nformation for Authors

The editor of the ANNALS seeks to publish original, timely, d innovative articles that advance knowledge in all fields the discipline. To be accepted, papers must meet the ghest standards of scholarship, address significant research oblems, and be of interest to the broad readership of the urnal and geography as a discipline.

Contributors should submit manuscripts to Stanley D. unn, Editor, The ANNALS, Department of Geography, Uni-rsity of Kentucky, Lexington, KY 40506-0027. Because each anuscript is reviewed by an associate editor and at least o outside reviewers, authors should send five copies of e manuscript and illustrations (photocopies are acceptable). gh postage costs preclude returning items submitted.

Manuscripts should be in English with a writing style that clear, direct, in the active voice, and understandable to e journal's readers. Authors should avoid sexist language age. The manuscript should be in clear type (using a new bon), double-spaced, with wide margins, and using one le of the paper. The abstract, list of references, tables, and list of figure captions should be typed *double-spaced* on parate sheets.

The transmittal letter accompanying a manuscript should ntain a statement affirming that it has not been submitted published elsewhere and will not be submitted elsewhere publication until a decision is rendered by the editor of e ANNALS. In accordance with copyright law, the manu-ipt must not duplicate, in part or in whole, copyrighted aterial that has been published elsewhere. Failure to com-y with these instructions may preclude publication of all part of the manuscript.

Title Page. The title page should include the full names of thors, academic or other professional affiliations, and the mplete and current address and phone numbers of the ntact author with whom the editor can correspond.

Abstract. Each paper should be accompanied by an abstract no more than 250 words. The abstract should summarize arly the purpose, methods, and major findings of the pa-r. Key words should appear at the end of the abstract. It ould be written in the active voice.

Footnotes. Because footnotes are expensive to typeset, they ould be used only when necessary. In many cases, such formation can be accommodated in the body of the text. sential footnotes should be brief and limited to explaining point in the manuscript. They should not be combined ith references to literature, which are to be placed in a parate list at the end of the text. All footnotes should be ped, double-spaced, on a separate sheet under the heading "Notes" placed at the end of the text.

References. Cite references in the text by typing in paren-eses the last name(s) of the author(s), followed by the year e work was published. Two or more cited publications by e same author(s) that appeared in the same year should be stinguished by a, b, c, etc., after the year, for example lercator 1943b). On a separate sheet immediately after the xt (or following the "Notes" section, if any), under the eading "References," list complete reference citations al-habetically by first author's last name. A reference to "in ess" implies that the paper has been accepted for publi-ation. Titles of periodicals should be given in full. Examples f correct citations appear in this issue. For further guidance, fer to *A Manual of Style*, The University of Chicago Press.

Units of Measure. Authors must use the International Sys-m of Units (metric) but may show other units in parenthe-s.

Equations. Equations should be numbered sequentially in parentheses in the right-hand margin. Authors should provide instructions in the margin for any special type required (Greek letters, boldtype, etc.) the first time the symbol is used. Authors should be careful to differentiate between capital and lower-case letters, Latin and Greek characters, and letters and numerals. For example, the numeral 1 and the letter l are often confused.

Tables. Each table should be discussed in the text, but readers should be able to understand tables without reference to the text. Type all tables on separate sheets, double-spaced, numbered sequentially with Arabic numerals. Each table should have a descriptive title and informative column headings. Table titles should concisely summarize the relationship or pattern presented by the table. Do not repeat row or column headings or include qualifying phrases that might conveniently be presented in a footnote to the table. For example, use "Population Change in the Middle West," not "Percentage Rates of Population Change and Net-Migration, States of the Middle West, 1960–70 and 1970–80."

Illustrations. Maps and graphs for the ANNALS should be legible, clean, and clear presentations coordinated with text material and referenced directly, e.g., "The map in Fig. 4 shows" or indirectly, e.g., "(see Fig. 4)". Each graphic illustration should be designed for the smallest format necessary to contain the information, usually one or two columns in width and taking up less than a full page. Conventionally-drafted graphics should generally be rendered for one-third to one-half reduction to final size. A fine neatline defining the area of the graphic is recommended both as a guide for the camera operator and as a visual boundary to separate the graphic from text on the page. Lettering size should be carefully chosen to be clearly legible at final size. Printing screens between 85 and 150 lines (preferably 120 or 133) should be used rather than adhesive patterns. Well-executed computer-drawn graphics are acceptable if comparable in quality to those produced conventionally; solid, readily reproducible linework is essential. Computer-plotted characters are best replaced with typeset lettering. Above all, graphic displays should be well designed with respect to content. Simplicity should be achieved through design, not through limiting of content.

High-contrast photographic copies at final scale should be submitted with the original manuscript for review (do not send originals of graphics); if clearly legible, xerographic copies are acceptable with the other four manuscript copies to be submitted. Plate-ready negatives, right-reading emulsion side down, are preferred when the manuscript goes to press. Authors wishing to include color prints will likely be asked to pay the costs of color printing. Likewise the authors of map supplements will be responsible for the costs of printing and folding the necessary copies for all subscribers.

Graphics will be reviewed by the cartography associate editor or a selected cartographic reviewer. Graphics not meeting the ANNALS standards will be returned for redesign and reconstruction.

Permissions. If previously published material of substantial extent is included in a manuscript, the author is obliged to obtain written permission from the copyright holder and bear any cost for use of copyrighted materials.

Articles

Specialization in the Structure and Organization of Geography

Michael F. Goodchild and Donald G. Janelle

Department of Geography, University of Western Ontario, London, Ontario, Canada N6A 5C2

Abstract. Specialty groups are a relatively recent innovation within the Association of American Geographers (AAG), but have grown rapidly to play a major part in the functioning of the organization. This paper examines the role of specialization within and between disciplines, with special reference to geography, as a response to the complexity of knowledge and of scientific activity, and as a phenomenon of social organization. The scale and basis of organization of the specialty groups are seen as responses to needs for communication and survival. Natural and empirical views of the organization of disciplines and other academic divisions within the field of knowledge, and of the processes operating on individual career paths, are discussed. The empirical (or pragmatic) view provides the basis for analyzing the membership of AAG specialty groups to determine the structure of the current discipline and the trends to which it is subject. A multidimensional scaling and an elementary linkage analysis of the cross memberships of specialty groups for 1984 show patterns of affinity and divergence of topical interest and of general research paradigms. The revealed cores of the discipline confirm the earth-science, man-land and spatial traditions identified by Pattison (1964). In contrast, the area-studies tradition does not display any unified core, but links to the general body of geography through systematic concerns. Applied geography, historical geography and cartography are most central to the structuring of specialty group memberships and appear to be prominent sources of unity for those groups that represent the different traditions. A diversity-of-interest measure, based on an information statistic, reveals that socio-demographic (age and sex), institutional (Ph.D.-granting departments), and technological factors also play significant roles in structuring the pattern of specialization.

Key Words: geography, specialization, sociology of knowledge, multidimensional scaling, elementary linkage analysis, information statistic.

IN recent years specialty groups have become established within several national and international organizations as a strong new level and form of organization in geography. Listings of formalized specialty groups of associations from Canada, the United Kingdom and the United States, and from the International Geographical Union (IGU), provide ample evidence of their significance in the current structuring of geographic activity (Table 1). Whereas this is a recent phenomenon for the national associations, specialized Commissions of the IGU date from 1891 and were formalized as part of its structure in 1925. Its three levels of organization included only nine groups in 1952, but by 1986 they had expanded to 42 (Fuchs 1986). The rapidity of this growth at the national level is illustrated by the Association of American Geographers (AAG). The special 75th anniversary volume on its history (James and Martin 1978) mentions only a recommendation for the formation of specialty groups, yet by 1986 they numbered 37 and were re-

Annals of the Association of American Geographers, 78(1), 1988, pp. 1–28

Table 1. Formalized Specialty Groups in Geography: 1986

Association of American Geographers	Institute of British Geographers	Canadian Association of Geographers	International Geographical Union	
Specialty Groups:	**Study Groups:**	**Special Interest Groups:**	**Commissions:**	
Africa	Biogeography	Environmental Impact Assessment	Geographical Education	Changing Rural Systems
Aging	Developing Areas	Geography of Parks, Recreation & Tourism	Geographical Data Sensing and Processing	Coastal Environment
Applied	Geography and Planning	Industrial Geography	Geographical Monitoring and Forecasting	Industrial Change
Asian	Geomorphology	Marine and Coastal Zone Management	Measurements, Theory and Application in Geomorphology	International Division of Labour and Regional Development
Bible	Higher Education	Medical Geography	Mountain Geoecology	The Significance of Periglacial Phenomena
Biogeography	Historical Geography	Rural and Urban Fringe	Population Geography	Geography of Tourism and Leisure
Canadian Geography	Industrial Activity and Area Development	Canadian Women in Geography	Urban Systems in Transition	Comparative Research in Food Systems of the World
Cartography	Medical Geography			History of Geographical Thought
Chinese Geography	Political Geography		**Working Groups:**	Geomorphological Survey and Mapping
Climatology	Population Geography		Resource Management in the Drylands	International Hydrological Programme
Coastal & Marine	Quantitative Methods		Cartography of the Dynamic Environment	Geography of Transport
Contemporary Agriculture & Rural Land Use*	Rural Geography		Environmental Atlases	Dynamics of Land Use Systems
Cultural Ecology	Social Geography		Mathematical Models	Urbanisation in Developing Countries
Energy	Transport Geography		Tropical Climatology and Human Settlements	Energy Resources and Development
Environmental Perception	Urban Geography		Landscape Synthesis	Man's Impact on Karst Areas
Geographic Information Systems*	Women and Geography		The Great World Metropolitan Cities	Geography of Commercial Activities
Geographic Perspectives on Women	History and Philosophy of Geography			Geography of Telecommunication and Communication
Geography in Higher Education			**Study Groups:**	Map Use
Geomorphology			Climatic Change	Environmental Perception in Resource Management
Historical			Topoclimatological Investigation and Mapping	Marine Geography
Industrial Geography			World Political Map	
Latin American			Development in Highlands and High Latitude Zones	
Mathematical Models & Quantitative Methods			Geography and Public Administration	
Medical			Famine and Food Crisis Management	
Microcomputers*				
Native American				
Political Geography				
Population				
Recreation, Tourism & Sport				
Regional Development & Planning				
Remote Sensing				
Rural Development				
Socialist				
Soviet & East European				
Transportation				
Urban				
Water Resources				

* Not included in analysis of 1984 data (Table 2).

sponsible for organizing 151 of the 319 academic sessions for the Twin Cities Annual Meeting (AAG 1986, 10).

The formation of specialty groups within the Association originated with the AAG Council's decision, in October 1976, to form an *ad hoc* Long-Range Planning Committee (LRPC). Its broad mandate spanned a variety of questions on matters of governance, finance, publications, services to members, and the organization of annual meetings. According to President Melvin Marcus (1977–78), this was:

> "the most significant activity undertaken by the Association in the decade. The results will influence our goals, operations, and professional philosophies for many succeeding decades" (Marcus 1977, 1).

In its final report to Council, in April 1978 (LRPC 1978), it was clear that the LRPC viewed the establishment of semi-autonomous specialty groups as a central element of its proposed reforms. This new level of organization would help to capture the support of special interest groups by giving them identity within the broader Association. The 1960s and early 1970s had seen increasing evidence of fragmentation along subdisciplinary lines. While the benefits of such specialization were recognized, there was fear that this could lessen the significance of the Association and erode the strength of geographers generally. Groups were identifying themselves and operating outside of the Association. Examples included the annual Applied Geography Conferences, the annual Conference of Latin Americanist Geographers (CLAG), and the meetings of Eastern Historical Geographers. Even within the Association, annual meetings witnessed a pattern of increasingly specialized sessions. Council's acceptance of the proposal for specialty groups provided a flexible framework for accommodating the growth and changing patterns of specialization among geographers. The guidelines for the formation of specialty groups specified the requirements for recognition by the Association, established their accountability to Council, and described their responsibility for taking an active role in organizing sessions for the annual meeting (AAG 1978).

Aside from providing a framework for the Association's adaptation to changes in the practice of Geography, specialty groups may be seen as a response to a perceived need for a parti tioning of interests within the discipline, as means of facilitating communication, and as structuring influence on the profession, influ encing one's perceptions of the relative im portance of various specialties, and indeed o the importance of specialization itself. Whil many scholars view the increasing level of spe cialization as an inevitable component of sci entific development (Law 1976; Ziman 1980) some geographers have expressed concerns.

Specialization has been characterized as threat to the continuation of the academi profession of geography (Goudie 1986), and a representative of reductionist tendencies tha preclude the holistic linkage of problems, phi losophies, and techniques (Eliot Hurst 1985) The view of geography as a link between th natural and human sciences, represented in th classic statement by Wooldridge and East (1958) is at odds with Johnston's (1986) opinion tha human and physical geography are indepen dent streams of academic research and wit Worsley's (1985) suggestion that geomorphol ogy and other branches of physical geograph would be stronger outside of geography. I contrast, others, such as Portugali (1985, 236 point to parallel currents of theory develop ment in the natural and social sciences and not "that social science cannot be detached fron nature and from interaction with the natura sciences." Another view sees specializations and their fusion in academic departments as symp tomatic of external institutional controls ove the development of disciplines (Grano 1984) Indeed, Peet's (1985) arguments on the devel opment of environmental determinism as dominant theme in late nineteenth-centur geography suggest that the basic paradigm o a science may be governed more by the socio political milieu in which it is practiced than b the idiosyncratic and unfettered choices of in dividual scholars.

Arguments for and against specialization may rest on deeply-held beliefs about the appro priate character of a discipline, and concern for the social context of a discipline's characte may evoke and interesting clash of perspec tives. While recognizing the legitimacy and importance of these issues, our intent in this paper is to juxtapose them with an empirically based discussion of the current structure o specialization in the discipline.

Objectives

In this paper we examine the structure of specialization within contemporary American geography through an analysis of individuals' affiliations with AAG specialty groups. Three conceptual sections provide the framework for this analysis. The first draws from literature on the sociology of knowledge (Griffith and Mullins 1972; Storer 1978; Whitley 1984; Price 1986) to identify sources and processes of unification and diversification in science, while the second considers how the organization of science (particularly learned societies) responds to changes in the economics of communication and to social factors that may limit communication (e.g., nationality and language). The final conceptual section considers the division of knowledge for purposes of identifying the boundaries and cores of disciplines and the career paths of individual scholars.

Throughout the three conceptual sections, attempts are made to root the examples in geography and its development. Thus, discussion on the sociology of knowledge isolates institutional agents that structure the distribution and intensity of scientific activity in geography—universities, funding agencies, journals and learned societies. The objective of the second section, which focuses on technological and social constraints to scholarly communication, is to consider rationales for, and problems associated with, organizing scholarly activity at national and regional levels, or according to systematic categories of knowledge. Finally, a general framework for viewing the division of knowledge is presented in order that the cores (and peripheries) of geography may be identified in relationship to the levels of interaction among its subspecializations.

The objectives of the empirical section are to describe how scholarly specializations in geography, represented by affiliations with AAG specialty groups, fit within the main body of the discipline, and to establish their degrees of linkage with one another. The cross-memberships among 35 specialty groups for more than 5000 members in 1984 provide the principal basis for analysis, but auxiliary data on regional interests, demographic traits, and educational experience of members allow for a more direct focus on how specialization may be influenced by the age and sex of geographers and by the structuring influence of Ph.D.-granting institutions.

Because of limitations in the available data, our discussion about changes in the discipline's structure over time is speculative. But as data for longer time periods become available, either through archival work or by the addition of annual records on membership in specialty groups, it should be possible to establish benchmark profiles of geography's structure and to monitor their changes over time. We maintain that this and other forms of self-examination are an essential overhead of academic and professional activity. Structures of linkage among geographers and patterns of change in these structures may be diagnostic of both strengths and weaknesses of the internal relationships among the discipline's specialty groups and of geography's external associations with society generally and with other branches of knowledge.

The problem of identifying the structure of specialization in a discipline in relationship to developments in knowledge generally is a broad one. Putting this in the context of social and institutional forces compounds the task. This limited empirical analysis, based as it is on only a small set of relevant measures and on aggregate statistics, gives only a partial view of the complex underlying dynamics of specialization and social formation in geography.

Geography and the Sociology of Science

Diversification

Perhaps the simplest view of specialization in science is that it is a rational response to increasingly detailed knowledge. To function effectively in a particular field, a scientist must possess a comprehensive knowledge, together with technical skills not necessarily unique to the field. The early role played by natural historians such as Alexander von Humboldt, a scientist with a comprehensive view of the natural world, became increasingly difficult with the rapid growth of scientific knowledge of the 18th and 19th centuries, and with increasingly complex techniques for the pursuit of that knowledge. The space of all knowledge is clearly infinite, revealing more and more detail at every

level of examination in analogy to fractal geometry (Mandelbrot 1982; Goodchild and Mark 1987). Thus, developments in science require greater and greater specialization, first into disciplines and then either by continued fragmentation or by the emergence of finer and finer divisions within disciplines, processes that have been documented by historians of science (Geison 1981; Law 1976; Woolgar 1976).

Within geography the same argument can be applied independently to both systematic and regional specialization. But as progress in science demonstrates, spectacular advances have often been made by drawing on knowledge from apparently unrelated areas. Thus reductionism has been attacked, particularly within biology (Laszlo 1972, 1973; Boulding 1968; Waddington 1971), as fundamentally ineffective. Geography's long tradition of regarding itself as an integrating discipline may argue directly against the process of specialization within geography. Regional studies provide a particular case—the emphasis is on the integration of knowledge that spans a wide range of humanistic, social and scientific concerns.

These arguments lead to a view of specialization as an infinite continuum, with the possibility of subdivisions and organizational structures at all levels. The processes of diversification and unification operate in opposite directions on this continuum. Since there are no points of reference, it is possible for organizational structures to emerge at any level, and to be based on combinations of the specialization dimension with other factors such as nationality, gender, or language.

Unification

Countering such tendencies for fragmentation are needs to exchange information across subdisciplinary boundaries, requirements for groups to meet a critical size that allows for activities essential to their development (for example, departmental status in universities, journals, and effective lobbying of governments), and difficulties in organizing new administrative structures to meet the needs of a new discipline. While the motivating benefits of specialization may be better communications and exchange within a narrow community of research scholars, the benefits of unification, in the pragmatic sense, are the opportunities for holistic planning at levels that retain linkages to the broader realm of knowledge. The problem for traditional disciplines (such as geography) and for scientific societies (such as the AAG) is to offer integrative administrative arrangements and intellectual concepts that allow subspecialists to develop and to feel at home as part of a larger whole.

The historical materialism of Karl Marx, the unified science movement of the 1930s, concepts of a unified field theory (Lewin 1951), and systems analysis (von Bertalanffy 1968) represent previous attempts to address the intellectual unity of science at the broadest level. Quests for a unified geography are evident in the arguments of such prominent scholars as Harlan Barrows (1923) and Carl Sauer (1941) and in the search for a general paradigm for geography. Recent claimants include the positivist approach to spatial analysis, most clearly articulated by Abler, Adams and Gould (1971), and a general spatial systems theory, elucidated by Warntz (1973) and Coffey (1981). In sharp contrast, Eliot Hurst (1980, 1985) sees unity achievable only in terms of the de-definition of geography and other disciplines, and their merger with the broader social philosophy of historical materialism. In spite of these efforts, opportunities for and threats of increased specialization remain important issues in the discipline, receiving special attention recently in *Geoforum* (1982, no. 2) and *Transactions, Institute of British Geographers* (1986, no. 4).

Intensity of Activity and Specialization

If specialization is driven by increasing diversification, then one might expect the process of division to reflect the need to limit complexity; subdivision would occur when practitioners no longer felt capable of comprehensive knowledge of a field. On the other hand the unification arguments would suggest that two fields would separate when the practitioners of one felt that knowledge of the other was no longer of benefit. However these arguments ignore variations in the levels of activity among the sub-branches of disciplines.

Intensity of activity clearly affects the process of specialization and yet is not uniformly distributed over all fields. The supply of scientific effort and the distribution of this effort over

the fields of science may be controlled very little by science itself, and much more by external factors operating in society at large. To be recognized, a field must be associated with a level of activity dependent on the scale of recognition; to be recognized as a new discipline, a group must clearly be of a size compatible with intuitive notions of that particular scale of specialization.

Institutionalization and Specialization

Another set of processes can be referred to generally as institutionalization. Recent attention to this process within geography is represented in the work of Capel (1981), Grano (1981, 1984), Johnston (1983), Harvey (1984), Peet (1985), and Taylor (1985). In general, these authors have stressed the relationship between the division of labor in geography and the demands of society, demands that are reflected by the presence of geography and its specialties within the university curriculum, and by the presence of jobs within the civil service of the state and within the corporate sector.

For various administrative purposes within universities and governments, fields of scientific knowledge are divided such that the level of activity is similar within each division when measured across a wide range of indicators, such as student enrollment and the number of courses necessary to achieve a basic understanding of the field. Within this context the needs of administration and science may become hopelessly confused. Since it is administratively desirable that this system of division not change through time, despite the dynamic nature of scientific activity, it becomes increasingly difficult to justify divisions between departments, and lack of divisions within them, on scientific grounds. Although the term department tends to be associated with administrative division and discipline with scientific specialization, the process of institutionalization tends to make the distinction no more than semantic.

Funding agencies have similar structuring effects on specialization. The Office of Naval Research was of particular significance to the growth of spatial analysis, coastal studies, climatology, and remote sensing in the 1950s and 1960s (Pruitt 1979). Its mandate was initially quite flexible, and many of the funded projects showed little relationship to the operational needs of the U.S. Navy. Although topical restrictions are not imposed by the National Science Foundation (NSF), Abler (1986) indicates a bias for basic science over applied and policy research.

NSF's *National Register of Scientific and Technical Personnel* lists more than a thousand specific subspecialties. To deal with research applications in an efficient manner, it groups them into divisions that closely mirror current activity, subject to the need to ensure reasonable volumes of activity in each division. However the needs of administration may conflict with those of science; work in novel fields may be handled by committees made up of researchers in more traditionally recognized areas, and may frequently straddle the boundaries imposed by older systems of division. Recent examples of relevance to geography include regional science and geographic information systems.

Other structuring institutions have less of an administrative role, but nevertheless may influence the development of specialization in similar ways. Journals have associated and relatively stable subdivisions, as reflected in their titles and the membership of editorial boards. Work in new fields may therefore be less easily published than work that fits within a journal's traditional area of interest. In addition, learned and scientific societies, the parent bodies of many significant journals, represent traditional systems of division, as do departments in traditionally structured universities that sponsor a large number of disciplinary-oriented journals. These significant organizational structures appear less inclined to promote the interests of new specializations (and journals) than do the entrepreneurs of many commercial publishers.

Harris and Fellmann (1980, 7) have documented the acceleration of new journals in geography, increasing "from an average of about 45 a year in the 1950s, . . . to more than 100 a year in the 1970s. . . ." From their inventory of 3335 geographical serials, 1089 were considered active in 1979 (Harris 1980, 2); but, as a body of international scholarship, their use was limited by linguistic and national barriers. Although Harris judged 443 of these to be reasonably accessible to the international scientific community, it is likely that relatively new structuring institutions are serving to limit the breadth of literature search by many scholars.

Journal abstracting services (for example, Geo Abstracts, Ltd.) and citation indexes (for example, those provided by the Institute for Scientific Information) must make judgments on which publications to include as source journals, a function that may have a strong conditioning effect on the exchange of information. For instance, current volumes of the *Science Citation Journal Reports* include only nine journals in the geography category, while the *Social Science Citation Journal Reports* list only 25 geography journals. Increasingly, these data sources have dominated bibliometric studies on citation transactions among journals within and between disciplines. Examples include the work of Lenoir (1979) in the sociology of science, Laponce (1980) in political science, and Gatrell (1984) and Gatrell and Smith (1984) in geography. In addition, this same source was used by Turner and Meyer (1985) to compare geography departments in American universities according to levels of scholarly publication.

Disciplines as Social Organizations

We have suggested that the overall effect of structuring institutions is to weaken the scientific basis for new disciplines and other abstract divisions of scientific knowledge. The individual who finds his or her research increasingly incompatible with that of departmental colleagues is unlikely to change department or disciplinary allegiance even if another department would be more compatible. Membership in a department thus becomes analogous to membership in many social organizations where the criterion for belonging is relatively weak and irrelevant. It is not surprising, then, that many writers have analyzed academic disciplines as social organizations (Griffith and Mullins 1972; Blackburn 1973; Storer 1978; Whitley 1984). In the extreme view disciplines are analogous to tribes and are distinguished by the same social mechanisms.

From this sociological perspective, the formation of specialty groups and other divisions within disciplines is to be understood by similar reference to the behavior of groups; the scientific basis for each group's interests simply provides the key to membership, and serves to distinguish members of the group from nonmembers. Groups disappear or subdivide whenever the parent group becomes too large, so that belonging no longer satisfies some basic human imperative, or when the key to membership is no longer real. They may reform on regional or systematic lines; again, the choice is incidental and will be driven by independent concerns and technical factors, for example by nationality, language, and the economics of communication.

Technical Factors and Specialization

Reference has already been made to the need to specialize as a response to the complexity of knowledge, leading to the potential for a continuum of scales of division within science. Administrative needs require a consistent division into disciplines that can be associated with academic departments, learned societies, and a host of other institutions, but do not appear to dictate consistent division below that level. We now turn to a number of technical factors that may explain the emergence of organizations and groups on the basis of economies of scale, facility of communication, or the existence of political or linguistic barriers. From our earlier sociological perspective, these are factors that dictate the form of groups once the need for such groups has been established.

There are several possible dimensions on which group membership might be established. The United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Council of Scientific Unions (ICSU) both function as organizations for all of science everywhere, but only as umbrellas for more narrowly defined groups. Although Whitehand and Edmondson (1977) provide evidence of increasing trans-Atlantic communication among geographers; although the general internationalization of co-authorships in science has been documented (Frame and Carpenter 1979; Kerwin 1981); and although many national organizations, such as the AAG, have significant foreign membership; nevertheless, nationality remains the most significant basis for the organization of scholarly activity.

Organization at National and Regional Levels

Some organizations, such as the American Geographical Society and the National Geo-

graphic Society, use only this national dimension. The National Council for Geographic Education (NCGE) allows for state affiliates, but its principal activities occur at the national level. Others, such as the AAG and the American Association for the Advancement of Science, incorporate smaller regional divisions.

Nationality conveys several obvious advantages as a basis for organization; it frequently coincides with linguistic and ethnic bases, and allows organizations to function as effective channels to national government. The growth of strong academic organizations in Quebec is a clear response to the Canadian exception to this principle (Fournier and Maheu 1977). Gilbert and Thouez (1987) provide evidence of the linguistic basis for the distinctive linkages of Quebec geographers, nationally and internationally.

Regional dimensions are often combined with disciplinary or systematic divisions. However, the order of combination confirms the dominance of national identity. Thus the question of U.S. representation on the Commissions of the IGU is not referred to the specialty groups of the AAG; although both Commissions and specialty groups combine spatial and systematic divisions, the order of precedence is reversed.

Three points on the continuum of spatial division of the discipline have emerged over time as appropriate for the organization of American geography: the department, region, and Association. Of these, only the region has no obvious rationale. The Pacific Coast Division was organized in the late 1930s. Some divisions (e.g., Middle Atlantic, East Lakes, West Lakes, and Southeastern) originated as parts of the American Society for Professional Geographers (1943–48), which amalgamated with the AAG in 1948. Subsequent boundary shifts, principally to incorporate the growth of Canadian membership, have led to the current mix of nine regions (James and Martin 1978, 103, 120–21, 173–75). In principle, the number and spatial structure of regions should represent a compromise between the desire to have regional meetings that can be attended at minimal transport cost and the need to bring together a critical mass of practitioners in a variety of specializations to allow for productive discussions. In practice, the current regional divisions show considerable variation in membership and little compactness of spatial structure. This situation was described by Marcus (1978, 117) as "a particular embarrassment that, of all people, an association of geographers seems incapable of delineating rational and viable regions. Such sentiments suggest that the current divisions may not represent a stable state.

Communication Technologies

The development of new divisions within American geography will continue to be limited by costs of transportation as long as the primary method of communication remains the academic meeting, with its formal presentations and informal contact. Traditional communications by mail and telephone have done little to replace meetings, despite the potential of telephone conferring. Nevertheless much scientific activity occurs outside the structures imposed by institutions such as the learned societies, through meetings that cross these conventional boundaries. Electronic communication over Bitnet and electronic bulletin boards may affect this balance in fundamental ways if they remain essentially free to academics. This development adds a new dimension to the formation of what Crane (1972) and Price (1986) describe as "invisible colleges." Unlike telephone callers, users of these networks do not incur the risk of disturbing and annoying their contacts; both the social and economic costs are low.

Specialty Groups

The specialty groups represent a new point of reference on the continuum of systematic division—a set of formal subdisciplinary organizations. Most specialty groups' activities occur within the Annual Meeting and so incur no additional transportation cost. Under these circumstances there are few checks to growth in the number of groups; although the AAG requires a minimal membership, this has proven relatively easy to achieve since each member of the Association may select up to three groups at no immediate cost (AAG 1978). However each new group must now establish itself at the expense of membership in existing groups, which will, in the long run, act to limit the proliferation of groups.

Specialty groups appear to have escaped the technical and economic problems of overcoming distance by associating their activities with an existing, established annual meeting. They are as yet largely unaffected by processes of institutionalization, and new communications technologies have the potential of enhancing the levels of their activities. As scientific organizations they are at this time remarkably free from many of the practical constraints faced by other groups and divisions, and are, we believe, an accurate mirror of the structure of activity within the discipline.

Representations of Knowledge

We have referred to the set of all knowledge as a multidimensional space, with a complexity that depends on the level of detail at which it is examined, in analogy to geographical information about the surface of the earth. There appear to be two distinct images of how this space is subdivided into disciplines and other forms of specialization, which we will refer to as the structural and empirical representations of knowledge.

A Structural View of Knowledge

In the structural view (Fig. 1a) there exist clear and natural partitions of the space, forming domains or niches identified by the names of specialties. Domains may be further subdivided, again along natural partitions, into subspecialties ad infinitum. One might visualize the boundaries as lying along zones of low density of knowledge or perhaps as discontinuities in the set of skills necessary to advance knowledge at each point in the space. One of the domains at the disciplinary level of subdivision is labeled geography, and one of the most basic (but apparently endless) tasks of its practitioners is to find that verbal formula that expresses the domain's already naturally determined boundaries as succinctly as possible.

Individuals can be seen as points in this space, following career trajectories as their interests change. Change of discipline results when an individual's interests take him or her across a natural boundary into another domain. The specialized interests of departments, specialty groups, or journals can be represented as zones that perhaps overlap more than one disciplin or subdiscipline and whose boundaries ar probably fuzzy.

The Empirical View of Knowledge

In the empirical/pragmatic representatio (Fig. 1b) there are no natural partitions or ref erence points in the space of knowledge. Dis ciplines are represented by punctiform core with satellite cores for subdisciplines or spe cialties. Individual interests follow trajectorie among the cores, the affiliation of an individu at any time being judged by proximity of in terests to the various cores. The process o change of discipline is no longer abrupt; as in terests or the reward levels for participation i a given specialty change, the individual ma move away from one core and closer to anothe making a sequence of decisions to drop or ad journal subscriptions, learned society mem berships, and other symbols of affiliation. De partments are similarly represented by point in the space, moving in response to the inter ests of their staff and students, who in turn ma be responding to the changing foci of fundin agencies, to the policies of governments an universities, and to the broader dictates of th socio-political milieu.

The empirical representation of knowledg is dynamic and in a continual state of flux. Th cores themselves are not stable, but chang under the influence of key individuals and de partments and under pressures from externa forces. While the structural view sees the dis ciple's boundaries as immutable, the empirica view echoes the sociological perspective of th previous section, seeing the discipline as a trib of individuals wandering in the space of knowl edge with relatively weak ties to any absolut frame of reference. Interactions occur be tween all features in the space, whether core or individuals, and may be attractive or repul sive. For example, the interactions betwee Ph.D. students in a department operate in mos cases to reduce diversity of interests, while re pulsive forces often operate among the staff o a department as each individual attempts t establish an exclusive niche. The territorial im perative is not limited to individuals, but occur even between the major disciplines, and thei associations and journals, as cores move in re sponse to attempts to secure each one's future

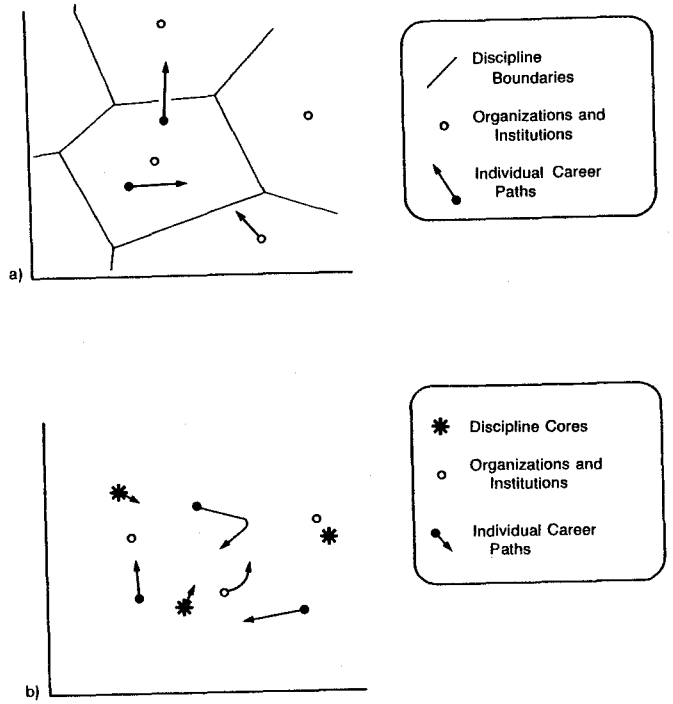

Figure 1. Representations of the space of knowledge: (a) structural/natural and (b) empirical/pragmatic.

Geography and the Empirical View of Knowledge

Several previous commentaries on the dynamics of geographical interests fit well with this empirical image. The unfolding life-paths of individual geographers, such as Allan Pred (1979), and the phenomenologically rooted construct of lifeworld (Buttimer 1976, 1981) provide substance for the importance of social milieu in the development of geographical ideas and paradigms, and for provision of ways to communicate geographical knowledge. The Association's diamond anniversary special issue of the *Annals* (1979, no. 1) gives further substance and a human face to the currents of change in the discipline, with a wealth of anecdotal insights on the development of important departments (Berkeley, Chicago, Clark, Iowa, Washington, Wisconsin, UCLA and others), key individuals (Carl Sauer, Fred Kniffen, Walter Kollmorgen, Fred Schaefer and others) and influential journals (*Economic Geography, Geographical Review,* and *Geographical Analysis*). Continued critical interest in the biographies of leading practitioners, such as Martin (1980) on Isaiah Bowman, and the circumstances of change in important departments, illustrated by Smith's (1987) account on the demise of geography at Harvard, will of course provide a basis for the long-term refinement of our empirical representation.

We have chosen to adopt the empirical/pragmatic view in this paper because of its implicit compatibility with an analysis of specialty groups, and because of its dynamic elements. The structural/natural scheme is perhaps more attractive as an abstract ideal, but seems inadequate as a description of the history of activities in this and other disciplines.

Disciplinary Cores in Geography

The notion of disciplinary cores has a lengthy history in geography. A unitary core has been viewed as a basis for overcoming the potentially divisive role of dualisms (distinctions in the nature of geographic work based, for example, on regional vs. systematic and human vs. physical splits). Fenneman's (1919) remedy for the splintering effect of systematic specialization was to focus on the region as an integrating concept that offers unique identity to the discipline. However the intellectual lineages of distinct traditions point to multiple possible cores in geography. In what McNee (1973, 296) described as a "more ecumenical approach," Pattison (1964) identified four principal traditions, all operating simultaneously: a spatial tradition, an area studies tradition, a man-land tradition, and an earth science tradition. Although Pattison saw these traditions as "joined in action," Haggett's systems-oriented approach gives an even more explicit focus to integrating concepts, namely: spatial analysis, ecological analysis, and regional complex analysis (Haggett 1983).

The names of the Association's specialty groups attest to the distintive purposes (e.g., teaching, planning) and objects of inquiry (both regions and systematic specialties) that form the reality of American geography. Our empirical view admits to no specific core(s) or network(s), but as a framework for positioning the specializations of individuals and groups relative to those of others, it allows for the identity of possible clusters and cleavages.

For science generally, Storer (1972) identified cleavages in the choice of field according to sex, geographic region, level of education, personality, and the ability to work with collaborators. In geography, Jumper and Harrison (1986) provide a general profile on the social, demographic, and career characteristics of AAG members. Specific examples of cleavages in the specialization of geographers include those based on sex (Gilbert 1987) and age (Hausladen and Wyckoff 1985). In the analysis that follows, we concentrate on age, gender, and the origins of university training.

Empirical Analysis

This section draws on our previous discussions concerning the sociology and division of knowledge to describe the structure of specialization in contemporary American geography. Data on the joint memberships of individuals in different AAG specialty groups provide a basis for identifying linkages among specializations, for recognizing clusters of specialty groups that represent distinctive subdisciplinary cores of geography, and for assessing the centrality of the different specializations to the discipline as a whole. Differentiation in the patterns of specialization for different age groups and according to gender are considered as possible evidence of social influences on the structure of the discipline and on the career choices of individual scholars, while similarities in the interests among the graduates of major university geography departments are seen as evidence of institutional influence.

The Data

Membership in AAG Specialty Groups is established each year at the time of payment of annual dues, when each individual selects up to three groups from the current list. Our analysis is based on the 5419 members in good standing at the beginning of May, 1984, and uses the set of groups in existence at that time it differs from the 1986 list in Table 1 by the absence of three groups, marked with asterisks and the inclusion of Environmental Studies (see Table 2). The set of groups, the ages, origins educations and locations of their members, and the pattern of shared memberships among groups provide a very rich and timely data source on the present state of the discipline Since individual affinities to specialty groups are reestablished each year, it is assumed that the structures they reveal provide a useful empirical comparison with the more abstract representations of the nature and organization of knowledge shown in Figure 1b.

In addition to specialty groups, the annual membership renewal form allows each individual to select up to three areal and three topical proficiencies from a predetermined list. We present below a number of analyses of areal proficiencies, but have limited our use of topical proficiencies as we believe members' active interests to be better represented by the social commitment of specialty group affiliations.

There are several grounds for believing that

Table 2. Membership of specialty groups of the Association of American Geographers, May 1984

Specialty group	Number of members
Africa	124
Aging	67
Applied	440
Asian	128
Bible	61
Biogeography	176
Canadian Geography	84
Cartography	483
Chinese Geography	82
Climatology	233
Coastal and Marine	134
Cultural Ecology	144
Energy	184
Environmental Perception	209
Environmental Studies	356
Geographic Perspectives on Women	150
Geography in Higher Education	167
Geomorphology	316
Historical	342
Industrial Geography	158
Latin American	202
Mathematical Models and Quantitative Methods	250
Medical	123
Native American	50
Political Geography	248
Population	256
Recreation	182
Regional Development and Planning	302
Remote Sensing	341
Rural Development	162
Socialist	96
Soviet	123
Transportation	208
Urban	531
Water Resources	283

Source: May 1984 membership records of the AAG.

this annual process of self-allocation (particularly to specialty groups) provides a more objective and reliable method of revealing structure than a more direct approach, such as the distribution of a series of questions about perceptions of structure. Choices are made between concrete, perceivable alternatives rather than between abstract constructs, and under real rather than hypothetical constraints. And we could not possibly have obtained a 100 percent response by any other means.

Linkages among Specialty Groups

The largest specialty group in number of members at that time was the Urban group (Table 2). Fifty-seven percent of members chose at least one specialty group, 47 percent chose at least two and 32 percent chose the maximum of three. The propensity of members to identify specialty groups varies strongly with seniority in the profession. Among student members only 29.5 percent identified no specialty groups while 42.7 percent identified the maximum of three; among university faculty members the figures are 41.1 percent and 32.2 percent, very close to the percentages for the membership as a whole; and among retired members they are 79.2 percent and 7.3 percent respectively. Females are slightly more likely to identify specialty groups than are males. While 43 percent of the membership identified no specialty groups, there is much less reluctance to identify topical specialties (only 7.1 percent identify none) or areas (16.3 percent). There are no strong associations between reluctance to identify specialty groups on the one hand and particular topics or areas on the other.

To obtain a measure of the degree of cross-membership between each pair of groups, only those who belong to two or three groups were considered. To ensure that all individuals are weighted equally, a score of ⅓ was given to each of the three possible pairs for those 1734 individuals who identified three groups, and 1 to the pair for those 813 individuals who identified two. On this basis the most strongly linked pair of groups was Cartography and Remote Sensing, with a score of 68. A high cross-membership score can be taken as indicative of the interaction between groups and of their similarity of interests.

In this phase of the analysis, no attempt was made to assess the expertise of individuals (as for example, by level of training or years of experience) or to weight members by academic credentials. A later section that focuses on the role of geography departments in structuring the patterns of specialization will concentrate only on Ph.D. members of the Association.

Non-metric multidimensional scaling (MDS) (Young and Torgerson, 1967) provides a convenient means for visualizing structure in the matrix of cross-memberships. Given a matrix of measures representing the relative similarities between pairs of objects, an MDS procedure

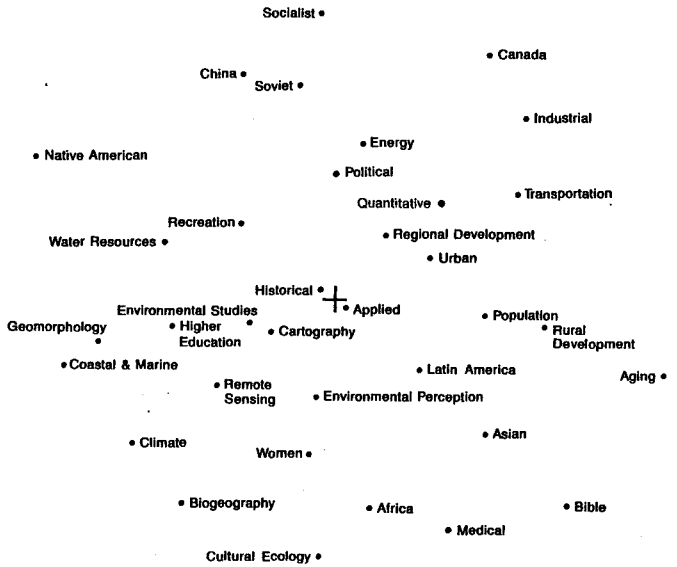

Figure 2. Two-dimensional non-metric scaling solution from cross-memberships of specialty groups, May 1984.

searches iteratively for locations for the objects in a space of a prescribed number of dimensions, such that the distances between the objects in the solution are in the same rank order as the similarities in the input matrix. A general description of MDS as a spatial analytic technique can be found in Rushton and Golledge (1972). When it is impossible to preserve perfect agreement between the rank orderings of similarities and distances in a space of the prescribed number of dimensions, an index of stress, ranging from 0 to 1, can be used to measure the degree of disagreement.

Spaces of two dimensions have been used in many applications to obtain a visual representation of matrices of interactions between objects, on the understanding that strong interaction can be equated with similarity and thus with proximity in two dimensions. Gatrell and Smith (1984) have used this approach to analyze structural relations in the cross-referencing of journal citations and Frame and Carpenter (1979) used MDS to study international research collaboration. A two-dimensional space in which each specialty group has been located such that proximity in the space (based on straight line distance) is directly related to the cross-membership score is shown in Figure 2. Pairs with high scores are close together and pairs with low scores are far apart. With these data it is not possible to obtain a perfect monotonic fit between proximity and cross-membership, as the inherent dimensionality of the data is greater than two; the stress index is 0.30. Although this index indicates that higher dimensionality solutions may reveal additional structure in the data, we believe that the loss of information is more than outweighed by the simplicity of two-dimensional display and that supplemental techniques of analysis will help account for residual interpretations.

Several interesting features are revealed in Figure 2. First, it clearly identifies major divisions of the discipline, grouping the physical specialties on the lower left and the human specialties above and to the right, with no apparent overlap in the group centroids. Resource and technical specialties (water resources, environmental studies, cartography, and remote sensing), as one might expect, provide a hinge relationship between the broad human and physical divisions. Although Urban

is the most populous group, it is not the most central as its cross-memberships are more specialized than those of the Applied and Historical groups, both of which are more able to cross the major cleavages of the discipline. The most peripheral groups, with the least consistent patterns of cross-memberships, are exemplified by Canadian Geography, Aging, and Native American. Note also that while the spatial analysis paradigm produces a clear grouping (Quantitative, Urban, Transportation, Regional Development), the regional specialties are scattered over the space with no strong community of interest.

The central positions of Historical Geography, Applied Geography, and Cartography allow for interesting speculations. Have they replaced Fenneman's regional geography as the new core(s) of geography? While it may not be possible to equate historical geography with the historical approach or with humanism per se, interest in historical geography is at least suggestive of humanistic concerns among geographers. Applied geography represents the discipline's outreach in the service of society. Although Frazier (1978, 236) suggested that it may be "premature to speak of an applied geography paradigm," the central position of this specialty group is significant. Finally, Cartography's position confirms the importance of maps as one of geography's principal tools of communication and analysis.

Another approach to visualizing the structure of the cross-membership table is through Elementary Linkage Analysis (McQuitty 1957), in which the strongest linkages (based on similarity measures from the MDS analysis) are used to establish groups. The results for the specialty group cross-memberships are shown in Figure 3; there are four natural groupings: Cartography/Remote Sensing, the physical specialties, Asian/China, and a large residual group. Within the latter it is interesting to note several pairings between regional and systematic specialties: Latin America is linked to the Urban core through Population, Canadian through Historical, Africa through Medical, and Soviet through Political. Again this approach implies a lack of community of interest in regional specialties; areal specialists tend to concentrate their efforts on a single region and to have low levels of interaction with those who study other regions. Furthermore, the evidence suggests that interest in a region derives not from some general interest in regions but from the associated systematic specialty.

Indicators of Change

The discipline portrayed in Figures 2 and 3 is for one point in time. Since specialty groups are a recent innovation, the longitudinal data cover an insufficient time span to document meaningful shifts in the structural patterns of cross-memberships. But indirect measures, based on ages of group members, and on the self-selection of areal and topical labels (as designated on the annual membership renewal form) provide some evidence of recent trends.

One indirect approach to identifying changes in the appeal of different specializations is to focus on age. The mean year of Ph.D., mean year of birth for those with Ph.D.s, and mean age at Ph.D. for the members of each group are shown in Table 3. The groups have been ranked by mean year of Ph.D. since this is the most accurate index available of the length of each individual's career in the profession. To a limited extent, this value may reflect the prevailing concerns and fashions or social influences at the time of one's training, but it should be borne in mind that more recent cohorts of geographers had more specialties to choose from. Nonetheless, the problems judged important by each generation of geographers should be reflected in the current pattern of specialty group membership.

The specialties populated by the newest graduates are technical (Mathematical Models, Remote Sensing, Cartography), physical (Geomorphology, Biogeography), and reflective of contemporary social concerns (Native American, Women, Socialist). At the other extreme, the "oldest" include all of the regional specialties, and the traditional, general systematic divisions (Historical, Political). By implication the groups with youngest members are growing or have recently grown, while those with the oldest members are or will soon be in decline. These results parallel those of Hausladen and Wyckoff (1985), whose analysis, by age cohort, of topical and areal proficiencies, suggested impending compositional changes in the specialties practiced by geographers.

The mean age at Ph.D. shows interesting patterns. It is highest at 36.1 years for the Bible

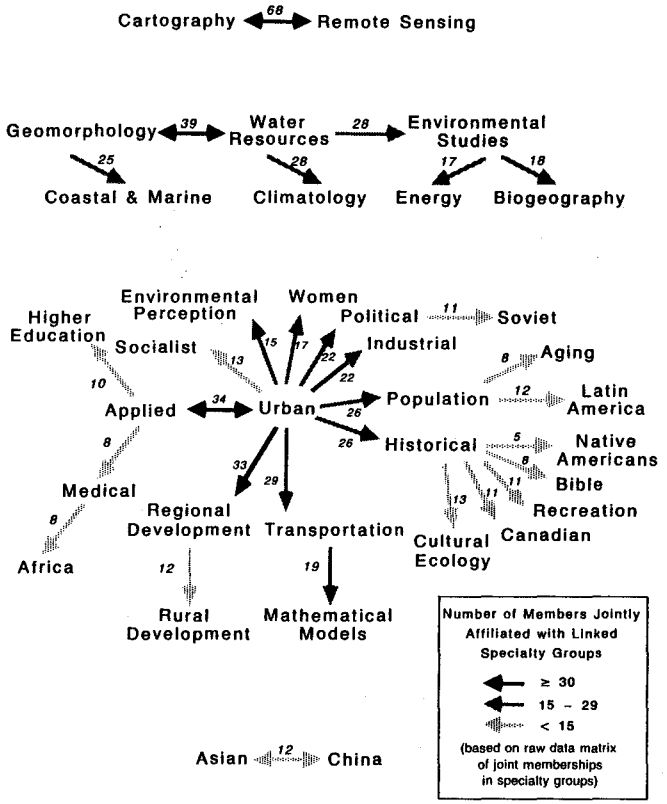

Figure 3. Elementary linkage analysis from cross-memberships of specialty groups, May 1984.

group, the second smallest in the Association after Native American, and conspicuously low for the spatial analysis specialties (Mathematical Models, Transportation, Urban, Industrial), and Socialist. Analyses of non-Ph.D. geographers might reveal different patterns.

Although the specialty group data do not lend themselves to direct longitudinal analysis at this time, members have identified topical proficiencies from a reasonably stable list for much longer. These proficiency data are seen as weak surrogates of the specialty group designations. Since the data do not reflect any standardized basis for measuring expertise or career commitment, the term "proficiency" may be a misnomer. With this reservation in mind, Figure 4 shows a comparison of the topical labels identified by all AAG members in 1984 with those of 1971. Percentages of the membership were calculated for each term in both years, and the percentage change for 1971–84 was plotted against the percentage in 1984. In this way it is possible to suggest topics that are growing or declining, and small or large. But caution is required. Individuals are selecting terminology to describe their interests from a pre-determined list; they are not selecting social-professional affiliation with a group.

Without the social commitment that is expected of members of a specialty group, the selection of labels is likely to show less stability over time and to be more easily changed in response to fashion. For example, Figure 4 shows the general label "Economic" in substantial de-

Table 3. Year of Ph.D., year of birth and age at Ph.D. by specialty group for members with Ph.D.s, May 1984, ranked by mean year of Ph.D.

Specialty group	Year of Ph.D. Mean	Year of birth Mean	Age at Ph.D. Mean
Soviet	1966.7	1933.5	33.2
Asian	1966.9	1932.9	34.0
Bible	1967.0	1930.9	36.1
Canadian Geography	1967.2	1933.4	33.8
Political Geography	1968.9	1936.2	32.7
Latin American	1969.3	1935.1	34.2
Chinese Geography	1969.7	1935.3	34.4
Historical	1970.2	1937.6	32.6
Africa	1970.4	1937.7	32.7
Geography in Higher Education	1970.5	1936.6	33.9
Recreation	1970.7	1938.1	32.6
Cultural Ecology	1971.5	1938.7	32.8
Rural Development	1971.5	1938.2	33.3
Water Resources	1971.5	1938.8	32.7
Transportation	1971.5	1941.0	30.5
Environmental Studies	1971.6	1938.6	33.0
Population	1971.8	1939.7	32.1
Climatology	1972.1	1939.4	32.7
Medical	1972.1	1940.0	32.1
Coastal and Marine	1972.6	1939.3	33.3
Regional Development and Planning	1972.6	1940.5	32.1
Aging	1972.7	1941.4	31.3
Industrial Geography	1972.7	1941.9	30.8
Energy	1972.7	1941.3	31.4
Environmental Perception	1972.8	1940.8	32.0
Applied	1973.0	1940.4	32.6
Cartography	1973.0	1939.6	33.4
Biogeography	1973.2	1940.9	32.3
Urban	1973.2	1942.4	30.8
Geomorphology	1973.7	1941.0	32.7
Socialist	1973.7	1942.9	30.8
Remote Sensing	1974.4	1941.0	33.4
Geographic Perspectives on Women	1974.7	1942.6	32.1
Mathematical Models and Quantitative Methods	1974.8	1944.3	30.5
Native American	1975.3	1941.4	33.9

Source: Calculated by authors from May 1984 AAG membership records.

cline. Yet, much of this may be associated with shifts to more specialized divisions of the field—for example, to social (as in Marxian analysis of economies), location theory, marketing, economic development, or applied.

Among the popular topical labels, the older and more general systematic ones are clearly in decline. Economic most seriously and Urban, Cultural, Physical, and Historical to a lesser extent, while Cartography and Remote Sensing are the most rapidly increasing. The less popular topics (e.g., Soils or Field Methods) are at the same time more stable, with only slow rates of increase or decline. Despite its significance to the discipline, the Regional proficiency is smaller than Population or Climate and in fairly rapid decline, supporting our earlier conclusion that it is not the basis for any substantial or stable community of interest.

The areal proficiency data suffer the same weaknesses associated with the labels for topical proficiencies, but they are suggestive of current structure in the pattern of regional specialization and of recent changes in the levels of interest for different parts of the world. The two-dimensional space recovered from a multidimensional scaling of cross-identifications between areal proficiencies for all AAG members who listed two or three regional labels (stress equals 0.30) is shown in Figure 5. The center of the space is occupied by World, USA, North America, Anglo America (now a somewhat dated term), and USSR. The major world regions are clearly preserved, but organized with increasing specialization (or decreasing geographical coverage) toward the periphery. Thus Africa appears close to the center, while increasingly narrow subdivisions are arranged outward beyond it and toward the edge of the space. Within Canada, the Maritimes, Prairies, British Columbia, and Northwest Territories appear as more specialized than Ontario or Canada as a whole.

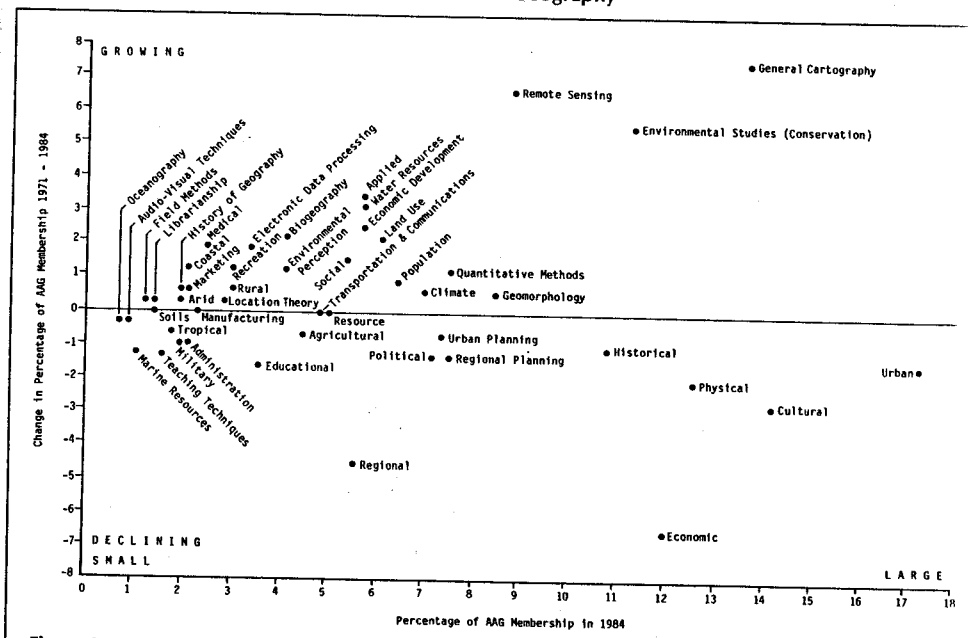

Figure 4. Percentage changes in declarations of topical proficiencies, 1971–1984, plotted against the number of members that claimed proficiency for each topic in May 1984.

The ordering of sectors around the periphery shows several interesting features, all of which appear intuitively reasonable. Quebec appears within the Canadian sector, but close to Europe; West Indies and Caribbean are the most African of the Latin American divisions; Scandinavia appears within a Polar group of North Pole, N.W.T. and South Pole, rather than in Europe; and Southern South America has stronger affiliations with Africa than with the divisions of Latin America.

The relative sizes and growth rates of the regional labels between 1971 and 1984 are shown in Figure 6. The U.S. is large and growing, while Anglo America is declining as a term of identification. All of the regions of North America are growing, while the major world regions are evidently in decline. Finally, as with topical proficiencies, the narrower interests remain small and stable, largely, one suspects, because of the stability of individual career interests. The overall impression is of a discipline that is increasingly concerned with local, North American problems, leaving specialization in distant regions to a few older, established professionals whose expertise is narrowly focused and rarely extended to continental scales.

The Department as a Structuring Institution

We previously identified some of the major types of institutions that shape the development of disciplines. Through their selective promotion of ideas and individuals, funding agencies, publishers, and the employers of geographers condition the demands for dif-

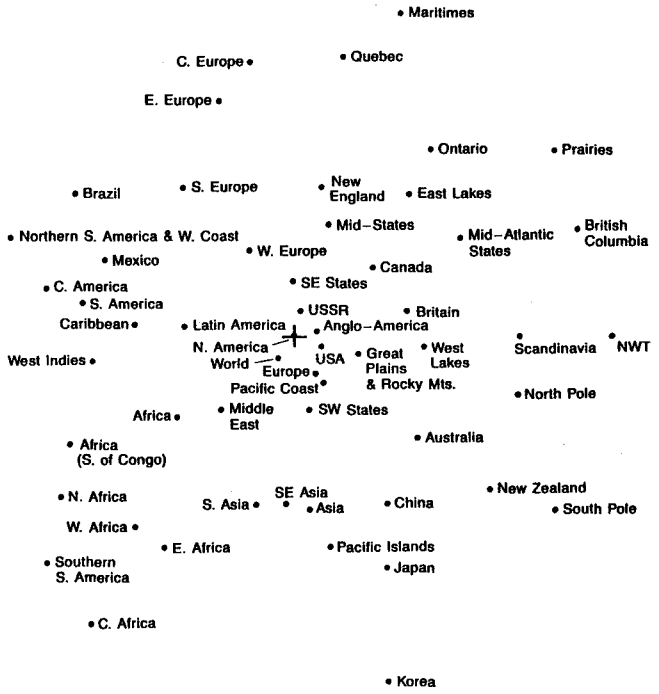

Figure 5. Two-dimensional non-metric scaling solution from cross-identifications with areal proficiencies, May 1984.

ferent specializations. Among these, major Ph.D.-granting university departments play a particularly important role in influencing the career paths of individual geographers; they also represent an important work environment for many. The 1984 data reveal that about half of the AAG members hold Ph.D.s. While 234 universities, worldwide, contributed to this output, only 54 were cited 10 or more times by AAG members as the sources of their doctorates.

The advantage of focusing on Ph.D. geographers is that a generally high standard of expertise is associated with this level of training. Research and teaching specialization at this level may be associated with a strong standing both within geography and among scientists generally. Nonetheless, the extension of this analysis to other levels of training would provide additional insight on the roles that departments play in structuring the pattern of specialization.

Some of the most crucial and taxing decisions that university departments must make concern the diversity and specialization of their faculty and programs. An ecological view of disciplines provides interesting speculation on this issue. For example, Blackburn (1973, 1145) maintains that scarcity of information "gives a competitive advantage to intellectual specialists," and this route may be seen as desirable from an individual-career perspective. He goes on to observe "that the longer an academic field matures, the more intense and diversified the degree of specialization within its ranks." The pursuit of diversity is a common strategy among geography departments. It assures greater stability within departments, promoting individual survival through the assignment of territorial responsibilities (e.g., courses) and provides a rationale for growth ("we must cover the field").

In contrast to the diversity approach, specialization at the departmental level may be seen as a high-risk strategy. It has been used rarely in American geography. Nonetheless, the ecological analogy holds that productive hot spots of specialized new innovation may thrive, at least for short periods, until the specialty becomes integrated into the mainstream of the science. This aggregation of specialists at a single location allows for short communication links, high levels of information exchange, and shared enthusiasm for new breakthroughs (geography at the University of Washington in the late 1950s?).

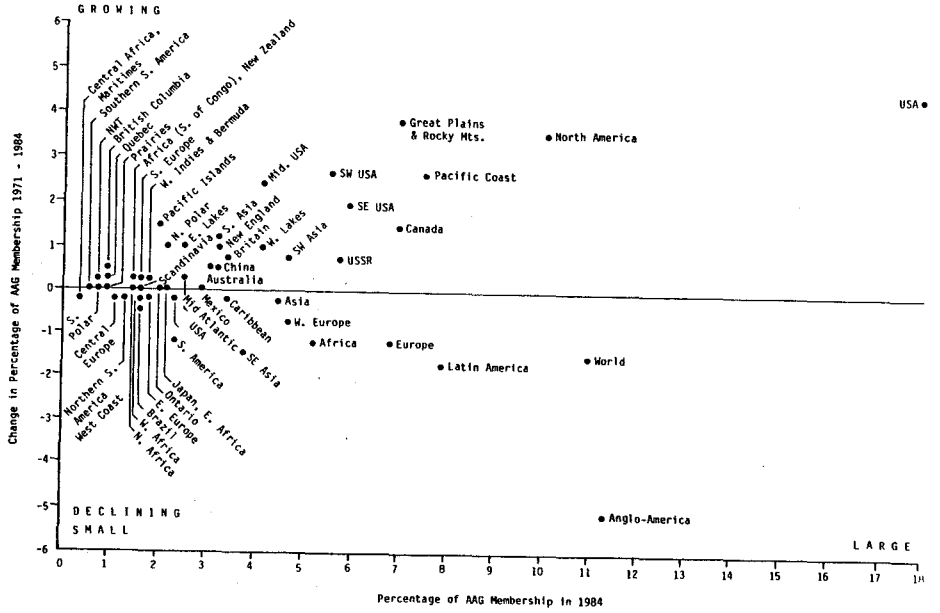

Figure 6. Percentage changes in areal proficiencies, 1971–1984, plotted against the number of members that claimed proficiency for each region in May 1984.

Analysis of Diversity

Given the significance of the specialization-diversity issue in geography, it would be instructive to compare diversity of interests at different scales of organization and in differing organizing structures. For example, do departments produce more or less specialization than specialty groups, or than the discipline as a whole? How do the levels of specialization compare for the graduates of different departments and for the members of specialty groups? What are the levels of specialization for different age cohorts of geographers? The Shannon-Weaver information statistic H provides a convenient measure of the degree to which a population is fragmented into distinct categories and offers a way of answering such questions (Hutcheson 1970).

If p_i denotes the probability that a randomly chosen individual is in class i out of m possible classes, then:

$$H = -\sum_i p_i \log p_i$$

In practice p_i is estimated from the proportions of a sample, $p_i = n_i/N$ where N is the sample size and n_i the number observed in class i.

H has several advantages as a measure of diversity of interest or degree of specialization. For a given number of classes it is minimum, H = 0, when all individuals belong to one class and maximum, H = log m, when each class has

Table 4. Diversity indices (Shannon-Weaver information statistics) of specialty group membership, computed from cross-membership data and ranked by increasing diversity

	H	Total cross-memberships
Geomorphology		
Remote Sensing	2.626	207
Industrial Geography	2.772	240
Water Resources	2.802	111
Coastal and Marine	2.814	203
Climatology	2.816	99
Aging	2.817	152
Transportation	2.819	45
Biogeography	2.905	145
Native American	2.934	119
Socialist	2.967	33
Canadian Geography	2.973	64
Bible	3.005	62
Mathematical Models and Quantitative Methods	3.036	43
Cartography	3.049	179
Chinese Geography	3.053	309
Culture Ecology	3.057	59
Regional Development and Planning	3.080	99
Population	3.084	210
Soviet	3.112	178
Urban	3.113	85
Medical	3.114	366
Rural Development	3.121	85
Energy	3.135	107
Environmental Studies	3.143	130
Applied	3.185	246
Political Geography	3.191	291
Environmental Perception	3.192	168
Latin American	3.215	144
Asian	3.217	139
Africa	3.225	92
Geographic Perspectives on Women	3.229	89
Geography in Higher Education	3.232	107
Recreation	3.236	108
Historical	3.244	125
All females	3.251	224
All males	3.353	
All members	3.391	
Theoretical maximum	3.409	
	3.555	

Source: Calculated by authors from May 1984 AAG membership records.

the same number of members. It is easy to calculate and increases as the number of classes increases.

With 35 Specialty Groups, the Association as a whole has a very high level of diversity of 3.409, compared to a theoretical maximum of 3.555. The distribution of members across groups is relatively uniform, as evidenced by Table 2. The interests of the Association's female members, at 3.353, are slightly less diverse than those of its males, at 3.391, and both are less diverse than the Association as a whole. The diversity of interests of the members of each specialty group, found by computing H across the corresponding row of the cross-membership table (the diagonal terms in this table are zero), is shown in Table 4. As one might expect, the highest diversities are associated with those specialties found to be in the center of the discipline in our earlier scaling analysis, and the lowest are associated with the more isolated, peripheral specialties. Members of the Geomorphology group have few other memberships, and these tend all to be in the same subset of groups, whereas members of the Recreation and Historical groups have a broad diversity of second and third memberships.

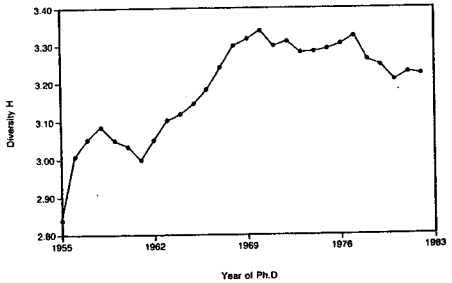

Figure 7. Diversity of specialty group membership in May 1984 (Shannon-Weaver information statistic) for Ph.D.s graduating by year from 1955 to 1983.

Three-year running means in diversity of interests of each year's Ph.D. graduates, computed from the specialties and year of Ph.D. reported by the members of the Association in 1984, are shown in Figure 7. Many current specialties were not available to the graduates of the early years of the period shown, which may account for the low diversities of interests among graduates of 1955–65. There is some evidence of a decline of diversity in the 1980s, which may indicate a narrowing of focus. However it seems to us that the more reasonable interpretation of the data, given the recent origin of many specialties, is that it indicates the relative ease with which individuals in the profession, particularly those graduating since 1960, are able to modify their interests in response to changing demand. This interpretation suggests that the diversity of interests of the 1980s cohorts will eventually increase to the levels of earlier cohorts. Unfortunately the lack of longitudinal data prevents us from testing this interpretation directly.

The diversities of current interests among

Table 5. Diversity indices (Shannon-Weaver information statistics) of specialty group membership for Ph.D. graduates and current faculty of major departments, ranked by diversity of Ph.D. graduates

	Diversity of Ph.D. graduates		Diversity of current faculty	
Department	H	N	H	N
Illinois	3.345	109	2.663	28
Michigan	3.328	117	2.197	9
Wisconsin–Madison	3.276	140	2.733	40
Minnesota	3.276	140	3.054	38
Syracuse	3.275	106	2.623	20
Michigan State	3.261	116	2.665	22
Clark	3.216	132	2.379	19
UCLA	3.206	116	2.867	38
UNC Chapel Hill	3.206	45	2.441	14
UC Berkeley	3.194	117	2.580	19
Washington	3.138	106	2.587	22
Rutgers	3.112	43	2.815	38
Chicago	3.088	144	2.364	17
London	3.078	49	1.332	5
Northwestern	3.051	105	0.637	3
Georgia	3.029	49	2.452	19
Indiana	3.012	67	2.576	37
Pennsylvania State	2.993	79	2.940	32
Louisiana State	2.969	71	2.399	18
Columbia	2.964	56	2.079	8
Pittsburgh	2.963	43	1.792	6
Kansas	2.919	84	2.880	31
Maryland	2.908	37	2.650	22
Ohio State	2.885	98	2.498	37
Iowa	2.884	95	2.865	26
Oregon	2.869	51	2.369	12
Nebraska–Lincoln	2.849	28	2.352	13
Florida	2.771	43	2.352	13
Tennessee	2.724	27	2.488	15
Oklahoma	2.708	24	2.274	16
Oregon State	2.699	46	2.138	12
Colorado	2.645	38	2.918	26
Toronto	2.614	29	2.659	18

Source: Calculated by authors from May 1984 AAG membership records.

Table 6. Membership of specialty groups by sex, May 1984, ranked by percentage female

	% female	% male
Geographic Perspectives on Women	84.5	15.5
Medical	37.4	62.6
Aging	37.3	62.7
Environmental Studies	30.5	69.5
Cartography	29.3	70.7
Biogeography	29.0	71.0
Socialist	28.4	71.6
Recreation	26.1	73.9
Population	26.0	74.0
Cultural Ecology	25.6	74.4
Native American	24.0	76.0
Environmental Perception	24.0	76.0
Water Resources	23.4	76.6
Rural Development	22.8	77.2
Africa	22.0	78.0
Urban	21.8	78.2
Regional Development and Planning	21.6	78.4
Coastal and Marine	21.6	78.4
Remote Sensing	21.2	78.8
Energy	20.7	79.3
Latin American	20.3	79.7
Geography in Higher Education	19.2	80.8
Historical	19.1	80.9
Applied	19.1	81.9
Asian	19.0	81.0
Geomorphology	18.7	81.3
Industrial Geography	17.8	82.2
Mathematical Models and Quantitative Methods	17.5	82.5
Chinese Geography	16.0	84.0
Climatology	15.9	84.1
Bible	14.8	85.2
Political Geography	14.6	85.4
Canadian Geography	14.3	85.7
Soviet	13.8	86.2
Transportation	8.3	91.7
All group members	23.4	76.6

Source: Calculated by authors from AAG membership records.

Ph.D. graduates and among current faculty in the most productive departments, defined as those identified as department of Ph.D. by more than 20 members, ranked by decreasing diversity of Ph.D. graduates, are shown in Table 5. Departments such as Minnesota, Michigan, Wisconsin–Madison, and Illinois produce graduates with a broad spectrum of current interests, whereas more specialized departments, such as Ohio State, Kansas, and Colo

Table 7. Sex by university of Ph.D. for those universities identified as such by at least 20 AAG members, ranked by percentage female

	% female	% male
Colorado	26.7	73.3
Pittsburgh	23.1	76.9
UNC Chapel Hill	18.8	81.2
Oregon	15.2	84.8
Minnesota	15.1	84.9
Oregon State	14.8	85.2
Clark	13.0	87.0
Columbia	12.2	87.8
UCLA	12.2	87.8
Johns Hopkins	12.1	87.9
Wisconsin–Madison	12.1	87.9
Iowa	11.3	88.7
Michigan	11.0	89.0
UC Berkeley	10.8	89.2
Ohio State	10.5	89.5
Maryland	10.3	89.7
Washington	9.2	90.8
Syracuse	9.2	90.8
Harvard	9.1	90.9
Chicago	9.1	90.9
Kansas	8.8	91.2
Rutgers	8.7	91.3
Northwestern	8.6	91.4
Louisiana State	8.5	91.5
Illinois	8.1	91.9
London	7.7	92.3
Indiana	7.3	92.7
Toronto	6.7	93.3
Oklahoma	6.7	93.3
Michigan State	6.1	93.9
Pennsylvania State	4.4	95.6
Tennessee	4.2	95.8
Florida	3.0	97.0
Georgia	2.7	97.3
Nebraska–Lincoln	0.0	100.0
All members with identified Ph.D. university	12.0	88.0

Source: Calculated by authors from May 1984 AAG membership records.

Note: Values are based on degrees declared by graduates of both geography and non-geography departments for each university.

rado, appear much lower on the scale. The interests of current faculty are generally less diverse, due in part to smaller sample sizes. However there are two extreme cases, Colorado and Toronto, where diversity of current faculty interests actually exceeds that of Ph.D. graduates. If we assume that interests remain fixed throughout academic careers, these data would suggest that the processes operating within departments lead to greater pressure for diversification among graduate students than among faculty. But it would again seem more reasonable to assume that interests are comparatively narrow at the time of graduation and that some department's graduates are more responsive, or better able to respond than others, to later career pressures for diversification, for a variety of reasons.

Gender Effects

The effects of gender on specialization have already been noted in the form of diversity indices. The memberships of each specialty group by sex for May 1984, shown in Table 6, indicates a strong association between gender and specialty. After Geographic Perspectives on Women, the most female specialty groups are clearly those strongly associated with current social concerns, including Medical, Aging, Population and environment. Also, Cartography has a high percentage of female members. At the other end of the spectrum are the male-dominated specialties, particularly Transportation.

There are also strong links between gender and department of Ph.D., shown in Table 7. The gender balance is clearly highly variable between departments, and in turn affects the balance across specialties through the structuring effects of the Ph.D.-granting institutions. Unfortunately the membership data are not sufficiently complete to allow us to examine relationships between gender balance among students and the corresponding balance among faculty of these institutions. The relative influences of gender of faculty and specialty of faculty in determining the gender balance among graduating Ph.D.s are difficult to determine from these data, so this linkage remains an interesting question.

Similarities among Departments

To explore the relative positions of departments within the subject matter space of the discipline, the numbers of Ph.D. graduates who are currently members of each specialty group were tabulated by department of Ph.D. In the analysis that follows only departments with more than 35 tabulated memberships are shown. Pearson correlation coefficients were then calculated between the membership totals by specialty group, including zeroes, for each pair of departments, and the resulting correlation matrix was used as the basis for Elementary Linkage Analysis.

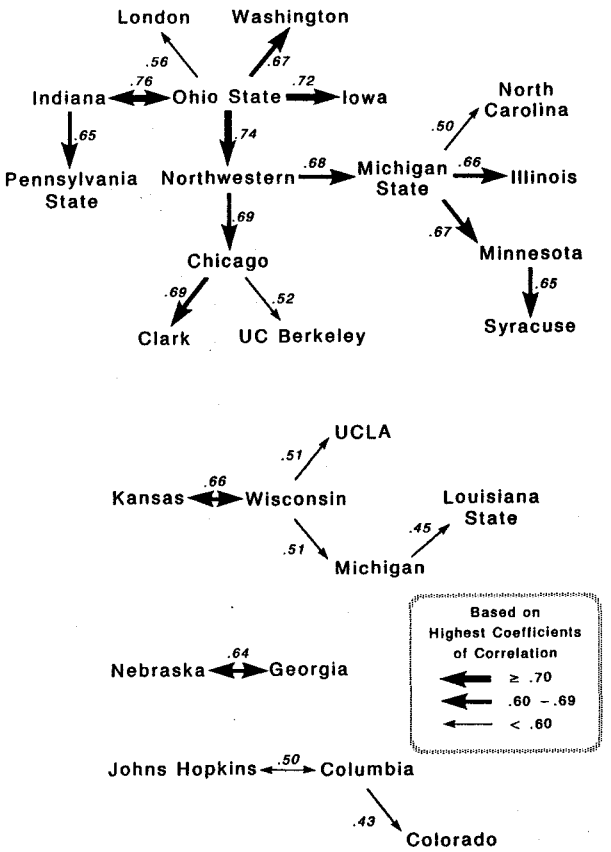

Figure 8. Elementary linkage analysis of correlations between specialty group membership patterns for Ph.D. graduates of major departments, May 1984.

The results are shown in Figure 8. The first major grouping is centered around Ohio State and Indiana and include other major departments strongly associated with the spatial analysis paradigm, such as Iowa, Washington and Northwestern. The strong link between Kansas and Wisconsin is due largely to interest in cartography, while the reason for the Nebraska-Georgia link is found in common branches of physical geography. Colorado is particularly weakly linked to the fourth group, suggesting a uniqueness of interests among its graduates and the correlation between Johns Hopkins and Columbia is only slightly larger. The low linkage for Louisiana State may reflect the unique nature of its combined programs in geography and anthropology. In general, however, the matrix of correlations revealed an exceptionally high degree of intercorrelation, giving credence to the notion that there is a strong level of agreement in the way that graduates from different departments respond in their choice of specialization.

Conclusions and Conjectures

The Growth of Specialization

The comments that follow attempt to link the empirical findings of the previous section with the earlier discussions on the structures of knowledge and organization in geography. Data on affiliations with specialty groups for AAG members have provided a handle on the importance of specialization in geography and on the unfolding nature of its divisions. The recent formal organization of these groups has given important focus to geographers who share common research interests.

The emergence of increased specialization in geography has been aided by the integrating effects of new technologies, which have reduced the significance of spatial limits to communication, and by the declining significance of social/cultural boundaries (as defined by age, sex, and language). Along with such facilitators of social communications as annual meetings, language translation services, sabbatical leaves, and equal employment opportunities, these developments have made it easier to access larger and larger pools of possible communicants, thereby enhancing the opportunities for even greater levels of specialization in the future. Although there are recognized benefits from this process, they must be balanced against the isolating effects that increasingly narrow specialization portends.

Structural Affinities and Isolation among Specialty Groups

A multidimensional scaling of cross-memberships among the constituents of AAG specialty groups has revealed patterns of both affinity and isolation. The clusters of similarly linked specialties accord well with three of geography's major traditions (Pattison 1964). The man-land theme is most central, represented in Figure 2 by historical geography and environmental studies; the breadth of this tradition is seen in the high measures of diversity for these specialties (Table 4) and in their linkages to several other specialty groups (Fig. 3). Figures 3 and 4 also identify the clear existence of spatial and earth-science traditions, each formed by cohesive membership linkages among a small set of related specialties. Because of the breadth and number of their linkages, cartography, applied geography, and historical geography occupy central positions in the space of geographic specialization, and may provide a core of intellectual and technical binding among the man-land, spatial, and earth-science traditions. In contrast, our analysis reveals no common core for the area-studies tradition, except indirectly, through systematic specializations.

Broad interest in regions is a declining specialization in geography. Regionally-oriented specialty groups are revealed as peripheral to the more systematic specialties and, as Figure 3 illustrates, their linkage to the more central specialties is through systematic divisions, such as medical geography, population geography, political geography, and historical geography. This pattern is at odds with the general public's conception of geography and with what many prominent geographers have advocated. De Blij (1987) sees areal specialism as a global outreach that may be more clearly associated with geography than any other discipline. Yet, Harvey (1984, 4) is concerned that recent tendencies to fragment for professional purposes have resulted in geography's failure to "build appropriate popular understandings to deal with a world undergoing rapid geographical integration . . . ." Have we, as Johnston (1985, 337) suggested, "disengaged" from the world?

Popular interest in places was the theme of a recent Presidential Address to the Association by Peirce Lewis (1985). Seeing this as a legitimate interest, he advocates that educating geographers in the art and science of describing places warrants a more prominent position on our agenda. There is need to articulate teaching and research agenda that are consistent with our acquired technical skills and theoretical understanding, and with the outside world's perception of geography. The acceptance of this idea may lead to a more central position for regional geography.

In contrast to the decline and to the lack of a revealed core in regional geography, the specialized branches of physical geography have cohesive membership linkages and have experienced recent growth (Figs. 2, 3 and 4). Yet, the cluster of these specialties peripherally, relative to the general pattern of specialization in geography, accords with the perception of an uneasy relationship between human and physical geography. In Britain, Worsley (1985) has argued for the recognition of separate disciplines, with separate university departments (as in Sweden and Holland), while Orme (1985) has argued the cause of integration. Lewis (1985) says that students of human geography need training in physical geography to interpret landscapes, but Johnston (1986) finds only the "vernacular" interpretation of physical geography as physical environment of broad interest to human geography. Is a vernacular link sufficient or does unity require a deeper epistemological bond? Is this to be found in a revived regional geography? Or is the unity of our discipline derived from other traditions?

Additional insights into many of these questions might be gained from the analysis of alternative data sets. For example, the relative abundances of presentations and journal articles might be used to monitor the progress of specialties. Surveys of linkages based on telephone calls, electronic mail, letters and joint attendance at meetings may suggest "invisible colleges." Members might be tracked between papers and sessions at the AAG Annual Meeting as a basis for establishing affinities and linkages. Although such surveys would provide an independent basis for evaluating and extending the conclusions reached in this paper, they are likely to require careful experimental design.

The importance of these kinds of analysis lies in their potential for establishing benchmarks of structure and change in the practice of geography. Annual specialty group membership data provide a basis for tracing trends in the discipline and for examining specific questions which go beyond the context of the present paper. For example, the Association has recently established GIS and Microcomputer specialty groups. Were their members drawn from across the Association, or from specific segments, such as those who previously identified less than three groups, or from members of specific groups? Can the membership be modeled as those who rarely identify specialty groups, those with lifetime affiliations to certain groups, and those who change affiliation in response to current trends? And what are the associated motivations?

Social Imperatives in Geography

The empirical analysis of cross-memberships in AAG specialty groups reveals cohesive groupings of specializations, each derived from well-established intellectual roots. But there are also divisions, some distinguished by the natu of research problems, and others, to a less extent, by the alignment of geographers a cording to demographic and social attribut (for example, age and sex were considered this study). The high level of diversity of mem berships for some specialties, and for the gra uates and faculty of many academic units (d partments), would appear to provide eviden of both intellectual and social bonding, eve among disparate specialists.

The social basis for geography as a distin discipline, made up of identifiable specialtie has been discussed by Johnston (1983) and Ha vey (1984), and documented by Grano (198 for the case of Finland. But, more generall Storer (1972, 229) notes how the term "disc pline" refers to both a body of knowledge an to a group of scientists. The mutual interde pendence of these conceptions of disciplin suggests that, as with other divisions of labo there are social roots to the present structu of geography.

Our proposed empirical/pragmatic view knowledge is neutral to the social and institu tional influences that guide the developme of disciplines, but individuals' career paths an choices are not; they are guided by the reward that society allocates for different choices an for different levels of performance, howeve judged. In turn, these decisions guide th emergence of new paradigms, shape the iden tity of the discipline's core(s), provide the bas for linkages among specialties, and determin their persistence.

As mediators in the choice of career path by individuals, a variety of institutions contrib ute to structuring the perceptions of purpos opportunity, and constraint that guide a dis cipline's development. The Ph.D.-granting de partments of geography were given special at tention in this analysis. Though som departments are more focused than others, the are seen to share the same fundamental tra ditions, and to show generally high levels diversity in the declared research interests their graduates and faculty.

The apparent contradiction between the in tense specialization of individuals and the di versity of departments as a whole is consisten with the career interests of individuals and wit the growth prospects for departments. Surviva instincts often bring forth a social solidarity geographers in the name of the departmen

regardless of their differences in specialization, to protect their niche among professionals. A parallel situation exists at the more general level of the Association as a whole. The Association has a higher level of diversity than any of its component specialty groups, and it is because of this that it can seek to provide the ecumenical bridge among geographers of diverse philosophies and purposes, and to speak for the discipline as a whole.

Acknowledgments

The data on which this study is based were supplied to the authors by the Central Office of the Association of American Geographers during the planning of the Detroit Annual Meeting (1985). We are grateful for the research assistance of Brian Klinkenberg, Harry Taylor Jr., and Bill Sawruk, and for graphic support from the Cartographic Unit, University of Western Ontario. We also thank Tony Gatrell, the editor and the anonymous referees for their critical reviews and helpful suggestions.

References

Abler, Ronald. 1986. Funding opportunities for geographic research: the National Science Foundation. *Ohio Geographer* 14:10–15.

———; **Adams, John S.; and Gould, Peter.** 1971. *Spatial organization: The geographer's view of the world.* Englewood Cliffs: Prentice-Hall.

Association of American Geographers. 1978. AAG specialty groups. *AAG Newsletter* 13(10):1.

———. 1986. Twin Cities annual meeting is Association's fourth largest. *AAG Newsletter* 21(7): 10,14.

Barrows, Harlan H. 1923. Geography as human ecology. *Annals of the Association of American Geographers* 13:1–14.

Bertalanffy, Ludwig von. 1968. *General system theory: Foundation, development, applications.* New York: George Braziller.

Blackburn, Thomas R. 1973. Information and the ecology of scholars. *Science* 181:1141–46.

Boulding, K. E. 1968. General system theory—the skeleton of science. In *Modern systems research for the behavioral scientist*, ed. Walter Buckley, pp. 3–10. Chicago: Aldine.

Buttimer, Anne. 1976. Grasping the dynamism of lifeworld. *Annals of the Association of American Geographers* 66:277–92.

——— 1981. On people, paradigms, and "progress" in geography. In *Geography, ideology, and social concern*, ed. D. R. Stoddart, pp. 81–98. Oxford: Basil Blackwell.

Capel, Horacio. 1981. Institutionalization of geography and strategies of change. In *Geography, ideology and social concern*, ed. D. R. Stoddart, pp. 37–69. Oxford: Basil Blackwell.

Coffey, William J. 1981. *Geography: towards a general spatial systems approach.* London and New York: Methuen.

Crane, D. 1972. *Invisible colleges.* Chicago: University of Chicago Press.

de Blij, Harm. 1987. Confusion of innovation. An address to the Association of American Geographers. Portland, OR: 23 April.

Eliot Hurst, Michael E. 1980. Geography, social science and society: Towards a de-definition. *Australian Geographical Studies* 18(April):3–21.

———. 1985. Geography has neither existence nor future. In *The future of geography*, ed. R. J. Johnston, pp. 59–91. London and New York: Methuen.

Fenneman, Nevin M. 1919. The circumference of geography. *Annals of the Association of American Geographers* 9:3–11.

Fournier, Marcel, and Maheu, Louis. 1977. Nationalisms and nationalization of the scientific field in Quebec. In *Perspectives in the sociology of science*, ed. Stuart S. Blume, pp. 131–54. New York: John Wiley.

Frame, J. Davidson, and Carpenter, Mark P. 1979. International research collaboration. *Social Studies of Science* 9:481–97.

Frazier, John W. 1978. On the emergence of an applied geography. *The Professional Geographer* 30:233–37.

Fuchs, Roland J. 1986. Geography as an international science: Current problems and future prospects. *International Geographical Union Bulletin* 36(no.1–2):30–9.

Gatrell, A. C. 1984. The geometry of a research specialty: Spatial diffusion modeling. *Annals of the Association of American Geographers* 74:437–53.

———, **and Smith, Anthony.** 1984. Networks of relations among a set of geographical journals. *The Professional Geographer* 36:300–7.

Geison, Gerald L. 1981. Scientific change, emerging specialties, and research schools. *History of Science* 19:19–40.

Gilbert, Anne. 1987. La géographie pratiquée par les femmes: Une analyse de contenu des sujets des memoirs et theses presentes dans les universités du langue français du Canada. *The Canadian Geographer* 31:253–62.

———, **and Thouez, Jean-Pierre.** 1987. Les affiliations des géographes quebecois: Essai de generalisation typologique. *The Canadian Geographer* 31:348–56.

Goodchild, M. F., and Mark, D. M. 1987. The fractal nature of geographic phenomena. *Annals of the Association of American Geographers* 77: 265–78.

Goudie, A. S. 1986. The integration of human and physical geography. *Transactions, Institute of British Geographers, New Series* 11:454–58.

Grano, Olavi. 1981. External influence and internal change in the development of geography. In *Geography, ideology and social concern*, ed. D. R. Stoddart, pp. 17–36. Oxford: Basil Blackwell.

———. 1984. The relationship between intellectual content and institutionalisation in Finnish geography. *Fennia* 162:9–12.

Griffith, Belver C., and Mullins, Nicholas C. 1972. Coherent social groups in scientific change. *Science* 177:959–64.

Haggett, Peter. 1983. *Geography: A modern synthesis.* Revised third edition. New York: Harper & Row.

Harris, Chauncy D. 1980. *Annotated world list of selected current geographical serials, fourth edition, 1980.* University of Chicago, Department of Geography Research Paper No. 194.

———, **and Fellmann, Jerome D.** 1980. *International list of geographical serials, third edition, 1980.* University of Chicago, Department of Geography Research Paper No. 193.

Harvey, David. 1984. On the history and present condition of geography: An historical materialist manifesto. *The Professional Geographer* 36:1–11.

Hausladen, Gary, and Wyckoff, William. 1985. Our discipline's demographic futures: Retirements, vacancies, and appointment priorities. *The Professional Geographer* 37:339–43.

Hutcheson, Kermit. 1970. A test for comparing diversities based on the Shannon formula. *Journal of Theoretical Biology* 29:151–54.

James, P. E., and Martin, G. J. 1978. *The Association of American Geographers: The first seventy-five years 1904–1979.* Washington: Association of American Geographers.

Johnston, R. J. 1983. *Geography and geographers: Anglo-American human geography since 1945.* Second Edition. London: Edward Arnold.

———. 1985. To the ends of the earth. In *The future of geography*, ed. R. J. Johnston, pp. 326–38. London and New York: Methuen.

———. 1986. Four fixations in the quest for unity in geography. *Transactions, Institute of British Geographers New Series* 11:449–53.

Jumper, Sidney R., and Harrison, Ivor Glen. 1986. Characteristics of AAG membership in 1982. *The Professional Geographer* 38:390–96.

Kerwin, Larkin. 1981. International science—an overview. *Science* 213:1069–72.

Laponce, J. A. 1980. Political science: An import-export analysis of journals and footnotes. *Political Studies* 28:401–19.

Laszlo, E. 1972. *The systems view of the world.* New York: Braziller.

———. 1973. *Introduction to systems philosophy.* New York: Harper.

Law, John. 1976. The development of specialties in science: The case of x-ray protein crystallography. In *Perspectives on the emergence of scientific disciplines*, ed. G. Lemaine, R. Macleod, M. Mulkay, and Peter Weigart, pp. 123–52. The Hague: Mouton.

Lenoir, Timothy. 1979. Quantitative foundations for the sociology of science: On linking block-modeling with co-citation analysis. *Social Studies of Science* 9:455–80.

Lewin, Kurt. 1951. *Field theory in social science.* New York: Harper & Row.

Lewis, Peirce. 1985. Beyond description. *Annals of the Association of American Geographers* 75: 465–77.

Long Range Planning Committee of the Association of American Geographers. 1978. Report and recommendations, Minutes of the Executive Committee Meeting, Association of American Geographers, 7 April 1978. In *AAG Newsletter* 13(6):9–12.

Mandelbrot, B. B. 1982. *The fractal geometry of nature.* San Francisco: Freeman.

Marcus, Melvin G. 1977. A letter from the president. *AAG Newsletter* 12(7):1–2.

———. 1978. The Association of American Geographers: Planning for the future. *The Professional Geographer* 30(2):113–22.

Martin, Geoffrey. 1980. *The life and thought of Isaiah Bowman.* Hamden, CT: Shoe String Press.

McNee, Robert B. 1973. Does geography have a structure? Can it be "discovered"? The case of The High School Geography Project. In *Directions in geography*, ed. R. J. Chorley, pp. 285–313. London: Methuen.

McQuitty, L. L. 1957. Elementary linkage analysis for isolating orthogonal and oblique types and typal relevancies. *Education and Psychological Measures* 17:207–29.

Orme, Antony. 1985. Understanding and predicting the physical world. In *The future of geography*, ed. R. J. Johnston, pp. 258–75. London and New York: Methuen.

Pattison, William D. 1964. The four traditions of geography. *The Journal of Geography* 63:211–16.

Peet, Richard. 1985. The social origins of environmental determinism. *Annals of the Association of American Geographers* 75:309–33.

Portugali, Juval. 1985. Parallel currents in the natural and social sciences. *Geoforum* 16:227–38.

Pred, Allan. 1979. The academic past through a time-geography looking glass. *Annals of the Association of American Geographers* 69:175–80.

Price, Derek J. de Solla. 1986. *Little science, big science . . . and beyond.* New York: Columbia University Press.

Pruitt, Evelyn L. 1979. The Office of Naval Research and geography. *Annals of the Association of American Geographers* 69:103–08.

Rushton, G., and R. G. Golledge. 1972. *Multidimensional scaling: Review and geographical applications.* Washington: Association of American Geographers, Commission on College Geography, Technical Paper No. 10.

Sauer, Carl O. 1941. Foreword to historical geography. *Annals of the Association of American Geographers* 31:1–24.

Smith, Neil. 1987. "Academic war over the field of geography": The elimination of geography at Harvard, 1947–1951. *Annals of the Association of American Geographers* 77:155–72.

Storer, Norman W. 1972. Relations among scientific disciplines. In *The social contexts of research,* ed. Saad Z. Nagi and Ronald G. Corwin, pp. 229–68. New York: Wiley-Interscience.

———. 1978. *The social system of science.* New York: Holt, Rinehart and Winston.

Taylor, Peter J. 1985. The value of a geographical perspective. In *The future of geography,* ed. R. J. Johnston, pp. 92–110. London and New York: Methuen.

Turner II, B. L., and Meyer, William B. 1985. The use of citation indices in comparing geography programs: An exploratory study. *The Professional Geographer* 37:271–78.

Waddington, C. 1971. Thinking about complex systems. *Ekistics* 32(193):410–12.

Warntz, William. 1973. New geography as general spatial systems theory—old social physics writ large. In *Directions in geography,* ed. Richard J. Chorley, pp. 89–126. London: Methuen.

Whitehand, J. W., and Edmondson, P. M. 1977. Europe and America: The reorientation in geographical communication in the post-war period. *The Professional Geographer* 29:278–82.

Whitley, Richard. 1984. *The intellectual and social organization of the sciences.* Oxford: Clarendon Press.

Woolgar, S. W. 1976. The identification and definition of scientific collectivities. In *Perspectives on the emergence of scientific disciplines,* ed. G. Lemaine, R. Macleod, M. Mulkay, and P. Weingart, pp. 233–45. The Hague: Mouton.

Wooldridge, S. W., and East, W. Gordon. 1958. *The spirit and purpose of geography.* London: Hutchison University Library.

Worsley, Peter. 1985. Physical geography and the natural environmental sciences. In *The future of geography,* ed. R. J. Johnston, pp. 27–42. London and New York: Methuen.

Young, F. W., and Torgerson, W. S. 1967. TORSCA, a FORTRAN IV program for Shepard-Kruskal multidimensional scaling analysis. *Behavioural Science* 12:498.

Ziman, J. M. 1980. The proliferation of scientific literature: A natural process. *Science* 208(25 April): 368–71.

Cattle and Sheep from Old to New Spain Historical Antecedents

Karl W. Butzer

Department of Geography, University of Texas at Austin, Austin, TX 78712

Abstract. The transfer of cattle and sheep from Spain to Mexico during the sixteenth century raises questions about regional evolution and variability of livestock economies in the source area, the regional and socioeconomic roots of the emigrants, and the ecological and economic integration of specific animals, management methods, and related products within New Spain. Such issues of diffusion, cultural adaptation and transformation must be disentangled before interpretation is attempted, and this paper focuses on the Old World antecedents. Traditional nineteenth-century patterns of livestock herding in different regions of the Iberian Peninsula were already established in Roman times and changed but little during the Islamic period. Long-distance sheep transhumance is verified prior to the Christian reconquest and was greatly amplified thereafter. Yet late Medieval Spain was not a great ranching frontier, but an agrosystem in which farming and livestock raising always formed a complementary but interlinked economy. This duality was expressed in different forms of land ownership: cultivated land was intricately subdivided and carried clear title, while pasture zones remained to some degree in the public domain. Sheep raising, both within the mixed, Mediterranean economy and in the form of long-distance transhumance (the Mesta), was broadly familiar throughout Castile and was reflected in similar counterparts on the Mexican plateau. But cattle raising was small-scale and of subordinate importance in Spain, except in the estuarine marshland below Seville. Whereas the early cattle owners in Mexico came from all over Spain, their highly extensive management style appears to derive from the Marismas of Sevilla. This evidence may explained by the interplay of cattle own and cattle herders as they adjusted to a n ecology in the tropical lowlands.

Key Words: agrosystem, diffusion, Mesta, Me co, Spain, ranching, transhumance.

CULTURAL and historical geograph working in eastern North America ha until recently focused almost exc sively on European-derived culture spher viewing native American contributions as n nor or peripheral. By comparison, Latin Am icanists, both geographers and anthropologis have concentrated their attention on indig nous roots, paying only nominal attention Iberian components.

Latin Americanists, in their perception Spain as seen from Hispanic America, ha tended to assume a monolithic, common c tural hearth, even though sixteenth-centu Spain consisted of a dozen or so culturally d tinctive regions (Foster 1960). On the oth hand, North Americanist geographers ha sought to disentangle the multiple strands European elements intertwined in the differe culture spheres that emerged between the S Lawrence River and the Georgia seaboard. Th have also been explicitly interested in wh Harris (1977) has called "the simplification Europe overseas," i.e., the process whereby t great cultural variety encompassed by the Nor European immigrants was reduced to a mu simpler and relatively homogeneous Americ and Canadian cultural repertoire.

These different preoccupations of researcl

Annals of the Association of American Geographers, 78(1), 1988, 29–56