PRESIDENTIAL ADDRESS

The Nature of Geographic Knowledge

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The nature of geographic knowledge today is very different from what it was fifty years ago. It has evolved from phenomenal (declarative) to intellectual (primed by cognitive demands). Surges of interest in systematic specialties and technical innovations in representation and analysis have changed the nature of geographic knowledge, advanced geographic vocabulary, defined and examined geographic concepts, and developed spatially explicit theories relating to human and physical environments. Explorations of interactions between these domains has generated a new interest in integrated science. This interest has produced a unique way of examining human-environment relations, and has provided the basis for a vastly different underlying knowledge structure in the discipline. But the future still challenges and significant problems face geography if it is to remain a viable academic discipline in the new information technology society. *Key Words: geographic knowledge, spatial thinking and reasoning, incidental and intentional learning, spatial relations, geographic skills.*

> Everything is related to everything else, but near things are more related than distant things.
>
> —Tobler (1970, 234)

The Changing Nature of Geographic Knowledge

Geographic knowledge is the product of geographic thinking and reasoning about the world's natural and human phenomena. Eliot (2000, 2) suggests that "knowledge *of* space is phenomenal, knowledge *about* spaces is intellectual." In geography, knowledge *of* space represents the accumulation of facts about the spatial arrangement and interactions comprising human-environment relations and recognition of fundamental concepts—i.e., the declarative base of geographic knowledge. Knowledge *about* space consists of the recognition and elaboration of the relations among geographic primitives and the advanced concepts derived from these primitives (such as arrangement, organization, distribution, pattern, shape, hierarchy, distance, direction, orientation, regionalization, categorization, reference frame, geographic association, and so on) and their formal linking into theories and generalizations. Using Eliot's terms, intellectual or created knowledge extrapolates far beyond simple sensory or observational information. In geography this extension is captured in part in the various forms of representation used to summarize data that has been constructed from information sensed by human or technical means and then analyzed and interpreted to unpack embedded (and often obscured) spatial existence and relational characteristics.

In the latter part of the 20th century there has been a substantial change in the nature of geographic knowledge. Throughout most of the history of the discipline, geographic knowledge has been declarative—i.e., it has focused on collecting and representing the physical and human facts of existence. In the latter part of this century there has been a change from inventory dominated activity to the creation of knowledge generated by emphasizing cognitive demands, such as understanding "why" and "how" in addition to "what" and "where." This has required a change from an emphasis on form to an emphasis on process. The accumulation of geographic knowledge has consequently changed from item recognition, place labeling, and place inventory or gazeteering to feature and distribution matching in real or image settings, item manipulation, and item transformation (e.g., using logical reasoning, deductive and inductive inference, analysis of complex forms, and multi-modal representation). This has facilitated solution of tasks such as recognizing geographic associations, understanding spatial colinearity in either positive or negative directions, undertaking map overlaying, understanding the results of scale transformation and rotation of separate displays

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to achieve maximal coincidence, and so on. A new way of thinking and reasoning in turn required the development of new data (e.g., primary data on attitudes, perceptions, beliefs, values, emotions, preferences, all collected directly from individuals), new methods of representational formats and modalities (e.g., computer cartography and graphics, tactile and auditory maps), new modes of analysis or interpretation (e.g., spatial analysis, multiple analysis of variance, metric and non-metric multidimensional scaling, spatially based cluster analysis, gap analysis, spatial autocorrelation, measures of geographic association), new sources and types of information (e.g., rankings, ratings, scaled values, sketches, model building, simulation, long term chemical analysis, tree ring analysis, hydrologic stations, recordings from ocean buoys, satellite images), and the recognition that geographers must consider multiple environments (natural, built, interactional, socio-cultural, and cognitive) (Golledge and Stimson, 1997, 7–22).

Perhaps the single greatest changes in the nature of Geographic Knowledge over the last half-century have been:

1. Recognition of the difference between the acts of accumulating geographic facts and representing the spatial form embedded in these facts, and understanding the processes involved in understanding and analyzing those facts to produce new information and knowledge that is not directly observed during data gathering; and
2. The development of spatially relevant theories about the location, arrangement, and distribution of geographic phenomena and the spatial interactions among both physical and human components of those phenomena.

In different decades of the 20th century, different purposes have dominated thought about what was considered important in a geographic knowledge accumulation. These have included regionalism, behavioralism, Marxism, neo-Marxism, structuralism, postmodernism, critical theory, feminism, environmentalism, and information science. A significant part of the quest for geographic knowledge has been detoured by attempts to understand the latest "ism" rather than advancing geographic knowledge—i.e., geographers have focused on perspective rather than substance and in doing so have wasted much effort in internecine conflict and criticism.

Understanding Human-Environment Relations (HER) has been a constant theme throughout the history of geography. For much of that history "environment" largely referred to physical space (i.e., the tangible natural world). With an increasing emphasis on the human side of this equation, "the environment" began to take on many new facets. Initially, the term was expanded to include the "built" environment (i.e., the tangible additions that humanity had made to the physical world). Then, in the latter part of the century, the term "environment" was expanded to include the behavioral environment (the environment of human interactions and movements), the social-cultural environment (i.e., the hidden structures of customs, beliefs, and values that constrained human relations), the political environment (i.e., the human-defined boundaries, legal structures, and organizational structures within which human action takes place), and the cognitive environment (i.e., the internal representation of the world in our memories). During the last half-century, geographic knowledge of each of these environments has advanced remarkably. In different decades, one or another of the "ism"-perspectives and the most relevant related environment have become dominant and have contributed to our understanding of the complexities of human-environment relations.

Each of the themes that have temporarily dominated geographic thinking and reasoning has defined its own criteria, elaborated its own methods, experimented with its own data types and representational modes, developed its own theories (or adapted acceptable ones from other disciplines), and has differentially chosen qualitative or quantitative criteria for evaluating the significance of efforts to produce and accumulate geographic knowledge.

The expansion of the nature of geographic knowledge has occurred for a number of purposes. These include:

1. increasing our understanding of place-to-place relations and variations;
2. obtaining a more complete base for interpreting human-environment relations at scales ranging from personal to global spaces;
3. assisting us to think about the spatial arrangement or organization of features, interactions, and relationships; and
4. facilitating the performance of efficient and effective spatial behaviors.

Geographers generally are aware that, to pursue these goals, an integrated approach gives the maximum understanding. While regional geography—an approach that epitomized integrated thinking—dominated much of geography up to the early 1960s, during the next thirty years, systematic specialties grew at the expense of the integrated regional approach. There is no doubt that systematic specialization was a necessary and inevitable step in the development of geographic knowledge. It was during this period that the full impact of the "Theoretical

Revolution" (often loosely called "The Quantitative Revolution") was made evident. General knowledge was replaced with detailed knowledge. As specific human-environment relations were closely examined, increased awareness of these relations facilitated the development of axiomatic, law-like, theoretical and generalized statements, and laid out a formal knowledge base that could justify policy recommendations. Normative theories (e.g., location theory, central place theory, urban population density gradient theory, and so on) first emerged because they simplified the world by assuming away much of the geographic variability continued within it (Harvey, 1969). Then less rational and optimal "theories" (or partial theories) emerged (e.g., Migration, Mobility, and Spatial Interaction Theories) (e.g., Amedeo and Golledge 1975); then social theory (e.g., social justice, political economy and Marxist theory applied to American urban life) (Harvey 1973) attracted supporters who were disenchanted because no immediate ethical and socially responsible solutions were offered to counteract social ills by existing approaches. Researchers then drifted on to the next "ism"—post modernism (Scott and Soja 1996), then to critical thinking (often regarded as the escape from Marxism) (Gregory 1994), and, more recently, to spatial information science (SIS) (Longley, Goodchild, Maguire, and Rhind 1999) and environmentalism (nature/society) (Turner, Kates, and Meyer 1994). All emphasized restricted points of view, and all but the SIS and nature/society developments drifted away from an integrated human-environment relations theme. Regionalism—still a paramount example of integrated HER—maintained a presence throughout the years, and, allied with a new cultural geography, has resurfaced as an important component of the discipline in recent years (Hudson 1994). In the past decade, this revival of integrated approaches in geography has been stimulated in part by the emergence of global communities and global domains that required integrations of knowledge about place, culture, interactions, politics, economics, resources, and natural environmental characteristics. Also, it has been the result of the efforts of Gilbert White and his many students, associates, and followers whose work on the occurrence and impacts of a variety of natural and technological hazards required the systematic integration of knowledge of physical events, human attitudes, and the concepts of risk and uncertainty to present a powerful HER integrative approach that at this time appears to have culminated in "Sustainability" and "Vulnerability" studies (Cutter 1984a, 1984b, 1985, 1996; Kates and Burton 1986; Turner, Kates, and Meyer 1994). As the world of academe once again turned its face to ever more evident global problems, it has become more and more evident that the HER integrative approach that has a natural home in geography has resurfaced as an important knowledge seeking procedure.

Geography as a Unique Way of Thinking and Reasoning about the World and Its Inhabitants

In the mid-1960s, a psychologist at Clark University, after working with an inspired group of geographic researchers including Jim Blaut, Roger Hart, and others interested in spatial knowledge (such as psychologist David Stea and architect Gary Moore), began asking questions as to why geographers "think differently" from other academics. Although not fully answering this question, Beck suggested that spatial thinking and spatial imaging and representation (i.e., the way geographers organized their thoughts and presented data to others) was unique to the discipline (Beck 1967). Finding an answer to questions of how and why geographers think the way they do has stimulated much of my research over the last 35 years, and I have constantly wondered why other geographers have neglected the active (not incidental) pursuit of this question. In this section, I offer some of the reasons that I have entertained at various times that might help understand the uniqueness of geographic thought.

Beck argued that development of spatial meaning in an environmental context requires an interpretation of both the physical and social components of the world as it is observed or perceived. He argued that neither geography (which at that time he saw as being concerned with tangible physical properties of the earth-system) nor psychology (which he saw as being concerned with personal attributes and functional and symbolic transactions between humans and their physical environment) was equipped alone to deal with the development of spatial meaning. And, although he contended that finding spatial meaning might require input from many disciplines, he (like another psychologist, Uttal, 30 years later [2000]) suggested that the way geographers reasoned about space, and particularly their penchant for representing complex spatial meanings in a clearly understandable form (spatially based maps, graphics, and images) emphasized that geographic thinking and reasoning gave a perspective that was not matched by any other single academic discipline.

So what comprises Geographic Thinking and Reasoning? By examining published geography literature over the past 50 years I have compiled a partial list of thinking and reasoning processes that should help to answer this question. The list includes:

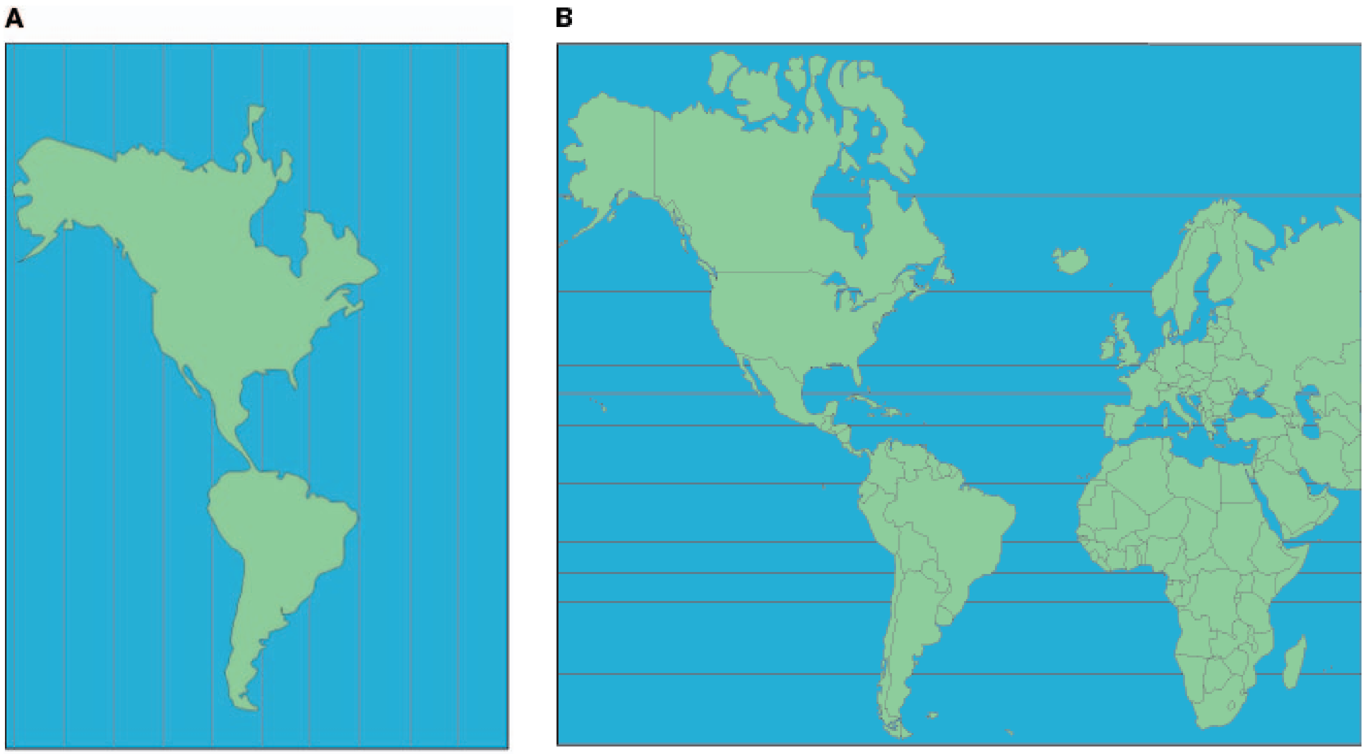

Figure 1. Aligned global maps. Figure 1(A) shows the results of a longitudinal continental "alignment" process that results in people believing that the South American west coast city of Santiago, Chile is west of the North American east coast city of Miami, Florida, while in geographic fact, the reverse is true. Figure 1(B) illustrates the latitudinal "alignment" process in which the continents are perceptually moved North or South producing misstatements such as "the equator passes through North Africa." *Source:* Compiled by Susan Baumgart, University of California, Santa Barbara.

- Comprehending scale transformations (Montello 1993; Montello and Golledge 1999; Clarke 2001; Montello and Golledge, in preparation).
- Being able to transform perceptions, representations and images from one dimension to another and the reverse (Monmonier 1996).
- Comprehending superordinate and subordinate relations and frames of reference (cardinal, relational, local, global) (Longley et al. 1999).
- Comprehending problems of spatial alignment (Figure 1A, 1B).
- Comprehending distance effects (e.g., distance decay, Morrill 1963) (Figure 2).
- Comprehending spatial association (positive and negative [Robinson and Bryson 1957; Cliff and Ord 1973; Hubert and Golledge 1982; Getis, 1989]) (Figure 3).
- Comprehending orientation and direction (e.g., forward-backward; left-right; up-down; back-front; horizontal-vertical; north/south/east/west) (Nyerges et al. 1995).
- Comprehending spatial classification (regionalization) (King 1969).

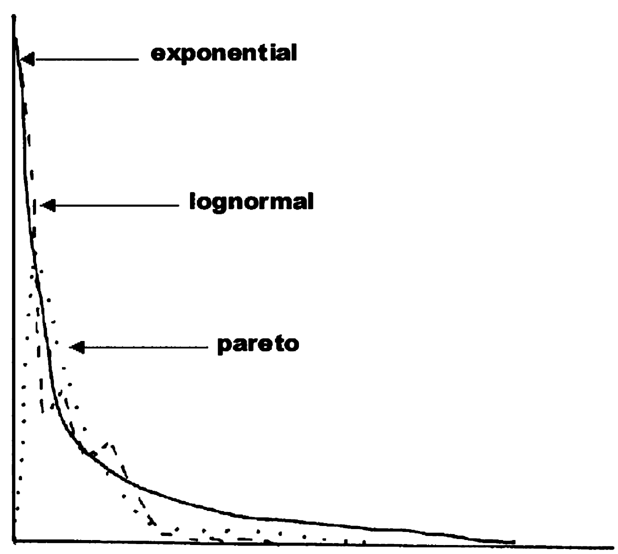

Figure 2. Typical empirical distance decay curves. These constitute examples of empirically derived distance decay functions for distances apart of marriage partners (exponential), urban population, density (lognormal), and urban land values (Pareto). Morrill (1963) pointed out that many different mathematical functions could be fit to the same empirical data and that selecting a specific function should be justified by reference to relevant theory.

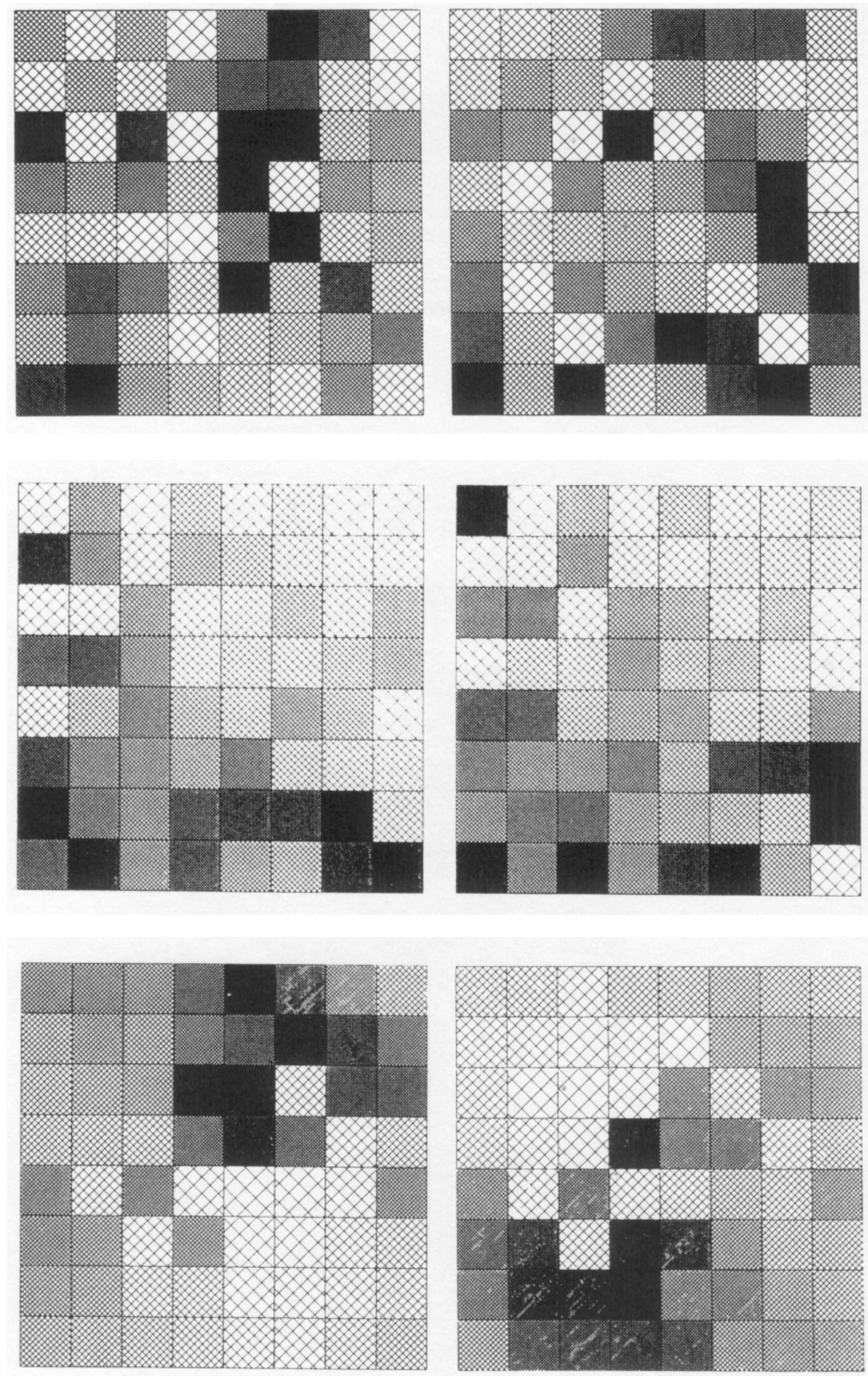

Figure 3. Three maps of spatial association. These figures (top to bottom) show a spatially mixed moderate positive correlation ($r = 0.67$), a spatially obvious moderate positive association ($r = 0.67$), and a spatially negative moderate correlation ($r = -0.67$). *Source*: adapted from Hubert et al. (1985, 45–46, figures 4, 5, and 6). Reprinted by permission. Copyright © 1985 by The Ohio State University Press. All Rights Reserved.

- Comprehending clustering and dispersion (centralizing and dispersing tendencies) (Gould 1975, 1993).
- Comprehending spatial change and spatial spread (spatial diffusion) (Hägerstrand 1968; Brown 1981).
- Comprehending non-spatial and spatial hierarchy (Golledge, Rayner, and Rivizzigno 1982) (Figure 4).
- Comprehending densities and density decay (population density gradients in different cultural settings) (Berry, Simmons, and Tenant 1963; Casetti 1973).
- Comprehending spatial shapes and patterns (geometry and topology) (Sack 1972).
- Comprehending locations and places (Haggett 1965; Tuan 1989).

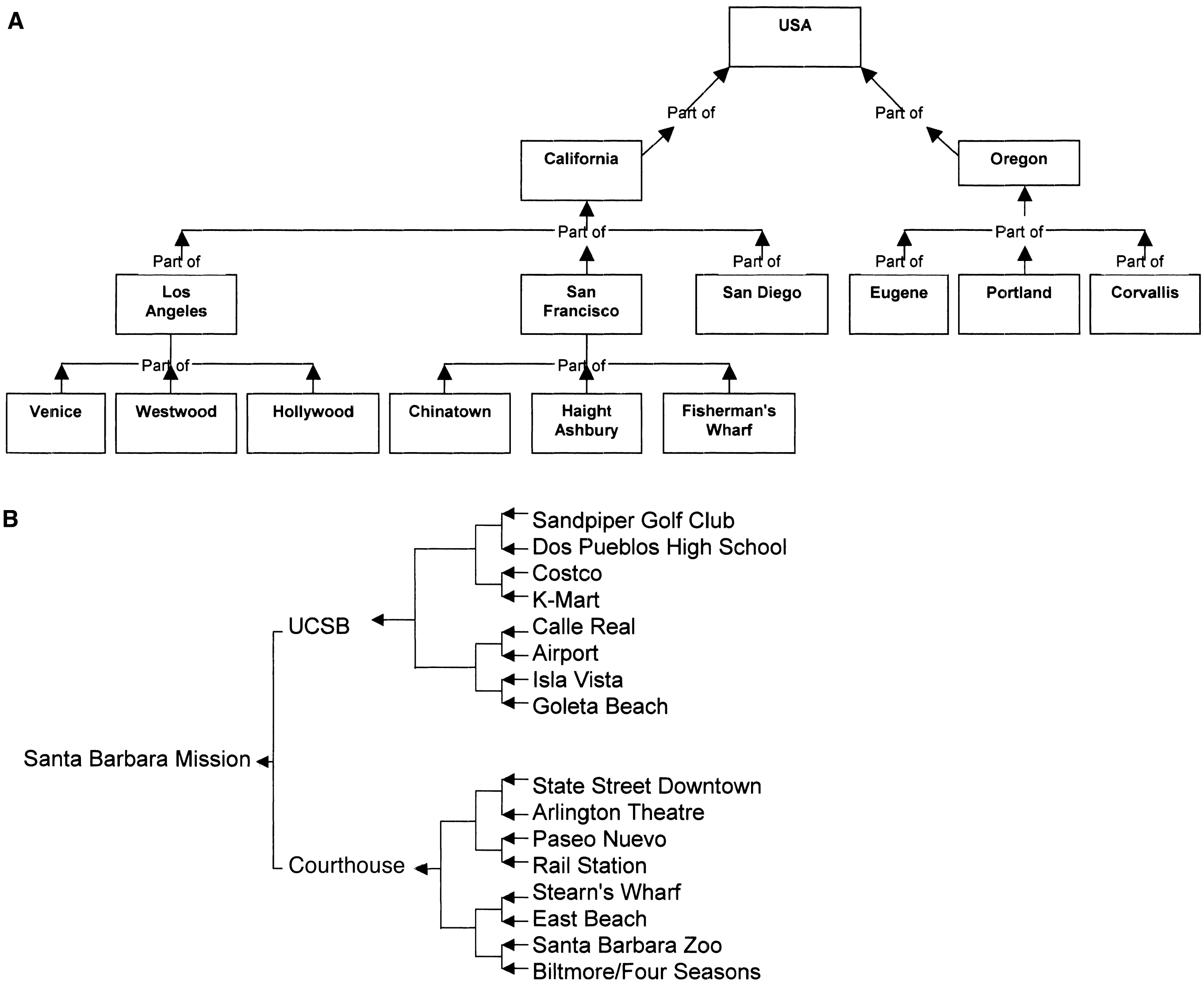

Figure 4. (A) Non-spatial hierarchy. This shows an inclusionary hierarchy that is semantically encoded. (B) Spatial hierarchy. This spatial hierarchy is based on interpoint distances (proximities).

- Comprehending overlay and dissolve (spatial aggregation and disaggregation) (Albert and Golledge 1999).
- Comprehending integration of geographic features represented as points, networks, and regions (Golledge 1978) (Figure 5).
- Comprehending spatial closure (interpolation) (Boyle and Robinson 1979; Muehrcke and Muehrcke 1992).
- Comprehending proximity and adjacency (nearest neighbor) and their effects (distance decay) (King 1969; Getis and Boots 1978; Boots and Getis 1988; Golledge 1995).
- Recognizing spatial forms (such as city spatial structures; relating traverses or cross-sections to three-dimensional block diagrams or images) (Marsh and Dozier 1983; Longley et al. 1999).

In short, geographic thinking and reasoning has provided a basis for understanding—or reasoning out—*why* there are spatial effects, not just finding *what* they are! Further, it enables us to reveal patterns in spatial distributions and spatial behaviors that may not be obvious to a casual observer in the real world (e.g., the pattern of shopping centers in a city) and consequently helps us understand the reasons for occurrences of episodic behaviors (e.g., obligatory and discretionary activities) in terms of spatial processes.

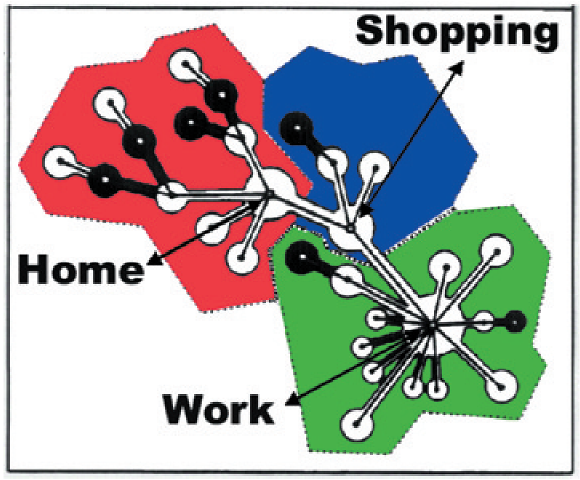

Figure 5. Anchor point theory. This figure shows a spatial knowledge structure consisting of best-known points (landmarks), paths (transport routes), and areas (communities and neighborhoods).

In a paper presented at the Pittsburgh meetings of the Association of American Geographers, Goodchild and Anselin (2000) outlined some unique contributions made to qualitative and quantitative science by the thinking and reasoning processes of geography practitioners. Loosely interpreted and modified somewhat, these include:

1. The *integrative nature* of geographic science, linking human and physical dimensions by seeking to understand human-environment relations.
2. The development over four decades of *Spatial Analysis*—the set of spatially based analytical tools that explicitly focus on comprehending the spatial component of geo-referenced data.
3. The use and comprehension of *spatial representations*—whether prepared in paper and ink and hardcopy format (e.g., cartographic maps), as on-screen visualizations (e.g., images and graphics), or in digitized remotely sensed imagery (e.g., satellite data and air photos), these unique ways of representing data have changed the way geographers reason and infer the existence of patterns, distributions, and relationships in spatial data.
4. Geography now has *spatially explicit theory* to complement the economic, social, political, cultural, biotic, meteorological, hydrological, geomorphological, and other symbiotic theories that it "borrowed" from adjacent disciplines during the first sixty years of the 20th Century. Whether in human science or physical science domains, spatially explicit theory has added much to general understanding of the world around us.
5. Geographers use *place-based reasoning* in their scientific endeavors, because, whether identified in absolute (e.g., global co-ordinate) or relative (proximal or local relational) ways, the place-specific nature of all things in real, imagined, or virtual worlds is paramount. Today's geographers—more so than ever before—relish this factor and make a search for understanding place-specificity their guiding objective.
6. In a digital world where scale transformation (zooming) comes at the click of a mouse button, understanding the implications of *scale change* (scale-dependent and scale-independent processes) for theory, practice, and policy has reached critical levels. Geographic reasoning has made people aware of scale, and has graphically illustrated how changing scale can subtly (and not so subtly) change the world as we represent and interpret it (Monmonier 1996; Montello and Golledge in preparation). New *scale-dependent relationships* are brought to view by spatially explicit reasoning. And finding *scale-independent relations* is the first step to developing robust geographic theory.

Spatial Concepts and Relations: The Bases of Geographic Knowledge

The development of geographic knowledge has been hampered because the discipline has not developed a widely accepted vocabulary. We *do* have dictionaries that provide defined lists of terms (e.g., Johnson et al. 2000). But little attention has been focused on defining primitives, combining them to derive more complex spatial/geographic concepts, and exploring what "error" gratuitously accumulates as we build primitives and low order concepts into more highly ordered (complex) terms. Exceptions include the works of Nystuen (1963), Papageourgiou (1969), Golledge (1995), and Nyerges (1995). Place-specific identity, location, magnitude, time, boundary, and distance have been suggested as primitives upon which geographic knowledge is built. Examples of "first order" derivable concepts include: distribution or arrangement (from multiple locations), regions (from aggregations of place-specific identifiable phenomena), frames of reference (providing structures that allow absolute or relative locations to be identified), orientation and directions (from location, identity, time and reference frames), spatial hierarchies and dominance (from magnitude and location). Higher order (complex) concepts include such things as pattern, clustering and dispersion (from internal arrangement of distributions), spatial association (from location, magnitude and distribution) and density and distance decay (from boundary, distance, magnitude and distribution). The structure of the language of geography is ill-defined, under-researched, and has been only casually taught and learned. An important step to mitigate our ignorance of the structure of our disciplinary vocabulary has been undertaken by the joint efforts of the AAG, NCGE, and NGS (Geography Standards—Geography for Life Curriculum, 1994). This curriculum defines important geographic concepts and builds a K–12 curriculum around those concepts. Yet they are presented as independent units—their derivative nature and use in developing more complex concepts is under-emphasized.

Some basic premises embedded in the spatial concepts and relations that are the essence of geographic knowledge and the accommodations made by cognitive processing are summarized in Table 1. This offers examples of findings from geographic observation over time as well as statements of how geographers accommodate tangible observations.

Partly as a result of cognitive filtering and processing, and partly because of inevitable technical errors in data capture and representation, biases occur in geographic knowledge. These biases include:

- Conceptual biases based on improper thinking and reasoning.
- Perceptually based biases resulting from inadequate use of gestalt principles for grouping, symmetry, figure-ground clarity, closure, and so on.
- Biases occurring during the processes of encoding, internal manipulation, or decoding geographic information.
- Biases that occur when geographic features are cognitively misaligned with respect to their actual positions in objective physical space, as represented in conventional reference frames such as latitude and longitude.
- Biases that occur when geographic information summarized in regional form is simplified to a substantial degree, and inclusion/exclusion errors abound.
- Biases resulting when non-symmetric geographic information is made symmetric, while symmetric relations are perceived as non-symmetric. Perceptual and cognitive factors combine to allow shorter distances to be overestimated, and longer distances to be underestimated in comparison to physical distances (regression toward the mean). Perceived distances to and from a particular place are often regarded as being asymmetric. They may

Table 1. Tangible Spatial Concepts and Geographic Accommodations

⇒ Geographic units are almost always irregular in shape and area. Our cognitive behavioral tendency is to make irregular shapes and areas more regular (smoothing and generalizing).

⇒ Geographic units invariably do not maintain a common uniform orientation relevant to the cardinal points of the compass. We may mentally rotate them to "fit" a reference frame.

⇒ Hierarchical ordering is common to both physical systems and to human organization (e.g., stream networks and geopolitical entities). Geographic units are cognitively and empirically organized into a nested hierarchical form (e.g., school districts).

⇒ Our knowledge about locations, places, regions, and other geographic units is not perfect. Even with imperfect geographic knowledge, effective geographic decision-making can take place, partly because we realize that geographic phenomena occur in proximal spatially distributed forms (Tobler's Law).

⇒ Geographic phenomena may be irregularly distributed over space. There are underlying cognitive behavioral forces working to facilitate the meaningful clustering and categorization of geospatial information.

⇒ Objectively defined geographic data is theoretically designed to have less bias than subjective data. Perceptual and cognitive sensory filters and behavioral restraints invariably produce biased personal knowledge.

⇒ Information on geographic phenomena can cover widely different scales. Geographic thinking uses plausible reasoning processes to operate on imperfect and incomplete beliefs about geography from local to global scales.

⇒ Geographic data compiled by and for machine use has to be more accurate and complete than that compiled by and for human use. Accuracy of geographic data depends on levels of human familiarity with the nature and source of the information.

⇒ Geographic knowledge can be spatially fragmented. Generalizations are made from knowledge-rich to knowledge-poor domains.

⇒ The nature of geographic knowledge is often made evident by the way it is represented. Bias in geographic judgments is often evident in the representation of the results of those judgments (Harley 2001).

⇒ The processes underlying geographic knowledge are different from the processes underlying other complex knowledge domains. Geographers are still ignorant of many of the processes (spatial and non-spatial) underlying geographic knowledge.

⇒ Not all geographic knowledge is spatial in nature (e.g., some is hierarchical and inclusionary in a semantic rather than in a spatial sense). Non-spatial factors influence memory for spatial locations (e.g., where function is more important than place in identifying phenomena). Biases often result when non-spatial knowledge frames are used to reason about spatial knowledge.

⇒ As we progress from local to global scale, geographic knowledge becomes more categorical than spatial.

further be distorted, depending on the direction of viewing.
- Biases can arise because of improper renderings of superordinate geographic structures.
- Biases in general geographic knowledge often result from a combination of an alignment heuristic and a rotation heuristic used at the time of encoding information. The alignment effect simply tends to align features relative to one another, regardless of true global setting, and the rotation heuristic includes the tendency for a feature to be rotated to fit a reference frame (e.g., "You are here" maps are often incorrectly oriented with respect to objective reality and thus require the difficult process of mental rotation to match with the real world).
- Biases occur in subjective estimates of locational precision and constancy (e.g., people don't always perceive the same object to be in the same place at different points in time); this justifies a need for accurate objective records and representations (e.g., maps).
- Biases when perspective changes influence evaluation of spatial relations (an object to the left of another becomes to the front or behind it following perspective change).
- Biases that result when internal representations are distorted or fragmented and produce error ridden spatial products (Figure 6), but note that a geographically correct "map" is not necessarily stored in long-term memory or created in working memory and is not needed to successfully solve geographic tasks.
- Biases that occur because geographic language lacks the metric information needed to build a correct spatial configuration: for example, when we say, "A is behind B and C is to the left of B" we can generate an infinite number of spatial configurations that comply with the logical rules embedded in the statement.

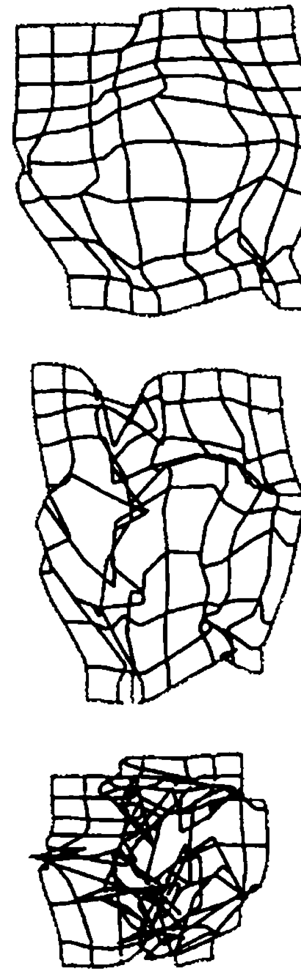

Figure 6. Three cognitive maps of newcomers, mid-term residents, and long-term residents. Examples of grids recovered using nonmetric multidimensional scaling of cognitive interpoint distances for long-term residents (top), 3-year residents (middle), and newcomers (bottom).

Informally and Formally Acquired Geographic Knowledge

Geographic knowledge consists of "informally acquired," "incidental," or "naïve" knowledge (Egenhofer and Mark 1995) and "formally acquired" or "intentional" ("taught," "learned," or "expert") knowledge. Informally acquired knowledge dominates in most of our everyday decision-making and thought processes. And a good deal of that knowledge is acquired using general guidelines that produce vague or error-prone knowledge.

Casually observing environments without a repertoire of spatial concepts, theories, and generalizations, produces this informal or incidental "knowledge." Inadequacies in this knowledge base result from (1) spatial biases in observing and internally representing information; (2) improper manipulation of stored information recalled into working memory for spatial decision-making; (3) lack of spatial skills that help comprehend perceived information; (4) insensitivity to sample size (generalizing from $n = 1$); (5) misconceptions of the nature of chance events (e.g., "we've just had a 20-year storm and won't have another for 19 years"); (6) illusions of validity (e.g., "my experience is typical"); and (7) personal aggrandizement ("I wasn't included in the sample so it's not representative!"). Unfortunately for many people (particularly in countries like the USA where geography is not an essential and integrated part of general education in all K–16 environments), informal or incidentally acquired geographic knowledge is the main source for understanding the world. Fortunately, during the last two decades, major assaults on geographic ignorance have been launched by cooperative action among the Association of American Geographers (AAG), the National Council for Geographic Education (NCGE), the National Geographic Society (NGS), the American Geographic Society (AGS), and the Committee on Geography (COG). Important results include the Geography Standards: Geography for Life Curriculum (1994) and the ARGUS and ARGWORLD projects (Gersmehl 1999). A National Research Council initiative brought forth a book summarizing the mission and content of geography today (NRC 1997). Other significant efforts have included projects on "Human Dimensions of Global Change" (Hanson 1997), Mission Geography (Bednarz and Butler 1999), and the institution of an Advanced Placement (AP) test for high school geographers (Boehm and Petersen 1999). Each of these emphasizes geographic concepts and geographic relations as well as offering insights into distributions, arrangements, patterns, and interactions. And all reflect the changing nature of geographic knowledge.

There is a remarkable difference between the quality and accuracy of the informal or incidental geographic knowledge that we acquire by personally experiencing places during activities dominated by other purposes (e.g., "experiencing" an urban environment during a work or shopping trip) and the deliberately structured formal or intentional geographic knowledge that we acquire via teaching and learning processes (e.g., by using the Geography for Life Curriculum, 1994). As geographers, we are amazed at the appalling geographic ignorance of those persons whose knowledge repertoire is dominated by informal or incidentally acquired information. Such people often cannot name the major continents, may not be able to identify the USA on a map or globe (Earhardt 1998), or may have completely spurious understanding of place (e.g., confusing the Mediterranean with the Caribbean).

Geographic knowledge levels change dramatically when formal or intentional knowledge is gained—particularly when people are taught to observe fundamental geographic principles like location, place, connectivity, interaction, distribution, pattern, hierarchy, distance, direction, orientation, reference frame, geographic association, scale, region, and geographic representation (many of these have been incorporated into the Geography Standards-Geography for Life Curriculum). This implies that geography—like other disciplines—has a language and knowledge base that is not casually accessible or easily (naively) accumulated. Rather, it is a concept rich and structured body of knowledge that is based on specific modes of thinking and reasoning that usually have to be taught. This is especially true of geographic knowledge today.

To more completely understand the nature of geographic knowledge, we must be aware of differences in the levels of spatial abilities among people. But, even more fundamentally, we must be aware of the very nature of the spatial abilities and skills that accommodate the acquisition of geographic knowledge. An ongoing National Research Council initiative on "Spatial Thinking" (headed by geographer Roger Downs) is focusing on this precise problem.

The Usefulness of Geographic Knowledge

Geographic knowledge is useful for two fundamental reasons: (1) to *establish* where things are and (2) to *remember* where things are to help us in the process of making decisions and solving problems. Establishing where things are has produced the need for exact forms of locational determination and place and feature representation as epitomized in cartographic developments. Remembering where things are is part of everyday life and everyday decision-making. Inadequacies in remembering force us either to make mistakes or to consult representations of where things are before we can effectively use knowledge of geographic patterns and relations.

But establishing where things are is but one way that geographic knowledge is found useful. Other aspects consist of making us aware of the spatial relations amongst things (e.g., soils and vegetation), the regional or categorical classes to which things belong (e.g., groupings of urban functions; culture regions), the extent to which things interact (e.g., urban land values and population densities), and the extent to which things are co-related in terms of their spatial occurrence and distribution (e.g., professional sports teams and large cities). In other words, it helps us to know *why* things are where they are, and *how* and *why* they are spatially related to other things.

Acquiring geographic knowledge helps to develop a capacity for recognizing occurrences of similar phenomena in different environments (knowledge transfer) and recognizing one, two, or three-dimensional transformations of phenomena (this knowledge includes a capacity for transforming three-dimensional objects into two-dimensional representations as when making a map or creating a geologic profile from a block diagram). Other transformations include rotation and alignment (e.g., of maps and the scenes they represent or resulting from perspective changes). In movement, spatial knowledge is necessary to undertake route reversals, take shortcuts, and navigate through unfamiliar territory. It also helps to create integrated images from separate independent bits of evidence (e.g., compiling an integrated understanding of an environment from piecemeal explorations of it). In many circumstances, geographic knowledge is required to complete problem-solving tasks in imagined as well as real space (e.g., spatial simulations), understanding spatial correlations among geographically dispersed phenomena, and imagining integrative representational modes for communicating spatial information about phenomena in visual, cartographic (maps), auditory (auditory maps), kinesthetic (mental records of effort), and haptic (tactile map) domains.

Geographic knowledge is useful not only for effectively participating in everyday life, such as helping to remember the location of ATM's, shopping centers, and routes to local schools, but at all other scales of living. Federal and state policies are implemented at regional and local levels, and the process of regionalization is in essence, spatial classification. A significant geographic problem that emerges after every population census is to redistrict electoral regions. This is necessitated by spatial variation in natural population growth and migration (the process of redistributing population over space). Geographic knowledge is useful in every political decision ranging from the determination of national boundaries to the allocation of funds to maintain local transportation systems. There is little point in attempting to list all the areas in which geographic knowledge is pertinent. It is used universally, in all cultures, in all regions, but it is important to understand *why* it is used universally. Which brings me to the crux of this section. The natural world and the human activities embedded in it are incredibly diverse. The human brain does not deal well with extreme diversity (chaos), but can handle variability. We do this in a spatial sense by searching for locational regularities that can be cognitively categorized and spatially associated so that information can be ordered and communicated. In this way, variability and diversity can be interpreted, and what might otherwise be considered chaos can be comprehended at some scale of organization. Geographic knowledge thus helps us make sense out of chaotic or apparently highly diversified environments.

Problems Involved in Pursuing Geographic Knowledge in the 21st Century

Some questions and tasks that the discipline must face as we move further into the 21st century include:

1. Will there be a Geography Discipline in, say, 50 years? That is, will emerging trends that de-emphasize disciplinary boundaries, reorganize collegiate structures, and facilitate the development of research communities in universities, eliminate the need for departments, particularly those—like geography—that appear to lend themselves to diffusion of sub-areas into other academic units?
2. What will distinguish Geography's contribution to knowledge from that of other disciplines with Spatial Information or Integrated Science interests? What aspects of Geographic Knowledge will help us compete equally for students and research funds with other information processing disciplines and agencies?
3. How will Geographic Knowledge increase if the world we live in becomes more reliant on digital information technology? What will be the research and instructional role of technical innovations such as virtual worlds and wearable wireless computers?
4. What aspects of geographic thinking and reasoning help us to create an accepted identity as the pre-eminent link between human and natural sciences? Geographers for decades have claimed to best represent that link, but in fact for over 30 years much of both human and physical parts of the discipline have virtually ignored each other. What is needed to reintegrate the discipline? Is it necessary to do this?
5. What geographically specific knowledge can be accessed to help solve some of the world's "Great Challenges" such as effects of Climatic Change, the task of creating or maintaining Sustainable Natural and Urban Environments, or deciding how many people the Earth can support and where they will be located?
6. What unique output or consequences occur due to spatial and geographic thinking? The role of geographic knowledge in the history of the growth and spread of human populations has not been articulated, so we do not at this time know *why* geographic knowledge has been important in the emergence and growth of human civilization.
7. What will be the ideal format for geographic representations in the future? Will they be electronic or hard copy? Single or multiple media?
8. How can Geographic Knowledge contribute to the comprehension and solution of problems involved in society-space relations? Can geogra-

phers help solve problems of inequality, inequity, and social justice as well as just identifying and cataloging their existence?

9. What future role can Geographic Knowledge play in establishing global international, national, regional, and local policy?
10. What geographic knowledge can we create to enhance understanding of global societies, cultures, economies, and political and information structures? Will global mapping provide the ultimate knowledge structure to achieve such goals?

Summary

Johnson (1997, 35) stated that: "To most of us, there is no such thing as geography, other than as a vaguely defined discipline to which we are attached as much for political and economic (that is, job security) reasons as for intellectual ones." He further states "And does it matter? I believe not. There is no such thing as geography, only a lot of separate geographies all of which share characteristics with the others, but are quite considerably self-sufficient." While such an impression may be gained because of the specialization and fragmentation of geography over the last 40 years, I cannot agree with this statement because (1) it ignores the fact that topical specialization has been a necessary step in the development of detailed geographic knowledge by providing the deep understanding of knowledge segments prior to their integration into relevant theories and models; (2) it fails to acknowledge the existence of a common set of primitives and concepts that span both physical and human sides of the discipline; and (3) such a position is defeatist and only provides fuel for others to continue their assault on the discipline in terms of departmental closures and exclusion of geographers from multidisciplinary challenges to which they have much to offer. Rather, I believe that geographic knowledge is concept-rich, has a substantial theoretical base, is replete with distinct analytic forms (both qualitative and quantitative), lends itself to graphic, cartographic, and other forms of geo-representation, and is imbued with knowledge derived from using place-specific reasoning to integrate components of its physical and human domains.

The changes that have taken place over the last 50 years have given structure and substance to a discipline that was concerned largely with inventory. Today we have all the components deemed necessary to define and justify the existence of a scientific discipline—a huge array of empirically verified factual data, spatial theories and models, innovative methods of spatial analysis, unique modes of representation, and practical usefulness for decision-making and policy formulation.

Geographic Knowledge is universal. But it can *not* be acquired only informally or incidentally by casual observation. We must define and accept a comprehensive set of concepts on which knowledge can be based. Without such a base, our knowledge structure is speculative and hard to justify or defend. With such a base, we can erect a formidable and rich array of concepts, generalizations, laws and theories which are equivalent to acceptable bodies of knowledge in other disciplines. It is important that we realize that we need to deal with well-defined concepts as opposed to vague ones. Understanding this will in part provide a basis for assessing the validity, reliability, and justifiability of our arguments and conclusions—much debated questions by critical thinkers throughout the discipline. Geographic knowledge represents a body of science that has much to offer humanity, and, as its professors, we must do our best to continue adding to all facets of that knowledge set. Geography is a healthy discipline, and maintaining it as such in the future *does* matter.

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