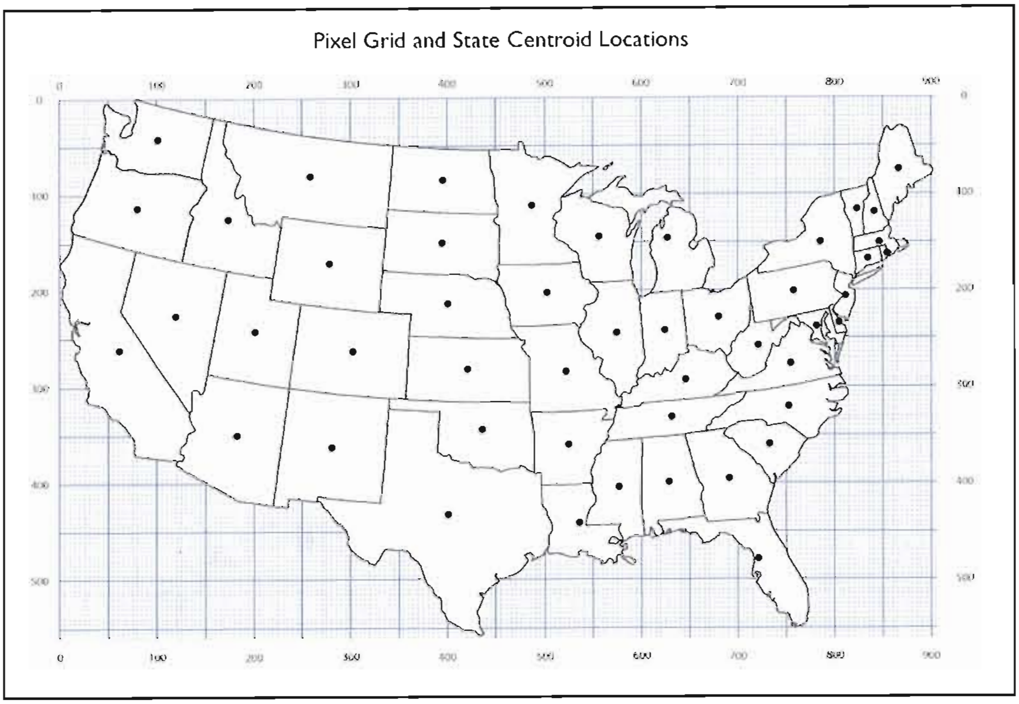


Figure 13. Pixel grid used to determine state centroid locations.

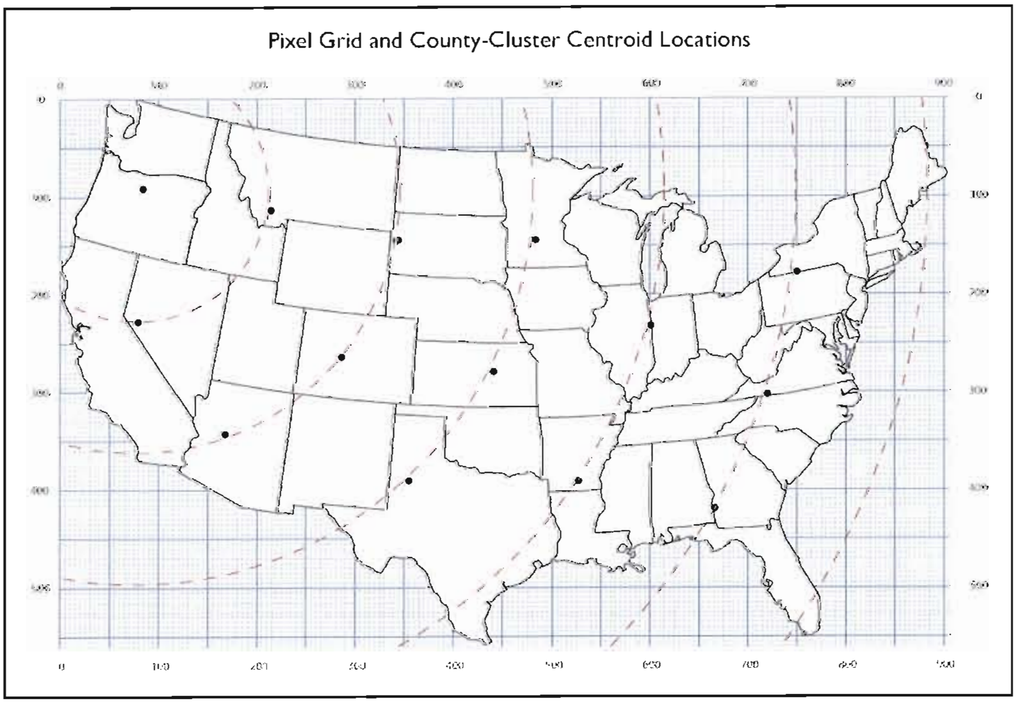


Figure 14. Pixel grid used to determine county-cluster centroid locations.

Table 2. XY pixel coordinates of county-cluster centroids.

ZN	CL	X1	Y1	X2	Y2	X3	Y3	XAV	YAV	DOR
0	OR	83	90	78	94	86	93	82	92	0
1	MT	209	115	213	110	215	118	212	114	132
1	NV	77	238	73	221	80	228	77	229	137
2	SD	338	135	348	135	341	135	342	135	264
2	CO	286	264	285	267	281	263	284	265	266
2	AZ	167	344	166	344	161	343	165	344	265
3	MN	480	143	479	145	483	147	481	145	403
3	KS	439	277	438	281	441	281	439	280	403
3	TX	353	390	352	391	353	394	353	392	404
4	IL	599	228	599	234	600	236	599	233	536
4	AR	524	389	525	394	527	394	525	392	535
5	NY	747	173	747	181	751	180	748	178	668
5	VA	718	301	719	301	718	306	718	303	670
5	GA	666	424	663	422	663	415	664	420	668

ZN = zone#, CL = cluster name, DOR = distance to OR cluster centroid
X1, Y1 = x coordinate and y coordinate of 1st-ring centroid
X2, Y2 = x coordinate and y coordinate of 2nd-ring centroid
X3, Y3 = x coordinate and y coordinate of 3rd-ring centroid
XAV, YAV = average of x and y coordinates of all three rings' centroids

Table 3. XY pixel coordinates of state centroids.

ST	X	Y	DOR	ZN		ST	X	Y	DOR	ZN
OR	80	115	0	0		IN	621	244	556	6
WA	102	44	74	1		LA	535	443	561	5
ID	174	127	95	1		MS	576	405	575	6
NV	120	228	120	1		TN	629	332	590	5
CA	62	262	148	1		KY	643	293	590	5
UT	200	244	176	2		OH	678	229	609	6
MT	258	82	181	2		AL	627	399	616	6
WY	278	174	207	2		WV	719	258	655	6
AZ	183	352	258	2		GA	690	396	672	6
CO	300	265	266	3		PA	756	203	682	7
ND	395	87	316	3		VA	753	277	692	6
SD	395	152	317	3		SC	731	362	696	7
NM	281	362	318	3		NC	751	322	702	6
NE	400	215	335	3		NY	783	151	704	8
KS	421	282	380	4		MD	780	239	711	7
MN	486	113	406	4		DE	802	235	732	8
OK	435	346	424	4		FL	719	478	735	7
IA	501	204	430	4		NJ	810	206	736	8
TX	400	434	452	4		VT	821	117	741	9
MO	520	285	472	4		CT	834	169	756	9
WI	554	147	475	5		NH	840	121	760	10
AR	524	359	507	5		MA	845	152	766	9
IL	574	245	511	5		RI	852	162	773	10
MI	625	148	546	6		ME	865	76	786	11

ZN = zone#, ST = state name, DOR = distance to OR centroid

Using a t-test, the total mean pixel distance between the Oregonian and non-Oregonian groups was found to be different at a 0.041 significance level, with participants in the Oregonian group clicking locations nearly 41 pixels closer on average than the non-Oregonians (Table 4). A t-test was used instead of a chi-squared test because the comparison was between *actual* outcomes not *predicted* outcomes, and a normal distribution was confirmed using a Kolmogorov-Smirnov test.

Table 4. Comparing mean pixel distance between Oregonians and non-Oregonians.

t-test (assuming equal variances)	*OR*	*NOR*
Mean pixel distance	291.260	331.019
Variance	7892.313	5591.156
Observations	37	34
Pooled Variance	6791.760	
Hypothesized Mean Diff.	0	
df	69	
t Stat	-2.082	
P(T<=t) one-tail	0.021	
t Critical one-tail	1.667	
P(T<=t) two-tail	0.041	
t Critical two-tail	1.995	

OR = Oregonians
NOR = Non-Oregonians

P < .05, the null hypothesis of equal means is rejected

State and County-Cluster Selections

On a map-by-map basis, a t-test revealed that Oregonians selected Oregon at a higher percentage at a 0.001 significance level than non-Oregonians when the state or Oregon county-cluster was in the target category (Table 5). (See Appendix F for a complete map-by-map breakdown.) Oregonians clicked on their home state almost 16 percent more on average than non-Oregonians. In fact, non-Oregonians chose Oregon

Table 5. Percentage of clicks on Oregon when Oregon was in the target category.

Map#	OR	NOR
4	57	27
5	57	44
6	49	22
7	46	24
8	35	24
11	41	9
12	51	32
15	50	26
21	41	45
22	49	55
23	31	21
24	46	24
26	44	16
27	43	35
29	38	22
30	57	56
32	19	9
35	22	6

t-test *	*OR*	*NOR*
Mean	43.111	27.611
Variance	120.575	214.369
Observations	18	18
Pooled Variance	167.472	
Hypothesized Mean Diff.	0	
df	34	
t Stat	3.593	
P(T<=t) one-tail	0.001	
t Critical one-tail	1.691	
P(T<=t) two-tail	0.001	
t Critical two-tail	2.032	

P < .05, null hypothesis of equal means is rejected

OR = Oregonians
NOR = Non-Oregonians

* assuming equal variances

more often in only two of the 18 Oregon-target maps (Map 21 and Map 22) and then by only 4 and 5 percent, respectively.

A final t-test comparing the means of the number of times Oregonians as a group selected Oregon in the target category versus the number of times non-Oregonians as a group selected Oregon in the target category confirms that Oregonians selected Oregon more times on average than non-Oregonians (Table 6). This difference was significant at the 0.012 level.

Regression

Linear regression was employed to further explore the relationships between the various dependent and independent variables. The mean pixel distance to Oregon was regressed against the five independent variables of age, sex, major, quiz score, and home

Table 6. Comparing mean number of Oregon selections for Oregonian and non-Oregonian groups.

t-test (assuming equal variances)	*OR*	*NOR*
Mean	7.676	4.853
Variance	25.836	15.826
Observations	37	34
Pooled Variance	21.049	
Hypothesized Mean Diff.	0	
df	69	
t Stat	2.590	
P(T<=t) one-tail	0.006	
t Critical one-tail	1.667	
P(T<=t) two-tail	0.012	
t Critical two-tail	1.995	
P < .05, null hypothesis of equal means is rejected		
OR = Oregonians; NOR = Non-Oregonians		

state. The models show that only home state, defined as percent of life lived in Oregon, has any effect on mean pixel distance at the 0.05 significance level (p = 0.029) Thus, the Model 1 in Table 7 predicts that a 1 percent increase in the percent of life lived in Oregon variable results in a 0.518-pixel decrease in mean pixel distance to the Oregon state or county-cluster centroids. All other variables – including quiz score – had little or no effect on mean pixel distance to Oregon. A scatterplot and regression line in Figure 15 reveals the slight negative correlation of percent of life lived in Oregon to mean pixel distance to the Oregon centroids, however, there are several data points on both ends of the X-axis that fall well above and below the regression line.

Table 7. Linear regression coefficients for independent and dependent variables.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
% of life lived in Oregon	-0.518*					-0.546*
Quiz score		-0.164				-0.319
Major						
Non-geography (ref.)			---			---
Geography			-3.778			-9.280
Sex						
Female (ref.)				---		---
Male				21.409		24.098
Age					1.551	1.024
R^2	0.067	0.001	0.000	0.016	0.012	0.100
* p < 0.05						N=71 (all participants)

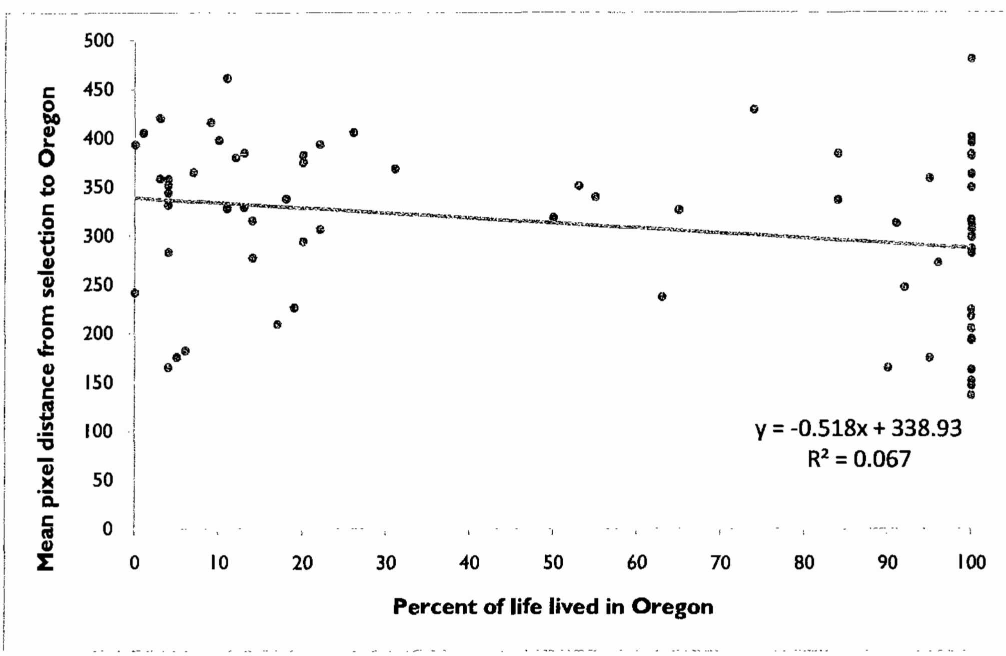


Figure 15. Scatterplot and regression line of home state and mean pixel distance.

CHAPTER V

DISCUSSION AND CONCLUSIONS

The goal of this thesis was to determine whether certain geographic and demographic factors influence an individual map reader's visual-search strategy and interpretation of classed thematic choropleth maps of the U.S. Understanding map readers' perspectives is a key component to the process of communicating spatial information via maps (MacEachren 1995). Much has been written about improving production and symbolization methods, yet few studies have addressed the idea of an egocentric map perspective. While the results did not show a positive relationship between age, sex, major or quiz score and mean pixel distance to the Oregon state and county-cluster centroids, a negative relationship – albeit a weak one – was discovered between home state and mean pixel distance. The more time participants spent living in Oregon, the shorter the mean pixel distance was between their selections and the Oregon centroids.

Thus, the answer to the first research question posed in Chapter I – "Do map readers exhibit 'egocentric' map behavior during the visual-search and decision-making processes when viewing classed thematic choropleth maps of the United States?" – appears to be yes. Since it is possible that people imbue their mental maps with knowledge about both the physical and cultural environments in which they are more familiar (Gould and White 1985, Gould 1975), participants who lived longer in Oregon might have drawn from their familiarity of Oregon's location (acquired from both their exposure to local maps and their navigational experience) and used that information to orient themselves when prompted to make decisions. The investigation of this question would have benefitted from recruiting participants from other regions of the country – the Midwest, Northeast or Southeast, perhaps – in order to confirm or deny the existence of an egocentric map perspective in those areas. Such an examination might have also revealed different levels of egocentrism in different parts of the country.

The answer to the second research question – "Do variables such as age, sex, and prior geographic knowledge significantly affect how such maps are read and discerned?' – would be no. It is apparent that these variables (at least for this particular population) have no significant effect on what locations map users choose on classed thematic choropleth maps. It was particularly surprising that quiz score, which was the dependent variable designed to measure prior geographical knowledge, was not a significant factor in determining the locations that participants selected. It might have been reasonable to assume that Oregonians who had less knowledge of U.S. state names and locations would have been more likely to click on states closer to Oregon because they were more familiar with states in their home regions. However, this was not the case. Oregonians with high and low quiz scores alike still chose locations closer to Oregon during the map-reading task than non-Oregonians. It is possible that a basic level of specific map knowledge of Oregon and its locational position in the U.S. was a stronger influence on participants' decision-making process than any kind of general map knowledge of the U.S.

Future studies may not only wish to confirm or deny the existence of an egocentric map perspective using samples from different locations around the U.S., but may also with to explore how different types of thematic map visualization – such as dot density, graduated symbol, isarithmic, dasymetric, and even cartogramic – might exaggerate or mitigate such a perspective, if it indeed exists.

Understanding that map readers might view the same maps through the egocentric lens of their individual experiences and thus extract their own messages is essential in understanding how maps effectively communicate spatial information. The results from this research are consistent with those of Saarinen (1999), which demonstrated that map sketchers tend to exaggerate their home areas, and Gould and White (1986) and Gould (1975), which concluded that people in certain regions appear to share their spatial images. This thesis contributes to this body of literature by demonstrating a relationship between map users' geographical perspectives and the choices they make when exploring classed thematic choropleth maps of the U.S.

APPENDIX A

MAPS IN THE MAP-READING TASK

Note: The following 35 maps appeared in this order during the map-reading task in the computer portion of the experiment.

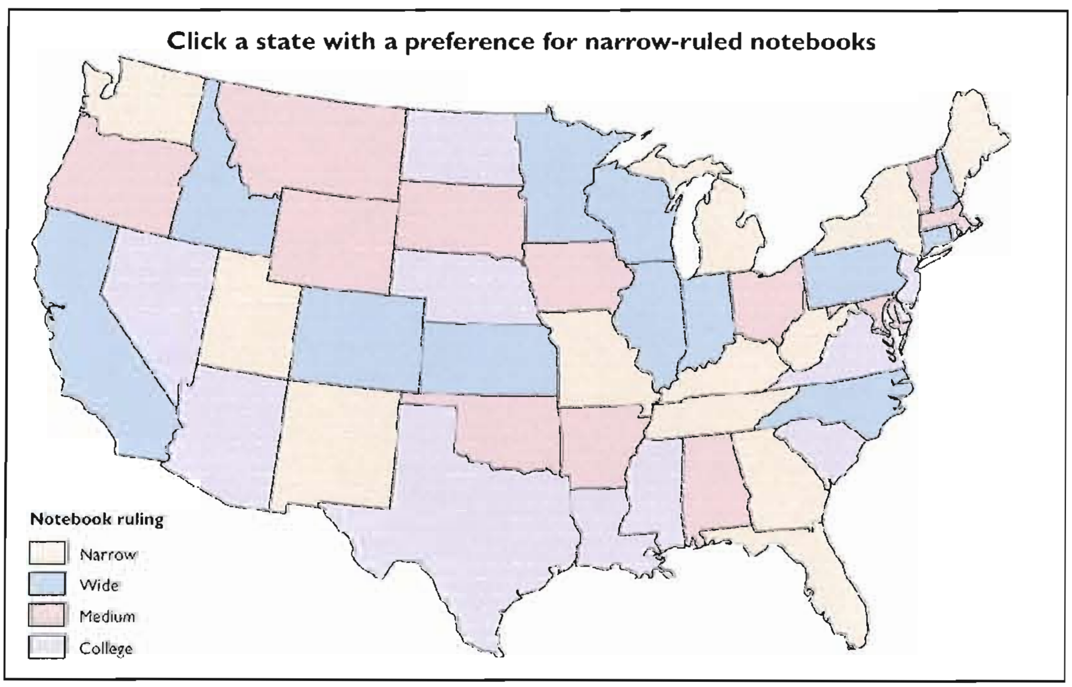


Figure A-1. Oregon not in target; Washington (State Zone 1) nearest target

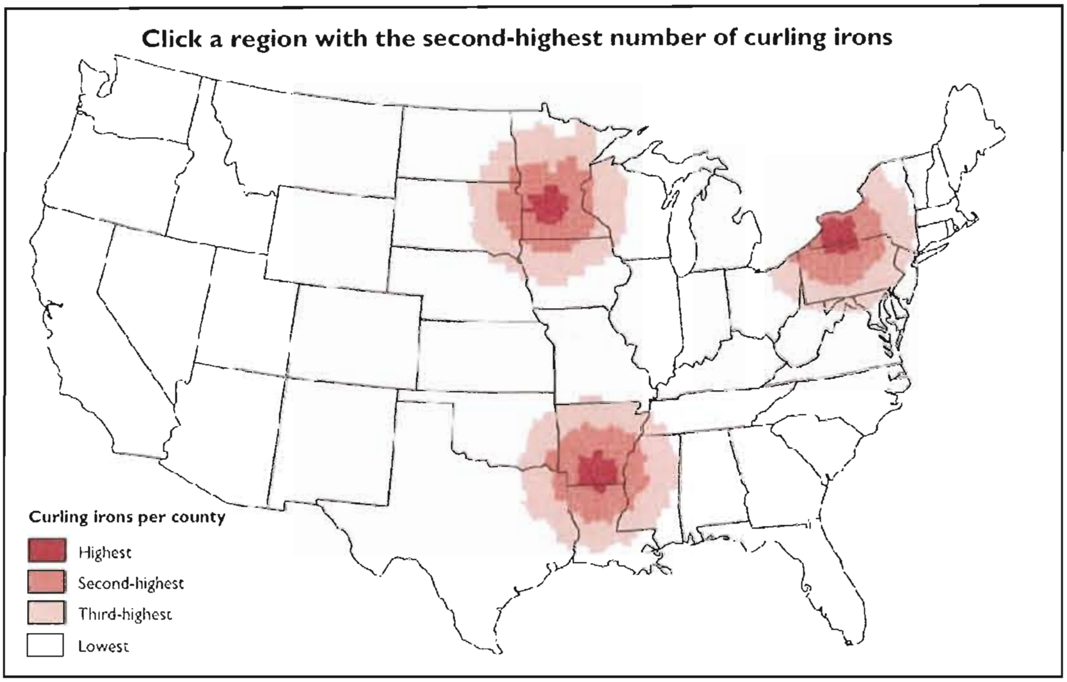


Figure A-2. Oregon cluster not in target; Minnesota cluster (Cluster Zone 3) nearest target.

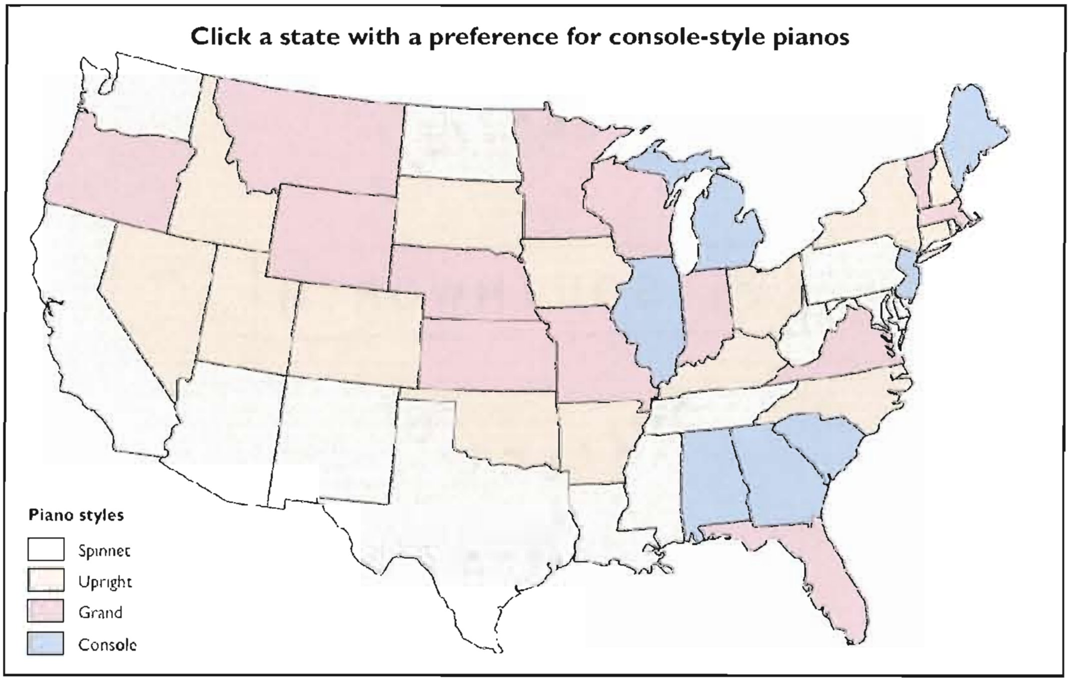


Figure A-3. Oregon in target; Montana (State Zone 2) next nearest target.

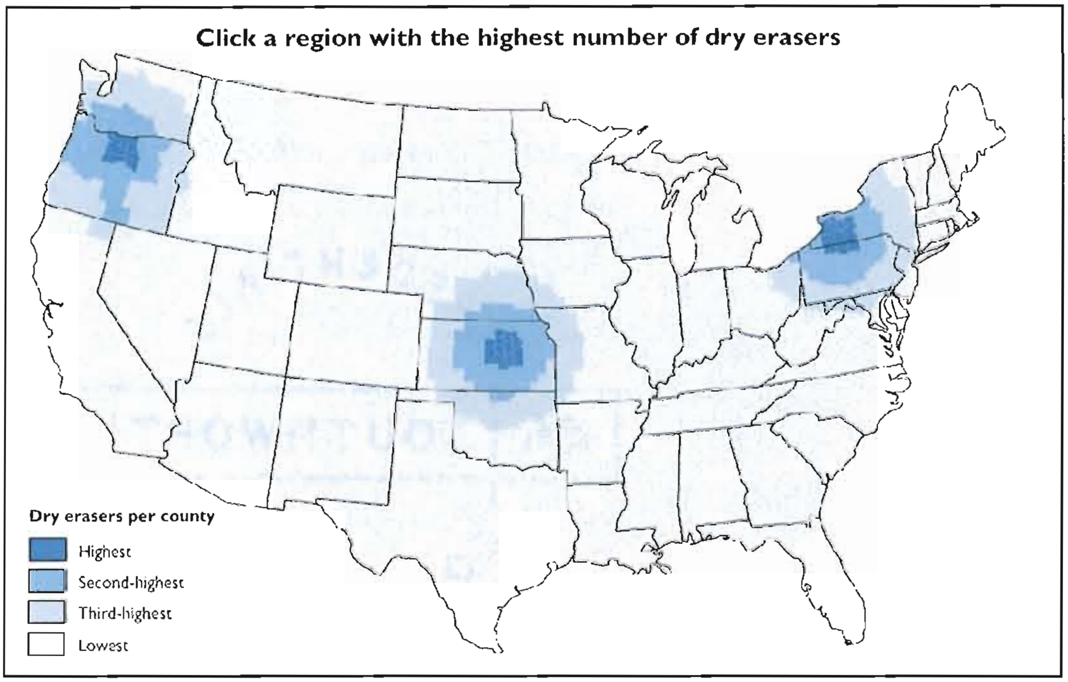


Figure A-4. Oregon cluster in target; Kansas cluster (Cluster Zone 3) next nearest target.

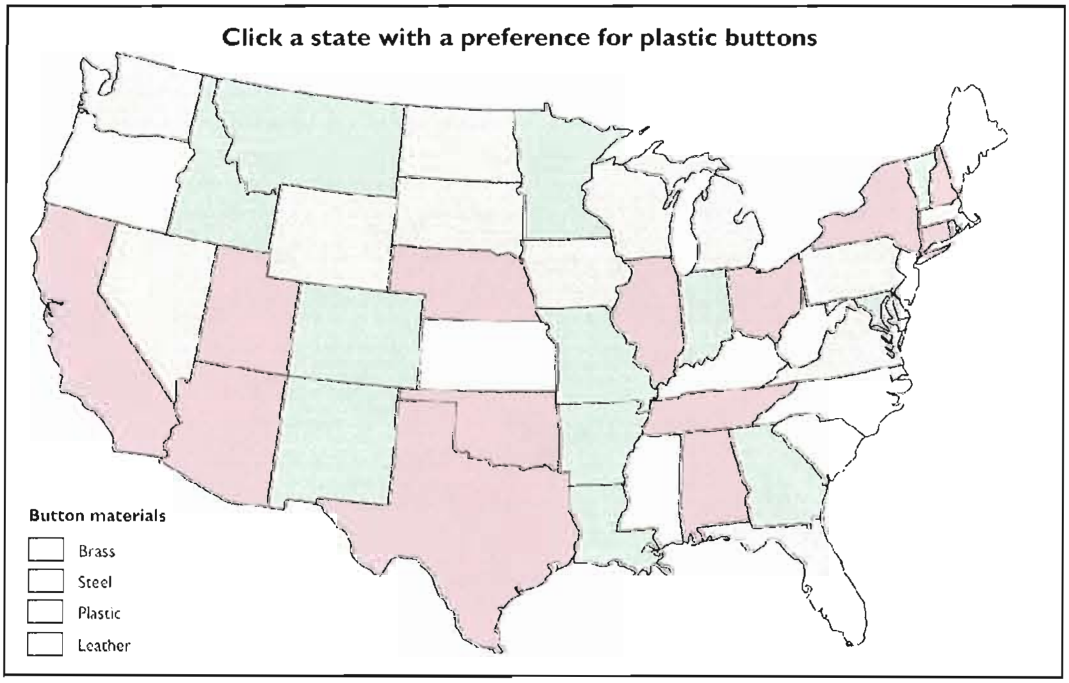


Figure A-5. Oregon in target; Kansas (State Zone 4) next nearest target.

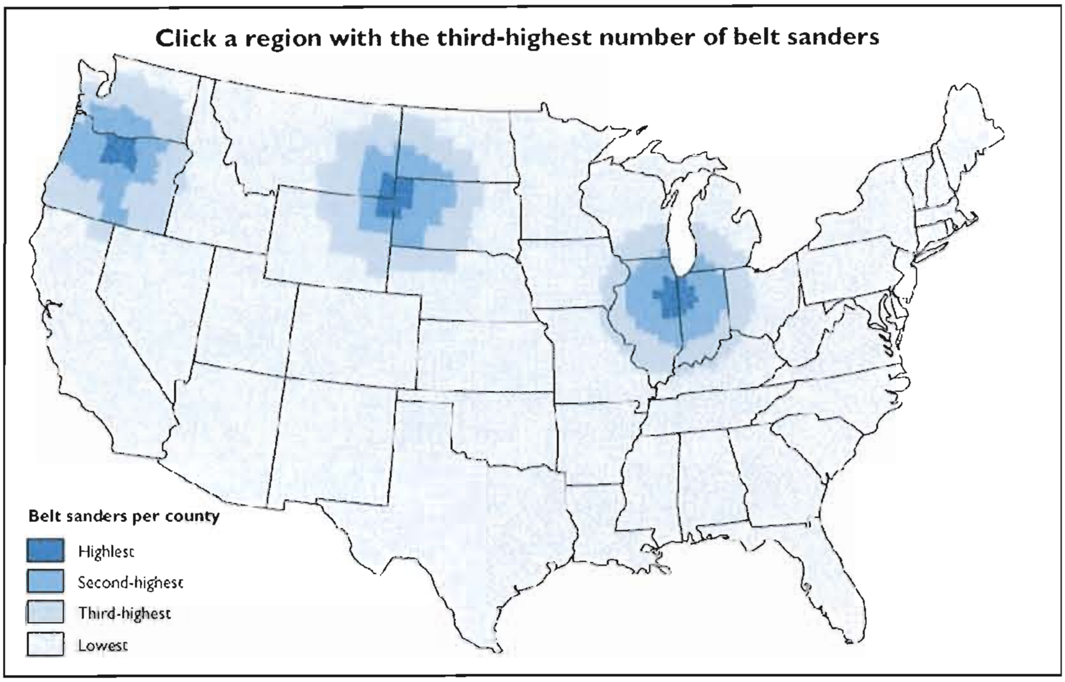


Figure A-6. Oregon cluster in target; South Dakota (Cluster Zone 2) cluster next nearest target.

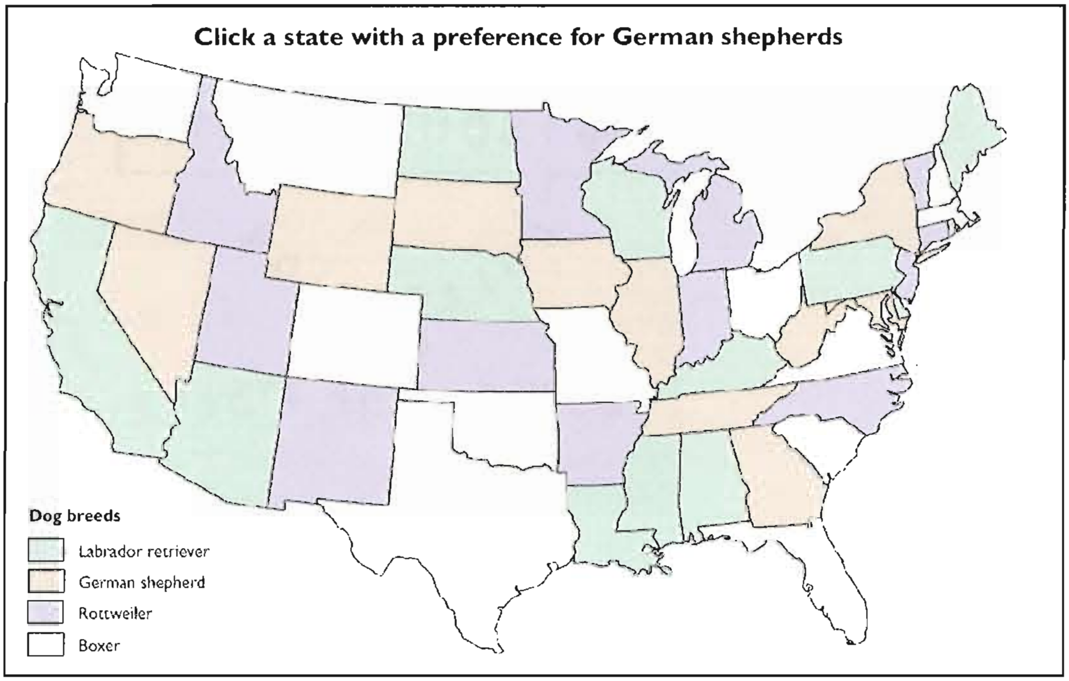


Figure A-7. in target; Nevada (State Zone 1) next nearest target.

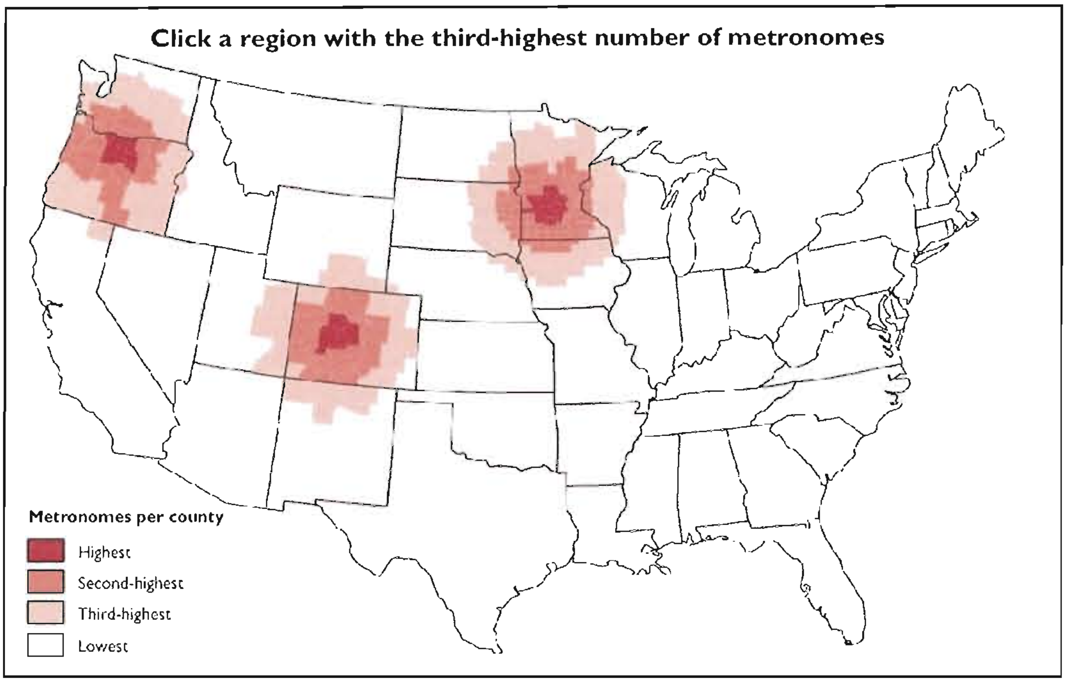


Figure A-8. Oregon cluster in target; Colorado cluster (Cluster Zone 2) next nearest target.

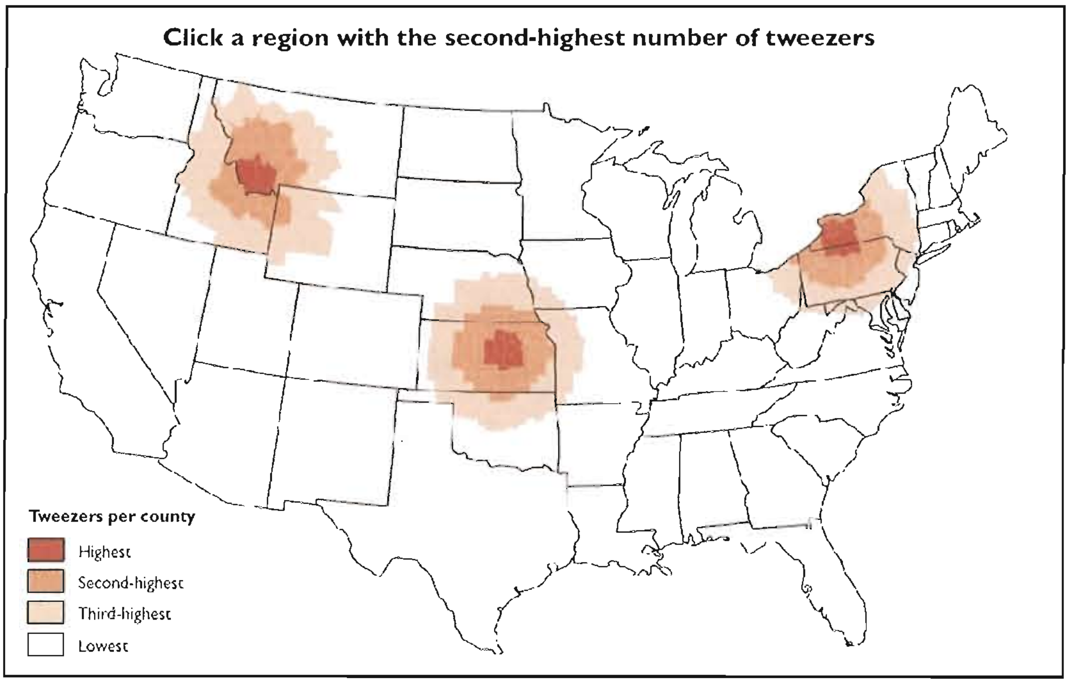


Figure A-9. Oregon cluster not in target; Montana cluster (Cluster Zone 1) nearest target.

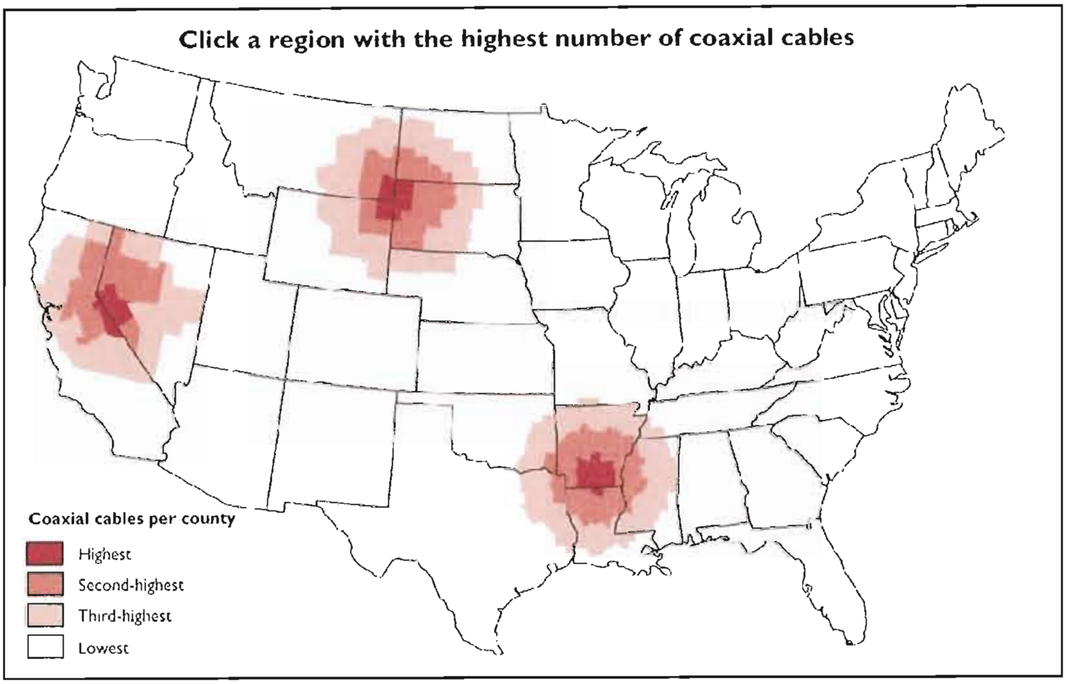


Figure A-10. Oregon cluster not in target; Nevada cluster (Cluster Zone 1) nearest target.

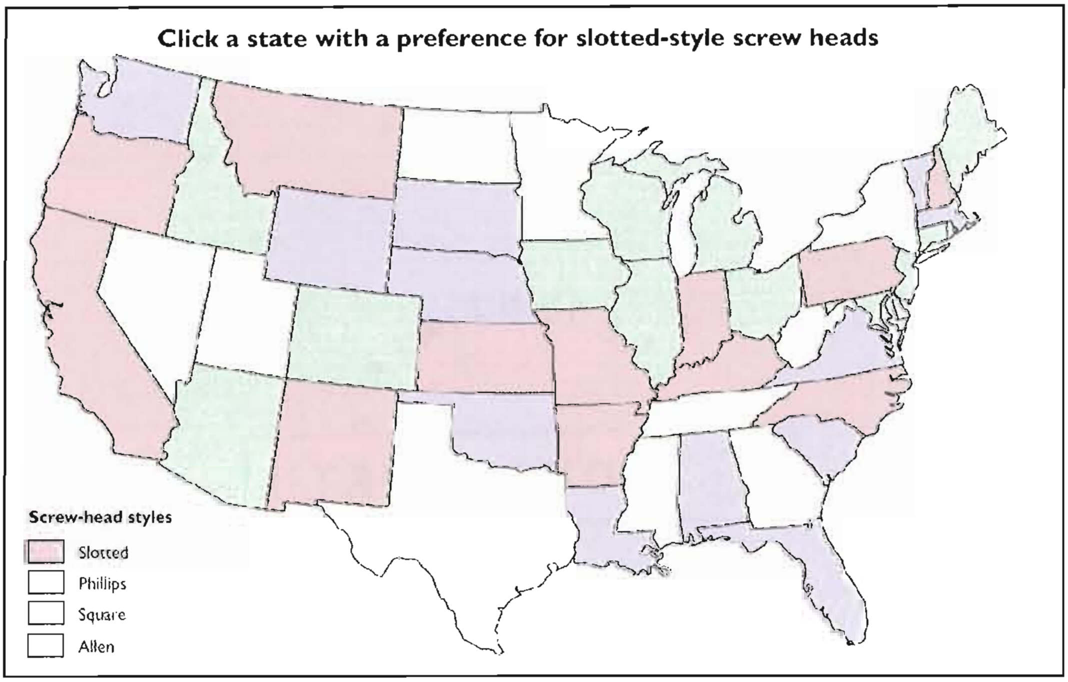


Figure A-11. Oregon in target; California (State Zone 1) next nearest target.

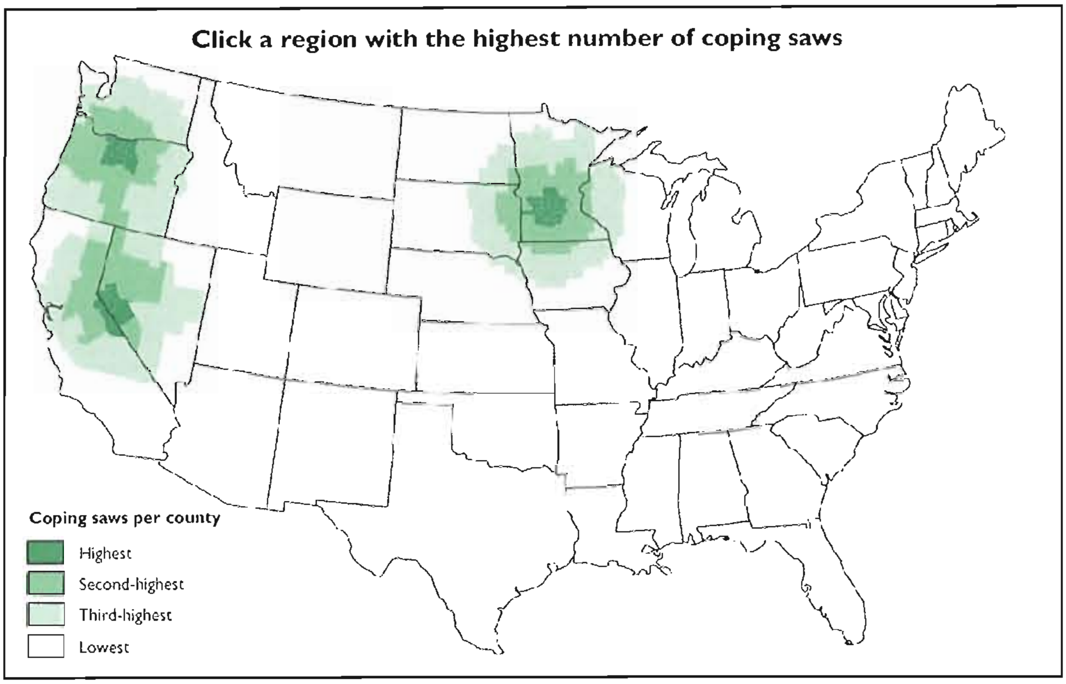


Figure A-12. Oregon cluster in target; Nevada cluster (Cluster Zone 1) next nearest target.

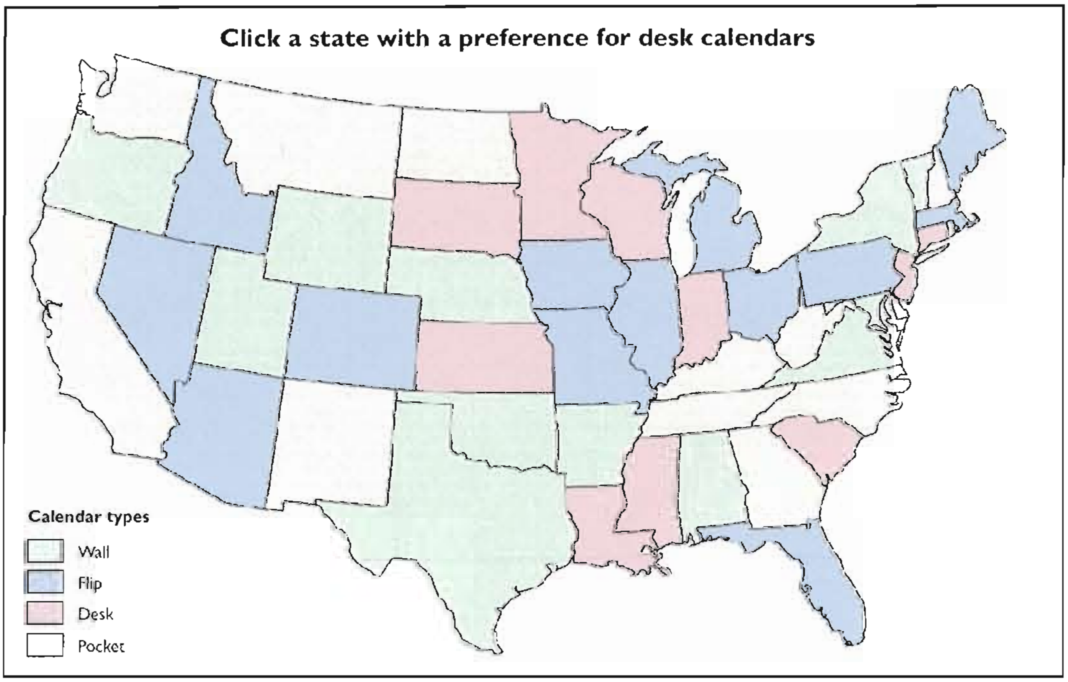


Figure A-13. Oregon not in target; South Dakota (State Zone 3) nearest target.

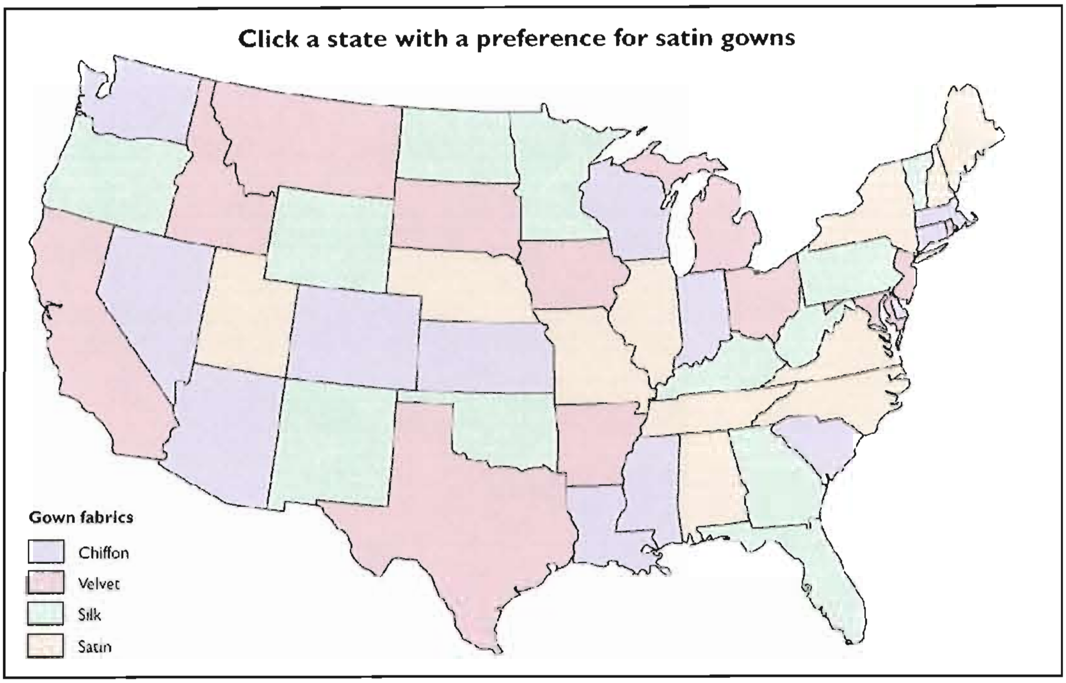


Figure A-14. Oregon not in target; Utah (State Zone 2) nearest target.

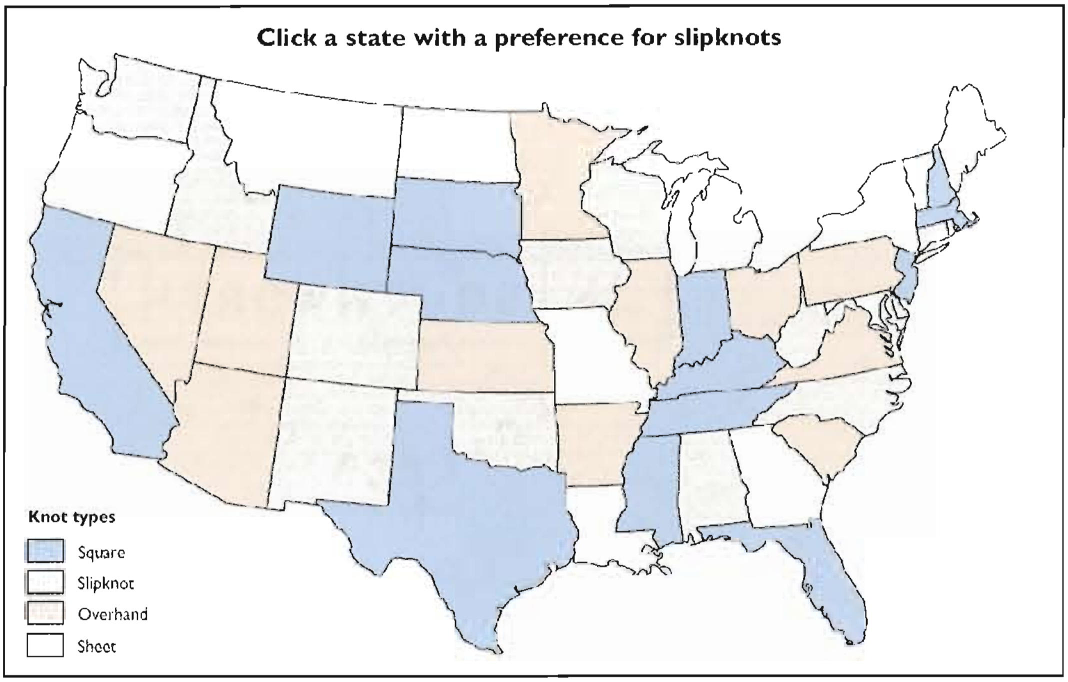


Figure A-15. Oregon in target; Montana (State Zone 2) next nearest target.

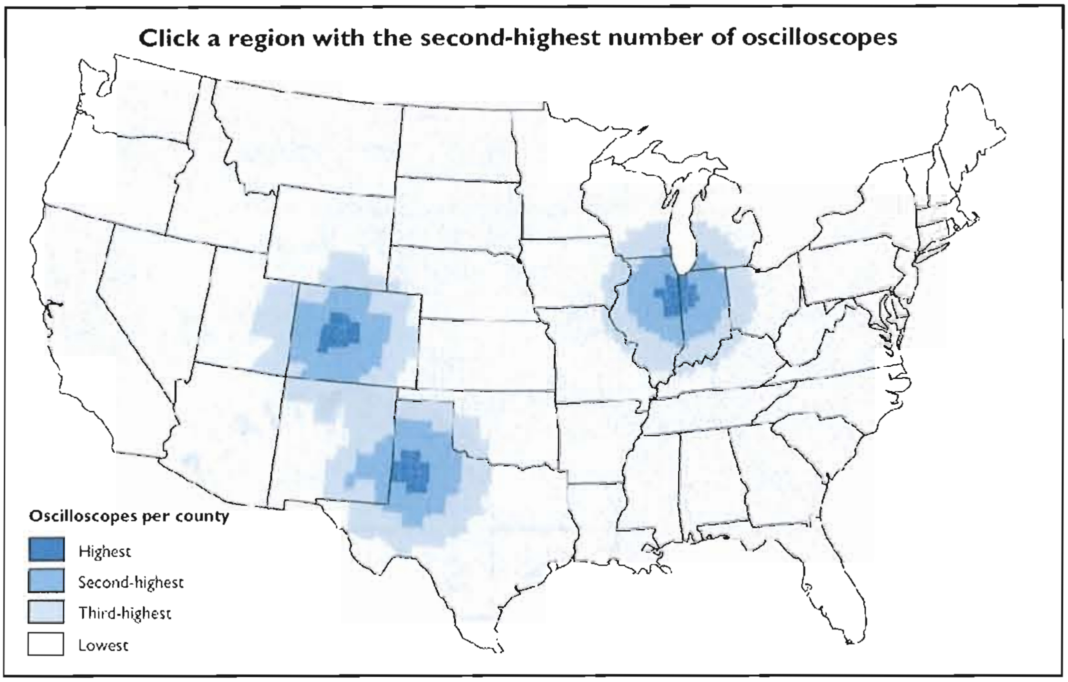


Figure A-16. Oregon cluster not in target; Colorado cluster (Cluster Zone 2) nearest target.

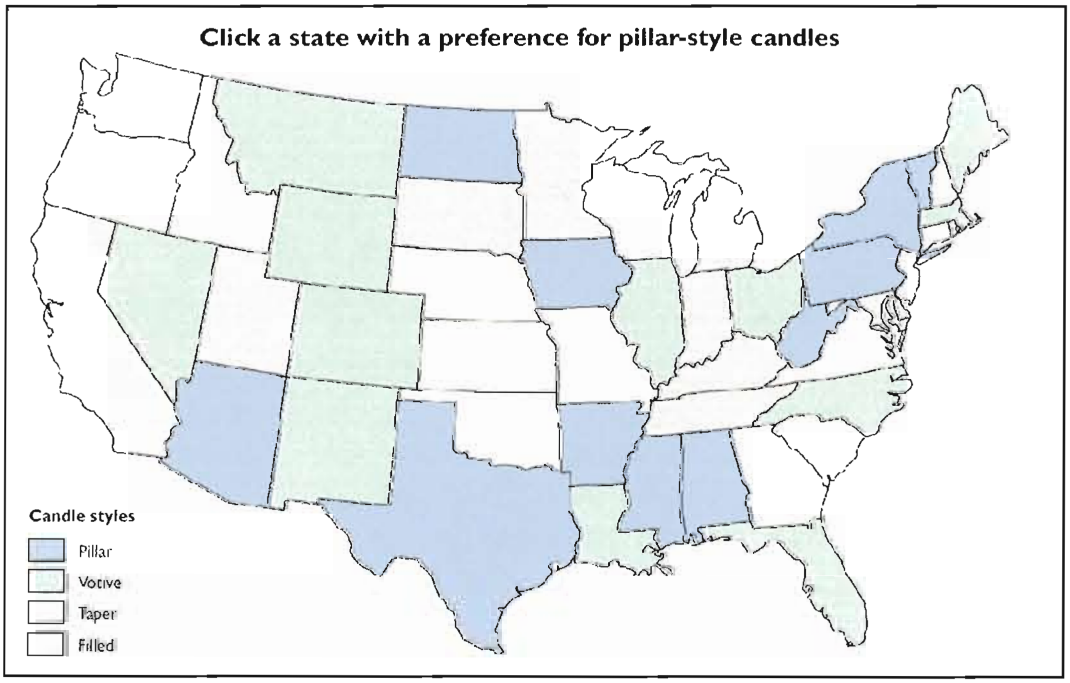


Figure A-17. Oregon not in target; Arizona (State Zone 2) nearest target.

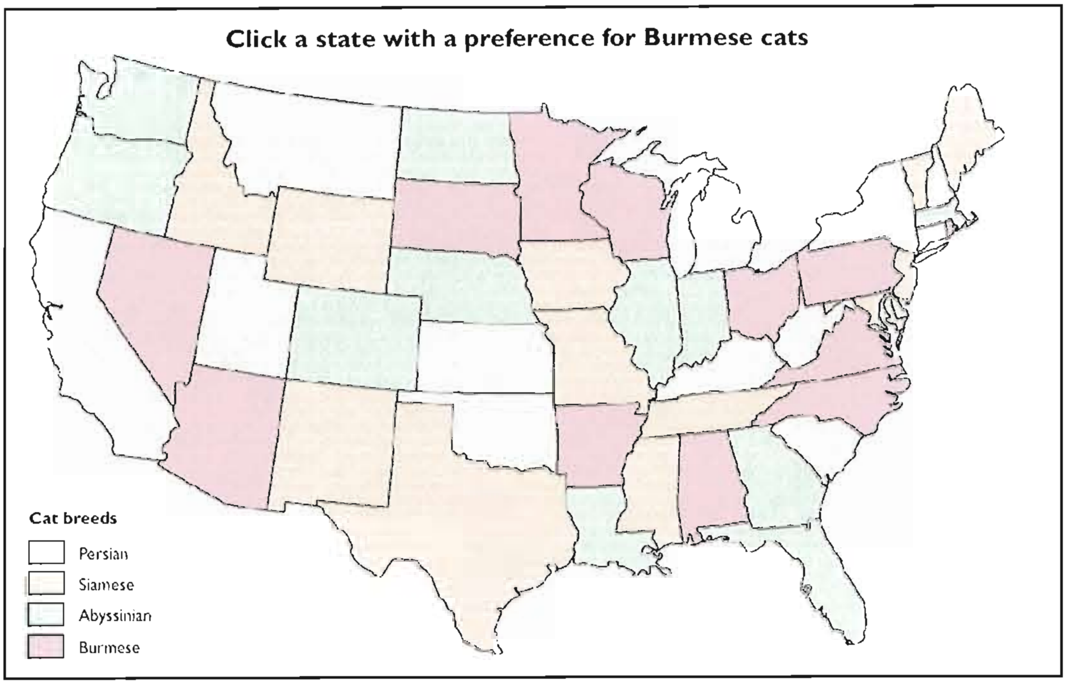


Figure A-18. Oregon not in target; Nevada (State Zone 1) nearest target.

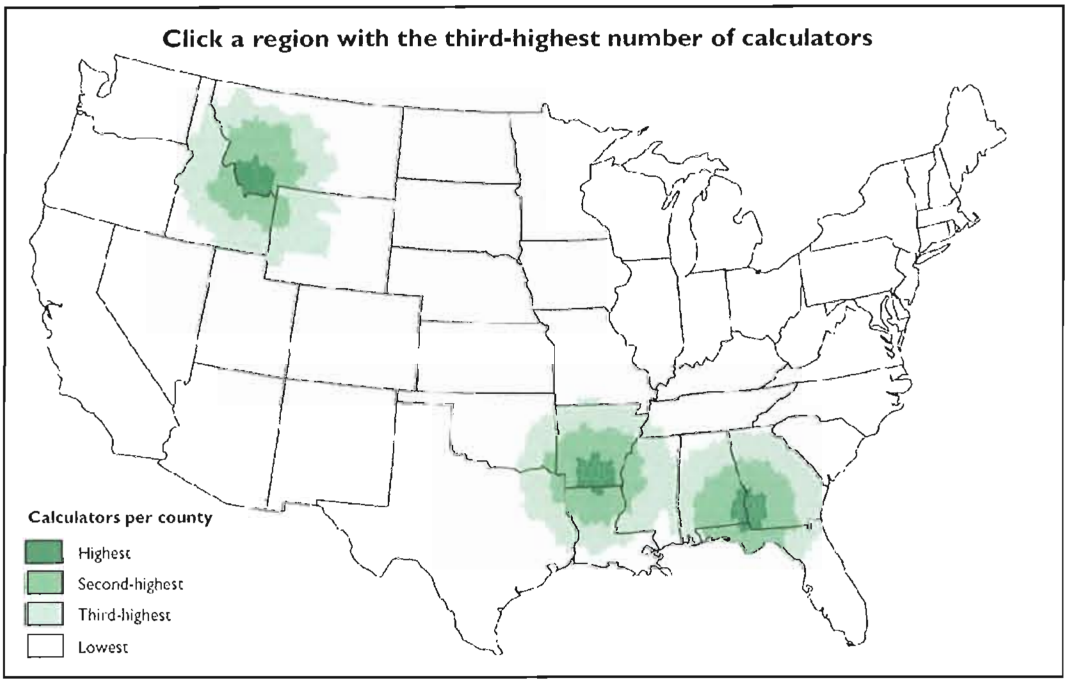


Figure A-19. Oregon cluster not in target; Montana cluster (Cluster Zone 1) nearest target.

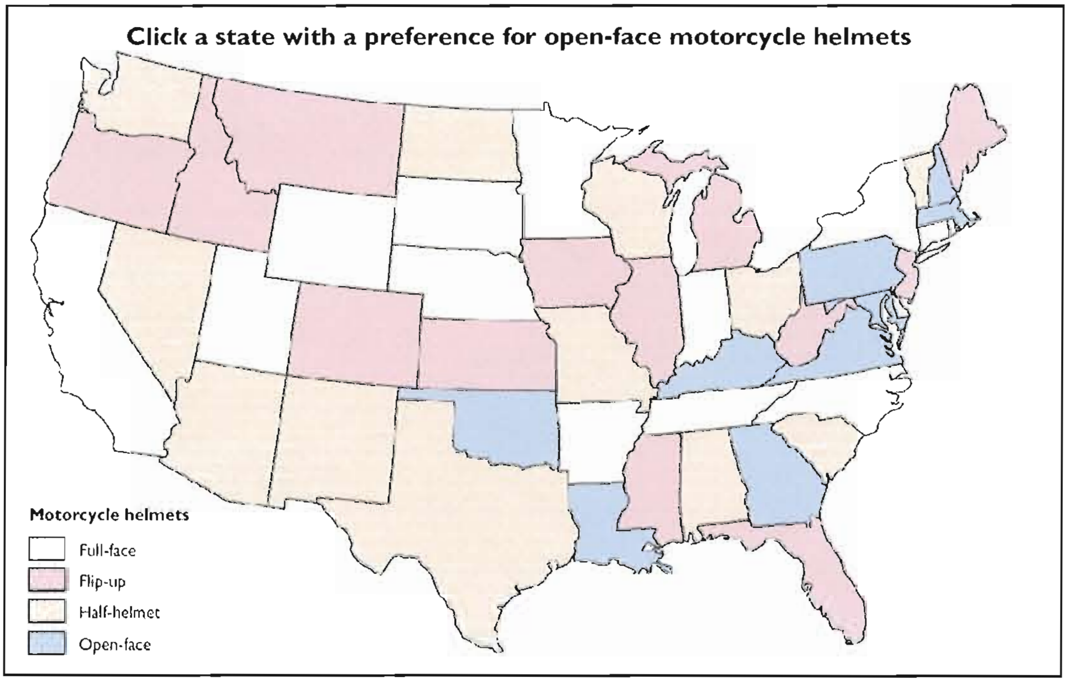


Figure A-20. Oregon not in target; Oklahoma (State Zone 4) nearest target.

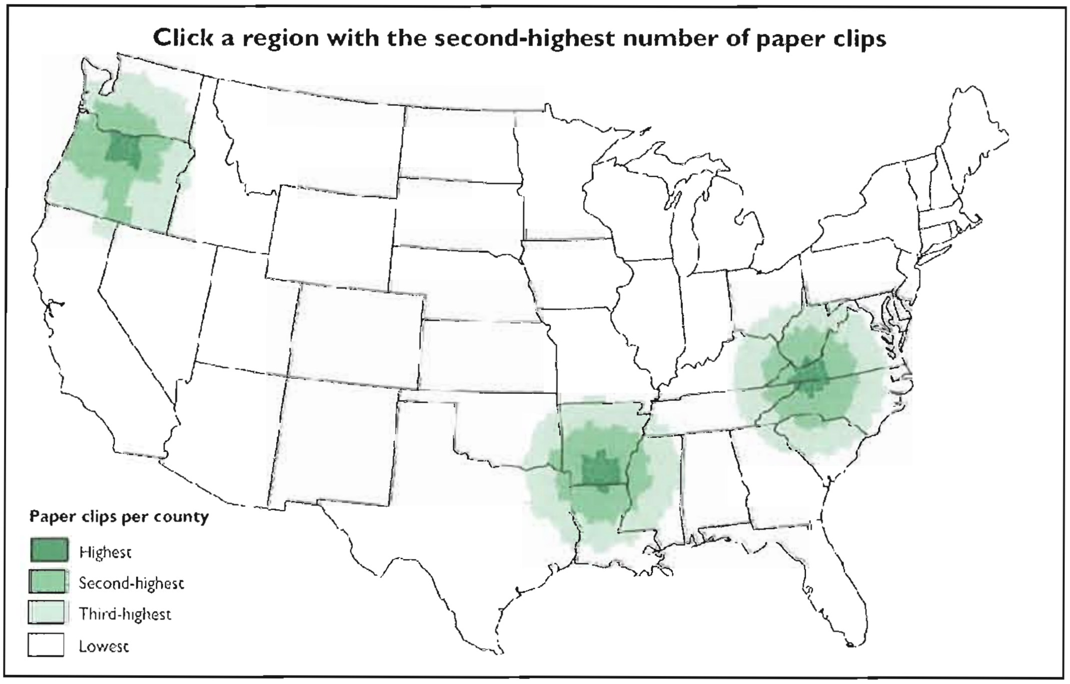


Figure A-21. Oregon cluster in target; Arkansas cluster (Cluster Zone 4) next nearest target.

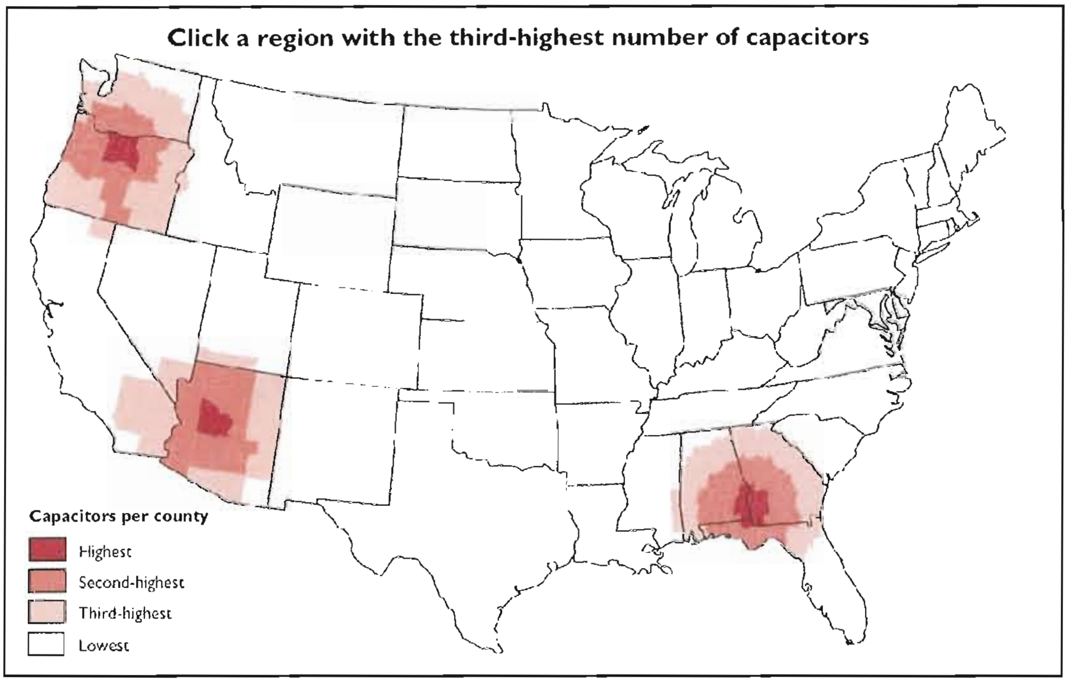


Figure A-22. Oregon cluster in target; Arizona cluster (Cluster Zone 2) next nearest target.

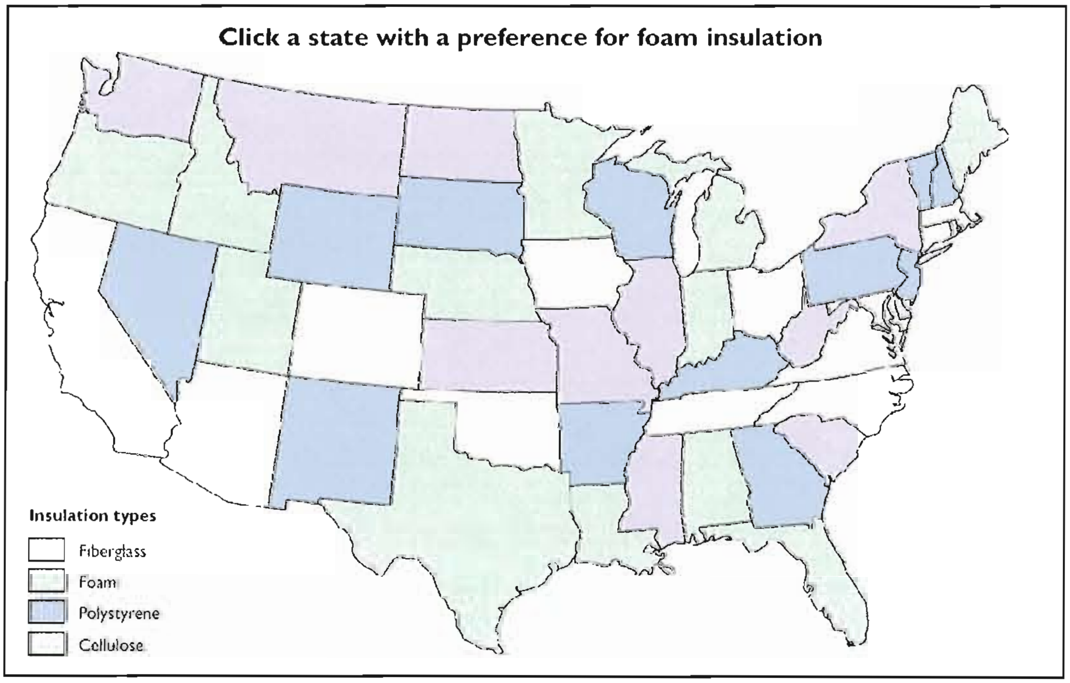


Figure A-23. Oregon in target; Idaho (State Zone 1) next nearest target.

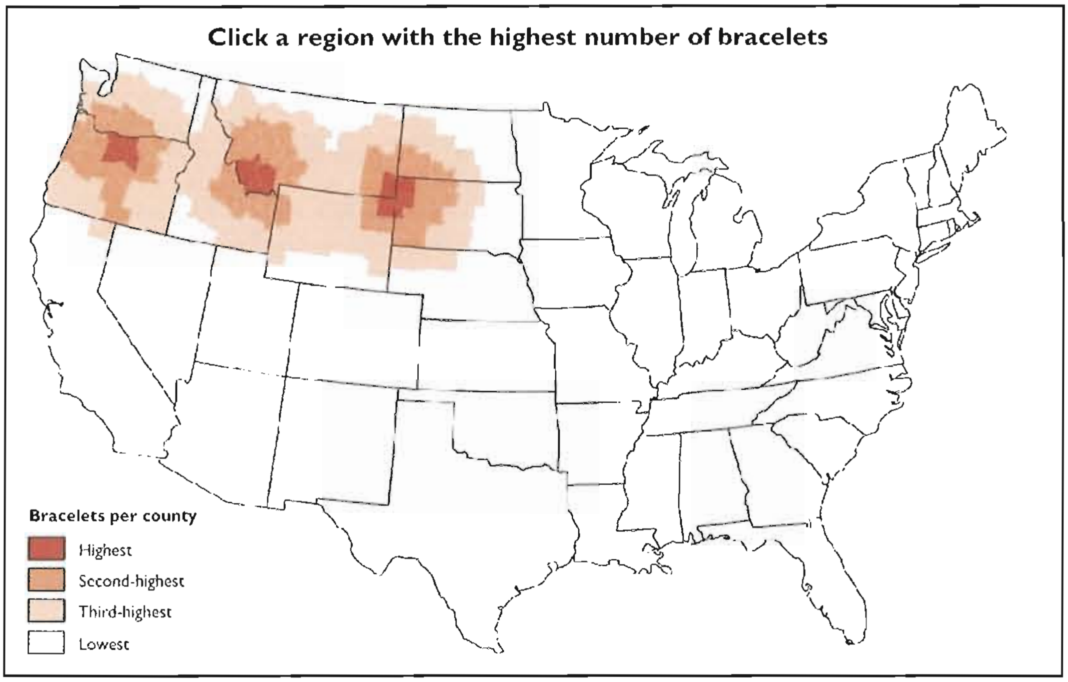


Figure A-24. Oregon cluster in target; Montana cluster (Cluster Zone 1) next nearest target.

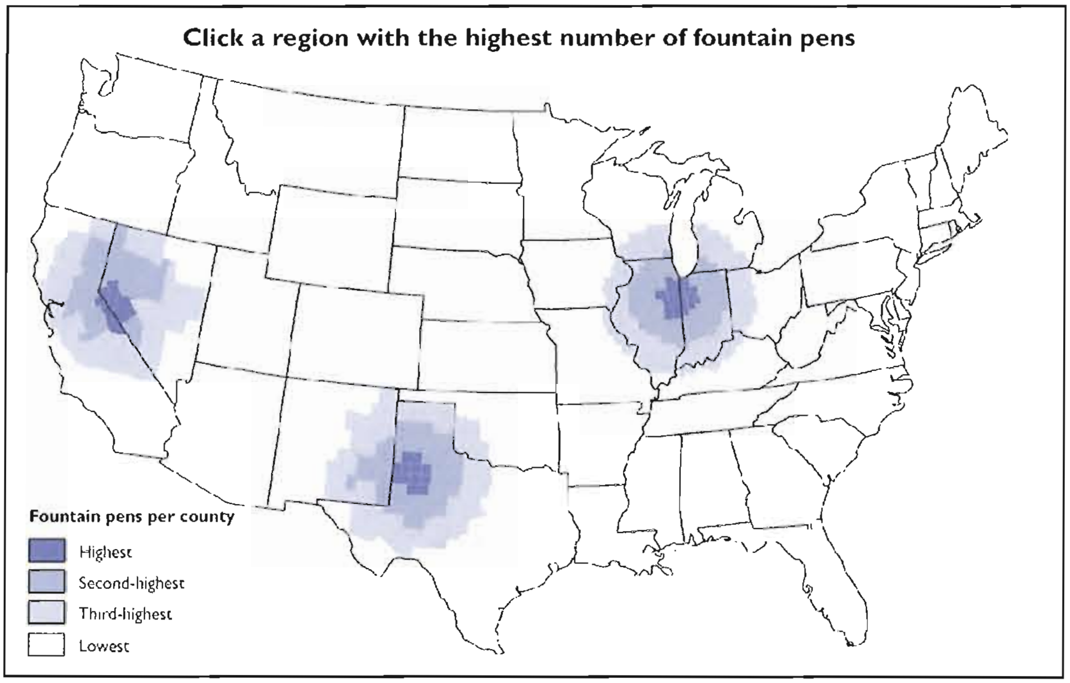


Figure A-25. Oregon cluster not in target; Nevada cluster (Cluster Zone 1) nearest target.

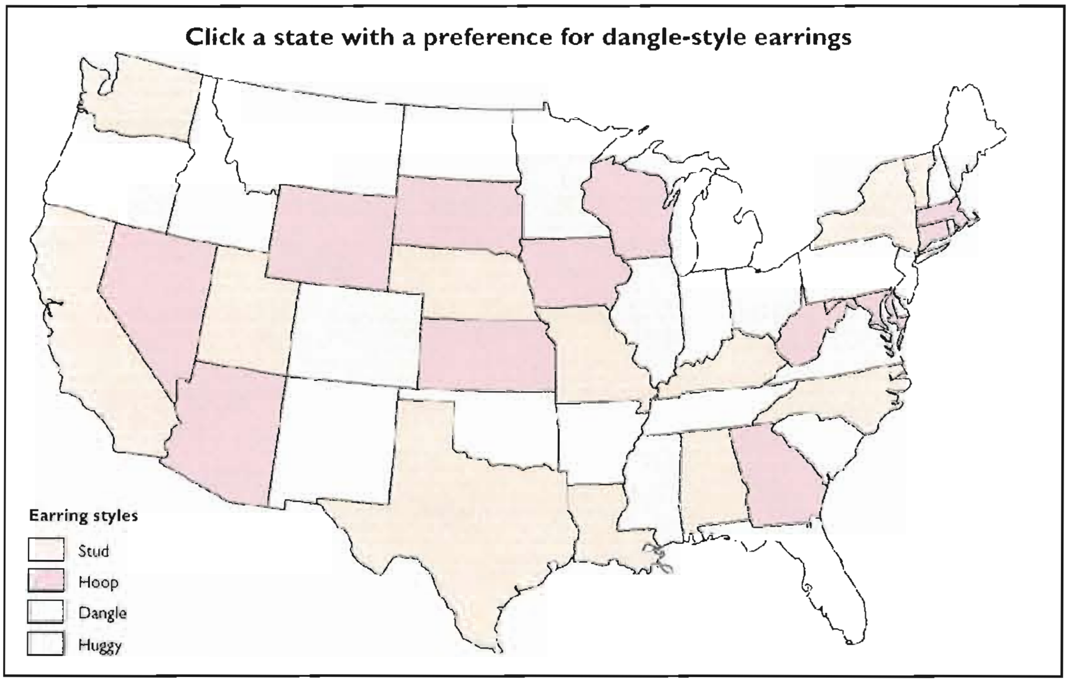


Figure A-26. Oregon in target; Colorado (State Zone 3) next nearest target.

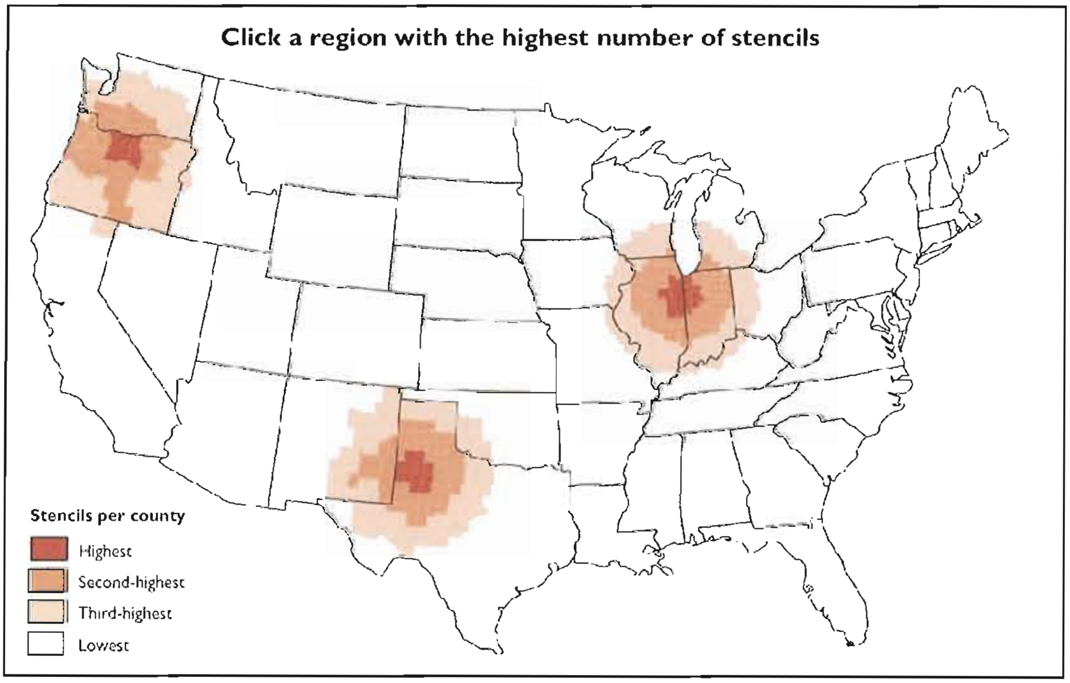


Figure A-27. Oregon cluster in target; Texas cluster (Cluster Zone 3) next nearest target.

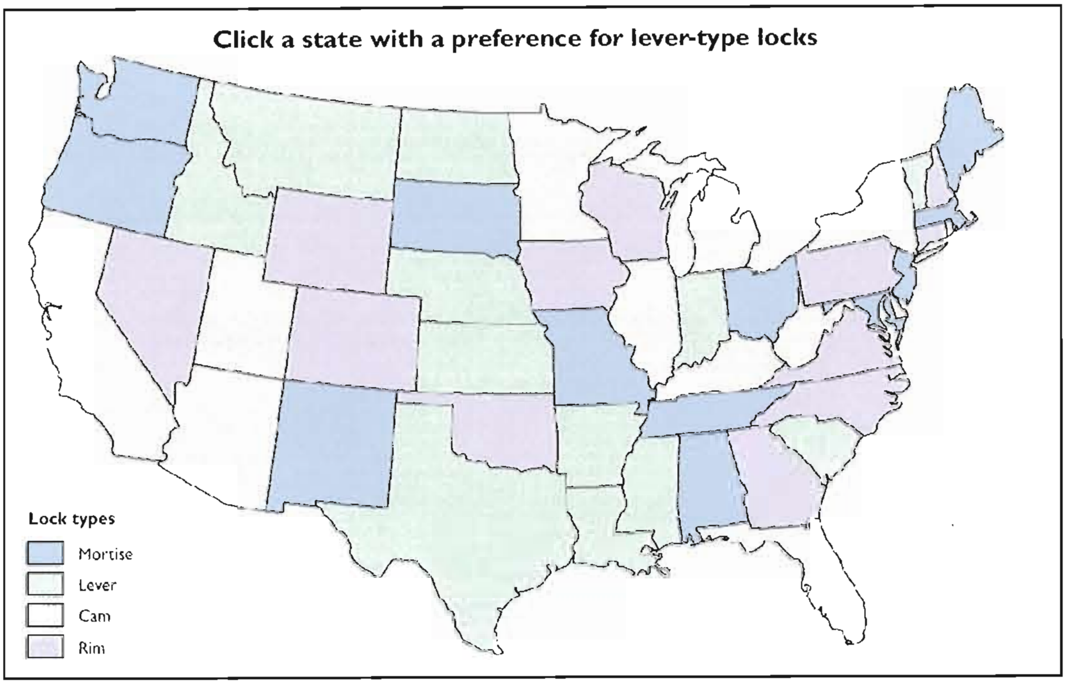


Figure A-28. Oregon not in target; Idaho (State Zone 1) nearest target.

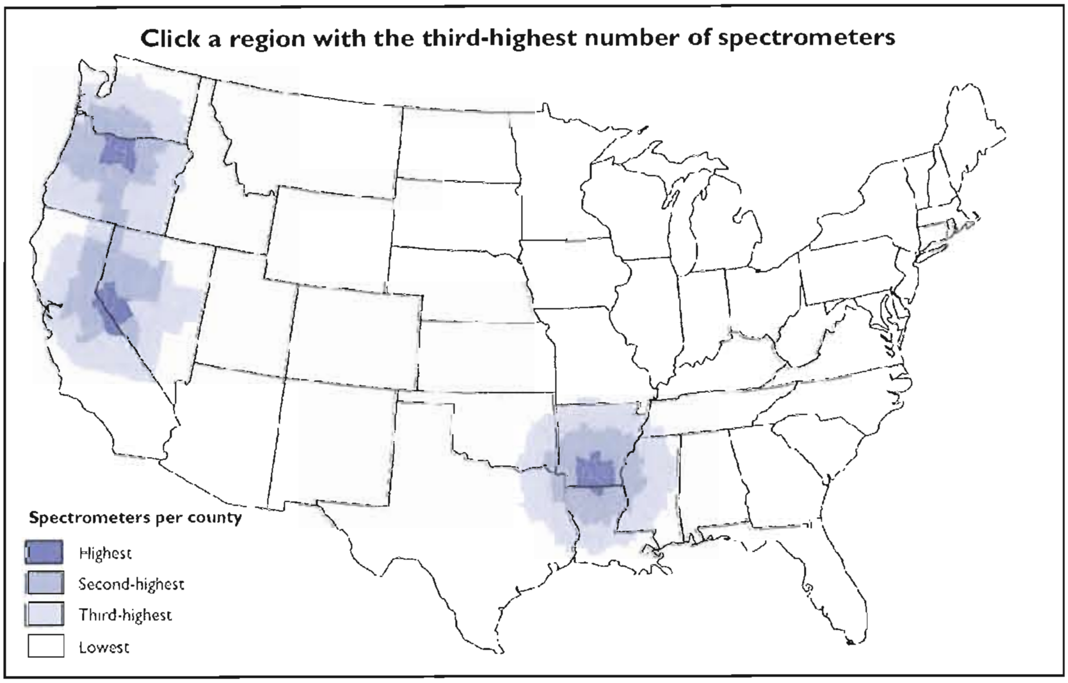


Figure A-29. Oregon cluster in target; Nevada cluster (Cluster Zone 1) next nearest target.

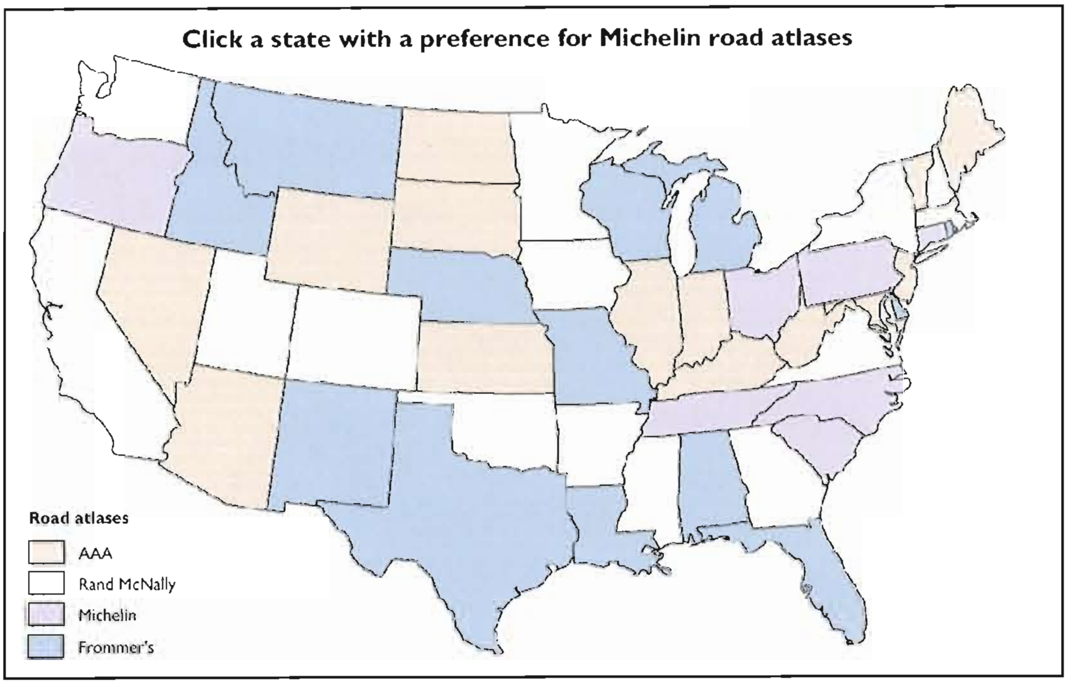


Figure A-30. Oregon in target; Tennessee (State Zone 5) next nearest target.

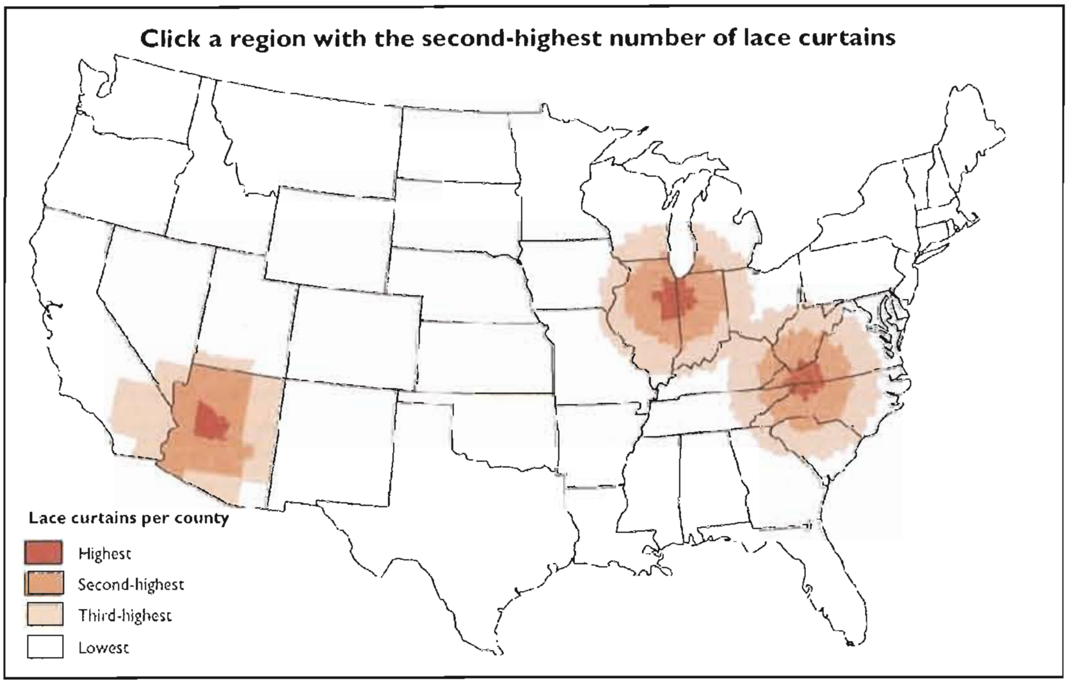


Figure A-31. Oregon cluster not in target; Arizona cluster (Cluster Zone 2) nearest target.

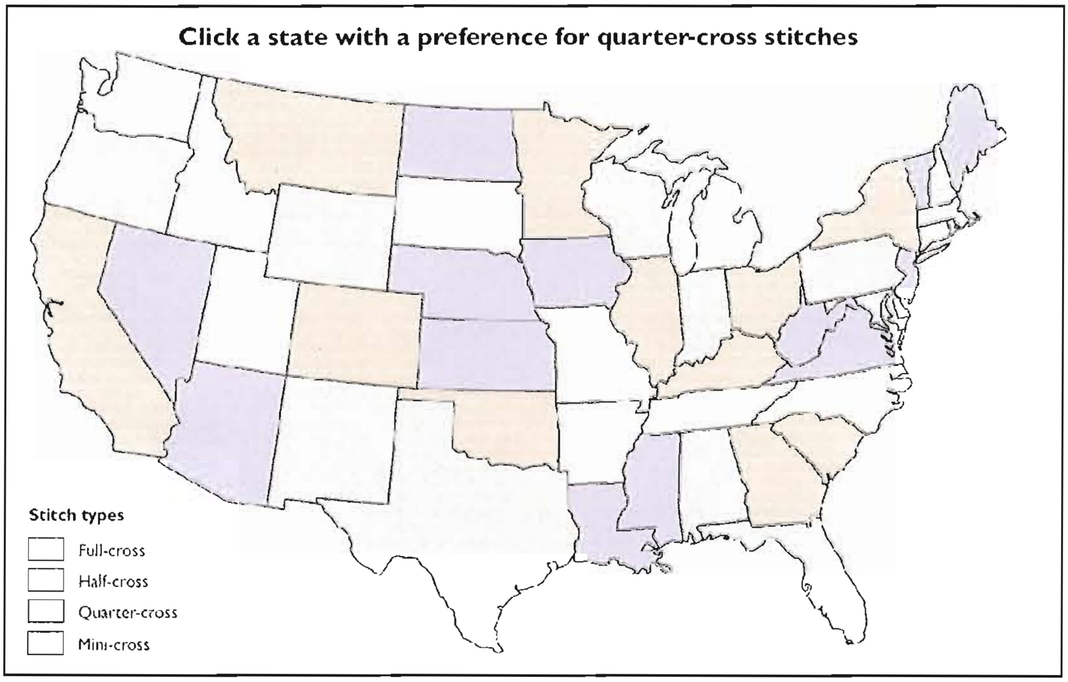


Figure A-32. Oregon in target; Wyoming (State Zone 2) next nearest target.

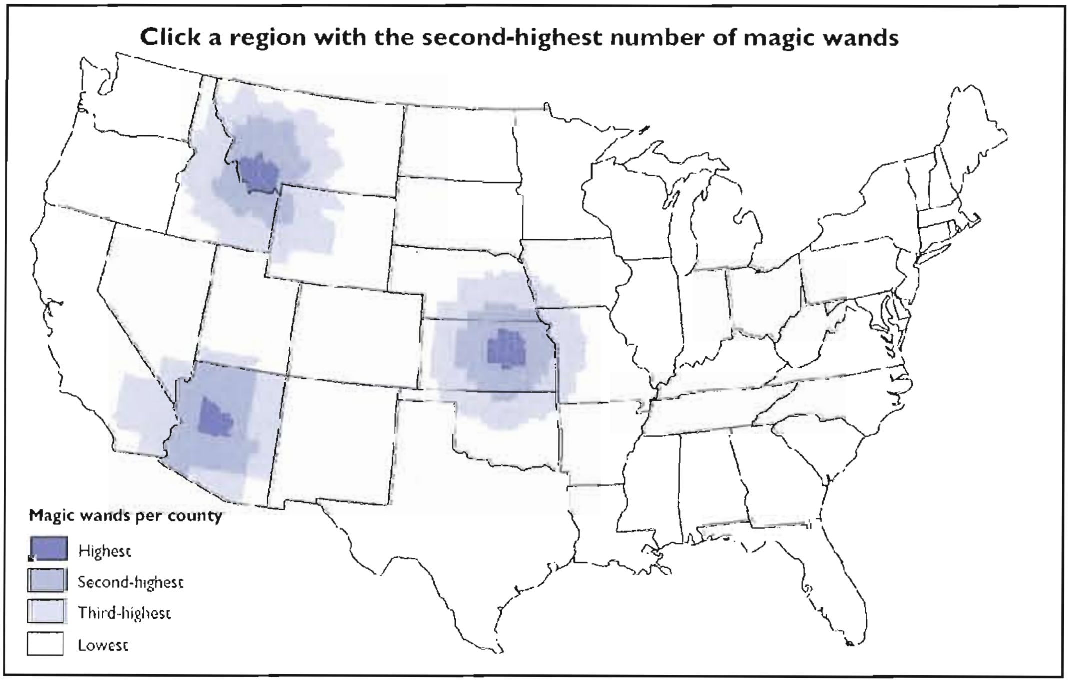


Figure A-33. Oregon cluster not in target; Montana cluster (Cluster Zone 1) nearest target.

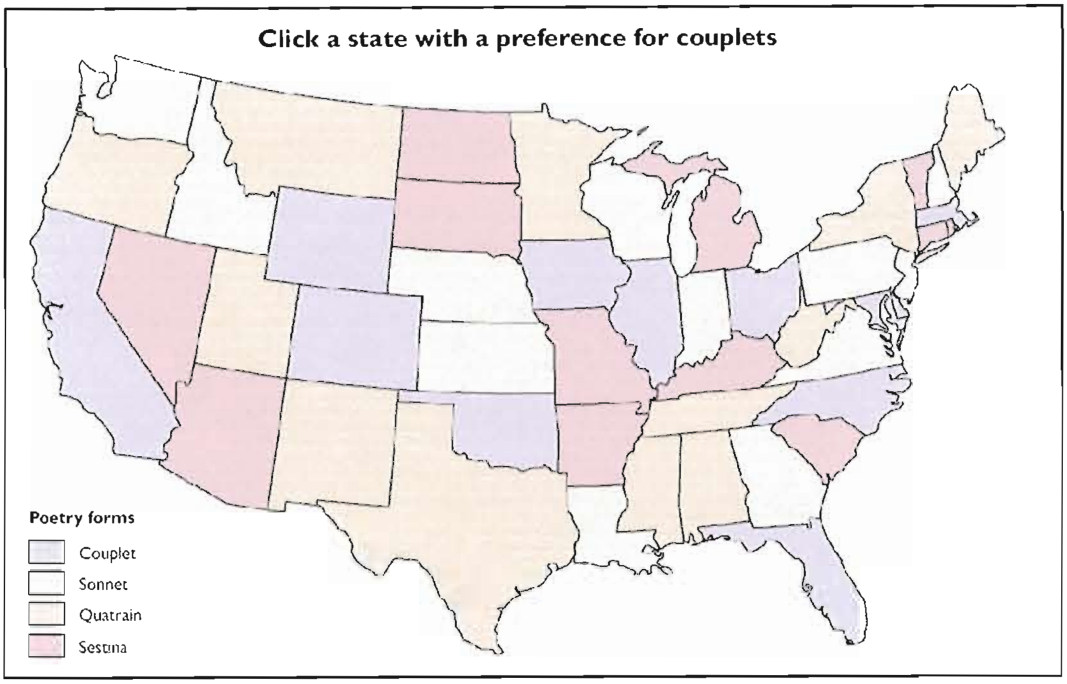


Figure A-34. Oregon not in target; California (State Zone 1) nearest target.

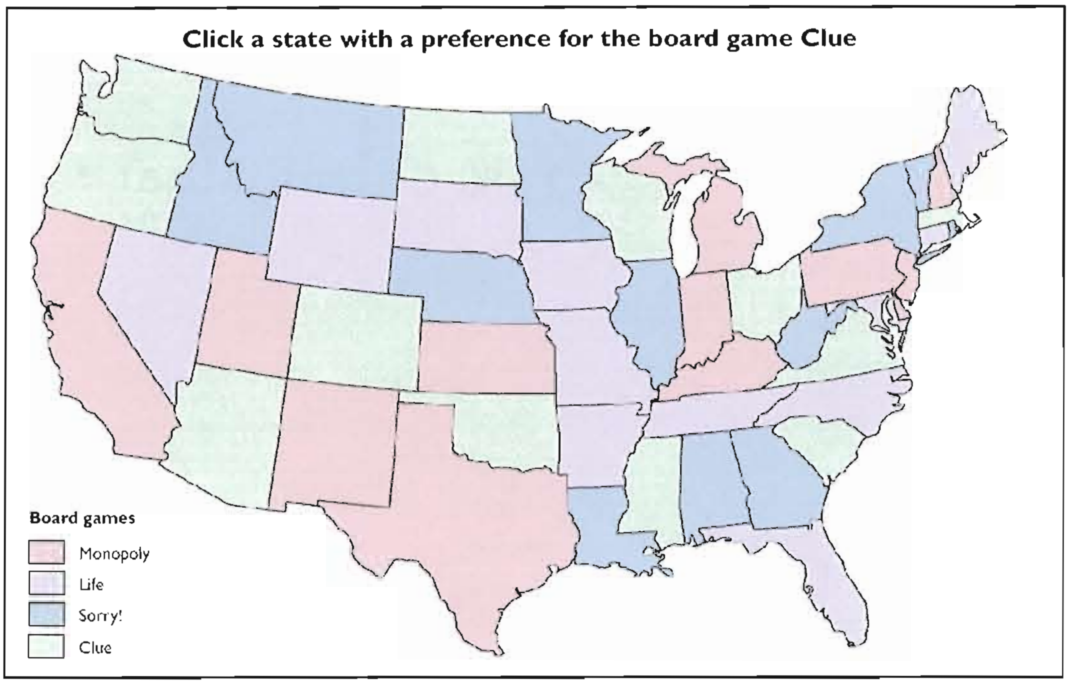


Figure A-35. Oregon in target; Washington (State Zone 1) next nearest target.

APPENDIX B

ZONE AND COLOR SCHEMES, AND CATEGORY ASSIGNMENTS FOR MAPS IN THE MAP-READING TASK

Table B-1. State map color schemes and legend order.

Map #	Color scheme*	OR in target?	Nearest target zone**	Nearest non-OR target	Legend order*
1	O B R V	N	1	WA	O B R V
3	B W R O	N	5	KY	M O R B
5	Y G R W	Y	4	KS	R M Y G
7	O V G Y	Y	1	NV	G O V Y
11	R V Y G	Y	1	CA	R Y V G
13	R G W B	N	3	SD	G B R M
14	O G V R	N	2	UT	V R G O
15	Y W O B	Y	2	MT	B Y O M
17	B G Y W	N	2	AZ	B G Y M
18	R W O G	N	1	NV	M O G R
20	B R Y O	N	4	OK	Y R O B
23	G V B Y	Y	1	ID	G V B Y
26	W R O Y	Y	3	CO	O R M Y
28	G B W V	N	1	ID	B G M V
30	V B Y O	Y	5	TN	O Y V B
32	W V O Y	Y	2	WY	Y V M O
34	V R W O	N	1	CA	V M O R
35	G R V B	Y	1	WA	R V B G

* B=blue; G=green; O=orange; R=red; V=violet; W=brown; Y=yellow

** Zones represent how many states away a state is from Oregon

Table B-2. Category assignments for state maps with Oregon in the target category.

States away	Map # →	5	7	11	15	23	26	30	32	35
	State Zone target →	4	1	1	2	1	3	5	2	1
	Color scheme →	YGRW	OVGY	RVYG	BWOY	GVBY	WROY	VBYO	WVOY	GRVB
0	Oregon (OR)	1	1	1	1	1	1	1	1	1
1	California (CA)	3	3	1	4	4	3	3	3	2
1	Nevada (NV)	4	1	3	3	3	2	4	2	3
1	Idaho (ID)	2	2	4	2	1	4	2	4	4
1	Washington (WA)	4	4	2	2	2	3	3	4	1
2	Wyoming (WY)	4	1	2	4	3	2	4	1	3
2	Utah (UT)	3	2	3	3	1	3	3	4	2
2	Arizona (AZ)	3	3	4	3	4	2	4	2	1
2	Montana (MT)	2	4	1	1	2	4	2	3	4
3	Nebraska (NE)	3	3	2	4	1	3	2	2	4
3	New Mexico (NM)	2	2	1	2	3	4	2	1	2
3	Colorado (CO)	2	4	4	2	4	1	3	3	1
3	North Dakota (ND)	4	3	3	1	2	4	4	2	1
3	South Dakota (SD)	4	1	2	4	3	2	4	4	3
4	Kansas (KS)	1	2	1	3	2	2	4	2	2
4	Minnesota (MN)	2	2	3	3	1	1	3	3	4
4	Iowa (IA)	4	1	4	2	4	2	3	2	3
4	Texas (TX)	3	4	3	4	1	3	2	1	2
4	Oklahoma (OK)	3	4	2	2	4	4	3	3	1
4	Missouri (MO)	2	4	1	1	2	3	2	4	3
5	Louisiana (LA)	2	3	2	1	1	3	2	2	4
5	Kentucky (KY)	1	3	1	4	3	3	4	3	2
5	Illinois (IL)	3	1	4	3	2	1	4	3	4
5	Tennessee (TN)	3	1	3	4	4	4	1	4	3
5	Wisconsin (WI)	4	3	4	2	3	2	2	1	1
5	Arkansas (AR)	2	2	1	3	3	4	3	4	3
6	West Virginia (WV)	1	1	3	2	2	2	4	2	4
6	Virginia (VA)	4	4	2	3	4	1	3	2	1
6	Indiana (IN)	2	2	1	4	1	4	4	1	2
6	Ohio (OH)	3	4	4	3	4	1	1	3	1
6	Michigan (MI)	4	2	4	1	1	4	2	4	2
6	Mississippi (MS)	1	3	3	4	2	1	3	2	1
6	Alabama (AL)	3	3	2	2	1	3	2	1	4
6	North Carolina (NC)	1	2	1	2	4	3	1	4	3
6	Georgia (GA)	2	1	3	1	3	2	3	3	4
7	South Carolina (SC)	1	4	2	3	2	4	1	3	1
7	Maryland (MD)	2	1	4	1	4	2	4	4	3
7	Florida (FL)	4	4	2	4	1	1	2	1	3
7	Pennsylvania (PA)	4	3	1	3	3	4	1	1	2
8	New York (NY)	3	1	3	1	2	3	3	3	4
8	New Jersey (NJ)	1	2	4	4	3	4	4	2	2
8	Delaware (DE)	4	3	3	2	2	1	2	4	2
9	Connecticut (CT)	3	2	4	2	4	2	1	1	3
9	Vermont (VT)	2	2	2	1	3	3	4	2	4
9	Massachusetts (MA)	4	4	2	4	4	2	3	1	1
10	Rhode Island (RI)	2	1	3	3	2	3	2	3	4
10	N. Hampshire (NH)	3	4	1	4	3	1	3	4	2
11	Maine (ME)	1	3	4	1	1	4	4	2	3

* 1 = target category; 2, 3 & 4 = other qualitative categories

Table B-3. Category assignments for state maps with Oregon *not* in the target category.

States away	Map # →	1	3	13	14	17	18	20	28	34
	State Zone target →	1	5	3	2	2	1	4	1	1
	Color scheme →	OBRV	BWRO	RGWB	OGVR	BGYW	RWOG	BRYO	GBWV	VRWO
0	Oregon (OR)	3	3	2	2	3	4	2	2	4
1	California (CA)	2	2	3	4	4	2	3	3	1
1	Nevada (NV)	4	4	4	3	2	1	4	4	2
1	Idaho (ID)	2	4	4	4	3	3	2	1	3
1	Washington (WA)	1	2	3	3	4	4	4	2	3
2	Wyoming (WY)	3	3	2	2	2	3	3	4	1
2	Utah (UT)	1	4	2	1	4	2	3	3	4
2	Arizona (AZ)	4	2	4	3	1	1	4	3	2
2	Montana (MT)	3	3	3	4	2	2	2	1	4
3	Nebraska (NE)	4	3	2	1	3	4	3	1	3
3	New Mexico (NM)	1	2	3	2	2	3	4	2	4
3	Colorado (CO)	2	4	4	3	2	4	2	4	1
3	North Dakota (ND)	4	2	3	2	1	4	4	1	2
3	South Dakota (SD)	3	4	1	4	4	1	3	2	2
4	Kansas (KS)	2	3	1	3	3	2	2	1	3
4	Minnesota (MN)	2	3	1	2	4	1	3	3	4
4	Iowa (IA)	3	4	4	4	1	3	2	4	1
4	Texas (TX)	4	2	2	4	1	3	4	1	4
4	Oklahoma (OK)	3	4	2	2	3	2	1	4	1
4	Missouri (MO)	1	3	4	1	3	3	4	2	2
5	Louisiana (LA)	4	2	1	3	2	4	1	1	3
5	Kentucky (KY)	1	4	3	2	4	2	1	3	2
5	Illinois (IL)	2	1	4	1	2	4	2	3	1
5	Tennessee (TN)	1	2	3	1	4	3	3	2	4
5	Wisconsin (WI)	2	3	1	3	3	1	4	4	3
5	Arkansas (AR)	3	4	2	4	1	1	3	1	2
6	West Virginia (WV)	1	2	3	2	1	2	2	3	4
6	Virginia (VA)	4	3	2	1	3	1	1	4	3
6	Indiana (IN)	2	3	1	3	4	4	3	1	3
6	Ohio (OH)	3	4	4	4	2	1	4	2	1
6	Michigan (MI)	1	1	4	4	4	2	2	3	2
6	Mississippi (MS)	4	2	1	3	1	3	2	1	4
6	Alabama (AL)	3	1	2	1	1	1	4	2	4
6	North Carolina (NC)	2	4	3	1	2	1	3	4	1
6	Georgia (GA)	1	1	3	2	3	4	1	4	3
7	South Carolina (SC)	4	1	1	3	3	2	4	1	2
7	Maryland (MD)	3	2	2	4	4	3	1	2	1
7	Florida (FL)	1	3	4	2	2	4	2	3	1
7	Pennsylvania (PA)	2	2	4	2	1	1	1	4	3
8	New York (NY)	1	4	2	1	1	2	3	3	4
8	New Jersey (NJ)	4	1	1	4	4	3	2	2	3
8	Delaware (DE)	4	2	3	3	2	4	4	3	1
9	Connecticut (CT)	2	4	1	3	3	2	3	4	2
9	Vermont (VT)	3	3	2	2	1	3	4	1	2
9	Massachusetts (MA)	3	3	4	3	2	4	1	2	1
10	Rhode Island (RI)	4	2	3	4	3	1	3	3	2
10	N. Hampshire (NH)	2	4	3	1	4	2	1	4	3
11	Maine (ME)	1	1	4	1	2	3	2	2	4

Table B-4. County-cluster map zone schemes.

Map #	Color	Zone Scheme	Cluster 1	Cluster 2	Cluster 3	Target ring
2	Red	3-4-5	MN (3)	AR (4)	NY (5)	2
4	Blue	0-3-5	OR (0)	KS (3)	NY (5)	1
6	Blue	0-2-4	OR (0)	SD (2)	IL (4)	3
8	Red	0-2-3	OR (0)	CO (2)	MN (3)	3
9	Orange	1-3-5	MT (1)	KS (3)	NY (5)	2
10	Red	1-2-4	NV (1)	SD (2)	AR (4)	1
12	Green	0-1-3	OR (0)	NV (1)	MN (3)	1
16	Blue	2-3-4	CO (2)	TX (3)	IL (4)	2
19	Green	1-4-5	MT (1)	AR (4)	GA (5)	3
21	Green	0-4-5	OR (0)	AR (4)	VA (5)	2
22	Red	0-2-5	OR (0)	AZ (2)	GA (5)	3
24	Orange	0-1-2	OR (0)	MT (1)	SD (2)	1
25	Violet	1-3-4	NV (1)	TX (3)	IL (4)	1
27	Orange	0-3-4	OR (0)	TX (3)	IL (4)	1
29	Violet	0-1-4	OR (0)	NV (1)	AR (4)	3
31	Orange	2-4-5	AZ (2)	IL (4)	VA (5)	2
33	Violet	1-2-3	MT (1)	AZ (2)	KS (3)	2

Table B-5. Fictitious phenomena for county-cluster maps.

Map #	County clusters present	Color scheme	"Click a region with the [insert degree] preference for ..."	Degree*
2	MN-AR-NY	Red	curling irons	Second-highest
4	OR-KS-NY	Blue	dry erasers	Highest
6	OR-SD-IL	Blue	belt sanders	Third-highest
8	OR-CO-MN	Red	metronomes	Third-highest
9	MT-KS-NY	Orange	tweezers	Second-highest
10	NV-SD-AR	Red	coaxial cables	Highest
12	OR-NV-MN	Green	coping saws	Highest
16	CO-TX-IL	Blue	oscilloscopes	Second-highest
19	MT-AR-GA	Green	calculators	Third-highest
21	OR-AR-VA	Green	paper clips	Second-highest
22	OR-AZ-GA	Red	capacitors	Third-highest
24	OR-MT-SD	Orange	bracelets	Highest
25	NV-TX-IL	Violet	fountain pens	Highest
27	OR-TX-IL	Orange	stencils	Highest
29	OR-NV-AR	Violet	spectrometers	Third-highest
31	AZ-IL-VA	Orange	lace curtains	Second-highest
33	MT-AZ-KS	Violet	magic wands	Second-highest
* Degree described as amount per county in all county-cluster map legends				

Table B-6. Fictitious phenomena for state maps.

Map #	Color scheme	"Click a state with a preference for …"	Legend header	Choice #1	Choice #2	Choice #3	Choice #4
1	OBRV	narrow-ruled notebooks	Notebook ruling	Narrow	Wide	Medium	College
3	WORB	console-style pianos	Piano styles	Spinet	Upright	Grand	Console
5	RWYG	plastic buttons	Button materials	Brass	Steel	Plastic	Leather
7	GOVY	German shepherds	Dog breeds	Labrador retriever	German shepherd	Rottweiler	Boxer
11	RYVG	slotted-style screw heads	Screw-head styles	Slotted	Phillips	Square	Allen
13	GBRW	desk calendars	Calendar types	Wall	Flip	Desk	Pocket
14	VRGO	satin gowns	Gown fabrics	Chiffon	Velvet	Silk	Satin
15	BYOW	slipknots	Knot types	Square	Slipknot	Overhand	Sheet
17	BGYW	pillar-style candles	Candle styles	Pillar	Votive	Taper	Filled
18	WOGR	Burmese cats	Cat breeds	Persian	Siamese	Abyssinian	Burmese
20	YROB	open-face motorcycle helmets	Motorcycle helmets	Full-face	Flip-up	Half-helmet	Open-fact
23	VGBY	foam insulation	Insulation types	Fiberglass	Foam	Polystyrene	Cellulose
26	ORWY	dangle-style earrings	Earring styles	Stud	Hoop	Dangle	Huggy
28	BGWV	lever-type locks	Lock types	Mortise	Lever	Cam	Rim
30	OYVB	Michelin road atlases	Road atlases	AAA	Rand McNally	Michelin	Frommer's
32	YVWO	quarter-cross stitches	Stitch types	Full-cross	Half-cross	Quarter-cross	Mini-cross
34	VWOR	couplets	Poetry forms	Couplet	Sonnet	Quatrain	Sestina
35	RVBG	the board game Clue	Board games	Monopoly	Life	Sorry!	Clue

APPENDIX C

SURVEY

ID Number

Please answer the following questions:

Age: _______

Sex (M/F/Other): ________

U.S. citizen? (Y/N): ________ If no, which country? ____________________

Major/degree (circle one and state the subject of your major or degree):

____

Current occupation(s): ____

List all of the places you have lived in chronological order starting with the most recent and going back in time. Include the years you lived there. If you have lived in more than 10 places, just list the most recent 10. See the example below:

EXAMPLE

State or country	**Years**	**Duration**
Oregon	2009-present	6 mos
China	2009	2 mos
Oregon	2008-2009	1 yr
California	1995-2008	13 yrs
Washington	1994-1995	1 yr
Iowa	1991-1994	3 yrs

State or country	**Years**	**Duration**

What *one* state would you consider to be your home state? ____________________
(It doesn't necessarily have to be where you're living now) (Choose only *one* state.)

APPENDIX D

RECRUITMENT SCRIPT

I am seeking volunteers for a study that is investigating map use. Participants will take a computer-and-paper-based test designed to measure how people read maps. Participants will view a short series of maps on a computer screen and answer questions about them; an even shorter paper survey will follow. The entire testing session is expected to take around 20 minutes and will take place at a time convenient for you (I will be scheduling testing sessions at different times of the day and most days of the week). Testing will take place in the Spatial Map and Cognition Research Lab (SMCRL) in 160 Condon. Volunteers must be at least 18 years old and must not be colorblind.

Participants will receive $10 for their participation.

Thank you for your consideration,

Matthew E. Millett
Graduate Teaching Fellow
Spatial and Map Cognition Research Lab
Department of Geography
University of Oregon
millett@uoregon.edu

APPENDIX E

CONSENT TO PARTICIPATE

Number

Informed Consent – Map Use Study

You are invited to participate in a research study conducted by Matt Millett from the University of Oregon Department of Geography. The purpose of the study is to explore how map users read maps.

If you decide to participate, you will be required to take a 30-minute computer-based test in the Spatial and Map Cognition Research Lab (SMCRL) located in 160 Condon Hall. There are likely no reasonable foreseen risks, discomforts or inconveniences associated with your participation in this project. Your participation in this project will help me better understand how well people use choropleth maps of the United States. However, I cannot guarantee that you personally will receive any benefits from this research.

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. To keep subject identities confidential, I will use a numeric code to associate subject responses with identities. No information will be released to any other party outside of the research group for any reason.

If you choose to participate you will be paid $10 for your participation. Your participation is voluntary. Your decision whether or not to participate will not affect your relationship with University of Oregon. If you decide to participate, you are free to withdraw your consent and discontinue participation at any time without penalty.

If you have any questions, please feel free to contact my adviser, Amy Lobben, Department of Geography - University of Oregon, (541) 346-4566. If you have questions regarding your rights as a research subject, contact the Office for Protection of Human Subjects. This Office oversees the review of the research to protect your rights and is not involved with this study. Office of Human Subjects Compliance, University of Oregon, Eugene, OR 97403, (541) 346-2510. You have been given a copy of this form to keep.

Your signature below constitutes your consent to participate, that you willingly agree to participate, that you may withdraw your consent at any time and discontinue participation without penalty, that you have received a copy of this form, and that you are not waiving any legal claims, rights or remedies.

Participant Name (printed) Signature Date

Researcher Signature

APPENDIX F

MAP-BY-MAP RESULTS

Map 1				Map 2				Map 3				Map 4			
ZN	ST	OR	NOR	ZN	CL	OR	NOR	ZN	ST	OR	NOR	ZN	CL	OR	NOR
1	WA	41	29	3	MN	43	50	5	IL	51	44	0	OR	57	27
2	NM	38	47	4	AR	41	32	6	AL	27	29	3	KS	35	56
3	UT	21	9	5	NY	16	18	6	GA	8	12	5	NY	8	18
4+	9 st	--	15					6	MI	5	6				
								7+	3 st	8	9				

Map 5				Map 6				Map 7				Map 8			
ZN	ST	OR	NOR	ZN	CL	OR	NOR	ZN	ST	OR	NOR	ZN	CL	OR	NOR
0	OR	57	44	0	OR	49	22	0	OR	46	24	0	OR	35	24
4	KS	38	47	2	SD	40	44	1	NV	16	24	2	CO	46	47
5	KY	--	--	4	IL	11	34	2	WY	22	21	3	MN	19	29
6+	6 st	5	9					3+	9 st	16	32				

Map 9				Map 10				Map 11				Map 12			
ZN	CL	OR	NOR	ZN	CL	OR	NOR	ZN	ST	OR	NOR	ZN	CL	OR	NOR
1	MT	62	36	1	NV	27	32	0	OR	41	9	0	OR	51	32
3	KS	35	48	2	SD	54	44	1	CA	22	32	1	NV	11	18
5	NY	3	15	4	AR	19	24	2	MT	11	24	3	MN	38	50
								3+	9 st	27	35				
									(NM)	(11)	(18)				

Map 13				Map 14				Map 15				Map 16			
ZN	ST	OR	NOR	ZN	ST	OR	NOR	ZN	ST	OR	NOR	ZN	CL	OR	NOR
3	SD	33	15	2	UT	44	29	0	OR	50	26	2	CO	49	50
4	KS	36	26	3	NE	14	21	2	MT	8	24	3	TX	24	24
4	MN	14	21	4	MO	8	15	3	ND	6	9	4	IL	27	26
5+	7 st	17	38	5+	8 st	33	35	4+	8 st	36	41				
	(LA)		(12)		(ME)	(11)			(MO)	(17)	(24)				

Map 17				Map 18				Map 19				Map 20			
ZN	ST	OR	NOR	ZN	ST	OR	NOR	ZN	CL	OR	NOR	ZN	ST	OR	NOR
2	AZ	24	30	1	NV	25	15	1	MT	62	71	4	OK	69	61
3	ND	16	18	2	AZ	25	38	4	AR	24	21	5	KY	6	--
4	IA	14	12	3	SD	14	15	5	GA	14	9	5	LA	17	15
4	TX	41	33	4+	9 st	36	32					6+	6 st	8	24
5+	7 st	6	6												

Map 21				Map 22				Map 23				Map 24			
ZN	CL	OR	NOR	ZN	CL	OR	NOR	ZN	ST	OR	NOR	ZN	CL	OR	NOR
0	OR	41	45	0	OR	49	55	0	OR	31	21	0	OR	46	24
4	AR	43	33	2	AZ	27	21	1	ID	11	9	1	MT	19	38
5	VA	16	21	5	GA	24	24	2	UT	11	18	2	SD	35	38
								3+	9 st	46	53				
									(TX)	(37)	(26)				

Map 25				Map 26				Map 27				Map 28			
ZN	CL	OR	NOR	ZN	ST	OR	NOR	ZN	CL	OR	NOR	ZN	ST	OR	NOR
1	NV	36	41	0	OR	44	16	0	OR	43	35	1	ID	35	21
3	TX	25	32	3	CO	31	44	3	TX	24	21	2	MT	5	12
4	IL	39	26	4	MN	--	3	4	IL	32	44	3	ND	--	--
				5+	7 st	25	38					3	NE	5	21
					(FL)		(13)					4+	8 st	54	47
													(TX)	(32)	(21)

Map 29				Map 30				Map 31				Map 32			
ZN	CL	OR	NOR	ZN	ST	OR	NOR	ZN	CL	OR	NOR	ZN	ST	OR	NOR
0	OR	38	22	0	OR	57	56	2	AZ	64	62	0	OR	19	9
1	NV	22	31	5	TN	24	29	4	IL	25	32	2	WY	6	3
4	AR	41	47	6	OH	3	6	5	VA	11	6	3	NM	22	44
				6	NC	3	6					4+	8 st	53	44
				7+	3 st	14	3						(TX)	(42)	(28)

Map 33				Map 34				Map 35			
ZN	CL	OR	NOR	ZN	ST	OR	NOR	ZN	ST	OR	NOR
1	MT	39	18	1	CA	67	38	0	OR	22	6
2	AZ	25	50	2	WY	11	18	1	WA	3	3
3	KS	36	32	3	CO	8	24	2	AZ	25	48
				4+	9 st	14	21	3+	9 st	50	42
									(CO)	(22)	(12)

ZN = zone number; CL = county cluster; ST = state; OR = Oregonians; NOR = Non-Oregonians
States in parentheses are those with notable percentages in the grouped-state results.

REFERENCES

Balchin, W.G.V. (1972). Graphicacy. *Geography, 57*, 185-195.

Bertin, J. (1983). *Semiology of graphics*. (W.J. Berg, trans.). Madison, WI: University of Wisconsin Press. (Original work published 1967).

Board, C. (1967). Maps as models. In R.J. Chorley & P. Haggett (Eds.), *Physical and information models in geography* (671-705). Worcester, United Kingdom: Methuen.

Board, C., & Taylor, R.M. (1977). Perception and maps: Human factors in map design and interpretation. *Transactions of the Institute of British Geographers, 2*(1), 19-36.

Brewer, C.A. (2010). ColorBrewer 2.0. Retrieved from http://www.colorbrewer2.org.

Brewer, C.A., MacEachren, A.M., Pickle, L.W., & Herrmann, D. (1997). Mapping mortality: Evaluating color schemes for choropleth maps. *Annals of the Association of American Geographers, 87*(3), 411-438.

Brown, L.A. (1949). *The story of maps*. New York, NY: Bonanza.

Bryant, D.J., & Tversky, B. (1999). Mental representations of perspective and spatial relations from diagrams and models. *Journal of Experimental Psychology: Learning, Memory and Cognition, 25*(1), 137-156.

Dent, B.D. (1972). Visual organization and thematic map communication. *Annals of the Association of American Geographers, 62*(1), 79-93.

Dent, B.D. (1999). *Cartography: Thematic map design* (5th ed.). Boston, MA: WCB/ McGraw-Hill.

Downs, R.M., & Stea, D. (Eds.). (1973). *Image and environment: Cognitive mapping and spatial behavior*. Chicago, IL: Aldine.

Eysenck, H.J., Arnold, W., & Meili, R. (Eds.). (1972). *Encyclopedia of psychology*. New York, NY: Herder & Herder.

Fearing, F. (1953). Toward a psychological theory of human communication. *Journal of Personality, 22*(1), 71-88.

Gilmartin, P.P. (1981). The interface of cognitive and psychophysical research in cartography. *Cartographica, 18*(3), 9-20.

Golledge, R.G., & Spector, A.N. (1978). Comprehending the urban cognitive environment: Theory and practice. *Geographical Analysis, 10*, 403-426.

Golledge, R.G. (1999). Human wayfinding and cognitive maps. In R.G. Golledge (Ed.), *Wayfinding behavior: Cognitive mapping and other spatial processes* (5-45). Baltimore, MD: Johns Hopkins University Press.

Golledge, R.G. (2002). The nature of geographic knowledge. *Annals of the Association of American Geographers, 92*(1), 1-14.

Gould, P.R. (1975). *People in information space: The mental maps and information surfaces of Sweden*. Lund, Sweden: The Royal University of Lund/CWK Gleerup.

Gould, P.R. (1973). On mental maps. In R.M. Downs & D. Stea (Eds.), *Image and environment: Cognitive mapping and spatial behavior* (182-220). Chicago, IL: Aldine.

Gould, P.R., & White, R. (1986). *Mental maps* (2nd ed.). Boston, MA: Allen & Unwin.

Harrower, M., & Brewer, C.A. (2003). ColorBrewer.org: An online tool for selecting colour schemes for maps. *The Cartographic Journal, 40*(1), 27-37.

Humphreys, G.W., & Bruce, V. (1995). *Visual cognition: Computational, experimental, and neuropsychological perspectives*. Hove, United Kingdom: Lawrence Erlbaum Associates.

Jenks, G.F. (1967). The data model concept in statistical mapping. *International Yearbook of Cartography, 7*, 186-190.

Kitchin, R.M. (1994). Cognitive maps: What are they and why study them? *Journal of Environmental Psychology, 14*, 1-19.

Kitchin, R.M., & Freundschuh, S. (Eds.). (2000). *Cognitive mapping: Past, present and future*. New York, NY: Routledge.

Kosslyn, S.M., & Pomerantz, J.R. (1977). Imagery, propositions, and the form of internal representations. *Cognitive Psychology, 9*(1), 52-76.

Krygier, J., & Wood, D. (2005). *Making maps: A visual guide to map design for GIS.* New York, NY: Guilford.

Kulhavy, R.W., & Stock, W.A. (1996). How cognitive maps and learned and remembered. *Annals of the Association of American Geographers, 86*(1), 123-145.

Levine, D.N., Warach, J., & Farah, M.J. (1985). Two visual systems in mental imagery: Dissociation of "what" and "where" in imagery disorders due to bilateral posterior cerebral lesions. *Neurology, 35*, 1010-1018.

Lloyd, R. (1982). A look at images. *Annals of the Association of American Geographers, 72*(4), 532-548.

Lloyd, R. (1994). Learning spatial prototypes. *Annals of the Association of American Geographers*, 84(3), 418-440.

Lloyd, R. (1997). Visual search processes used in map reading. *Cartographica, 34*(1), 11-32.

Lloyd, R. (2000). Understanding and learning maps. In R.M. Kitchin & S. Freundschuh (Eds.), *Cognitive mapping: Past, present and future* (84-107). New York, NY: Routledge.

Lloyd, R., & Steinke, T. (1977). Visual and statistical comparison of choropleth maps. *Annals of the Association of American Geographers, 67*(3), 429-436.

Lobben, A.K. (2004). Tasks, strategies, and cognitive processes associated with navigational map reading: A review perspective. *The Professional Geographer, 56*(2), 270-281.

Lynch, K. (1960). *The image of the city.* Cambridge, MA: MIT Press.

MacEachren, A.M. (1982). The role of complexity and symbolization method in thematic map effectiveness. *Annals of the Association of American Geographers, 72*(4), 495-513.

MacEachren, A.M. (1991). The role of maps in spatial knowledge acquisition. *The Cartographic Journal, 28*, 152-62.

MacEachren, A.M. (1995). *How maps work: Representation, visualization, and design.* New York, NY: Guilford.

Monmonier, M.S. (1996). *How to lie with maps* (2nd ed.). Chicago, IL: University of Chicago Press.

Monmonier, M.S. (1989). *Maps with the news: The development of American journalistic cartography*. Chicago, IL: University of Chicago Press.

Montello, D.R. (2002). Cognitive map-design research in the twentieth century: Theoretical and empirical approaches. *Cartography and Geographic Information Science, 29*(3), 283-304.

Morrison, J.L. (1974). A theoretical framework for cartographic generalisation with emphasis on the process of symbolisation. *International Yearbook of Cartography, 14*, 114-127.

Muehrcke, P.C. (1998). *Map use: Reading, analysis, and interpretation* (4th ed.). Madison, WI: JP Publications.

Olson, J.M. (1979). Cognitive cartographic experimentation. *The Canadian Cartographer, 16*(1), 34-44.

Peterson, M.P. (2008) Trends in Internet and ubiquitous cartography. *Cartographic Perspectives, 61*, 36-49.

Posner, M.I. (1980). Orienting of attention. *The Quarterly Journal of Experimental Psychology, 32*(1), 3-25.

Robinson, A.H. (1952). *The look of maps: An examination of cartographic design.* Madison, WI: University of Wisconsin Press.

Robinson, A.H., Morrison, J.L., Muehrcke, P.C., Kimerling, A.J., & Guptill, S.C. (1995). *Elements of cartography* (6th ed.). New York, NY: Wiley.

Rittschof, K.A., & Kulhavy, R.W. (1998). Learning and remembering from thematic maps of familiar regions. *Educational Technology Research and Development, 46*(1), 19-38.

Saarinen, T. (1999). The Eurocentric nature of mental maps of the world. Research in *Geographic Education, 1*(2), 136-178.

Slocum, T.A., Blok, C., Jiang, B., Koussoulakou, A., Montello, D.R., Fuhrmann, S., & Hedley, N.R. (2001). Cognitive and usability issues in geovisualization. *Cartography and Geographic Information Science, 28*(1), 61-75.

Thorndyke, P.V., & Stasz, C. (1980). Individual differences in procedures for knowledge acquisition from maps. *Cognitive Psychology, 12*(1), 137-175.

Tolman, E.C. (1948). Cognitive maps in rats and men. *Psychological Review, 55*, 189-208.

Trick, L.M., & Enns, J.T. (1998). Lifespan changes in attention: The visual search task. *Cognitive Development, 13*, 369-386.

Tufte, E.R. (2001). *The visual display of quantitative information* (2nd ed.). Cheshire, CT: Graphics Press.

Tversky, B. (2000). Levels and structure of spatial knowledge. In R.M. Kitchin & S. Freundschuh (Eds.), *Cognitive mapping: Past, present and future* (24-43). New York, NY: Routledge.

Tyner, J.A. (1992). *Introduction to thematic cartography*. Englewood Cliffs, NJ: Prentice Hall.

Virga, V. (2007). *Cartographia: Mapping civilizations*. New York, NY: Little, Brown and Company.