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Research Design and Proposal Writing in Spatial Science

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To f., m. and e.—JDG

To my wife, Susan, and children, Katherine, Helena, and Emily; my beloved family, around whom all of my geographic universe revolves—GDB

To Tricia and my children—RRJ

To my family—RRT

Foreword

Jay Gatrell, Gregory Bierly, Ryan Jensen, and Rajiv Thakur have produced a book that will be a valuable addition to many academics' bookshelves. While the examples are based on research in spatial sciences, the guidelines and examples are widely applicable in any science-based discipline. In today's competitive academic environment every faculty member is expected to engage in the process of funding their research with extramural grants and contracts. At a minimum, they must develop a logical proposal before they begin a thesis or dissertation. Far too often a graduate student's program of study does not include training in how to succeed in this competitive process. This book could serve as an excellent text for a one-semester graduate-level course devoted to proposal development. An instructor could guide a group of students through the entire proposal writing experience and expect each student to defend a completed proposal as a final project—if taken at the right stage in their career as students would jump-start their thesis or dissertation research. Feedback from other students would help to identify weaknesses and strengthen the proposal. Alternatively, graduate students and young faculty members who are unable to benefit from a formal course setting will find the book to be an excellent manual for self-study. In addition to providing:

> …an understanding of the scale and scope of spatial science, define the constituent parts of a research proposal, underscore the importance of design, and explore the many forms research output may take from the initial abstract through the peer reviewed article.

The book also includes nine original proposals that cover a wide range of application domains as well as intended audiences. These proposals can serve as models or blueprints that can help a researcher structure a successful document. As the authors state:

> Each of the models included in this collection has been selected as they have specific features that make them unique. In some cases, the exposition of the data or methods section, graphics, or budget features are distinct. In all cases, the unique features of each are noted in the prefatory comments and reflection. Additionally, we—the authors—have

endeavored to identify a diverse collection of models from across the spatial sciences. Further, all of the proposals have been successfully defended and/or grants have been awarded.

The book really has two distinct parts. The first eight chapters constitute a practical guide on how to approach a research problem in the spatial sciences and carry an idea through the entire process of proposal development, submission, and the ultimate dissemination of the findings. The first three of these chapters focus on general background information relating to literature, data, and methodology that is useful for any structured research program. The remaining five chapters walk one through the logical steps in developing a proposal, securing approval or funding and then provide a very useful discussion of the alternatives that now exist for the dissemination of findings. Throughout these eight chapters, the authors build on their extensive experience to provide helpful hints and insights. For example, there is a useful section on how to deal with rejection. (Don't take it personally, learn from the feedback, and strengthen the proposal).

The proposals are grouped into sections on master's theses, Doctoral Dissertations and grant proposals. The compilation of these successful proposals provides an excellent resource for any researcher. The authors have provided a brief introduction to each proposal to set its context. Each proposal demonstrates a need to have a clear outline, to clearly identify the research questions and to outline the data sources and methodology that will be followed. In some cases, the investigators have provided useful timelines and budget items. Even a casual review of these proposals will provide the novice researchers with a clear picture of the task in front of them. One quickly learns the importance of carefully laying out the details of the research plan and the expected results. The authors' comments relating to some of the proposals demonstrate that a well-structured proposal helps to place bounds around a research project. Armed with a detailed proposal that has been approved by the funding agency or a committee the researcher can be confident that there is no misunderstanding about the scope of a study. Far too often a research project wanders off course to explore additional study sites, data sources, or methodological approaches. The real value of this book is its focus on the proposal development process and its importance in a successful career. Most students lack the proper perspective on proposal development as a way of focusing and organizing their ideas and providing a blueprint for their research activities. This book is a timely addition to our literature and should be required reading for any graduate student in the field.

April 2020

David Cowen
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Chapter 1
Spatial Science and Its Traditions

> *... phenomena...take place in and are distributed across geographical space. It is reasonable, therefore, to argue that [scientists] are interested, indeed have long been interested, in social [and physical] phenomena distributed in geographical space. Yet, in the main, our theoretical frameworks and data-analytic capabilities do not include the geography of social phenomena.*
> Doreian (1981, p. 359)

> *People generate spatial processes in order to satisfy their needs and desires and these processes create spatial structures, which in turn influence and modify geographical processes.*
> Abler et al. (1971, p. xiii)

Research design is the critical process that transforms an idea, interest, or question from "just a thought" into a meaningful and purposeful investigation of human or physical processes. The central emphasis of research design is the process itself. For this reason, research design does not refer to the end product, the results, a new grand theory, or a specific methodology. Rather, research design is an iterative process that is an on-going negotiation between the researcher, peers, the standards of good science, and the dynamics of the evolving study itself. This process transcends discipline, epistemology, or subfield. Indeed, social and natural scientists alike must undertake the same steps to distill the essence of a research question and design a successful project.

As this text will demonstrate, good questions or good methods alone do not necessarily translate into a positive outcome, new knowledge, or a novel application of a previously established methodology. Rather, social and natural science research are pragmatic processes that exist within the context of established rules, boundaries, and knowledge, and a researcher's ability to negotiate these normative frameworks will determine the success of a project. As part of the negotiation process, emerging junior and senior scholars alike seek to expand the conceptual, methodological, and thematic boundaries of knowledge. Yet, in most cases the inherent pragmatism and incrementalism of the sciences suggest that a single research project will be able to accomplish each of these objectives: conceptual, methodological, or topical advancements.

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In this book, research design is considered within the context of a desired goal or objective and the very practical outcomes of these objectives. The most immediate goal is often the preparation of a thesis or dissertation proposal—and eventually a resulting monograph and/or peer reviewed article. In other cases, the objective may be to successfully propose research to an external funding agency, such as the National Science Foundation or a learned society. In both cases, the negotiation process and strictures of science require that very specific, logical, and measured steps be taken. In this book, we outline the entire design process from proposal development through the dissemination of research. As our examples will demonstrate, the design process cannot divorce the research proposal from the dissemination of the research, as these are inherently inter-dependent. In the remainder of this chapter, we: (1) define spatial science, (2) examine the role of spatial science in the academy and beyond, (3) situate spatial research within the four dominant paradigms within the social and natural sciences, and (4) present an overview of the text.

1.1 What is Spatial Science?

Spatial science is a synoptic (or holistic) science that systematically investigates natural or human processes within and across physical and social space (see Fig. 1.1).

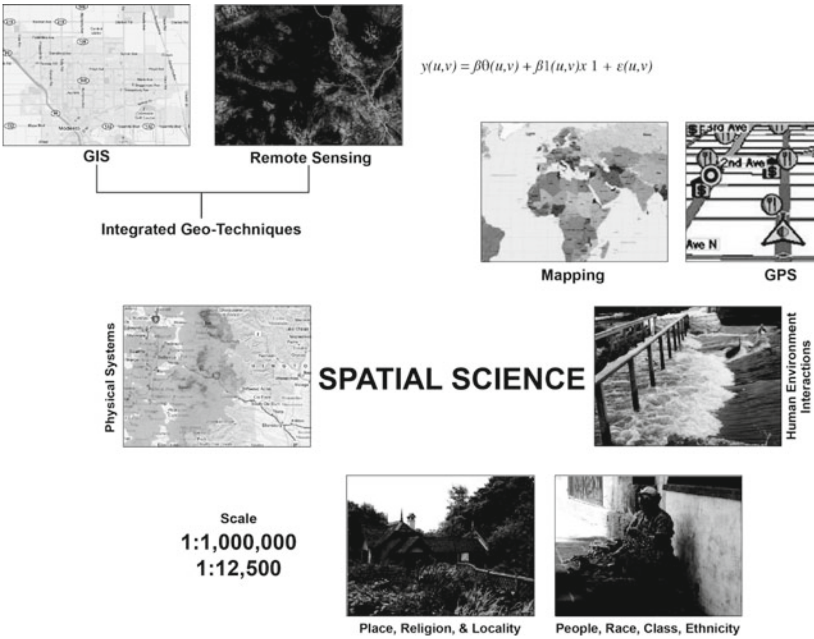

Fig. 1.1 Spatial science—a holistic approach

The genesis for spatial science—as a community of researchers interested in "space" in either abstract or relative terms was the work of William Pattison. In 1964, Pattison clearly articulated the philosophical and historical foundation of spatial science, or what he called the "spatial tradition," as western civilization's innate interest in the geometry of the world around us. This geometry was a basic geometry of points, lines, and polygons and the related concepts of distance, location, and direction that have served as the foundation for examining geographic unity, form, and separation.

Today, the simple geometric primitives of Pattison's Spatial Tradition have emerged as an increasingly complex collection of "spatial" interests (Robinson 1976). That is, the simplicity of geometry has been complicated by the emergence of new conceptualizations of space as a perceived or socially constructed concept—not merely Cartesian coordinates (Robinson 1976; Soja 1980). In addition to new conceptions of space, spatial science transcends the traditional "firewalls" scientists place between physical and social systems. Indeed, contemporary spatial science investigates the interactions between natural and social processes to unlock how this interaction produces locally observed phenomena. At other times, spatial scientists examine how people—in place—shape and re-shape economic, political, and even physical landscapes. When considered together, spatial science—like the closely aligned field of geography—attempts to identify patterns on physical and social landscapes and the social and physical processes that cause observed processes. For this reason, spatial scientists and geographers investigate a diverse collection of topics ranging from landscape ecology through income inequalities in urban centers. Today, spatial scientists can be found investigating questions in nearly every discipline geo-archeology, biogeography, statistical modeling, urban planning, economic development, and many others.

In most cases, spatial scientists seek out general explanations concerning observed natural and social conditions. Yet, spatial scientists may also seek out locally contingent explanations that elucidate the socio-spatial context of counter-factual cases. Whether at the local, regional, or global scale, spatial scientists employ a shared collection of tools and techniques to understand and explain the social and natural world around them. These tools include: statistics, mathematical models, geo-techniques, and spatialized neo-classical models—such as the product cycle to identify unique and shared geographies.

The growth and expansion of spatial science has been closely linked to the expansion of geo-technologies. The most prominent of these technologies are geographic information systems (GIS), remote sensing, and global positioning systems. These technologies have made it possible for spatial researchers to more accurately model, analyze, and predict spatial patterns. For example, prior to the 1960s, there was no efficient method to manage natural or anthropogenic resources associated with large areas of land. However, since the 1960s, GIS has been used extensively to perform spatial analyses of Earth's resources. The foundation of geo-technologies consists of geography, mathematics, computer science, physics, biology, engineering, and cartography (Bossler 2002).

1.2 The Place of the Spatial Science

Spatial science is emerging as a popular inter-disciplinary perspective as it is situated between the human and physical realms. Insofar as the spatial approach is versatile and inherently interdisciplinary (Fig. 1.2), it is being widely adopted across the social and natural sciences. Conceptually, spatial science's growth has been associated with the growing recognition that all research exists in both space and time. This means spatial science's inter-disciplinary commitment to serving overlapping research communities is intrinsically global even as new research opportunities emerge from fresh understanding of the changing planet or changes in the influence of climate on human evolution among many other changes goading us to continue thinking spatially. The NSF in recent years through its numerous awards continues to improve spatial understanding and literacy, and strengthen institutions specializing in spatial science (NSF 2017). In practical terms, the growth and expansion of spatial science has been fuelled—in part—by an increased awareness and policy relevance within government, as well as the emergence of new geo-technologies that transcend discipline identity.

In 1999, the National Science Foundation (NSF) funded the Center for Spatially Integrated Social Science at the University of California-Santa Barbara (Award

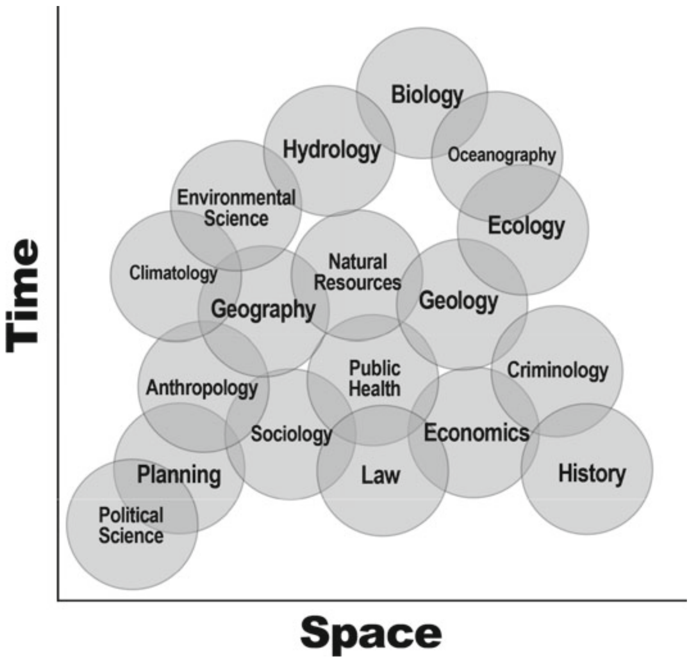

Fig. 1.2 Disciplines in space and time

9,978,058). The intent of the center was to establish the important role geo-technologies, such as global positioning systems, geographic information systems, and remote sensing, play across the sciences. Since then, the notion of a spatial social science has emerged as a priority within and across several NSF directorates. For example, in 2005 spatial science was identified as a priority area targeted for continued funding across multiple disciplines (Smith and Mathae 2004). Indeed, the spatial science approach and application of geo-technologies has expanded across the academy and spatial scientists are at the forefront of a great variety of research across the academy. Interestingly, even though, at the NSF the formal name 'Geography and Spatial Sciences Program (GSS)' was not adopted until March 2008, the GSS Program today continues to take initiative and advance a framework for charting future developments with respect to geography and spatial science's contributions to scientific understanding and decision making (Baerwald 2009; NSF 2017).

The notion of spatial science—as a way of knowing the world—continues to evolve. Spatial Science has assumed significance because we are increasingly concerned with quality wellbeing of people and the planet. Achieving this is largely dependent upon understanding the future directions of our environment given the diverse and evolving threats to national security (including scarcity and disruption of food and water supplies, extreme weather events, and regional conflicts around the world). It is in this context that emerging geospatial tools and techniques embedded in intellectual and conceptual vigor, and enhanced analytic abilities have a role in the preparation of the next generation of spatial scientists. To that end, there is growing awareness that spatial science in general, and geospatial technologies in particular, are critical to the competitive advantage of individuals, institutions, and regions (Berry et al. 2008; NAS 2019).

The above initiatives at NSF has over time resulted in the change of research and teaching focus towards spatial science. Such changes have happened at many institutions involving a change of formal name, focus, mission and vision. Examples include the University of Illinois Urbana Champaign's Department of Geography and Geographic Information Science; the University of Southern California's Spatial Sciences Institute; North Carolina State University Center for Geospatial Analytics; Indiana State University's Department of Earth and Environmental Systems interdisciplinary doctoral degree in Spatial and Earth Sciences; Texas State University graduate program in GIS; South Dakota State University's Geospatial Science and Engineering program; and the George Washington University Spatial Analysis Lab that extends from an intentional geospatial data science initiative. While these are only a few of many examples in the U.S., similar changes have been made in programs and at universities around the world.

The institutionalization of spatial sciences in recent years has occurred not merely through a change in focus of educational and research programs at universities worldwide to respond to both preparation of human capital and facilitation of spatial decision making, but also through the embracing of geospatial tools by supranational institutions such as the European Union and fund banks such as Asian Development Bank, among others to address challenges faced by communities economically, socially and environmentally. Therefore, geospatial tools and techniques are increasingly assisting global, regional and local needs through combination of information and the ability of spatial scientists to find patterns and make new connections to see clarity in chaos and finally impact improved strategic decisions and policy making. As an example UNCTAD in 2012 began exploring development through the lens of 'geospatial science and technology' in order to address sustainable urban-regional development, land administration, disaster risk management as part of its strategy to make appropriate recommendations.

For spatial sciences, its institutionalization has also meant increased funding to support cutting-edge work in the areas of public health, climate change, urban and regional economic development at the forefront of geospatial and educational research by NSF, USDA, USGS, NASA, CDC, NIH and NCI among others. In 2017, NSF awarded more than $ 10.2 million through its Geography and Spatial Sciences (GSS) program to fund 64 new projects that will facilitate advancing knowledge about spatial patterns and processes, as well as help understand changing complex dynamics between the human and physical systems (NSF 2017). In the process of expansion of research and knowledge sharing by spatial science professionals many new peer reviewed journals have emerged in recent decades such as *International Journal of Applied Geospatial Research*, *International Journal of Health Geographics, Journal of Spatial Science (formerly known as Cartography and Australian Surveyor), Cartography and Geographic Information Science* (formerly known as *Cartography and Geographic Information Systems* and *The American Cartographer), Journal of Spatial Information Science, Geospatial Today (India),* and *Geo-Spatial Information Science (China)* among many others. The various ways in which spatial sciences are being institutionalized reflects the evolving needs of our times. The emergence of geospatial tools and its advancement reinforces the influence of spatial analytics in a variety of management and planning decisions in both the public and private sectors.

Whereas spatial science was once associated only with research centers or laboratories, stand-alone departments—like the Department of Spatial Sciences at Curtin University in Australia or the University of Maine's Department of Spatial Information Science and Engineering—now exist. The common denominator in this shift and emphasis on spatial science across institutions in its myriad forms is the use of cutting-edge technology, tools and, faculty expertise with specialization representing both contemporary concerns such as globalization, regional and ethnic conflict, environmental hazards, terrorism, poverty and sustainable development along with new and evolving interdisciplinary methodological advances in artificial intelligence, machine learning and data science (NAS 2019; Rey 2019).

The shift from spatial analysis to spatial science in the last few decades is also a reflection of geography increasingly becoming an applied practice that informs policymaking and as a coherent set of methodologies to gather and analyze data about aspects of our planet and its occupants. The rise of geography as a 'science' has also been attributed explicitly by Martin (2015) the official archivist of the Association of American Geographers in his very influential book titled *American Geography and Geographers: Toward Geographical Science.* Even as institutions recognize the significance of spatial science and its attendant tools we also notice an increased collaboration with a cross cutting array of researchers, businesses, non-profits, and many other stakeholders from a wide range of disciplines and industries to analyze, model, visualize location-based data. Such institutions include the World Bank, UN agencies, bilateral and multilateral development aid agencies (USAID, IDRC, OXFAM, etc.), local, regional, national and global NGOs, grassroot initiatives as well as corporations. Hence, we find cutting edge research focusing on GIS and sustainability, human security and geospatial intelligence. Increasingly, collaborations between institutions and across scales have created programs that are developing our next generation of spatial professionals capable of addressing local, regional and global challenges with respect to international trade, environmental change, population growth, information infrastructure, the condition of cities, and human health (Rey 2019; Seidel et al. 2018).

1.3 Spatialized Disciplines

Spatial science at its most basic level—mapping—is rather straightforward. Indeed, natural and social scientists have long used cartographic representations to present spatial information and relevant attribute data. However, most maps merely re-present data in space without "spatial interaction" and can be used to elucidate only the most basic spatial relationships (i.e., left/right, to/from, in/out). Beyond mapping data, many spatial scientists are interested in dynamically representing and modeling spatial relationships from both known and unknown locations. In some cases, spatial science has been used to predict observed behaviors. For this reason, the social sciences have been the most heavily influenced disciplines.

In addition to the social sciences, the natural sciences are also being influenced by a range of concepts and technologies associated with spatial science. In particular, the work of ecologists has been enriched through the adoption of geo-technical tools and methods. For example, Formica et al. (2004) used remote sensing and GIS technologies to chart the spatial dynamics of reproduction of the White-throated Sparrow. Indeed, some spatial science techniques, particularly trend surface analysis and concepts, such as spatial autocorrelation, have become staples in ecological research (i.e., Lichstein et al. 2003) and graduate training (i.e., Urban 2003). More recently, the growing field of 'movement ecology' has drawn from studies of human–environment interaction (soils and water, forests and wildlife, agroecology, food plants and consumption, rangelands and mountains) offering important insights into the complexity that arises from historical, cultural and scale-related processes of cultural ecology with an emphasis on local and regional settings. Seidel and colleagues review extensive literature using spatial science toolkits to understand animal behavior in the context of environmental degradation and planning, conservation, biodiversity and the broader environmental discourse as well as overview the commonly used metrics and methods of spatial analysis (Seidel et al. 2018).

1.3.1 Spatial Science Beyond the Academy

While discussions of a "spatialized" social or natural science are often confined to the academy, space and the importance of understanding socio-spatial and natural processes in and across space is increasingly recognized as an essential component of public policy and private sector decision making. The growing collection of inexpensive and increasingly user-friendly geo-technologies have put space and spatial relationships clearly on the agenda. In the public sector, space and spatial technologies such as GIS, GPS, and commercial remote sensing initiatives have expanded the visibility of spatial science across all sectors. However, the availability of spatial data and the increasing ease within which they can be digitally manipulated and assessed has not been accompanied by a critical understanding of research design or the guiding principles of geography. Today, many decision makers are uncritically adopting the trappings of spatial science (maps, digital images, and the rest) to aid the decision making process. As spatial science evolves its ability to analyze a range of complex themes and communicate with a wider audience, geospatial tools are increasingly being used in the public domain by institutions such as the World Bank and the United Nations system at the global level to address infrastructure needs, socioeconomic and environmental concerns on the one hand and by local government institutions as well as nonprofits both in developed and developing countries to make governments more open and accountable facilitating citizen participation in governance process, creating opportunities for economic development and democratizing decision making in both private and public sectors.

1.4 The Scientific Method and Other Ways of Knowing

Spatial science is a diverse collection of research initiatives situated throughout the social and physical sciences that have either a primary or secondary interest in issues of space, place, and region. For this reason, spatial scientists have embraced a great variety of epistemologies. While the majority of spatial science is performed under the rubric of logical-positivism or the scientific method—positivism is not the sole philosophical perspective. Today, the dominant epistemological paradigms are: Empiricism, Logical-Positivism, Humanism, Structuralism, and Post-Structuralism. While not all of the perspectives are traditionally associated with spatial science per se, the spatial approach is not limited to logical-positivism. In this section, we will briefly consider the implications of situating yourself, as a researcher, your interests, and potential questions within each framework and how the relative positioning within these frameworks will influence the design process. Of course, it is important to recognize that some research—particularly research into "natural" or physical processes—is almost exclusively performed within the empirical and positivist paradigms.

1.4.1 Empiricism

Empiricism is the earliest epistemological tradition in spatial science. Empiricist researchers catalog, measure, and assess social and physical phenomena via observation. In most cases, the empirical tradition is a purely idiographic or descriptive endeavor. For the first half of the twentieth century, spatial science was a primarily descriptive endeavor of cataloging and measuring observed physical and social phenomena as discrete locations or regions. The descriptive work of spatial scientists serves to provide the necessary and important foundation for subsequent research. Examples of empirical research include: regional geography, simple Cartesian coordinate geometry, mapping, and other taxonometric exercises.

1.4.2 Logical-Positivism

By the 1950s, spatial scientists—particularly geographers—began to acknowledge that empiricism alone was an intellectually limited approach towards knowing the natural world and people around us. As such, a new "quantitative revolution" sought to replace description of observed conditions with a new framework—rooted in the rigors of science—that had the capacity to explain observed conditions and identify key socio-spatial processes. Based on the intellectual foundation of empiricism, positivists seek to explain observed conditions. Using the scientific method, positivist research identifies the human and physical processes that explain the distribution of physical or human conditions. More importantly, logical-positivist research systematically attempts to verify the validity of its explanations through rigorous methodologies and strict protocols. Throughout the 1960s and early-1970s mathematical modeling and inferential statistics were the primary tool kit of spatial scientists. Examples of logical-positivist research include regional econometrics, geographical information science, location/allocation modeling, and other research that uses data analysis (Table 1.1).

1.4.3 Behavioralism

In many respects, behavioralism is a logical—if socialized—version of logical positivism. Whereas logical positivism makes basic assumptions concerning the independence of actors, or variables, behavioralism recognizes that the spatial world—and people's knowledge of it- is important. By the 1970s, the explanatory power of logical-positivism was increasingly considered to be somewhat limited—particularly with respect to understanding and explaining socio-spatial processes and related decision-making. The majority of the work of behavioralists focused not on space

Table 1.1 Approaches in spatial science

Empiricism—Observation
Logical-Positivism—Scientific Method
Behavioralism—Bounded Rationality and Decision Making
Humanism—Experiential and Qualitative
Structuralism—Political Economy
Post-Structuralism—Difference

as a collection of points and measurements—but on space as perceived or conceptual phenomena bounded by the everyday experiences of people. That is, space—in abstract Cartesian terms—was seldom how people experience everyday life and/or made decisions. For this reason, behavioralists began their important work of individual and group perceptions of space and spatial relationships within the context of imperfect or bounded rationality. This new understanding of people and their behaviors produced a more nuanced collection of spatial models and statistical analyses. Examples of behavioral approaches are highly diverse and include: environmental perception, cognitive mapping, and studies of individual decision-making in space (i.e., housing mobility). Today, behavioral geography and related cognitive sciences are a growing research area across the spatial sciences.

1.4.4 Humanism

In contrast to behavioralism's attempt to bring people's perceptions into the "equation" (literally and figuratively), some spatial scientists would become interested in how space and place shape the human experience. That is, how do people experience location and space and how do these concepts give meaning to the shared material and symbolic landscape. In large part, the humanist movement of the 1970s and 1980s was limited to cultural geography. Today, humanism has come to be associated with components of the post-structuralist community. Yet, the visibility of humanism has decreased over time.

1.4.5 Structuralism and Post-Structuralism

By the late-1960s, some spatial scientists became interested not in the observed landscape—but in the inherently hidden nature of socio-spatial relationships that determine the structure and form of the material and symbolic landscape. The initial structuralist movement of the 1960s focused on economic relationships—particularly capital and labor relations and the production process. Specifically, structuralists—buoyed by empirically observed conditions such as housing segregation, poverty, and suburbanization—sought to explain the observed distribution of resources vis-à-vis the entire complex of socio-spatial relationships that produced a local, regional, or global space-economy.

By the 1980s, functionalist interpretations focusing primarily on production and the political economy of geo-politics, uneven development, or the urban landscape were seen as too limited. The result was the advent of post-structural research. Post-structuralists sought to identify other non-economic socio-spatial processes or conditions that shape space and define place. The result was an explosion of research that sought to examine how issues of race, gender, ethnicity, or sexuality (often in tandem with economics) produced similar or dissimilar social spaces. The result has been a robust body of research and explanations of the impact of non-economic structures such as racism, patriarchy, anti-Semitism, and consumerism on observed or perceived spaces. In 1999, Marcus Doel clearly articulated the contours and cleavages of a post-structural spatial science in his book Post-Structuralist Geographies: The Diabolical Art of Spatial Science. *The Diabolical Art* focuses on the use of language and other insights drawn from the broader community of cultural studies to examine the spatiality of everyday life and social (and interestingly physical) processes at the global and local scale. Unlike positivist and empiricists, the spatial science of post-positivists seldom corresponds to the measure and ordered structure of the scientific method or concrete description.

Today, the various paradigms of spatial science outlined above are seldom mutually exclusive. Indeed, much contemporary research, particularly human–environment research, has explicit policy implications. Because of the importance of public policy, nearly all examples of spatial science research are situated at the nexus of two or more traditions and must consider the impact of research and new knowledge on a broader collection of socio-spatial actors. However, the legitimacy of spatial science (or a spatialized social or natural science) is a function of the "science" and effective research design.

1.5 Organization of the Book

The book is organized in three parts. The first section (Chaps. 2–4) introduces key components of research design and the constituent parts of the research proposal. Section 2 is organized around the types of research proposed, the audience, and the intended output (Chaps. 5–7). In the final section, examples of successful research proposals are presented. Examples of masters and doctoral thesis proposals are provided in the areas of human (including human–environment interactions), physical, and geo-techniques. Overall, the collection of model research and grant proposal should serve as an effective guide for the preparation of proposals with a spatial science emphasis (Table 1.2).

Table 1.2 Organization of the book

Section 1	
Chapter 2	Literature Reviews
Chapter 3	Research Questions
Chapter 4	Data and Methods Issues
Section 2	
Chapter 5	Structure of Thesis and Dissertation Proposals
Chapter 6	Competitive Funding and Contracts
Chapter 7	Disseminating Research
Chapter 8	Conclusion
Section 3	
Chapters 10–11	Masters Thesis Proposals
Chapters 12–14	Doctoral Dissertation Proposals
Chapters 15–18	Grant Proposals

1.6 Closing Thoughts

This book is inherently unconventional. Unlike research monographs or texts, the structure is organized into discrete sections and each—in some ways—is independent of the other. The form and function of each is unique and each serves as an independent "handbook" on various types of proposal writing and the necessary components of research proposals as well as the "how to" information for each of these. Nevertheless, the intent is to provide the reader with an understanding of the scale and scope of spatial science, define the constituent parts of a research proposal, underscore the importance of design, and explore the many forms research output may take from the initial abstract through the peer reviewed article. Finally, the book presents "work samples" of proposals that might prove as useful models or guides for the novice graduate student, junior scholar, or even individuals outside of academe.

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Chapter 2
Literature Reviews

Writing [the literature review] well is a sign of professional maturity; it indicates one's grasp of the field, one's methodological sophistication in critiquing others' research, and the breadth and depth of one's reading.
Krathwohl (1988, p. 4)

As the epigraph suggests, the literature review may be considered a rite of passage (and sometimes a roadblock) in the career of the professional researcher. The literature review is the foundation of any research project and an essential component of any professional research endeavor. A comprehensive review of the literature should be performed at the earliest stage of any research project as it simultaneously grounds a project within a specific historical context, positions the researcher within a given theoretical landscape, establishes the relevance of the proposed study, and is a key determinant of the subsequent research methodology. Yet, performing an effective review and "writing it up" are difficult tasks that require the development and maintenance of specific skill sets over time. In this chapter, the process of writing the literature review will be discussed in general terms, as will the intended audience of the literature review. Finally, the chapter will differentiate the scale, scope, and purpose of the "lit review" insofar as it may be written for various audiences.

2.1 The Process

The literature review process is a deceptively simple one for the novice and established scholar alike. At the most basic level, the literature review requires you to "read" and summarize concepts, methods, or case specific details on a topic. Yet, reading articles or other forms of peer reviewed research on a topic alone is seldom sufficient as it is incumbent upon the researcher to read the "right" works and to demonstrate a substantial understanding of the topic, the discipline, and the associated research methodologies. Further, an effective review draws thematic and substantive connections across the literature, identifies areas of common understanding, disagreement, or uncertainty, and reveals the history of the theoretical developments. As such, the literature review is an exercise in multi-tasking that requires separating the "wheat

J. D. Gatrell et al., *Research Design and Proposal Writing in Spatial Science*,
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from the chaff". In some ways, the emergence of information technologies and vast on-line research libraries has facilitated this process. However, the proliferation of information has also frustrated the process as differentiating authoritative scholarly works and the “grey” or popular literature.

To complete the literature review, the investigator effectively conducts and blends four distinct perspectives to determine the:

1. historical development of the research on the topic across the academy and multiple disciplines (if appropriate);
2. historical development of the research specialization within the discipline;
3. theoretical—not just topical—nature of the research; and
4. range of research methodologies used by researchers interested in the topic.

In addition to the items identified above, the spatial sciences are unique in that the literature review must also clearly establish the centrality of the spatial perspective of the research. For example, research on suburbanization of producer’s services should include discussions of movement and directionality, as well as the manner in which data are represented spatially. Similarly, research exploring the migration of the gypsy moth should position the reader within the study area—as well as its broader spatial context and the conditions of adjacent regions. While this may seem to be an obvious point, it is incumbent upon the review to identify the spatial component, as much of the literature cited outside of the traditional realm of geography seldom articulates the spatiality (or potential spatiality) of a problem. The inclusion of a discussion of spatial relationships in some disciplines may be entirely foreign and require special attention be paid to articulating the spatial component of any research project vis-à-vis the literature review.

While the notion of performing separate reviews may seem daunting, the reality is that the broad reviews outlined above are inter-dependent and in many cases do not require separate reviews per se. However, the literature review process requires a close examination of the literature and a critical analysis that identifies each of the elements above. An effective review requires an investigator to locate information, critically assess the work of others, and provide the researcher with the legitimacy to serve as an authority in that area. In terms of research design, the literature review plays a crucial role as it provides the basis of support for research questions and methods. In contrast, a poorly conducted review, or a poorly written one, will fail to clearly establish the background, purpose, and relevance of the study.

A first step of the review process is to identify the exact objective of the review and to determine the stage of the research. If the project is at its initial stage—that is to say prior to formulating a research question, the primary objective is to gauge the general scale and scope of research in a broad area. The purpose of the general review is to identify key research themes and discussions within an area of specialization (see Fig. 2.1). In contrast, a more focused or specialized review is later developed to demonstrate a project’s specific contribution to the literature and to provide a conceptual framework for a given study. In either case, the first stage of a literature review process is the same.

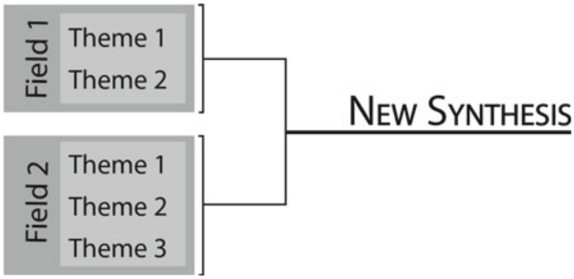

Fig. 2.1 The thematic review

2.2 Finding the Literature

The following discussion concerning how to implement a review makes one key assumption—that the researcher is new to the literature process, or in the case of the more established scholar, unfamiliar with the structure of the spatial literature. For this reason, the discussion begins with the fundamentals of isolating appropriate literature and assessing the validity of sources. As such, this chapter serves as a "how-to" guide to performing and writing a literature review.

The first step of the review process is to identify and locate the "general" body of literature on a subject. But, the first step includes several "phases". When possible, researchers should avoid performing a "cold search" and always seek assistance from colleagues, peers, or advisors as part of an initial informal process (Fig. 2.2). Specifically, colleagues and advisors are key resources and will provide key citations and enable the student researcher to begin the process of sifting through the initial literatures and will limit the number of "blind alleys" or "false leads" that accompany a simple "keyword" search in a library search engine. Yet, all literature reviews do require researchers to seek out new literature and a survey of key journals. The most

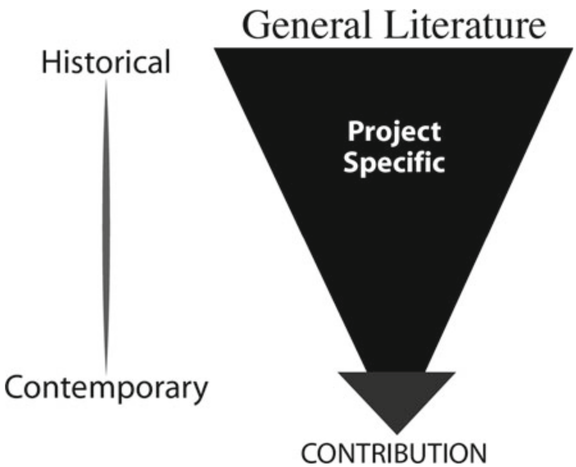

Fig. 2.2 The chronological literature review and narrowing concept

effective way to begin a search is to locate recently published collections of edited works or review articles in scholarly journals, such as *Progress in Human Geography* or *Progress in Physical Geography*. In some cases, more specialized journals such as *Geomorphology* or *Urban Geography* may be more appropriate, if the researcher has a more narrowed topic.

This general review is useful as it will enable you to situate your more specific interests within the scale and scope of current trends found throughout the literature. An additional technique that is useful is to review the table of contents and abstracts of each of the major journals in the discipline for the past several years. This approach further assists you in understanding the research area's overall trajectory and relative position within a discipline. Additionally, table of contents surveys often yield unexpected results and enable researchers to find new little known articles that may be directly related to a project. In some research areas, special issues may be available and these resources prove to be useful. For example, the *Professional Geographer's* 1995 special issue on methodology in feminist geography or the *Great Lakes Geographer's* 2002 issue on women in geography, and more recently *Regional Studies'* 2020 issue on new financial geographies of Asia. In addition to reviews and special collections, resources such as *Current Geographical Publications* (CGP) are a useful resource. The CGP is published by the American Geographical Society and indexes recent research throughout the spatial sciences (not just geography) by topics and regions. In addition to indexing journals, the CGP also indexes selected books and maps. As a rule of thumb, the initial papers reviewed should be as recent as possible. By initially selecting recent works, you will be able to develop a historical road map through the literature that includes the intellectual development of the field, details established and emerging methodologies, and articulates key theoretical debates.

In an effort to remain "current", some graduate students (and professors, too) resort to the internet or constrain their searches to full-text resources available on-line at major research libraries. Unfortunately, a "blind" internet or keyword search in a library catalog is seldom sufficient to locate significant works that often pre-date the emergence of the World Wide Web. Indeed, the internet is an especially dubious tool for the researcher new to the field as the validity and authority of web-based resources is seldom verifiable. Yet, some useful internet resources do exist. For example, the Gender Geography bibliography published by the discussion list for Feminism in Geography (https://www.emporia.edu/socsci/fembib/) is an excellent example of a peer moderated bibliography. However, the internet alone does not suffice and the resources located on-line should be carefully and critically assessed. That is to say, the overall validity of materials posted on-line may appear to be scholarly—but in some cases they are not. In particular, the on-line availability of published reports, working papers, and similar non-refereed materials is especially problematic and should be scrutinized (Table 2.1).

After reviewing 3 or 4 edited collections, several reviews, and recent articles, the reviewer should begin to identify recurring citations, or key publications, that unite the various works. A thorough review and comparison of the bibliographies in even a few chapters of an edited collection should yield several important works by key researchers that can be used to trace the historical development of a field. In the end,

Table 2.1 Research resources

Informal	Formal-traditional	Emerging
1. Peers	1. Review Articles	1. Internet Bibliographies
2. Advisors	2. Research Articles	2. On-Line Papers and Reports
3. ListServs	3. Indexing Services or Publications	3. On-Line Journals
4. Librarians	4. Special Issues of Journals	
	5. Edited Collections	
	6. Monographs	
	7. Theses/Dissertations	

though, it is incumbent upon the individual researcher to determine whether or not the literature review's scale and scope were appropriate. However, it should be noted that no researcher can read everything. The objective is to be grounded in the major works and to present a general survey of the scale and scope of a body of work.

Beyond locating the literature, the novice researcher will need to become aware of the complete collection of resources available in a research library. As research libraries at universities are often only one component of a larger campus collection of libraries, a visit with a reference librarian is always useful. In the case of large library systems with a myriad of special collections or dedicated locations (such as a science library), reference librarians are excellent sources for locating little known resources. Additionally, librarians will be able to assist in the preparation of catalog queries, if necessary.

2.3 Conceptual and Methodological Reviews

Traditionally, literature reviews are a single component of a larger project and serve to position the project within its appropriate body of literature. In order to properly frame a research proposal or article, two separate, but inter-related, reviews of the literature are performed.

The review of conceptual or theoretical literature in a subject area is often the initial component of the review. The conceptual framework clearly defines the author's philosophy of science and explicitly links the research to a well-defined and specialized niche within a wider body of scholarship. In the case of the social sciences, the construction of a conceptual framework is a crucial step in the research process. While the natural sciences do not necessarily share the same philosophical diversity as the social sciences, the conceptual review is important to natural sciences too as it establishes the key assumptions the preceding research used. In both the social and natural sciences, the conceptual review presents a collection of works and uses these works to validate the research perspective.

In addition to providing a conceptual framework, the review is also used to clearly articulate the research's importance and to provide a rationale for the research question. For this reason, researchers must analyze earlier research papers, critique their accomplishments, and sometimes note their deficiencies. The success of a research proposal or the publication of a journal article often rests on the strength of the assessment, synthesis, and effectiveness of the prose in the initial review of the conceptual materials.

The second component of the literature review is highly dependent upon the philosophical perspective forwarded in the conceptual review. That is, the data and methods used in the study or proposed study are closely associated with the paradigm adopted in the earlier stage of the review. To that end, the methodological review examines the research design of previous studies, outlines the methods to be used, and, if appropriate, presents a review of parameters used in previous studies. Additionally, methodological review also should include a list of acknowledged limitations or potential shortcomings associated with a specific quantitative or qualitative approach. When discussing limitations, the reviewer should also acknowledge relevant points of methodological disagreement that have been identified by previous researchers. The intent of the section is to explicitly detail the proposed research design including variable selection, methods of data collection, and analysis. The review of methods should be detailed enough to assure the reader that the results can be independently reproduced.

In terms of the required elements of the methodological review and the ensuing discussion that directly follows, the following items should be present:

a. Secondary data sources.
b. Primary data collection procedures.
c. Variable definitions.
d. Method of data analysis and related data manipulations.
e. Detailed assumptions drawn from the conceptual literature.
f. Data and methods limitations.
g. Instrumentation and software descriptions.

2.4 The Write Up

The "write up" of the literature is the most challenging component of the process. In the case of students, the literature review is often a painful and tedious process of summarizing and categorizing previous theory, studies, and findings. However, the write up is much more than a summary or an elaborated annotated bibliography. Instead, literature reviews serve as the author's opportunity to build a compelling case that their research is important, scholarly, and rooted within a specific identifiable community of scholarship.

The emphasis of any literature review is to articulate the primary rationale for and significance of a research endeavor. The written review must demonstrate the author's ability to synthesize the varied works of scholars in a range of related fields and to marshal the authority of previous works to justify the new project. However, the written review is unique because it must provide a compelling argument for a specific research project and demonstrate the author's expertise in the subject. To do this, a well written narrative must be innovative and demonstrate the author's ability to construct creative and effective scholarly analogies. In the case of the interdisciplinary work of spatial science, researchers are often faced with the challenge of integrating perspectives or methods from other disciplines and it is the ability of the write-up to construct a seamless—often new—conceptual and methodological discussion.

The style and tone of the write-up is the most important component of the entire process provided the reviewer's performed an effective search of the literature. To accomplish this task, the writer must approach the write-up as a discursive—not informational process. While the writer does convey information, the intent is to persuade the reader that based on the researcher's exhaustive search of the literature and understanding of the field the study to follow is valid. To that end, the question of style and tone are important.

In terms of style, the emphasis should be on the prose and content—not the individual papers and authors cited. Well-written reviews are effective essays that meld together the conceptual and methodological in an unobtrusive manner. The reader seldom recognizes the individual components as it is the narrative that drives argument. The key is to present the concepts and methods not as individual items—but integrated components organized around major themes or conflicts (often presented as a chronology) identified during the review process. The themes or chronology should coalesce around shared perspectives or methodologies and provide the reader with a general understanding of "what is" and "what is not" known based on the current state of the literature. In contrast, a poorly written literature review is laborious to read and is often presented as a stilted summary of individual research papers often within the context of a simple chronology.

In the following paragraphs, an excerpt from a literature review is examined. The first paragraph is taken from an article by Bradbury et al. (2003) and is an example of a well-written synthesis of technical literature. The review is general in its use of language and provides an overview of the research on the genesis of regional storm tracks associated with Northeastern cyclones. Additionally, Bradbury et al. clearly establish the spatial relationships and positions the reader within a specific geographic context. As a result, the paragraph is an effective work.

In contrast, the second paragraph is a slightly re-written version of the paragraph that is less effective and stylistically more cumbersome. Nonetheless, the second paragraph contains similar information and the same references. In the second example, the language concerning movement and exact geography have been slightly altered. The result is a less effective position of the reader within the exact study area and its broader spatial context—and as a result a less effective review of the literature. Overall, the first paragraph is stylistically preferred.

From Bradbury et al. (2003, p. 545).

> Winter cyclones traversing NE [northeast US] originate in a wide range of locations around the North American continent (Ludlum 1976). Important regions of cyclogenesis include a long band in the lee of the Rocky Mountains, extending almost continuously from the Northwest Territories to northern Texas (Zishka and Smith 1980). Two other active cyclogenesis areas include the Gulf of Mexico and the East Coast, particularly near Cape Hatteras, North Carolina (Zishka and Smith 1980; Whittaker and Horn 1981, 1984). In general, winter cyclones that reach NE either traverse the Great Lakes and the St. Lawrence River Valley or follow the Atlantic seaboard northward (Whittaker and Horn 1984). Regional storms typically avoid the Appalachian Mountains, although low-pressure centers that do track over this high terrain frequently deepen (Colucci 1976). Atlantic cyclones generally either travel parallel to the coastline toward NE or diverge from the coast and follow the northern boundary of the Gulf Stream eastward (Colucci 1976). The convergence of the St. Lawrence and coastal storm tracks in the vicinity of NE has long been thought to contribute to the complexity of this region's climate (Ludlum 1976).

The paragraph below has been re-written and is based on Bradbury et al. (2003, p. 545). The intent of the re-write is to demonstrate the importance of "style" in the preparation of an effective and interesting literature review.

> In 1976, Ludlum states that winter cyclones traversing NE originate in a wide range of locations around North America. However, Zishka and Smith (1980) emphasize that important regions of cyclogenesis include a long band in the lee of the Rocky Mountains. In addition to the Rockies, Whittaker and Horn (1981, 1984) identify two other active cyclogenesis areas including the Gulf of Mexico and the East Coast. Whittaker and Horn's findings are also echoed in the earlier Zishka and Smith (1980) and indicate that winter cyclones that reach NE either traverse the Great Lakes and the St. Lawrence River Valley or alternately follow the Atlantic seaboard. These findings indicate that regional storms, as Colucci (1976) notes, typically avoid the Appalachian Mountains. Colucci (1976) found that Atlantic cyclones generally either travel parallel to the coastline toward NE or diverge from the coast and follow the northern boundary of the Gulf Stream eastward. For these reasons, Ludlum (1976) correctly identifies that the convergence of the St. Lawrence and coastal storm tracks in the vicinity of NE have long been thought to contribute to the complexity of this region's climate.

2.5 Narrowing

Beyond style, the write-up also should move from broad themes to more specific themes and deliberately narrow its scope (see Fig. 2.2). The ideal literature review places research within a broad literature and then proceeds to narrow its focus. The closing paragraphs or sentences should be directly related to the current project's research. In the case of Bradbury, Keim, and Wake, the paragraph begins with a broad discussion of cyclones and cyclogenesis. The paragraph ends with a very specific emphasis on storm tracks and positions the reader for subsequent paragraphs in the review that focus on the inter-connection between storm tracks, seasonal precipitation, and teleconnection. Bradbury, Keim and Wake organize their literature around these broad themes and then rapidly conclude with their project's contribution followed by research methodology. As these closing sentences below indicate, a clear gap in the literature exists and the proposed research is intended to fill it.

> Thompson and Wallace (2001) observed an increase in the frequency of "nor'easters" during low NAM index (negative NAO) conditions. Still, few studies have explicitly examined how large-scale changes in cyclone frequency or storm-track distribution relate to variability in surface climate, particularly in the northeastern United States. As a result, the underlying mechanisms for major past changes in NE regional hydroclimate remain poorly understood." (p. 546).

In addition to conceptual and topically narrowing it's focus, the Bradbury et al. example also employs a chronological technique that presents research from "older" to "newer". This technique is especially effective and demonstrates the development of a field and positions a contribution on (or near) the "cutting edge".

2.6 Differentiating the Purpose of the Literature Review

Conceptually, literature reviews perform the same task in a variety of venues. However, the scale and scope of the review and its specific purpose varies slightly from case to case. In the following section, the roles of the literature review in a master's thesis, doctoral dissertation, research article, and review article are considered independently.

2.7 MA/MS Thesis

The master thesis is a student's opportunity to demonstrate that she or he has the capacity to do academic research. In this respect, the purpose of the literature is considerably more limited at the master's level. Generally, the MA/MS thesis and the associated literature review demonstrate that a student is able to review and understand the existing literature and has the capacity to replicate previous research. That is, masters students are not expected to 're-invent' the wheel (although it sometimes feels like it). Rather, the purpose is to identify established research methodologies and to apply these methods to a research question of their choice. In this sense, the objective of the master's thesis is to demonstrate a capacity to complete a scholarly review and write up the finding of the research.

Because of the limited scale and scope of the thesis, the literature review tends to emphasize research methodology over concepts and theory. However, it is important to recognize that the research question will necessarily extend from the concepts and theories reviewed in the literature. In most cases, the theory section of an MA thesis is limited to a single discussion of a key concept and the presentation of an associated model, such as central place theory or diffusion. However, the emphasis should be on identifying and implementing a solid research methodology which includes data collection, analysis, and a discussion of the findings. Given the MA thesis' emphasis on methods, the primary contribution of the thesis is replicability. That is, MA theses should replicate previous research and demonstrate an individual's skill as a researcher.

2.8 Doctoral Dissertation

In contrast to the MA thesis, the doctoral dissertation is decidedly more complex and exacting. The scale and scope of the theory and conceptual sections is greater and the emphasis is on defining the research's specific contribution to the literature—sometimes referred to as the "gap in the literature". More importantly, it is the objective of the literature to demonstrate the researcher's thorough examination of the literature and the existence of the "gap" in the literature. In essence, the doctoral research is responsible for creating new knowledge—not merely replicating previous research. The success or failure of a dissertation project is closely tied to the researcher's ability to persuade the readers (i.e., the committee) that the student has either created a new theoretical synthesis of the literature and/or developed (or borrowed) an innovative methodological approach towards a traditional research question. Both outcomes require a thorough survey of the historical development of the entire sub-field (not just one or two theories) and an understanding of a variety of methodological approaches across both quantitative and qualitative fields. In short, the doctoral dissertation's literature review should be comprehensive and demonstrate the research's linkage to the historical and contemporary knowledge base.

Defining a project's contribution is often a daunting task, yet the reality is that a well-crafted literature review can use creative analogies from allied disciplines to greatly assist the researcher. Unlike the novice MA student, it is incumbent upon the doctoral candidate to search out relative literatures in other disciplines than theirs and to identify any and all research methods applicable to the student's area. For this reason, the specific selection of literature included in the final write up, its presentation, and style are crucial.

When a student's review of the literature has been extensive and well written, the gap in the literature should be self-evident. In some cases, the gap extends from a topic being under-researched in a discipline and very basic questions need to be answered. Alternately, a gap could be created through the synthesis of new ideas into an existing literature. In the 1960s and 1970s, Marxist analysis was used by urban and economic researchers to re-examine a variety of well-researched topics such as place hierarchy. Alternately, new methodologies from other areas can be used as a device for defining a research project's contribution. For example, the introduction of the dendrochronology toolkit in the 1980s enabled physical geographers to reconsider previous research in biogeography and paleo-climatology. In either case, an outside reader should be able to succinctly summarize the dissertation's primary contribution and methods within a few short sentences.

Finally, the comprehensive literature review of the dissertation is unique in that it should represent a new synthesis of the literature and should make three major contributions. First, the literature should present a new synthesis of theory and concepts and present an alternate or nuanced perspective on an established field of research. Second, the project's methodological tool kit should demonstrate the researcher's ability to creatively and authoritatively integrate data collection methods and analytical techniques. Finally, the research must by virtue of the identified gap in the literature make a topical contribution that makes it distinct from previous work (i.e., a previously un-studied or under-studied region, species, or process). For example, the growth of urban studies in the 1960s and 1970s was a direct response to the over-examination of rural landscapes. More recently, the emergence of research on suburbanization, edge cities, and exurbs indicates the growing importance of these types of regions and the historical emphasis on the central business districts of cities.

In any event, the literature review should be clear and convincing. More importantly though, the contribution should be clearly stated. Below is an example of an explicit statement concerning an identified gap in the literature from a dissertation abstract:

> It is hoped that these [trend surface] findings can help close a major gap in the literature of economic geography, shed new light on evidence collected at other scales of Thünian Analysis, and lead to additional investigations at the continental scale in other advanced economies. (Muller 1971)

As the example demonstrates, Muller explicitly makes topical (agriculture), conceptual (re-scaling Von Thünen's location theory), and methodological (trend surface analysis) contributions vis-à-vis a macro-scale investigation of American agriculture. Ideally, the reader should readily glean the exact contribution identified in the abstract by the author. That is, the reader should—based on the literature review—come to the same conclusion that the author does concerning the contribution.

2.9 Research Articles

Like the dissertation, articles must establish that the research study makes a substantial contribution to the literature. These literature reviews are often brief because the writing style must be economical. The goal is to effectively and efficiently position the paper and the research (which are not necessarily mutually exclusive) within the context of the recent literature. For this reason, the historical development of literature is seldom reviewed. Yet, some articles—particularly research that suggests the existence of contradictory evidence—should include a more developed discussion of the historical development of a field (beyond the past 10–15 years). In short, research articles require the strategic selection of representative works—not an enumeration of everything written or read. In very basic terms, the article's contribution to the literature—based on the strength of the literature—should demonstrate a conceptual, topical, and/or methodological gap and articulate how the paper fills the "gap in the literature." While making a contribution to literature is a daunting task, articles often focus on making single small contributions in either methods, concepts, or topic—but not more than one area. These strategic contributions are sometimes referred to as the "least publishable unit" or LPU.[1] Yet, some ambitious papers published in premier journals regularly seek contributions in multiple areas.

For the purposes of illustration, literature reviews in articles are often very short—particularly in the sciences. As the example from the journal *Ecology & Society* demonstrates, literature reviews in articles are sometimes expected to rapidly serve as a justification for the study and to outline the major issue. In the excerpt from Suvanto et al. (2004) provided below, the rationale for their study of fire and landuse in Sumatra is efficiently presented in the first paragraph and the remaining contextual review is case specific—not conceptual:

> Fire has commonly been used to prepare land for timber and oil palm plantations, transmigration sites and shifting cultivation because it is cheap and effective (Tomich et al. 1998b). In 1997–1998, 80% of the smoke and haze problem experienced by Indonesia and its neighbors was caused by burning forests to prepare land for, in particular, plantation development on peat soils (Applegate et al. 2001). (p. 1)

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Additionally, the example of Suvanto et al. (2004) is especially useful as it demonstrates the importance of the efficient and economic exposition of relevant literature. In fact, the paper cites only 13 scientific papers or agency reports.

2.10 Review Articles

Review articles or "progress reports" are a special type of literature review. The goal of the review article is to construct a broad framework that captures the conceptual and topical essence of an entire research area. Additionally, the review article enables the writer to create his or her own synthesis of the literature and has the capacity to alter the trajectory of literature. Normally, review articles are published in journals dedicated to "progress reports"—like *Progress in Human Geography* or *Progress in Physical Geography*. In addition to these journals, some journals, such the *Social Science Journal*, have dedicated review or note sections that serve as a potential outlet for literature reviews. In the case of *SSJ*, review essays are used as a means of introducing researchers in one area to the recent and relevant developments in other disciplines. In either context, the review article should represent a novel synthesis of new or existing literature.

[1]The LPU is a somewhat controversial approach towards scholarly research (see Owen 2004). Our reference to the concept of the LPU is only to compare and contrast it to the other strategies of scholarly publication.

One example of an innovative and timely review article is Colin Flint's (2003) Progress Report entitled "Political Geography II". In this review, Flint seeks to position post-9/11 political geographies around five key themes: terrorism, modernity, the state, geopolitics, representation, and narrative. The review "un-packs" and "packages" the very recent contributions into five discrete literatures and seeks to frame subsequent research within the proposed structure. Whether or not Flint is successful remains to be seen, yet the Progress Report clearly articulates a new vision of political geography and the article has the potential to shape future research. As stated earlier, a serious literature review is not only challenging to do well, but also takes considerable time to complete because the review is both a process and a product. In this context, a more recent literature review by Steiger et al. (2015) titled "An Advanced Systematic Literature Review on Spatiotemporal Analyses of Twitter Data" is a very good example of a literature review done coherently and sensibly. The authors cast a wide net and do a good job organizing the review systematically. Even as the authors deal with the current state of spatiotemporal research of twitter data which is significant given volunteered geographic information or crowdsourcing space–time data provides a unique perspective on location-based social networks. This review article is a good example of how to be comprehensive yet concise, coherent, cumulative and critical. The authors conduct a systematic literature review beginning with a discussion of 'volunteered geographic information, social media and location-based social network' in general terms, and progresses through 'review method' and a discussion of the results, displaying how past literature reviews have contributed and led to partial answers, as well as how new questions are relevant. This review article is a classic example of how to write literature review persuasively and succinctly based upon a wealth of published material that is relevant to the topic which is not only interdisciplinary but also relatively new research. Undoubtedly, this review article has emerged as an influential work given its high number of citations. For this reason, review articles are an important—if sometimes unrecognized—resource for researchers.

2.11 Conclusion

The purpose of this chapter was to provide an overview of the literature review process and to discuss its core components. Additionally, this chapter outlined key differences between the types of literature reviews performed for specific purposes and venues. While this chapter was not intended to be an exhaustive account of the literature review, it provides a foundation for researchers interested in doing spatial science research.

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Chapter 3
Research Questions

Spatial science research describes and explains the distribution of human and physical phenomena over the earth's surface. Such research problems exist and may be analyzed across a vast spectrum of traditional scientific disciplines. By focusing on spatial variation as a key element of discovery, spatial science seeks to uncover relationships between human and physical parameters that are not typically addressed in traditional social and natural science disciplines. Unlike many other forms of scientific analysis, spatial science does not operate solely within a single, closed theoretical framework (such as mechanical physics), but may mesh the methods of disparate source disciplines. What spatial science shares with all other forms of scientific analysis, however, is the need to pose clear, answerable questions within a research framework that is coherent and logical. Collectively, this process is known as research design. In this chapter, the core task of articulating the research question is considered.

3.1 Importance of Research Questions

Establishment of clear research objectives, framed as questions or hypotheses, is arguably the first and most critical step in the design and execution of spatial science research. The research question is the essential element of inquiry; it distills one piece of the investigator's broader curiosity into a coherent, potentially "answerable" thought. In fact, one has only to walk into many faculty offices where 'What is the research question?' is an early and core piece of inquiry during conversations with both graduate students and faculty colleagues. This framing helps both faculty and students return rambling research conversations back to the research question.

The research question emerges naturally (although often requiring considerable deliberation) from the framework of thought about a topic marshaled in the form of a literature review. Our most basic unknowns are treated first with questions; the research questions of scientific analysis reduce such large questions to specific,

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actionable strands. Alternatively, hypotheses posit particular solutions to research questions, solutions that may be then directly tested. Hypotheses thus represent a further reduction of the research question and its conversion to a form that suggests necessary data and analytical technique. By articulating research objectives as questions or hypotheses, the scientist recognizes that the research project has direction and purpose.

Once determined, research questions guide and simplify the subsequent research process in several ways. First, well-stated questions often plainly suggest the structure for the process and narrative of the related literature review and methods aspects of the study. By focusing on a very narrow question or set of questions, the researcher is better able to avoid a haphazard approach to assembling and surveying literature related to the topic. Literature reviews are often and notoriously challenging for first-time researchers. Although research questions are only possible after some familiarity with the subject has been achieved, reading and documentation after the questions have been posed is typically more effective and expeditious. Similarly, the act of posing a very specific question improves and hastens the elimination of data types and methods that may be appropriate in the general field but are ineffective in the area chosen by the scientist (Fig. 3.1).

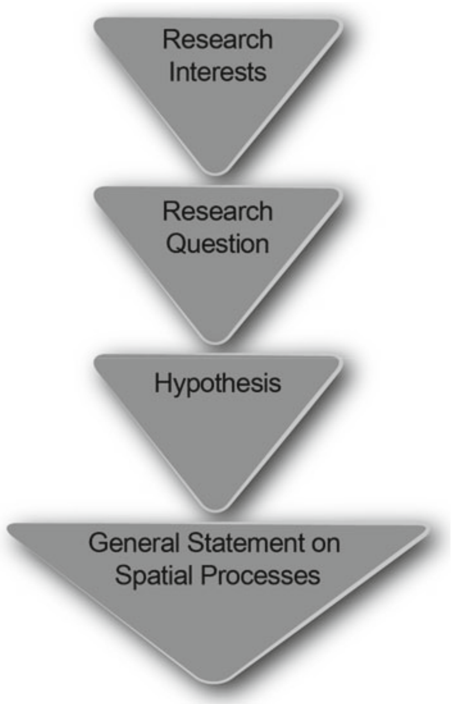

Fig. 3.1 Research questions

Second, well-designed research questions provide an explicit contract of study for student researchers in relation to their committees, or for grant/contract awardees with their funding agencies, etc. This contract provides the boundaries for the scope of the project and analysis to follow. For students, such a contract is particularly important, because it deters disorganized exploration during the writing of a thesis or dissertation. Such exploration is, of course, essential to good spatial science, but is not always compatible with timely completion of a degree program and should thus be confined to the pre-proposal phase. Research questions that are accepted as a part of a successfully defended proposal also protect students from overzealous committee members who might continue to expand the project through one more statistical test, one more data source, or one more field season.

Third, by specifying a contract of analysis, well-stated research questions provide an excellent indicator of what constitutes success or failure in the study—the extent to which the question is answered. Multiple research questions or hypotheses around a common theme can then define a significant portion of the "discussion/results" and "conclusions" sections. These pieces of the paper or presentation must, at the very least, return to the initial objectives as the guiding themes of the study and then provide some accounting of whether or not questions were answered conclusively.

In summary, research questions or hypotheses are essential to all good spatial science, but particularly for developing student scientists. They focus inquiry, refine the search for literature, suggest appropriate data and methods and provide an overarching structure for the narrative of the analysis (written or delivered orally).

3.2 Identifying Research Questions

Carefully crafted research questions or hypotheses drive the scientific process, from literature search, through selection of methods, and ultimately to the presentation of findings. However, the process of identifying, narrowing the scope, and articulating these questions can often pose the greatest challenge of developmental research, particularly for inexperienced scientists.

The classical scientific method, presented as the template for conducting research in science classes since elementary school, is seldom a precise portrayal of how research unfolds in professional settings. Indeed, most of the trappings of the scientific approach, objectivity, and purity of experimental design (Popper 1968) and progression from hypothesis to theory (Braithwaite 1953), etc. have been exhaustively reviewed and to an extent disassembled by authors such as Kuhn (1962) and, more recently, Gieryn (1994). Within spatial science, notably geography, the onset of postmodernist philosophy and epistemology have examined the very extent to which a scientific process can be adapted or effective (Bhaskar 1977; Moss 1979; Bernstein 1983; Demeritt 1996; Rorty 1991; Sismondo 1996). Such a discussion is clearly beyond the realm of this text—however suffice it to say a great diversity of frameworks for knowing the world around us now exists. In spite of the cacophony of epistemological voices, the basic process of articulating a research question remains the same irrespective of the postmodern turn. For our purposes, we will extract the basic structure of a research study and use that as the foundation for the formation of research questions.

The traditional scientific approach holds that observation leads to a hypothesis, which is then tested via data collection and experimentation and ultimately refined into theoretical explanation.[1] The essence of this process, regardless of its final sequence, remains intact through most kinds of research and consists generically of inquiry, test, and observation/assessment. The process may be linear, as that described in the first sentence of this paragraph, but is more often circular and iterative, with the observation of test results generating new or improved hypotheses, which suggest better experimental design, and so on. The path of the research process seldom follows lines (straight or circular). Rather, it frequently forks through multiple and perhaps conflicting strands of data or results, myriad experimental or data-gathering possibilities, and facets of a research topic that are interwoven at key points, but independent in other domains. These branches are simultaneously the source of intrigue and joy in science (the complexity and connectedness of things, particularly in a spatial context) but also a major source of confusion and pitfalls.

Research questions are the guideposts through this complexity, but, ironically, one must first sample and navigate the complexity before posing research questions. This is the initial dilemma facing first-time researchers (frequently true of those writing a master's thesis). A frequent complaint of young researchers is that "there seem to be no good research questions in my discipline that remain unanswered" or "all the good research questions have been taken." Interestingly, this sentiment is the exact opposite of that uttered by many harried research faculty, namely that "there are far too many research questions to ever be effectively investigated in the available time". The primary difference between the junior and senior researcher's perspective is the latter's on-the-job-training with respect to research design and the formulation of research questions.

No one can pose a research question without serious exposure to the discipline and topic of interest. The first order of business is always reading, and reading of prodigious amounts of material. This is particularly true for graduate students in their first academic year of program; they should be required and challenged to read the body of work in their field of future expertise. This reading experience has several functions. At the most basic level, it is intended to outline the fundamental principles at work in the discipline, the ground rules, theory, language, and core relationships. Rudimentary knowledge of this sort can be obtained in a lecture classroom, but any scientist quickly finds that specialization is developed by following the evolution of a field of thought as expressed by its proponents or practitioners. Reading therefore

[1]While this chapter focuses on hypothesis testing and related research design issues, the basic trajectory of research performed by humanists, structuralists, poststructuralists, and postmodernist requires the same clear, concise, and efficient articulation of research questions, objectives, and the exposition of data and methods. Functionally, the substantive difference between the scientific approach and other epistemologies is the scientific imperative to test hypotheses. As such, post-modernists and others can define and "answer" (or at-least marshal convincing evidence associated with) a research question.

reveals the theoretical landscape of a field, its most prevalent or accepted ideas, critiques of those ideas, unknown areas, and areas of dissent or uncertainty.

In the course of examining a discipline's theoretical structure and arguments, the reader will also happen upon key methodological approaches and techniques of investigation, including assessment of their appropriate domain and limitations. It is from these dialogues, between authors and their community of scientists, that the general themes of inquiry may arise. Frequently, authors will explicitly describe the areas of disconnect between theoretical ideas, voids in the literature related to a lack of analysis in a given region or given timeframe, etc. More often, the reader must glean and piece together the implicit holes in a field of knowledge, an exercise that requires time and serious exposure to literature (and guidance from a more experienced mentor).

Coupled to the immersion into the literature of discipline, direct observation of phenomena and data in a discipline is also critical for establishing a scientific curiosity that will lead to research. For young researchers, this opportunity is often afforded through a research assistantship, field course, or other experience structured by a faculty mentor. Again, a broad exposure to literature is essential to widen the theoretical perspective and position observations into context. For more experienced researchers, at the forefront of a discipline's specialization and well in command of its theoretical underpinnings, observation may become the central driver of inquiry.

A research question then emerges from a general line of questioning and is tightened until it becomes an answerable strand. In spatial science, the initial observation is usually based upon an interesting or peculiar spatial distribution of a mapped variable. The investigator's initial questions may be as simple as "what is the exact nature of this distribution?" or "Does/how does this distribution change over time, or from region to region", and, ultimately, "What drives this distribution?" If the data under consideration are primarily physical, an explanation for the spatial distribution of the dependent variable may be devised from related physical measurements and parameters, and then tested through mathematical experiment or detailed observation. If the data relate to human systems, socio-economic for example, independent variables that are logically related to the dependent variable (as shown by existing analysis) may be examined statistically. Strong statistical correlation between independent and dependent variables in a distribution increases the likelihood that suggested causal mechanisms exist.

Consider the following example: A review of literature raises the possibility that 15 independent variables are related to the dependent variable of the distribution, and to one another. Additional statistical refinement reduces the key independent variables to 4. The inquiry might then begin to focus on which independent variables were actually related to the dependent variable and its distribution (or how strongly). The final research question, as posed in the thesis, dissertation or article, might be articulated as "To what extent is Independent Variable A spatially related to Dependent Variable X and its distribution?" Related research questions might deal with the relationship of the independent variables to one another, and so on. The final research questions can now be answered simply with description and statistical treatment. Their solutions do not answer the original question completely (what drives the observed distribution?), but they begin to cast light on the problem.

By stating the final research questions as hypotheses, even more definitive answers result. Hypotheses may be null (no significant relationship exists between the factors investigated), research (a relationship exists between factors investigated) or directional (a particular type of relationship exists between factors investigated). For example, a hypothesis is posed: "Independent Variable A is positively correlated to Dependent Variable X in a spatial pattern." Testing this directional hypothesis may yield a different result from: "Independent Variable A is correlated to Variable X", a non-directional research hypothesis, or "Independent Variable A is unrelated to Variable X", a null hypothesis. Additional hypotheses may address the relationships between the other variables. The hypothesis affords the researcher the possibility of a yes/no answer, but does not necessarily suggest the next avenue of analysis. Typically when reporting on a project through either written or verbal form, only the alternative hypothesis is presented as the null hypothesis is implied.

3.3 Qualities of an Effective Research Question and Hypothesis

To be effective, a research question or hypothesis should satisfy several criteria. First, the question must be answerable (yes, no or maybe) as posed and within the constraints of available data. That is, a question/hypothesis that might be refuted, but for which no data can be collected (Haring et al. 1992 use the example of characterizing the lost continent of Atlantis), is interesting, but insignificant.

Second, the question must define the extent to which it operates within (and is consistent with) an existing theoretical paradigm. For example, if a research question relies heavily upon well-established tenets of thermodynamics (to which a tremendous body of evidence provides unrefuted support), the researcher may not ignore or violate thermodynamics in its formulation or solution. If a research question rejects the laws of thermodynamics, the scientist must be prepared to present an alternative paradigm that accommodates the considerable evidence for these laws.

Third, the questions must permit and demonstrate an *objective* analysis of the findings, by the scientist conducting the study and by those who follow and then scrutinize the results when they have been formally disseminated. It has been made abundantly clear by those who have investigated the philosophy of the scientific method that true objectivity in a systemic, human enterprise is not possible (Rorty 1991; Sismondo 1996). Indeed, the infringement upon process by individual and systemic bias may contaminate the pure factual discovery that science is devised to uncover. Nonetheless, as biased as the framing of questions and answers may be, it remains possible, through the clarity of a research question, to selectively gather information in a way that is testable and duplicable. Thus, by clear statement of a research question, its provenance, and the procedure used to answer it, the scientist may avoid, or at least make transparent, individual bias.

Fourth, a research question must honestly convey all assumptions made in the analysis. Such assumptions might include reliance on the parameters of an existing, recognized paradigm and the knowing reduction of causal factors included in the research design to those that might be easily examined and tested within the constraints of time or resources (with the assumption that other factors, excluded, are negligible or unrelated).

When assumptions are made, limitations in the scope or applicability of potential results naturally arise. As research questions are posed (and long before results are gathered and examined), the analyst must consider the sum of consequences of introducing and accepting various limitations. Often, if limitations are severe, the explanation of consequences should occur in the introduction of the paper, even as an explicit section. Where limitations are accepted in the interests of time (e.g., period of record or number of variables reduced in order to generate a manageable data set for a 2-year thesis program) or resources (fewer samples taken to reduce costs), the impact on the contribution of the study must be recognized. For all studies, but particularly those attached to completion of a graduate degree, limitations are necessary, expected and part of the inherent imperfection of the scientific process. Recognizing and managing the effects of limitation is key to the design of research and the questions that drive it.

Related to the resolution of the problems of assumption and limitation are the decisions regarding the number of research questions and/or alternative hypotheses. The scientist, within the bounds of resources and time, explores the various possible explanations or mechanisms related to the topic under investigation. Although the generation of alternative questions or hypotheses does not entirely remove the possibility or appearance of bias in research, it is characteristic of an honest and open approach, one that approaches fact by examining and eliminating as many false avenues as possible. Each member of the research question set must, therefore, be verifiable and preferably, falsifiable. By defining the study so that the questions may be answered in the negative or hypotheses may be refuted, the researcher ensures that the study will yield some sort of definitive contribution, even if it is unexpected.

It should also be noted that research is not conducted in a vacuum of pure curiosity. If the resources required to collect data to answer a question are prohibitively large, or the time required to conduct the analysis too great, the research question may not be viable. This assessment is particularly important for graduate students, who are usually tightly constrained in terms of both money and time.

3.4 Types of Research Questions

Research questions may be as varied as the complexity of the phenomena to be investigated and depend to some extent on the amount of information known a priori. Basic research questions may be dedicated to fleshing out the simple description of phenomena. Descriptive questions may deal with developing ideas about the central tendency and variability of behavior of the subject, determination of the extent and patterns of spatial distribution, and classification of behavior. Such questions, related to the distribution of weather in the eastern United States, might proceed as follows:

What are the seasonal trends of temperature and precipitation in this region? What are the statistical extremes? How do these weather characteristics vary, and how do they vary across space? How have they varied through time? When the large patterns of behavior are observed, are any modalities, tied to position, observed? What is the level of modality and spatial dependence observed (are their variable or spatial clusters evident)? Does this spatially-dependent modality change through time?

Note that in the above sequence, no attempt is made to inquire into the relationship between weather variables, or to explain underlying causes of behavior or distribution. The emphasis is on description: identifying behavior and patterns, and quantifying the coherence of patterns. The challenge to the researcher here is to determine which specific variables to use to describe the subject and how precisely to define the bounds of the region to be analyzed. Why the selected variables and region are more appropriate than others and must be defined to avoid the challenge that the data are arbitrarily chosen or biased.

Above the questions of description and characterization, a higher level of inquiry poses questions that probe the nature of the inter-variable relationships and the underlying rules that govern the phenomena. These questions rest on the answers to the previous set (whether supplied by the literature or the investigator) and proceed as follows:

How are moisture and available energy related in the observed distributions? What aspects of spatial variation are linked to meteorology, and to what extent (e.g., topography, moisture sources, air mass provenance, circulation systems and regimes, vegetation types, human activity, etc.)? Based on the observed statistical tendency, how does physics describe the interaction between variables? Are the relationships observed in this setting transferable to a larger set of variables and environments and indicative of generalized behavior (induction)? Can the observed relationships be used to predict behaviors not observed (deduction)?

Once causation is suggested by strong mathematical relationships, then supported by a theoretical/physical framework, a more complete picture of the entire system may be established. That is, if variable relationships and distributions may be understood and duplicated within a consistent physical framework, then basic modeling of the system is possible. Research questions are then directed beyond bivariate and regressive statistics of variable sets and toward accurate simulation of the entire system. Modeling enables variables to be tested against one another in a controlled setting and variations within the system to be simulated. Research questions concerned with models deal with the accuracy of the simulation, its complexity and sensitivity and its applicability beyond the datasets from which it was derived. On the other hand, if an accepted theoretical framework for relation of variables does not exist (such as physical laws), the strength of the mathematical linkages between variables defines the extent of the model.

As can be seen, several levels of complexity are possible in the inquiry that research questions dictate. A frequent concern faced by graduate student researchers is how deeply to query their topic, and how much they should accomplish with a single research thesis or dissertation.

In general, and as mentioned in previous chapters, a student project should only attempt to resolve a particular strand of research and not hope to achieve broad synthesis across a discipline. In particular, a master's thesis is often limited to broadening an established study or method, with the expansion of scope occurring in application of methods to a new domain (in spatial science that domain is often a physical region) or by testing a new method within an existing domain. The emphasis is not pure duplication of a previous study, but rather an extension of existing work. The thesis generates new knowledge, but is generally not required to expand a theory or provoke a new paradigm.

Dissertations, on the other hand, while still the first major formal work conducted by a beginning scientist, are intended to make a more definitive mark upon a field. A dissertation should pose research questions that address a major gap in understanding, or put theoretical ideas to a test. To discern the key unknowns in a discipline, doctoral students must exhaustively review the literature and receive strong guidance from their program chair.

Just as spatial research questions are posed at a variety of levels of sophistication, the ultimate goals of the questions and the research projects they guide are also quite variable. While intellectual curiosity has always been, and remains, a key stimulus of scientific inquiry, researchers are encouraged to examine their motivations and the larger potential contribution their work will make to the discipline and other disciplines. Is the research simply intended to satisfy personal objectives, or will it improve the quality of life for others? Pure research, that is, scientific endeavours directed at the generation of causal inference (improving understanding of "how things work") is always of at least limited value within its field; innumerable cases exist where pure research led to far-reaching and unexpected developments, well-removed in time from the initial study. Frequently, research that is perceived to benefit the larger good, of humankind and the Earth environment, is most likely to receive support and funding.

3.5 New Ways of Thinking

It has been established that the articulation of research questions by individual researchers involves an iterative process of thinking and reflection guided by the world we live in—realist, liberal, tribal, warming or a tech world. While this iterative process recognizes the researchers prior knowledge, skills and individual differences that influence their spatial thinking, the emerging changes in spatial thought, is also a manifestation of the interaction between the prevailing philosophical viewpoints and the major methodological approaches in vogue. The emerging researcher must also keep the big picture in mind which often reflects changing priorities and new directions embraced by communities across the globe (Maude 2016). In recent years, as the researcher ploughs through conceptual ideas and processes such as capitalism, globalization, digital revolution, resource management, culture and identity or geopolitics, a realization soon dawns that global warming is no longer a speculation, that we are in a digital era where spatial methods are more often than not guided by new practices of spatial data collection, manipulation, analysis and visualization options and we literally live in a post-globalization era with its attendant challenges (Remmel and Fortin 2010).

Today, irrespective of the fact that a researcher pursues issues of human- society relationship or environment-society or environmental dynamics, the researcher's spatial knowledge, spatial ways of thinking and acting, spatial capabilities are constantly challenged by the choice and implications arising from comprehensive research and interdisciplinary research. All these processes influence the designing of research questions and often results in change of initial strategies, purpose, and approach (Harden 2012; Maude 2016; Ziegler et al 2013).

3.6 "Bonding" with One's Research Objectives

It is important for all researchers to have a profound personal interest (read: love) toward the problem they are investigating. This investment in the subject is particularly critical for student scientists, who are experiencing the challenges and rewards of research for the first time.

All research projects experience lulls of activity brought on by puzzlement during the literature review and interpretation of results, as well as technical difficulties during data collection and analysis. Experienced researchers have developed strategies to cope with these periods of struggle and challenge; novice researchers may languish and experience such speed bumps as stress. When coupled to the other difficulties of graduate school, thesis-related stress can threaten the likelihood of degree completion.

It is during these times of reduced progress on a research project that students may begin to question their selection of topic (or advisor!) and become disillusioned with the entire prospect of advanced study. The personal connection a student has made with her/his research topic and objective is now critical. If a student has developed a deep, self-driven interest in the project and is in command of the research design, she will probably maintain an energy and motivation for its conclusion that will enable success. Alternatively, a student that has selected a topic by default, or simply settled on one to expedite the degree may lose enthusiasm as pitfalls arise.

For these reasons, we strongly encourage academic advisors to allow students to discover their own research projects, even if they are derived from the data and initial interests of the advisor. Students must feel ownership of the topic and their specific inquiry into it, if they are expected to aggressively pursue spatial science.

3.7 Conclusion

This chapter was intended to suggest the importance of articulating sound research objectives in the form of questions or hypotheses. Further, a method for identifying entry points into scientific inquiry was provided, with discussion of the qualities of effective research questions and their development.

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Chapter 4
Data and Methods in Spatial Science

Space hesitates about its identity.
Lyotard (1990, p. 106)

One of the core strengths of scientific analysis is that it relies upon a base of evidence to make decisions and correct errors in the development of theory. The evidence that is used to describe the operative processes in spatial science is assembled as data, derived through observation, measurement and experiment, directly and indirectly. Hence, data and the methods used to collect it enable spatial science to identify and articulate key spatial phenomena in both human and physical systems. Given the importance of this task, researchers should be mindful of the quality of data, their freedom from error and bias, and the extent to which they represent the phenomena under investigation, as these issues greatly affect the strength of any study. In this chapter, we will examine issues related to the types of data typically used in spatial science, their derivation, analysis and representation.

4.1 Understanding Data

Understanding the inherent complexities of data is a challenging task. Yet, data are the necessary building blocks of any research program. Indeed, the collection, organization, analysis, and exposition of data are not always intuitive tasks—this is particularly true with spatial data. Spatial data are used to represent variables (and their interaction) and elucidate processes that control the distribution of various physical and social phenomena over the earth's surface. In most cases, the technical definition of "spatial data" refers to X and Y coordinates, such as polygon centroids or simple locations in latitude and longitude. However, the exact definition is often less clear as spatial data may also refer to additional attribute data that accompany locational attributes (Table 4.1). Similarly, spatial datasets might be organized around places—not necessarily coordinates (Table 4.2). Because of the diversity of fields that may be analyzed in a spatial context, the researcher is faced with a number

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Table 4.1 Spatial data based on coordinate geometry

Site	X	Y	Attribute 1—soil
1_Green_Co	1	7	Silt
2_Green_Co	2	7	Clay
1_Clay_Co	3	8	Sand

Table 4.2 Spatial data based on place

County	Attribute 1—mean income	Attribute 2—total high schools	Attribute 3—Hwy access
Green	32,517	3	N
Clay	27,442	1	Y

of initial questions when assembling the data set. Will my data be derived directly from personal observation or experiment, or indirectly, via reputable sources (or a combination of the two)? Are the phenomena under investigation subject to precise or approximate numerical measurement or are they difficult to quantify? How many variables must be sampled in order to objectively assess a phenomenon?

To some degree, the research design of a project or thesis, as stated in its objectives, questions and hypotheses, will determine the answers to these questions. The scope of the analysis, the limitations of time and resources, and the guidance of existing studies all exert some control on the quantity and nature of data to be used. The differences in the specific subject of investigation, for example, the spatial distribution of streamflow patterns versus that of political dispositions, strongly constrain the types of data to be used.

In addition to the thematic direction a study has taken, time and manageability issues frame the scope of data collection. Just as it is necessary to limit research questions to lesser, more solvable components of an expansive inquiry, so too should the array of variables closely match the phenomena and processes to be investigated. Variables should be selected that address research questions directly (a research design that specifically refers to variables is helpful). By reducing the number of variables to a manageable subset, the scientist places a priority on closely addressing the questions or hypotheses actually posed, and thus economizes the project workload. With a small set of variables, the labor-component of the study may be focused on accurate representation of data, determination and exploration of the relationships between variables and space, and in the relation of the study's findings to existing knowledge. A concise presentation and analysis of data is more readily interpreted by readers and listeners, whose attention and understanding are the main objective of any dissemination of findings. Conversely, a comprehensive array of variables, while ultimately desirable in terms of thoroughness, is seldom digestible in a single thesis, dissertation, published article, or presentation.

4.2 The Hierarchy of Data Sources

Once variables have been determined, a key, initial decision is how directly they are to be obtained (see Fig. 4.1). Data may be generated directly by the scientist through experiment, observation and sampling. These data are *primary* data. A keen advantage of direct sampling is that the investigator possesses full knowledge of potential sources of error and bias and controls all aspects of the sampling process. Although clearly the safest choice for research, the advantages of direct data collection are counterbalanced by several challenges. First, the researcher must make all decisions concerning which variables to measure or omit, and how to measure them, including selection of instrumentation and a sampling scheme. Such decisions are significant and must be objectively and statistically defensible; each choice can influence the outcome of a project. Second, the researcher must then conduct the collection process, which may be considerably more time-consuming than using an existing or "canned" data set. Third, the researcher must then convert the data to a form that can be integrated into the research. In spatial science, such data processing usually includes referencing information to geographical coordinates. Finally, the scientist must conduct the data extraction (and describe it) in such a way that her audience may follow all steps and verify the process.

An alternative to meticulous direct collection of data is the usage of existing data sets or data gathered from literature. The advantage of using these *secondary* data is obvious; the data collection portion of a project is bypassed or significantly reduced. In cases where a data set already exists that represent the key elements of a study, a research design may be composed with such a resource specifically in mind. In general, however, the direction and imaginative pulse of a research project should not be confined from the outset by which data sets may be downloaded most promptly.

Pre-existing data sets are limited by a finite number of available variables. Some data sets may be readily adapted to research questions as posed; others may not. In many cases, a limited variable set is simply unavoidable. When it comes to development indicators a comprehensive listing of data and datasets are published by

Fig. 4.1 Hierarchy of data types

the World Bank including some sub-national and raw data from surveys. In the United States the Census Bureau is home to the changing population, housing and workforce through its American Community Survey and Economic Census. These datasets when combined with a variety of GIS and statistical software packages allow researchers to engage in complex decision problems more than ever before. Conversely, a spatial scientist seeking to investigate electromagnetic emissions over the earth's surface is limited to the resolution parameters of available sensors. Electromagnetic spectra sought through research questions must either be represented by proxy with available bandwidths, or the questions must be modified to conform to these bands.

Similarly, meteorological data are routinely gathered for standard thermodynamic variables. Certain derived variables deemed useful to the general atmospheric science community are calculated from these measurements and archived; however, additional and also useful variables, while not archived, might be calculated with some effort by the scientist from the raw data.

Spatial scientists must also consider and possibly modify the format of so-called "canned" data sets. Data must be referenced properly to geographic coordinates, presented in consistent units, and normalized for certain statistical operations. If multivariate analyses will be conducted, the data set must be arranged and imported as a suitable matrix. Occasionally, software packages, notably geographic information systems, STATA, R, SPSS etc. are capable of handling data from disparate sources, managing or identifying formats and distribution problems and performing many of the mathematical operations necessary to determine variable interrelationships. More frequently, the scientist must devise software or macros to prepare data from different sources for use in a common analysis setting.

Perhaps most importantly, the sampling process used to derive secondary data is not always evident simply by examining its form (nor is documentation always attached to the data set when acquired). It is imperative that the scientist develops an understanding of the sampling process and how it may impact the results of the project. An investigation of the sampling process might be as simple as locating and reading documentation from the source. It is highly recommended that the researcher conduct a preliminary test on the data to determine its completeness and general accuracy. If the test reveals errors, a complete, systematic examination of the data set must commence.

Meta-analyses or studies that summarize a range of evidence in a discipline may rely on published summaries of data sets derived elsewhere and previously. When dealing with these *tertiary* data sets (and beyond), the spatial scientist benefits from a body of accumulated existing work and the labor of numerous scientists, but must exercise caution as the systems and standards for deriving those data sets becomes more and more remote. Given the increasing availability of tertiary and secondary resources, issues of data quality associated with data sources are addressed vis-à-vis *metadata*. Metadata refers to accompanying documentation that details the data collection methods, provenance, as well as a range of measurement issues such as error. In short, metadata are the data about the data.

4.3 Quantitative and Qualitative Data

The first step in identifying appropriate data and ultimately collection methods is to determine the nature of the data to be collected—*quantitative* or *qualitative*. In some research projects, both types of data may be used. But, in most cases, a single data type is used. In those cases where both quantitative and qualitative data are used, quantitative data are used to establish general conditions and qualitative data might be used to more fully understand (not necessarily explain) the heterogeneity in population or a specific case. In the end though, the subject or process chosen for investigation, along with the nature of the inquiry, determines the mathematical precision possible in measurement of variables. The level of "quantification" afforded in data collection, in turn, restricts or expands the avenues of statistical analysis available to the scientist. As noted previously, spatial science often blends the data and methods of physical and social sciences as it focuses on the description and explanation of distributions.

Physical data lend themselves readily to quantitative measurement. Scientific studies that assess time and space, energy and mass, and identified forces of nature (gravity, strong and weak nuclear, electromagnetism) rest on a well-established theoretical foundation and a standardized set of units and techniques—principles that are expressed most simply and accurately in mathematical terms. The spatial analysis of physical phenomena, therefore, may draw from, and be tested against, laws of mechanics and thermodynamics.

Social data are more difficult to quantify, as they often attempt to measure distribution of human attributes that are influenced by decisions or attitudes for which no common metrics or mathematical relationships are known. As such, social-science research questions often grapple with higher order problems than those of physical science. Where quantification is possible, the units used to measure human phenomena are sometimes not compatible and must be scaled and related in a statistical analysis. For example, the socio-economic variables of migration, education and cost of living can conceivably be quantified (or categorized) in a number of ways, but are not related to one another as simply or clearly as physical variables, such as mass and momentum.

Where human attitudes and perceptions are central to the explanation of spatial distributions, qualitative data are often the best source of detailed information. Qualitative data are usually collected as narrative statements that describe or classify the views of a sample of human subjects. These data are typically gathered through surveys or interviews. Additional methods of qualitative data collection include participant-observation, content analysis, and cognitive mapping. Although they lack the numeric precision or clear applicability to statistical analysis, they can improve upon quantitative data by offering detailed nuance (not reduced to a single value) and unexpected insight. Increasingly though, new software packages, such as HyperResearch, AtlasTI, and Nud*ist, are enabling qualitative data to bridge the "statistical gap".

Ultimately, the degree of quantitative precision possible in spatial science studies depends on the presence of a demonstrated mathematical framework for the variables, the amount of human-physical integration attempted in the study, and the level of description or explanation the researcher is seeking. As before, well-crafted research objectives will clarify this issue prior to data collection.

4.3.1 Intensive and Extensive Approaches in Spatial Science

In general, the decision to do qualitative versus quantitative research is dependent upon the nature of the problem and the scale of the analysis. While certainly many spatial scientists use a mixed methods approach that combines both quantitative and qualitative assessments of the observed world, the scale and scope of research is often a key determinant with respect to whether or not a study is quantitative or qualitative. In recent years, spatial scientists have increasingly used Sayer's (1992) Intensive-Extensive (Table 4.3) model of social science research as a framework for conceptualizing and positioning quantitative and qualitative research as complementary research regimes. According to Sayer, in-depth case studies can be used to tease out and reconfigure the theory concerned with general processes. Or as Cox and Mair (1989) suggest, intensive research at the local scale grounds theoretical abstractions

Table 4.3 . Sayer's (1992) Realist intensive-extensive framework in spatial science

	Extensive	Intensive
Questions	General Processes	Specific Cases
Relationships	Formal-an emphasis on observed classes and an agreed upon system of classification system over space	Relative-relations of connection in place
Scale	Regional and Global	Local
Groups Studies	Independent	Inter-dependent
Methods and Accounts	Quantitative-statistical analysis, standardized surveys, and scientific sampling. The accounts describe general processes as observed across space	Qualitative-open ended surveys, In-depth interviews, participant observation, and ethnography. The results of qualitative approaches explain the specific relations observed in a place
Tests of Validity	Replication	Corroboration or "Triangulation"
Limits	Provides important insights into general processes—but may be of limited use when examining specific places and problems	Explains the observed conditions in a place—however, these conditions may vary across space. As a result, the insights may not be applicable to other cases as a result of local contingencies

and contribution to new syntheses of the literature. Whereas Sayer's approach has been widely adopted by social scientists, it is increasingly recognized as a useful device for organizing a range of natural science research, too (Richards 1996).

4.4 Ethics in Data Collection

As spatial data are collected, researchers must conduct their measurements or surveys with the basic ethical tenets of science as a guide. Data should be gathered and presented with maximum accuracy and consistent adherence to the stated procedure. With adequate resources, time, and opportunity, fellow scientists should be able to follow the data collection process as described and derive similar results. Additionally, complete disclosure is mandatory with respect to mathematical transformation of quantitative data (rounding, scaling, inter-/extrapolation). Results should be reported completely, as outlined in the objectives and methods sections of the research, even if data sources appear to contradict one another or are in conflict with the stated hypotheses or personal convictions of the researcher. Science, spatial and otherwise, works as a method of understanding because it is embodied with "error-correcting" machinery (Sagan 1996). Central to the error-correcting principles is professional honesty when handling data, during the collection, analysis, reporting and interpretation phases.

The ethics of data in the scientific sense are quite straightforward. The key to understanding science is that it is guided by what Locke et al (1999) refer to as the "Habit of Truth". Beyond reporting how data are collecting and avoiding the temptation to "cook the books", researchers are obliged to report all the results—not just those that support a hypothesis. Moreover, research that has unexpected results or might be objectively classified as "failed" make an important (if sometimes underestimated) contribution to science.

Particular care must be exercised when sampling human subjects and in other sensitive areas. Federal guidelines require institutions and organizations to review all aspects of human data collection, particularly for surveys, interviews and experiments, extending to secondary data and beyond; similar oversight is given to medical and animal research. In the United States, Institutional Review Boards are required by law to oversee all human-subjects research. These organizations and their protocols constrain many facets of research that may potentially influence the outcome of a study, including the testing environment, wording of questionnaires, privacy and anonymity issues. Additionally, the review process mandates researchers obtain "informed consent" of all participants that clearly state the research objective, as well as the risks and benefits associated with participation. Spatial scientists must make every effort to closely follow any guidelines established for human subjects research and, beyond these, to make every effort to ensure the dignity and welfare of human participants in spatial science research. Standards and practice in research within spatial science varies between countries, institutions and disciplines. This leads to complex problems and can also cause confusion, particularly, when spatial scientists engage in international collaborations (TIP 2016).

Plagiarism, the deliberate presentation of data, analysis or narrative as one's own effort, without attribution to its source, is a profound insult to the scientific discipline and scholarly enterprise as a whole, as well as to the audience, the administrators of the published venue, and particularly to those who conducted the original work. Proper citation is essential, not only as a matter of fairness, but to establish and maintain the clear provenance of data and results, elements that will be built upon by subsequent studies. Beyond the unwritten and universal rejection of plagiarism in science, academic and professional institutions have established clear rules and severe sanctions for such infractions.

4.5 Big Data, Data Science and Data Mining

In recent years, the demands of the global economy and the rapid pace of innovation and change have begun to generate unprecedented amounts of data in every walk of life. We have witnessed technology becoming cheaper with the proliferation of mobile computing, an abundance of social networking (Facebook, twitter, Pinterest etc.), and cloud computing. These trends have combined with an increase in the volume, velocity, and variety of data leading to a shift in traditional data management and analytics software and hardware technologies, and open-source technologies creating new alternatives (McKinsey 2011; Thatcher et al. 2018; Wang 2016).

In the last decade there has been a quantum jump in the production and consumption of a broad suite of geospatial big data and technologies generating new literature. This development has in turn caused a sort of paradigm shift as innovation shifts to data-driven machine learning, rather than being a product of human ingenuity. Data has always been a very critical component of any geospatial project. In the era of big data, spatial scientists are no longer as dependent on traditional methods of creating spatial data (or 'small data'). Today, data production technologies such as global positioning systems (GPS), wide area augmentation system (WAAS), and a realm of location-based services are critical in producing big spatial data with the help of artificial intelligence/machine learning and natural language processing (NLP) to name only a few. While big spatial data have been contributed by the government for a long time and used by academia and practitioners, we now see in practice a growing presence of the market (technology giants such as Google and Facebook and geospatial market leaders such as ESRI, Intergraph, Autodesk among others) in the production and consumption of spatial and 'big data', associated digital markets, creation, and maintenance of digital infrastructure.

As we all tweet, blog, Facebook, google earth etc. there is an implosion of data through millions of networked sensors embedded in mobile phones, automobiles, and other products which are continuously sensing, creating, and communicating data. Big data has emerged as the next generation of data warehousing. Many regard 'big data' as multifaceted, ambiguous, and dynamic suggesting that the term is relative with different meaning between spatial science professionals and practitioners (Thatcher et al. 2018). After all, spatial science researchers often rely on big data sources such as internet data, primary research, secondary research, location data, image data, supply chain data, and device data among others. While the existence and use of big data has been around for a while, spatial scientists have relied on small data studies for decades answering targeted questions. It is only now that the spatial science community has started thinking outside the box as the advantages with big data environments unfold and as data evolves over time (Kitchin and Lauriault 2015; Steiger et al. 2015). Thus, spatial scientists are increasingly using big data generated from location-based social networks, such as, Twitter, in understanding neighbourhood boundaries on the one hand and analyzing Black Friday patterns and trends nationwide (Shelton and Poorthuis 2019; Ye et al. 2020). In yet another example, a group of researchers in China use open big data from the high-speed rail's ticketing website to understand train frequency, passenger flow, and occupancy rates to improve the functionality of the transportation system (Wei et al. 2018). Such examples clearly have a message for the community of spatial scientists that social media in a geospatially connected urban and regional world can generate vast amounts of user-generated data that can be made available through data mining of social media resulting in fresh understanding of unknown spatial patterns and processes. To that end, data mining is simply a process of discovering spatial patterns, trends, and relationships from large data sets using machine learning (Thatcher et al. 2018; Wang 2016). Also, as spatial scientists engage with big spatial data, they are increasingly forced to ask questions away from descriptive and more towards predictive, and prescriptive analytics leveraging big data and data mining to achieve very real results which can be cutting-edge in nature (Wang 2016). For the emerging spatial scientist, any engagement with the ecosystem of big data and data mining presumes domain knowledge and geospatial computation skills (understanding of statistics, data mining, and machine learning) which can be a challenge.

Big data comes with opportunities of efficiency and optimization in spatial science, however, there are also challenges around epistemology, the landscape of privacy, rights and responsibilities, and ethical issues such as transparency, choice, consent, security, data integrity, access and accountability (Thatcher et al. 2018; Wang 2016).

4.6 Sampling and Statistics

Numerous sampling decisions confront the spatial science researcher. Phenomena do not typically occur (and data are not typically presented) in a grid of points that have a regular spatial arrangement. Rather, scientists are faced with a variety of decisions related to collecting samples across an uneven distribution and then estimating data values where sampling is not possible.

When sampling, the analysts must decide if representative point values from within the distribution will produce an adequate depiction of the population. Determination of the sample size appropriate for the project is one of the first and most important steps faced by the researcher. In addition to the limitations posed by time and resources, the sample size should reflect a balance between the level of confidence designated (to be attributed to the quality of the result) and the tolerance of error. Haring et al. (1971) suggest that the *minimum* threshold for sample size occurs when the percentage of the confidence interval (P) and $1-P$ (Q) are both equal to 0.5.

Some knowledge of the actual homogeneity of data should be used to determine whether random or systematic extraction of data will be effective. Statistical measures, such as scatterplots, indexes of dispersion about mean or median centers, regression and residual plots, spatial Lorenz and hypsometric curves, or geospatial devices, such as the semi-variogram or covariance functions for anisotropy, can be employed to investigate data distributions (Clark and Hosking 1986; Hammond and McCullagh 1974; Kitanidas 1997; Wrigley 1983). Once a general sampling scheme is selected, the scientist must make a series of critical decisions that determine the interval between data points, the boundaries of the sampling net around individual points and the dimensions of the overall sampling grid.

Additionally, the researcher may decide that an aggregate of neighbouring values will be represented at individual points, and then used to estimate unknown values across the space. In these instances, some measure of similarity and aggregation must be selected, such as central tendency (mean, median), Euclidean distance, Mahalanobis distance or parallelipid classifier (Kitanidas 1997).

Another set of issues that relates specifically to spatial data is caused by spatial autocorrelation, the covariation of two or more variables according to common underlying influences, and thus, common variance (Anselin 1988; Cliff and Ord 1981; Haining 1980). When statistical relationships are sought concerning the dynamic interaction of such variables, it is often desirable to test their spatial commonality with functions such as the spatial regressive-autoregressive model (Anselin 1988). The spatial scientist must determine to what extent spatial autocorrelation threatens to mask the actual relationship between variables or, conversely, where the spatial co-variance is of most interest.

Data reduction techniques, such as factor analysis and empirical orthogonal functions serve a unique purpose with spatial data. In most social science applications, eigenvector based methods are used to identify and align common variation in multiple variables sets. In spatial analysis, both space (geographical points and regions) and time (observations of cases or dates) may be submitted to eigenvector approaches to reveal not only conglomerations of variables, but also how such variables cluster in space and time). Clustering of data points and variables and subsequent identification and classification of regions of distinction in human and environmental variables is one of the strongest potential contributions of spatial science research.

4.7 How to Present the Data and Analysis Portions of Your Study

In a manuscript or presentation, the discussion of data collection should begin with a reiteration of the key objectives of the study and establish them as a context that necessitates the methods chosen. That is, the data types chosen and procedure for deriving them should be logically driven by the research problem. Particularly in an oral presentation, an abbreviated reiteration of the objectives of the study is useful to maintain the research themes with listeners. The design and logic of the research project should be presented as a story. The introduction and literature review establish the history, basis and necessity for conducting the study. The statement of objectives articulates with maximum clarity the specific problem the scientist will pursue. Then, the data and analysis (alternatively named "Procedure", "Methods", or even, and usually inappropriately, "Methodology") section outlines exactly how the research questions will be investigated.

The Data and Analysis section should identify and rationalize which variables will be used, when (or from what time period) and where they will be collected. Each variable should be linked to and rationalized by a strand of the objectives. In most cases, the rationale for data selection and scale of analysis is derived from the previous literature presented in the earlier review. Although, in some cases—most likely the dissertation or funded research proposal—the researcher may be proposing a novel approach of data collection and variable selection. In these cases, the rationale must be clearly stated and based on one or more of the established themes of the literature. The analytical approach should be described completely and justified in terms of possible alternatives. To that end, the works of previous researchers should be succinctly compared and contrasted in the methods sections.

Finally, problems that may arise as a result of variables or procedures chosen must be explored and their adverse influence on the outcome of the study adequately dispelled. These problems or issues are often addressed in a section entitled "limitations". In some cases, the analysis, data, or even both have obvious limitations and it is incumbent upon the researcher to clearly state these and provide appropriate caveats.

4.8 Conclusion

This chapter introduced general categories of data and outlined several of the advantages and problems involved in their collection. Various pitfalls and ethical issues encountered in selecting variables and dealing with human subjects were considered. Finally, introductory issues concerning sampling and conducting statistical analysis were discussed.

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Chapter 5
Graduate Degree Proposals

Graduate students are usually expected to write and defend a formal proposal of their thesis or dissertation project. While some students consider the proposal just another "hoop" in the graduate school process to jump through, this step is essential as they modify their research projects and define a clear path to graduation. Specifically, the proposal step should serve to:

- Conceptualize a researchable spatial science problem,
- Design a researchable study, and
- Produce a defendable thesis or dissertation about the problem investigated.

This chapter describes how a thesis/dissertation committee should be formed, how a topic is often chosen, and describes the structure and purposes of thesis and dissertation proposals. While some of the specific topics discussed in this chapter are addressed elsewhere in the book, the intent of this chapter is to provide a "one-stop" opportunity to review the core elements of the graduate proposal.

5.1 Graduate Committee

Before writing and defending their proposals, students must first select a graduate committee and research topic. Graduate committees consist of an advisor and two or more committee members. Students should carefully select their advisor and graduate committee members. In fact, this is one of the most important choices that students will make during their graduate careers. Usually, students arrive on a campus with an idea of who their advisor will be. The advisor should be someone who will continuously challenge the graduate student and provide valuable advice and support throughout the graduate school process. Indeed, the advisor is (or should be) the student's primary advocate.

The student should also choose committee members—with input from the advisor. Committee members should complement the selected topic by providing expertise

J. D. Gatrell et al., *Research Design and Proposal Writing in Spatial Science*,
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on various thesis/dissertation components. Unfortunately, students sometimes avoid potential committee members based on a perception of the faculty member being “too tough.” Using this kind of rationale when choosing committee members is short-sighted and will not result in the best thesis/dissertation.

5.2 Topic Selection

Thesis and dissertation research topics should be carefully selected. As the student will be expected to spend an incredible amount of time completing the project, it is important that the topic interests the student. Further, it is important that the student’s advisor is as interested in the topic as is the student. If the topic is not interesting to the advisor, the advisor may not be as anxious to help the student with the project. Students should consult with their advisor and committee members about any potential topics to ensure that everyone on the committee is supportive.

5.2.1 Proposals are Contracts

As noted in Chap. 3, a graduate student thesis/dissertation proposal can be considered a contract. The contract states that if the student completes the research as described in the proposal, they will complete this portion of their degree. Therefore, it should not matter what a student’s results turn out to be (e.g., statistical significance was not found or that a statistical relationship was weaker than expected), as long as the student completes the research work as described in the proposal. If students need to deviate from the work plan described in the proposal, they should keep their advisor and committee members apprised. This way there are no surprises when students defend their final research product.

5.3 Graduate Proposal Structure

One of the first questions that graduate students ask about proposals is “How long does it need to be?” Unfortunately, there is no specific size requirement that all graduate degree proposals must meet. Rather, proposals must be comprehensive enough to address all aspects of the research project and demonstrate to the graduate committee that the student is capable of completing the proposed project. Students need to realize that virtually all text written for the proposal will be placed in the final thesis or dissertation, so time spent in proposal preparation is time-well spent. Proposals should be structured in much the same way as described in Chap. 6. However, there are several key differences in some sections. These differences are described below.

5.3.1 Literature Review

Literature reviews should be done similarly to what has been described in previous chapters. However, the literature review is usually even more detailed in a graduate degree proposal. The literature review describes the reasoning on which the entire project rests, and all relevant literature must be referenced in the literature review. The review should be comprehensive, and in some cases, exhaustive on the research topic.

All theses and dissertations should contribute new knowledge to the discipline, and the literature review should describe the literature on the research topic from its beginning until the present—paying special attention to any voids or holes that the proposed research will fill. This demonstrates two things to graduate committees: (1) that the graduate student has a firm grasp of the literature, and (2) that the proposed project will contribute new knowledge to the discipline. For more information on literature reviews, please refer to Chap. 2.

5.3.2 Methods

When writing a proposal for funding, investigators usually have a research record that the funding agency will use to gauge the probability of the work being completed as described. This record may allow the researcher to be less specific in some proposal sections, or to defer to their previously published work. Further, proposals for funding usually must conform to specific page or word limits that don't allow for lengthy or extremely detailed methods explanations. Conversely, graduate students usually have not yet established substantive research records and should be very detailed in the methods section. Graduate students need to describe virtually every detail of the proposed project so that the committee understands exactly how the research will be completed. A detailed, clearly written methods section is a reflection of the coherence of the study's questions and a roadmap for the analysis. To review methods and data issues in greater detail, please refer to Chap. 4.

5.3.3 Expected Results and Conclusions

Students should revisit the concepts described in the literature review and fully describe how the proposed research will contribute new knowledge to their area of study. Specifically, this section should tell what contributions the project will make to the field of study that merits awarding the respective degree (e.g., MA or Ph.D.). While students should not employ hyperbole here, they should be optimistic and not undersell the potential impact of their study.

5.3.4 Preliminary Studies

In some cases, graduate committees may request evidence that the student is capable of performing the proposed research. To this end, students sometimes work on their proposed research before defending it to their committee. Even during this phase, it is suggested that the student's advisor and committee members are kept up-to-date with what is happening. When students complete preliminary research on their topic, it is often useful to include a "Preliminary Studies" or "Preliminary Results" section in the proposal. This section should detail results from the preliminary study and include difficulties and successes achieved in this part of the project.

5.4 Proposal Defense

Many institutions require formal MA and Ph.D. proposal defenses where students must defend their proposed research to their committee members and the general public. These forums provide students with the opportunity to "fine-tune" their research project and should be regarded as an intellectual discussion with their peers rather than an exam.

During a defense, it is not uncommon for committee members to probe and discover exactly how much a graduate candidate knows about topics relevant to the proposed research. Sometimes this requires extensive questioning along topical lines. This is done to ascertain if the student knows enough about the proposed research to be successful. Committee members may also suggest different research avenues and/or techniques. It is important that students are open to suggestions and maintain a good attitude while committee members conduct the defense. Students should answer all questions as honestly as they can and even respond "I don't know" if they don't know the answer to a particular question. If students become flustered with a line of questioning it is okay to ask the committee to be excused for a minute or two and go get a drink of water.

5.4.1 Presentation

Proposal defenses usually consist of a short (<30 min) presentation given by the student that describes the proposed project. Some students think that a long presentation will result in fewer questions from their committee members. However, students should remember that their committee members have already read their proposals and are very knowledgeable about the proposed project. So, when students give lengthy presentations, committee members may actually become agitated and more obliged to ask difficult questions. In short, students should regard the proposal defense presentation as a professional presentation and treat it as such.

5.4.2 *Rethinking Thesis and Dissertations: Innovations and Challenges*

As it may be clear by now writing a proposal in a graduate program is part of the first phase of planning graduate research work. However, it does not mean that the emerging researcher should not think about the execution and reporting stages. Very often graduate students are advised by their advisors to conduct a preliminary or exploratory research in order to understand critical issues emerging from research questions, data, data analysis and therefore consider refining and improving the details of the proposal. While much of the graduate research proposal follows a linear process not just in spatial science and related disciplines but also in the humanities. In the last decade, the graduate proposal writing process has been increasingly influenced by the innovative potentials of the digital era that we now live in. The global knowledge economy along with its attendant rationale for transformative research, inclusiveness and entrepreneurship is increasingly pushing not just the spatial science graduate student but also institutions of higher learning and other stakeholders in funding and publishing to consider 'openness' and its associated virtues as the new lens for conducting graduate research (Boyle et al. 2015; Covey 2013; NAS 2019).

To that end, openness has come to include many things including and not limited to the acceptance that knowledge truly is a social construction and hence collaboration must be further embraced and acknowledged in graduate research work i.e. from literature review, to data and analysis, eventually sharing the research process and findings with meta-information without restrictions.

Many universities and spatial science programs in the US, Europe and elsewhere (as discussed in Chap. 1) have already begun to recognize the changing cultures, practice and use of emerging internet technologies and open source technology. However, the unique issue at hand for emerging spatial scientists as they begin to frame their research is how do they converge these trends to continue to contribute to the communities and the nation's economy and quality of life even as they understand and consider enormous gains from efficiency, productivity, revenue and profitability.

In the current context, for our emerging spatial scientists the business of graduate proposal writing becomes even more challenging as they navigate through new metrics (emerging from a shift away from descriptive to predictive analytics), new and emerging ideas, discoveries or tools of communicating technologies and virtual learning environments that are radically changing our perspectives of how we create new knowledge in the spatial sciences i.e. between asking spatial questions, acquiring resources, visualizing geodata, answering spatial questions and sharing the results with the community (NAS 2019).

5.5 Conclusion

After successfully defending the proposal, there are usually multiple forms that need to be signed by the committee. It is very important for students to have these forms ready for faculty signatures immediately after the defense. After each faculty member signs the forms, students should make multiple copies of the forms and keep them in multiple locations.

This chapter has described some basic principles to guide graduate students through the proposal process. The ability to develop, write, and defend a high-quality proposal during graduate school is a skill that researchers will use throughout their careers. As students prepare their proposal, it is important to recognize that the traditional format and structure of culminating research continues to evolve and leverage online and broader digital resources (see https://www.grad.uiowa.edu/news/2018-08-13/new-ways-of-crafting-a-thesis).

All academic institutions have different graduate degree requirements, and students are encouraged to familiarize themselves with these requirements. Also, students should pay close attention to the advice of his/her advisor and committee members as their recommendations and advice supersede anything that is written here!

References

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Chapter 6
Grants and Grant Writing

6.1 Opportunity and Challenge

One of the many reasons that people enter into academia is for the opportunity to pursue their own research interests. The conduct of research often requires external funding, and obtaining support through submission of successful grant proposals is challenging. In fact, writing competitive grant proposals is one of the most challenging things that academics do. However, external funds are often essential to support the data needs of a project and the graduate students that are members of the research team; it is also very rewarding when researchers are provided funds that enable them to perform research to contribute to the building of new knowledge. External support is particularly vital in times of tight institutional budgets or fiscal insecurity.

Grants and contracts are usually the way that external agencies determine which research projects to support with their available funds. Grant and contract monies can be used to fund complete research projects, parts of research projects, and as "seed" money for research projects. External funding can also enhance the reputation of institutions and individuals, and some universities/institutions may even expect or require that faculty generate certain amounts of external funds for tenure and promotion.

This chapter describes some of the main considerations associated with acquiring external funding. It is not possible for one chapter to detail all of the components and issues of external funding; so general guidelines that are usually required are described.

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6.2 Extramural Grants and Funding Agencies

There are many different places to apply for external funding. These places range from governmental agencies (e.g., National Science Foundation or National Aeronautics and Space Administration) to private non-governmental organizations (NGOs; e.g., Nature Conservancy). Governmental funding agencies are usually charged with promoting science for the "good" of a nation while non-governmental agencies can fund projects that fit very specific agency goals. As a result, government funding opportunities may be less specific in scope than private funding opportunities. Both kinds of agencies are common sources for academic external funding.

6.2.1 RFPs and NRAs

Funding agencies typically release "Request for Proposals (RFPs)" or "National Research Announcements (NRAs)". These documents describe funding programs and provide all of the details required to write a proposal. When applying for funding from any agency, applicants should meticulously study the "Request for Proposal" or "National Research Announcement" to determine exact proposal requirements. These requirements can include: maximum number of pages, length of participant curriculum vitae, font size, budgetary guidelines, etc. Most funding agencies will not review proposals that do not adhere to these guidelines.

RFPs and NRAs typically list an agency contact person. Use this person as a resource for all questions that arise during the proposal process, as it is always better to ask questions about funding programs rather than spending hours trying to resolve issues on your own. However, be aware that these people become very busy as the deadline for the program approaches, and they may not have any time to respond to individual inquiries.

6.2.2 Proposal Review

Proposals are usually competitively reviewed through a two-step process: individual reviewers and a review board. Individual reviewers are knowledgeable in the field and will often provide their opinion of all proposals, rank the proposal in relation to other proposals, and assign an overall assessment of the proposal (e.g., poor, fair, good, or excellent). After the individual reviewers review the proposal, a review board will appraise and rank all proposals. External funding is highly competitive, and usually only those proposals that are ranked highly by individual reviewers and the review board will be selected for funding.

Pre-Proposals

Some funding agencies require pre-proposal statements to be submitted and reviewed prior to a full proposal being submitted. Pre-proposals provide agencies the opportunity to screen the kind of research projects that will be submitted with full proposals. This process is usually good for researchers as it allows them to briefly describe their project idea to the agency without having to develop a full proposal. If the funding agency thinks the pre-proposal is of interest to the program, the researchers will be invited to submit a full proposal. If the research is not of interest to the program, the researchers do not waste their time submitting a full proposal that has little or no chance of being funded. Pre-proposals usually have very specific guidelines listed in the RFP or NRA. If the guidelines are not followed, the pre-proposal will probably not be reviewed.

6.2.3 Funding Cycles

Some grant and funding agencies have predetermined dates during the year when they accept research proposals for various programs. These dates are usually very rigid and should be treated as such. Researchers should be careful and plan ahead to meet these deadlines—especially when the proposal has to be approved and routed throughout a university.

Some grant and funding agencies allow past versions of a current proposal to be used in consideration of the current proposal. This enables reviewers to see if concerns with past proposals have been addressed. Other agencies use the "first past the post" reviewing criteria where past proposals are not taken into consideration and the merits of the current proposal stand-alone against the merits of other proposals currently in review. For example, the National Science Foundation (NSF) provides detailed comments of all reviewed proposals. These comments allow researchers to improve proposals for resubmission during the next funding cycle. However, NSF does not review a current proposal on how it responds to past criticisms or weaknesses. Rather, the current proposal is treated as a "new" proposal and competes with all other submitted proposals on a level playing field. This is sometimes troublesome as reviewers and review boards usually change between funding cycles and so do reviewer's opinions and preferences.

6.2.4 Foundations and Fellowships

In recent decades there has been a proliferation of foundations and fellowships facilitating transformative research opportunities in spatial sciences as the need and demand for generating new knowledge has increased. For a long time, research in Geography and Spatial Sciences was the sole responsibility of the National Science

Foundation's Directorate of Social, Behavioral and Economic Sciences. With a recognition of the role played by GIS and spatial scientists in global climate change research as well as in improving public decision making in areas such as land, transportation and water resource management among others. Spatial science has thus come to play a key role across the realms of ideas, technology, and societal needs. Unfortunately, the above trend when combined with a decline in federal (R&D) funding, a growth in multidisciplinary research culture, and the potential for contributions by spatial science research to the public and private sector as well as the military and intelligence have all collectively resulted in participation by many stakeholders in government, the private sector as well the nonprofit.

Within the US federal government several funding opportunities have emerged with USDA, EDA, EPA, NASA, NOAA, and USGS among others. Several opportunities for grants also rest with National Endowment for the Humanities, National Institute of Health, National Geographic Society Committee for Research and Exploration Grants, National Council for Geographic Education, and several foundations such as Alfred P. Sloan Foundation, Carnegie Corporation, Ford Foundation, Kellogg Foundation, MacArthur Foundation, and Russell Sage Foundation, among others. Depending upon the focus of one's research, opportunities also exist with the American Geographical Society Library Short-term Fellowships, American Geographical Society Council Fellowships, American Institute of Indian Studies Fellowship Programs, Community Forestry Research Fellowships, Fulbright Program, Mellon/ACLS Dissertation Completion Fellowships, SSRC Dissertation Proposal Development Fellowship Program, among many others (www.aag.org).

6.3 Contracts

Contracts are similar to grants. However, the proposal process is often less structured and the "deliverables" are strictly defined. Contracts—like grants—may result from RFPs or through informal networks of professionals and require that academics perform a specific task for an agency or firm. For example, a GIS specialist may be contracted to assist in the production of a community's base map. Similarly, a climatologist may be contracted to provide on-site training for pilots. In both cases, researchers perform work that has been "contracted out".

In addition to the examples described above, some researchers may serve as subcontractors on major research grants. In these cases, investigators are sub-contracted by PIs or Co-PIs located at another university and charged with performing a limited—but well-defined—task on a funded award. For example, a survey research center at a major research university may design and deliver a mail survey for scholars located at a smaller institution. In either event, the contract fills a specific need and results in a defined deliverable and workable product.

6.4 Sheltered Competitions & Earmarks

In some cases, the competition for grant monies may be sheltered and in others research monies may be awarded through the process of congressional earmark. In either case, the primary policy objective of these programs—mostly funded by governmental agencies—is to promote regional and economic growth. While many of these programs and opportunities exist, access to sheltered competitions or earmark monies is inherently uneven and heavily dependent upon policy geography. Nonetheless, these special programs arise from time to time and they target specific regions, states, or research specializations.

Sheltered competitions refer to grant programs that limit participation to specific groups that meet well-defined criteria. One example of a modified, or sheltered, grant competition is the Experimental Program to Stimulate Competitive Research (EPSCoR). EPSCoR was designed to promote the expansion of research and development activities in selected states identified as historically less competitive relative to their peers and to decrease the concentration of research monies in a few large states. This competition is a supplement to existing grant programs at federal agencies, such as NSF, and designed to encourage quality submissions from target populations and results in competitive research being awarded a grant even when the open competition's resources have been depleted. In 1990, EPSCoR expanded beyond NSF to include several federal agencies including the Departments of Agriculture, Energy, and Defense; NASA; EPA and NIH. In the case of EPSCoR, the intent of the policy was to promote regional development through the development of complementary linkages between universities and industries through increased competitiveness of university research.

Congressional earmark monies are intended to site research in specific congressional districts. These projects are often large in scale and require significant resources. Unlike grant competitions, universities and their researchers have to approach members of congress (or a state legislature) and request funding for a specific project. While earmarks are an effective funding vehicle, obtaining earmarks requires a sustained lobbying effort on the part of universities and a keen understanding of the political and policy processes. In order to access these resources, researchers must often develop a series of relationships with their institution's governmental affairs officer, state agencies, and other decision makers.

6.5 Intramural Grants

Intramural grants are grant competitions and programs funded entirely by your home institution. No doubt most institutions house numerous programs at the university, as well as college/school levels. In most cases, these programs provide limited funds—but often serve as a springboard for future research funded by outside entities. While the sums may be somewhat limited (often ranging from $500–10,000—and sometimes greater amounts), these programs are important resources for obtaining seed monies. The proposal requirements for these programs are often less robust and the competitions are effectively “sheltered”.

6.6 Administration of Grants and Contracts

All grants should have a Principal Investigator (PI) who usually does most of the proposal writing and is probably the person who developed the project idea. The PI is the leader and point of contact for the project and is directly responsible for its success or failure. This person is accountable to the grant or funding agency for all funds awarded to the project. A typical grant project will also have one or more Co-Principal Investigators (CoPIs). CoPIs share the responsibility of grant success or failure, but not to the same extent as the PI.

At most universities, PIs and CoPIs are supported by a Grants and Contracts office (sometimes called “Office of Sponsored Programs” or “Office of Sponsored Research”) that helps administer grants. It is important to pay close attention to the advice and counsel of this office as they continuously assist grant management and are knowledgeable about many of the procedures of funding agencies and organizations. However, it is still the responsibility of the PI and CoPIs to manage their grant or project.

Projects may also list a number of Senior Personnel that will work on the proposed project. These people play crucial roles in the project and may be given salary and equipment through project funds, but they are not administrators of the grant. PIs and CoPIs work closely with Senior Personnel to ensure that the proposed work is completed.

6.7 Proposal Structure

Time spent working on proposals for grants and contracts is time well spent not only in terms of money that could be awarded, but in refining research questions and methods, or in learning more information relevant to the project. The following sections detail the main components that should be included in all grants (Fig. 6.1). Some RFPs and NRAs may stipulate other sections that need to be added. For a complete discussion of proposals see Chap. 5.

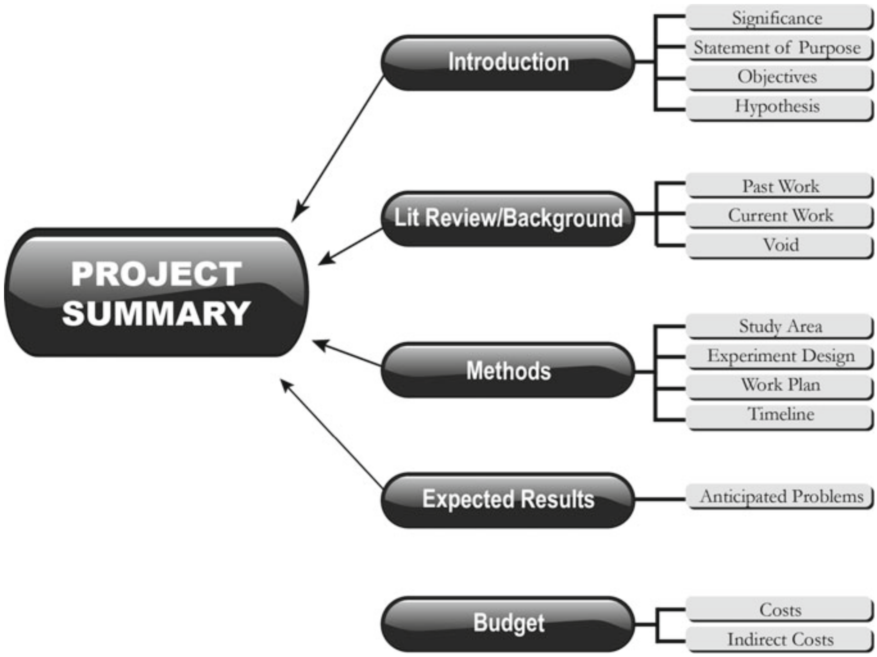

Fig. 6.1 Different proposal sections and their relation to the project summary

6.7.1 Project Summary

Most agencies require a project summary that details the proposed project. The summary should be concise enough to fit on one page and detailed enough to adequately describe the project. Researchers should pay particular attention to why the proposed project is important, methods, and expected results. In general, background, literature reviewed, and budgets are not incorporated into this section (Fig. 6.1).

6.7.2 Introduction

The introduction begins the main body of the proposal. It should describe why the proposed project is important. It should do this without writing “This project is important because…” For example, this section should engage the reader by moving from the broader to the specific in terms of what is already known and what we need to know. Few references are usually cited in this section. The introduction may include: statement of purpose, project objectives, significance of study, and hypothesis statements.

6.7.3 Literature Review and Background

The literature review should place the proposed project in the context of what has been done before, what is being done now, and how the project will fill a void. This section demonstrates to the reviewers what is already known and how that will be applied to the proposed study. There is no set number of references for any given proposal. However, there should be enough references through time that reviewers are able to make an informed judgment on the intellectual merits of the proposed project. For a complete discussion of literature reviews see Chap. 2.

6.7.4 Methods

The methods section should articulate exactly how the project is to be carried out through a comprehensive work plan. Study area and work plan figures are common in this section. Data that will be used and specific field and analysis techniques are also elaborated. Any supplies or data that will cost money also need to be described. A timeline that describes when each part of the work plan will be completed should be placed here. This section typically has fewer references than the Literature Review, but references may be cited as needed.

6.7.5 Expected Results

This section should be an optimistic assessment of the project's anticipated results. However, a subsection of Results should be "Anticipated problems" where potential problems and how they might affect the project are described.

6.7.6 Budget and Budget Justification

Agencies usually have explicit budget requirements that can be found in the RFP or NRA. Researchers should request the exact amount required to perform the proposed research. However, sometimes a project will be funded at less than the amount requested. When this occurs the budget must be revised to reflect the new amount. Budgets should be listed in tabular (line item) form and then justified.

Sometimes agencies may require dollar for dollar matches. This means that for every dollar the agency awards the project, the project's affiliated institution must provide a matching dollar. The matching contribution could come from the percentage of salaries that PIs, CoPIs, and senior personnel will devote to the project, existing capital equipment, etc.

Direct and Indirect Costs

Budgets should detail all direct and indirect costs associated with the project. Direct costs are all those expenses that can be directly attributed to the project. These could include student salaries, faculty salaries, travel funds, and equipment that will be used during the course of the project. Indirect costs (sometimes called facilities and administrative (F&A) costs) are costs related to expenses incurred while conducting or supporting research that are not directly attributable to a specific research project. These costs are recognized costs for doing research, and are used in a support function (purchasing, accounting, secretarial, security, etc.), space utilization and maintenance, depreciation of physical plant, and electricity.

Universities and other institutions usually have set percentages for indirect costs (e.g., 25% of total project cost). Most federal or large agencies allow indirect costs, but some smaller or local agencies may not. Most universities will usually allow indirect costs to be waived if an agency does not allow them. However, researchers must understand the process that this occurs in their institution.

6.7.7 References

All references cited in the proposal should be listed here. Do not list references that were not cited in the proposal, and pay particular attention to any citation style issues described in the RFP or NRA.

6.7.8 CVs and Bio-Sketches

Funding agencies usually require either 2-page CVs or bio-sketches of all project participants to help reviewers determine if the proposed research can be carried out by the participants. CVs and bio-sketches are usually placed at the end of the proposal package. CVs provide a list of all professional accomplishments (e.g., positions held, publications, previous funded research) relevant to the proposed project. Bio-sketches are usually narrative and describe professional accomplishments. Funding agencies should describe the exact format for these documents in the RFP or NRA.

6.8 Dissemination of Results

Most funding agencies allow grant or project results to be published and presented at local or national meetings. However, some agencies may not allow results to be disseminated through publication or presentation because of copyright, ownership or other considerations. When examining an RFP or NRA, care should be taken to ensure that project participants understand whether or not results can be published. If results cannot be published, the funding agency will usually have the PI and the PI's affiliated organization (e.g., the PI's university) sign an agreement stating that the results will not be published. In academia it is rarely a good idea for researchers to acquire external funding from agencies or programs that do not allow project results to be published.

Finally, when publishing results from grants or projects, it is important to acknowledge the funding agency for their role in the project. This relays to the reader the role that the funding had in the research.

6.9 Final Agency Reports

Most agencies require a final report of the grant that is given to the agency. The final report is usually written by the PI (with help and input from CoPIs) and should detail all project accomplishments and budgetary expenditures. Project accomplishments should include the work performed for the project, papers published or presented as a result of the project, and the impact of the project on existing knowledge. Budgetary expenditures should include a line-by-line summary of all money spent during the project. Justification needs to be given if specific budget line items were overspent or under spent during the project.

Some funding agencies may require the PI to present project results directly to the agency. Take this opportunity very seriously because this is an excellent chance to disseminate project results and a potential avenue to acquire additional funding from the agency.

6.10 How to Deal with Rejection

Funding rates vary according to where proposals are sent, but in general, few proposals are funded, and even fewer proposals are funded the first time they are submitted. It is important to not get discouraged if a proposal is not funded. Rather, consider it as an opportunity to improve the proposal for later submission. Often, even when researchers initially feel otherwise, proposal reviewers raise very good points that need to be addressed. After addressing these points, research projects become much stronger and more competitive for the next submission.

Reference

American Association of Geographers. www.aag.org

Chapter 7
Disseminating Research

Once the proposal has been approved or grant monies awarded and research completed, scholars are obliged to share their research with their colleagues and community. Graduate students are sometimes paralyzed by questions such as how do I turn my thesis/dissertation into usable research for my community? How do I disseminate my research? How do I write and publish a book? How do I disseminate my research online? How do I present my research at a conference? These questions are both valid and legitimate. Indeed, dissemination of research results is a very significant part of the research process. For this reason, no research proposal or research design effort is complete without carefully thinking about how to disseminate the proposed research. Additionally, many grant proposals require that the researcher clearly identify her/his research dissemination strategy. Traditional forms of scholarly communication include oral presentations, posters, conference papers/proceedings, research articles, research notes, and monographs. In addition to traditional outlets, emerging venues—many associated with the Internet—are now recognized as intellectually rigorous and credible forms of research dissemination. A host of new formats and styles have emerged which are popular, including blogs, video diaries, podcasts, online conferences, web pages, among others. Finally, the prominence of a new form of research dissemination under the rubric of outreach dissemination is growing rapidly.

Beyond the conventional format, scientific communication of ongoing and/or completed research is typically possible through a variety of methods—media coverage, press release, research summary documents, flyers, posters, brochures, research briefs, policy briefs, study newsletter, as well as dissemination through community agencies, publications, websites, and listservs and not to forget local events, seminars or conferences and community meetings. It is not unusual for the above formats to interface with or use internet-based platforms, such as Twitter, Facebook, Instagram, Pinterest, LinkedIn, Research Blogs, Social networks, Google Scholar, ResearchGate, and Academia.edu.

Keeping in mind the familiarity of the audience with the subject matter of the research, dissemination can be based on awareness (often the audience may have no

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detailed knowledge of the subject area), understanding (audience requires knowledge of the subject area and should benefit from the research results) and action (this group has skills, knowledge and understanding and may be able to apply aspects of the research results in their works). Accordingly, the emerging researcher must identify stakeholders—initiators (such as other researchers, research projects and research organizations), intermediaries (such as publishers, librarians, journalists, science communicators etc.), target audiences (fellow researchers, teachers, students, policymakers, practitioners, industry, donors/nonprofits and citizen scientists) and management (primarily research organizations and funding agencies/foundations).

7.1 Traditional Formats

7.1.1 Presentations

Professional paper presentations are an important component of any research program. The conference chat is often a researcher's first opportunity to gain valuable feedback from their peers. In many cases, presentations at professional meetings are often works in progress or initial findings. In some respects, conferences are intellectual "fishing expeditions" that allow researchers to test new ideas, novel methods, or new theories that will later be written up as more formal academic papers for publication. For this reason, the paper presentation is an important development in any research agenda. In the following paragraphs, the paper presentation and its individual components are discussed in greater depth.

7.1.1.1 Abstracts

While most conference papers are not written papers, but typically oral summaries supplemented with visual aids (think PowerPoint, overheads, or slides), they require an individual to clearly and concisely articulate the essence of a major project. In nearly all cases, presenters are required to submit short abstracts (100–300 words) that may or may not be peer reviewed as a condition of conference participation. More importantly, it is the overall strength of the abstract and the ability of the presenter to deliver the abstracted work that will draw an audience to attend the presentation and produce a positive outcome. For this reason, the abstract serves as the foundation of any effective oral presentation. Abstracts are also the first description of a research project that a reader or investigator encounters and can determine whether or not the full work will be examined.

All too often though, abstracts submitted in August seldom resemble the March presentations—8 months later. In some extreme cases, titles change or the results contradict the published abstract. While few academics intend to engage in such lapses of good judgment, many abstracts are written with the "best intention" of completing a research project or wishful thinking concerning what the results might be. However, abstracts should summarize research that has actually been completed and not attempt to “project” findings. While the presentation does serve as a sounding board for the researcher and may represent a work in progress, the abstract should be intellectually honest and report only findings to date. A failure to be honest will result in a presentation that is flawed—but more often than not is little more than a literature review. While graduate students are often accused of presenting only “literature reviews”, the fact is that even the most seasoned scholars do the same. In either case, a presentation that does not deliver is still considered to be at-least unprofessional and at worst a negative commentary of your home institution and professional training.

In the abstract below, Wu and Murray (2003) provided an interesting example of a paper that addresses a major methodological problem in spatial science—estimating population. The 190-word abstract then proceeds to outline the proposed method, the results, and estimates its overall efficacy.

> Population information is typically available for analysis in aggregate socioeconomic reporting zones, such as census blocks in the United States and enumeration districts in the United Kingdom. However, such data masks underlying individual population distributions and may be incompatible with other information sources (e.g. school districts, transportation analysis zones, metropolitan statistical areas, etc.). Moreover, it is well known that there are potential significance issues associated with scale and reporting units, the modifiable areal unit problem (MAUP), when such data is used in analysis. This may lead to biased results in spatial modeling approaches. In this study, impervious surface fraction derived from Thematic Mapper (TM) imagery was applied to derive the underlying population of an urban region. A cokriging method was developed to interpolate population density by modeling the spatial correlation and cross-correlation of population and impervious surface fraction. Results suggest that population density can be accurately estimated using cokriging applied to impervious surface fraction. In particular, the relative population estimation error is –0.3% for the entire study area and 10–15% at block group and tract levels. Moreover, unlike other interpolation methods, cokriging gives estimation variance at the TM pixel level.

7.1.1.2 Simple, Short, and On-Time

Beyond the abstract, the presentation is just that, a presentation—not the reading of a paper. The objective is to engage the audience with new ideas, recent results, and perhaps some open questions. The presentation is usually 15 min with 5 min for questions and answers (Q&A). Given the time specifications, the presentation must be well-thought out. Increasingly, conference papers are peppered with audio-visual material; but it is the ideas and the results—not the media, that gives the presentation meaning and intellectual merit.

While graphics and multimedia are now staples at professional meetings and paper sessions, it is crucial that the presentation say something—say anything. It should be clear, coherent and easy to follow. That is, the presentation should be neatly organized around three to five key points, present a brief conceptual framework, and empirical findings. Despite these rules of thumb, many papers often fail to meet these simple criteria and provide the audience with too many points, too much theory, or too much data. In worst-case scenarios, a presenter will present too much of all three and his or her presentation will drone on and on past the allotted time. Alternately, presenters who are technology dependent may encounter sudden and unexpected “technical difficulties” that are unable to be overcome and spell disaster. For these reasons, the conference presenter should be prepared to give an intellectually engaging presentation with or without the availability of multimedia. That is to say, the “bells and whistles” are not as important as the merit of the research.

Beyond the presentation itself, the presenter should be prepared to answer a range of questions from the audience. In the case of the young scholar, the 5 min Q&A session can be a stressful period. However, a well written abstract and a clear presentation go a long way towards reducing the speaker’s anxiety. In most cases, questions are a positive response to the speaker’s paper—it means the presentation has been engaging and sparked interest. In most cases, the questioning is collegial and professional. Yet sometimes—especially in the case of a shoddily-prepared presentation, the open question period can be a negative experience fraught with open hostility and “gotcha” questions. The best way to prepare for the questions of the attendees is to make sure you are prepared and to acknowledge the limitations of the research or in some cases that you just “don’t know”. As always, an honest answer is much better than an evasive one.

7.1.2 Posters

The poster presentation has evolved from simple low tech displays characterized by 4×5 photographs and 8×11 inch maps supported by stick pins to professional grade graphics and text layouts printed using wide-format plotters. The amount of information that can be displayed in a post area of 4 feet by 8 feet continues to grow. Because of new technologies, poster presentations are more popular today and participation in poster sessions continues to grow.

Historically, the poster presentation has been used as a vehicle for displaying graphic intensive research in a more casual environment of a hallway or banquet room. Unlike the formal structure of paper presentations, on-lookers meander through the exhibit area to view 10–20 posters during a single session. The atmosphere is low key and the one-to-one feedback on research is especially valuable. The format allows the presenter to engage in in-depth discussions with colleagues or students over a longer period of time—usually 70–90 min.

Like the conference chat, poster presentations require the submission of an abstract. However, the poster—unlike the talk—often includes the preparation of considerable text materials including an introduction, literature review, and the exposition of methods, the results, and a discussion. In this respect, the poster more closely resembles a research article—just in a wider format. Because of the ease of word processing, many posters can be quickly transformed from conference materials to a finished paper for submission to a journal following a meeting (Table 7.1).

Table 7.1 Forms of scholarly communication

Traditional	Emerging	Outreach
Conference presentations	E-journals	Workshops
Posters	On-line papers and reports	Training
Articles	Information sharing	K-12 curriculum
Proceedings	Illustrated papers	Conferences and symposia
Research notes		Public participation and web-interfaces
Monographs		

7.1.2.1 Better Posters Initiative

In recent years, there has been a movement for better posters and this initiative has been spearheaded by graduate students, like Mike Morrison, who are committed to improving scientific communication and enhancing access to research (Flaherty 2019). Specifically, researchers have raised questions about the traditional approach to posters–specifically posters are excessively cluttered, not "user-friendly", and may not facilitate meaningful discussion at conferences. The results is a movement that focuses on the big picture of the research (i.e. research findings) and its value to production of knowledge and the public good as well as being social media technology friendly (see Fig. 7.1.). In the end, the campaign for changing the dynamics of research posters represents movement in the right direction and focuses on the totality of the research (the proposed format even includes a QR code with a link to the full paper).

7.1.3 Articles

In the social and natural sciences, the publication of research in a peer-reviewed journal is the most important symbol of the researcher's contribution to a discipline or sub-field. In most cases, the article is a substantial work of scholarship and its length is generally between 3500–8000 words—depending on the journal. For this reason, the published peer reviewed article is situated at the pinnacle of the publication hierarchy. Yet, the process of writing an article is a complex combination of art and science.

The best advice for publishing peer-reviewed articles is to write them. While this is obvious, many academics are convinced that an article must be meticulously planned and perfect in every way. As a result, manuscripts often sit on desktops, computer disks, or in hanging files too long and sometimes their shelf life expires (i.e., survey data becomes dated, a similar article is published elsewhere, etc.…).

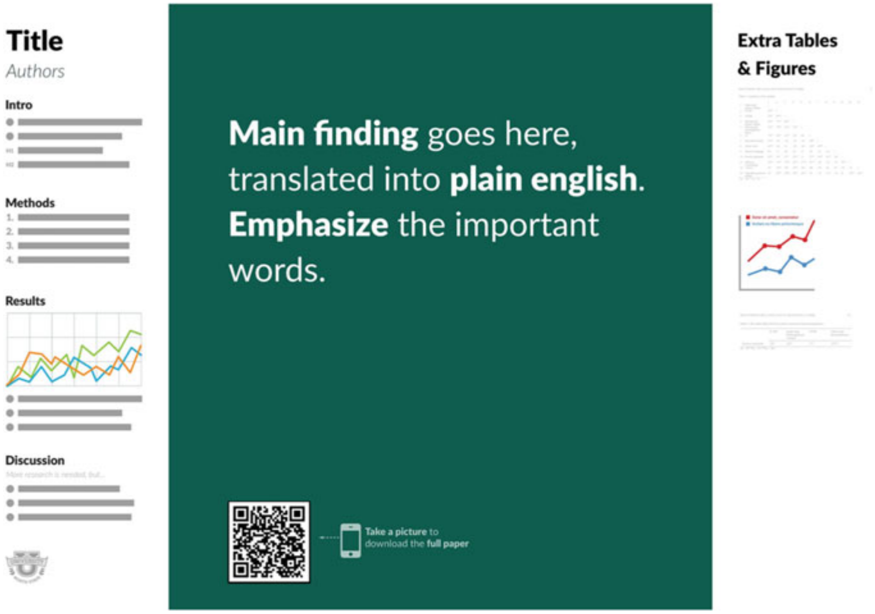

Fig. 7.1 The proposed structure from *Inside Higher Ed* (see https://www.insidehighered.com/news/2019/06/24/theres-movement-better-scientific-posters-are-they-really-better)

For these reasons, authors must prepare a realistic timeline and proceed with all due haste. However, the author should make every effort to insure that a manuscript submitted for publication is of the highest professional quality possible.

Unfortunately, over-planning and timelines may result in an author placing too much emphasis on the mechanics of the article and ignoring the reality that writing is an evolutionary and creative process. For this reason, creativity should be the guiding force behind the writing process as the research has already gone through an elaborate proposal development process and followed a strict methodology. In some cases, creativity is the most pragmatic approach as the results may not be those you expected.

While creativity should be the guide, all articles share a similar organization structure and are expected to conform to the basic structure outlined below:

- Abstract
- Introduction
    - Rationale
    - Initial exposition of the "problem"
- Context
    - Literature review
    - Case background

  - Research Question and Hypothesis
- Methods
  - Data
  - Analysis
- Interpretation
  - Results
  - Discussion
- Conclusion
  - Summary
  - Implications for future research

In terms of the procedures associated with publishing an article, many excellent resources already exist. For this reason, only the general process is outlined:

- Identify potential journal outlets
  - Consider the audience
  - Review recent issues
- Select a journal
  - Follow the exact style of the journal (i.e., citations, length, figures)
    - Consult previous issues and guidelines for authors

Once the manuscript has been submitted, the author should receive a letter verifying their submission is under review. After receiving this letter, the anxious author must wait two to three months or longer to learn of the editor's decision. As a rule of thumb, authors should politely inquire as to the status of the review roughly 90 days after they receive the submission confirmation notice from the editor. The editorial letter (or email) will usually include a cover letter that indicates the editor's decision and highlights the reviewer comments. Additionally, the editor will provide the more in-depth assessments and comments of the reviewer. The editorial decision itself may be somewhat confusing as few articles are accepted as submitted. Instead, editorial decisions are presented in the language below:

- Accept with minor revisions
- Accept with revisions
  - The editor will clearly articulate the desired revisions in the cover letter
- Revised & Resubmit (R&R)
  - The editor will highlight the concerns of the reviewers and request the author to revise and resubmit. Most likely, the revised will undergo full or a modified review process

- Inappropriate for the journal audience
  - Make revisions based on the reviews provided (as appropriate) and submit elsewhere
- Not Suitable for Publication (Rejection)
  - Use the reviews to strengthen the manuscript and submit elsewhere

While every author awaits an acceptance letter, R&Rs, rejections, or suggestions for another outlet frequently occur. However, all authors—even the most recognized researchers in every field—receive these letters and they should not be interpreted as a failure. Instead, use the peer review process to improve the article and re-submit elsewhere. In most cases, you—the author—will agree upon further reflection with the assessment and decision. In those cases where the decision seems to be unwarranted though, it is often difficult to understand how or why the rejection occurs. However, protesting the decision of the editor is seldom a prudent or professional strategy to pursue. Instead, the author should use the review process to improve the article and move-on. Indeed, many major manuscripts from across all disciplines that would eventually be recognized as seminal works have been rejected at one time or another. The important thing is to approach the publishing process as a developmental one and to keep forging ahead as determination and hard work always wins the day. Based on our own experiences, rejected articles have been subsequently revised and later published in more appropriate and even more prestigious journals.

7.1.4 Proceedings

The proceedings paper is an extension of the conference paper presentation and is a more detailed version of the presentation. The papers are similar to research articles—although usually shorter. In some cases, the proceedings are a collection of invited papers from a conference that are published as a single volume. In some cases, individuals are invited to submit papers for publication prior to the conference. However, some proceedings volumes are composed of papers solicited by the conference organizer after the presentation based on the response of the attendees. In most cases, conference proceedings are peer reviewed in some fashion. Yet, the proceedings peer review process is seldom as rigorous as the journal article.

7.1.5 Research Notes

The research note is an abbreviated article that focuses primarily on "works in progress" and tends to emphasize empirical observations or novel methodological approaches. According to the submission guidelines for the *Social Science Journal*, "research notes are works in progress where the Note seeks to make a contribution to the "established" body of knowledge and/or where the Note raises important questions and seeks solutions to recognized problems." Generally, the length of the note is less than 3500 words inclusive of bibliography, captions, and tables. The research note is intended to signpost the emergence of new research areas or concepts. Like the article, the research note is peer reviewed and the same rules apply.

Included within the definition of research notes are special sections of many journals dedicated to short notes on specialized topics. Examples of these special sections include *Tijdschrift voor Economische en Sociale Geografie's* The Netherlands in Map*, Southeastern Geographer's* Changing South, and the *Journal of the American Planning Association's* Practitioner's Notebook.

7.1.6 Monographs

Since this book deals primarily with writing proposals, the primary work product will be the thesis or dissertation. Of course, many resources exist that outline detailed strategies for completing graduate school and the thesis or dissertation—but few resources acknowledge that the thesis and dissertation are often the first professional contributions of emerging scholars and the importance of this initial enterprise and academic citizenship. While the purpose of the thesis is to demonstrate the ability to conduct research and the dissertation demonstrates a scholar's potential to make a significant contribution to the literature, these documents are important monographs. As monographs, the thesis and dissertation are testimonials to the scholar's training, program, and—given the committee structure—an individual's collegiality. For these reasons, the proposal writer should conceptualize the thesis and dissertation as research dissemination and be mindful of its status as a professional publication. Unfortunately, most students tend to emphasize the process and the training experience and miss the monograph's true nature as a publication. For this reason, the thesis and dissertation are sometimes stale exercises. However, students who pay special attention to the work as a monograph will be better positioned to transform it into publishable articles and possibly a book manuscript. Finally, the growth of ETD [electronic theses and dissertations] initiatives at major universities has increased the visibility of these monographs and greatly expanded their potential audience.

In addition to theses and dissertation, technical reports are another type of monograph. Technical reports are prepared primarily as a result of contracted research (for e.g. the World Bank, the Brookings Institution, USDA, EPA and other Non-Profits etc.). However, competitive grants often include provisions for the preparation of a technical report at the close of the grant period as a condition of the award. In either case, the researcher should be aware of the report requirements, guidelines, and relevant agency policies and procedures. At the most basic level, the technical report is a summary of all project activities and provides a detailed accounting of research expenditures. Over the past several years, technical reports have become considerably more visible scholarly contributions as they are often posted to the World Wide

Web by public agencies or the contracting organization. While the technical report provides a measure of accountability, the reports are also unique case-specific scholarly contributions and an important resource for scholars—particularly individuals interested in public policy issues. The emerging importance of the technical report coincides with an increased demand for outreach dissemination (to be discussed in greater detail later) that targets not only scholars, but also policy stakeholders and the public at large.

7.2 Emerging Venues

The growth and expansion of the Internet, other electronic media, and the high quality of Adobe Corporation's high resolution portable document file (PDF) structure have contributed to an explosion of scholarship on the web. Similarly, the increasing prominence of graphics software, GIS, and other visual aids has expanded the scope of traditional papers and posters as a means of disseminating research.

7.2.1 E-Journals

Electronic publishing has been embraced across nearly all social and natural science fields. Today, a robust collection of peer reviewed and non-peer reviewed outlets for research dissemination exist. Examples of premier peer reviewed electronic journals include *Ecology & Society* [www.ecologyandsociety.org], *Social Science Research Network* [ssn.org], *Geochemistry, Geophysics, Journal of Applied Remote Sensing* [https://spie.org/x3636.xml], *Geosystems* [gcubed.org], and many others. Many of these on-line resources, known as open access journals, are catalogued as part of digital library initiatives such as the Directory of Open Access Journals [www.doaj.org] and E-Journal Miner [ejournal.coalliance.org]. Over the past several years, the prestige and quality of on-line journals has grown considerably based on assessments of their citation impact, professional archiving practices and inclusion in major abstracting services. Today, many major learned societies have at-least one on-line venue.

7.2.2 Working Papers and Technical Reports

In addition to electronic journals, the Internet has revived the honored tradition of working papers. At research centers, such as the Regional Research Institute [www.rri.wvu.edu], the works of center-affiliated scholars are posted directly to the web. With the renewed visibility of working papers series, the quality and variety of working papers has improved significantly and now rivals peer reviewed journals.

Like working papers, the Internet has made technical and government reports much more available than they had been in the past. The contract related reports and policy papers are now much more accessible. Where reports were once an almost hidden publication venue with limited visibility, resources such as the Government Printing Office's GPO Access [www.gpo.gov] and UN Publications [www.un.org/pubs] as well as those produced by multilateral and bilateral funding agencies such as the World Bank, IMF, EU, ADB etc. have made technical reports an invaluable research resource.

7.2.3 Information Sharing

In addition to those resources that are electronic versions of more established forms of scholarly communication, new more radical approaches towards information sharing have also emerged. The open access concept has resulted in a new wave of information sharing that results in directly posting data and results to the web. While this unorthodox approach may seem to be of little value to the traditional academic, spatial data sharing networks and public participation GIS have occupied a major role in contemporary spatial science networks. However, the decision to publish directly to the web (without peer review or any formal organization affiliation) is a risky strategy. Questions of copyright, the intellectual merit of web-publication, and the professional-career implications of direct open access "publication" remain uncertain. As such, the decision to publish directly to the Internet should be carefully considered within context of one's career and desired goals.

7.2.4 Illustrated Papers

In recent years, a hybrid conference presentation has emerged called the illustrated paper. The illustrated combines components of the casual atmosphere with a more formal and brief oral presentation of 5–7 min. During the 5–7 min presentation, the presenter provides an overview of the work and guides visitors through the poster. Once all of the posters in the session have made their presentations, the audience will approach posters and presenters individually to discuss the research. The illustrated paper—like the poster and paper—requires an abstract be submitted and includes all of the components of the traditional poster. Unlike traditional poster sessions, the illustrated paper regularly has less than 10 papers per 90 min session.

7.2.5 Web Research Aggregators and Resources

Since around mid-2000, several networking platforms such as Google Scholar, Research Gate, Academia.edu, ResearcherID, and ORCID have emerged to facilitate professional, academic and research networks with the attendant emerging technologies boosting researchers' visibility and exchange of ideas. These social networking platforms provide unprecedented opportunities to connect with peers and colleagues for sharing information and dissemination of new ideas. For some emerging as well as established spatial science professionals these platforms can be a low-cost way to create a web presence.

While these platforms have become prominent in the market today, other more traditional forms of social networking such as Twitter or LinkedIn also continue to be used by many to manage one's personal online presence, promoting research (Wilson and Starkweather 2014). That ResearchGate has emerged as the most popular platform among scholars of all hue and color is largely due to the simplicity of their use and their adaptability to the researcher's need. Before the emergence of these platforms researchers were very limited in their visibility and depended upon library catalogues and their subject indexing routines. The significance of these academic web platforms also emerges from demands made by higher education administration who encourage faculty to engage in these public platforms for greater research visibility and so much goes beyond the scholarly context, facilitating informally for research funding institutions, government and accreditation institutions. Thus, in a competitive research landscape not just emerging spatial scientists, but virtually anyone interested in maintaining a research career can no longer afford to just publish and expect visibility. These networking platforms are here to stay, and hence graduate students must dive into these platforms early enough to understand and be on top of a range of issues pertaining to shifts in pedagogy, research impact and outreach. Clearly, these networking platforms in today's fast changing knowledge economy come with shifting everyday practice in the academy offering vast opportunities, and challenges in the research ecosystem.

7.3 Outreach

In the previous pages, several types of outreach dissemination have been discussed. The increased emphasis on outreach dissemination has grown out of the university's renewed interest in economic development and community engagement. The intent of outreach is to share university work-products with stakeholders throughout society—not just those sited on college campuses. Additionally, outreach efforts are specifically targeted to individuals and groups from under-represented communities and attempts are made to integrate public participation when and where appropriate. In addition to web-based interfaces that have made scholarly communication almost ubiquitous, research dissemination associated with outreach includes workshops,

Fig. 7.2 COVID-19 Dashboard (https://coronavirus.jhu.edu, accessed 4/16/20)

conferences, business symposia, training, and k-12 curriculum. Currently, many grant opportunities exist for researchers interested in designing and implementing community-based research that focuses explicitly on outreach activities.

With respect to geography and spatial science, the explosion of web-based technology and online GIS servers have made spatial data accessible to the public. Indeed, the Johns Hopkins University & School of Medicine's Coronavirus Research Center's COVID-19 Dashboard proved to be a critical resource for the nation and underscores the importance of spatial science and spatial data in everyday life (see Fig. 7.2.).

The COVID-19 example is one of many spatial data solutions that have made research and real time data sharing possible through ESRI's ArcGIS web-based platform. As a result of web-mapping capabilities, ESRI's continued to innovation and provided everyday users, community organizations, and others with the opportunity to leverage the power of GIS to promote positive change, share data, or heighten visibility for a critical initiative vis-a-vis their highly visual "story map' framework. One example is the University of Louisville's (U of L) Tree Map (Fig. 7.3). The U of L example provides the community with an overview of sustainability efforts across the university–and especially focuses on the campus' commitment to urban forestry and the Tree Campus USA program. In the end, the story map innovation builds and expands on the highly successful and engaging Public Participatory GIS movement (see Fig. 7.4) that provides community members and non-experts with access to spatial data to promote better decision making. Finally, it is important to note that in addition to specialized technology and web mapping applications, the ubiquitousness of social media and the ability to promote research across multiple

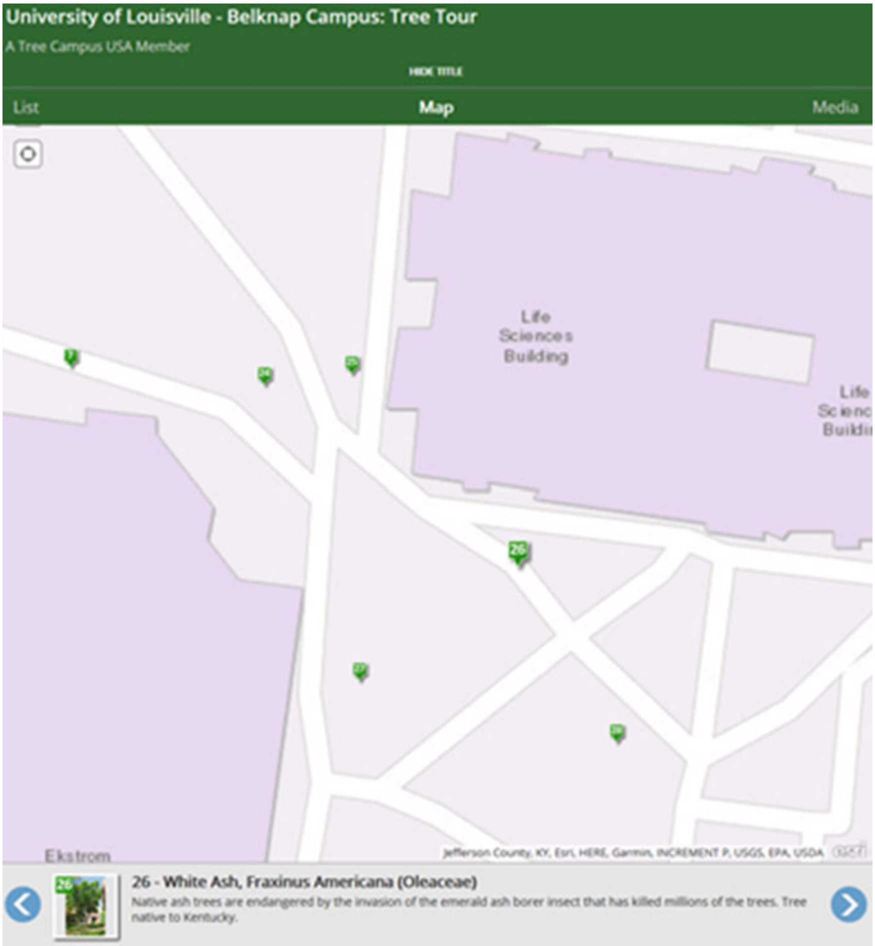

Fig. 7.3 University of Louisville, sustainability initiatives: trees of interest (Created with Arc Story Maps, https://louisville.edu/sustainability/operations/grounds, accessed 4/16/20)

platforms that engage non-specialists has made all academic research more accessible, impactful, and relevant. As such, outreach and cross cultural communication strategies are essential elements of the modern academic.

7.4 The Problem with Spatial Science Research

One of the persistent problems with spatial science (and the closely allied discipline of geography) is its interdisciplinary nature. Indeed, a large percentage of the scientific community holds the misconception that interdisciplinary research results in

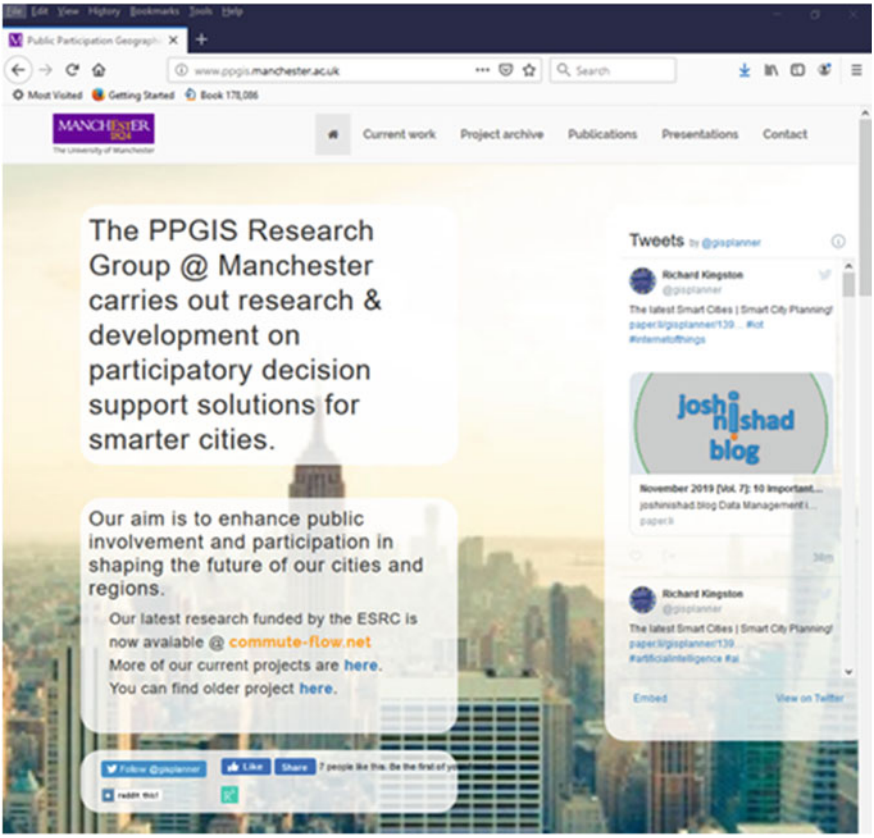

Fig. 7.4 Public participatory GIS [https://www.ppgis.manchester.ac.uk/, accessed 4/16/20]

"bad science". While strict disciplinarians in social and natural sciences may hold this view, spatial science and geography are correlative disciplines (Chappell 1989). As a correlative and continuously emerging enterprise, spatial science does not have a single recognized disciplinary template for disseminating research (see Jakle 1989). Whereas historians have narrative, sociologists use case studies, and natural scientists use author research letters, spatial science seldom fits neatly into any single format or structure—be it a conference program, journal outside geography, or book proposal. Indeed, the diversity of human, physical, and geo-technical research known collectively as spatial science share only a concern for spatial patterns and processes. For this reason, presenting and publishing research requires special attention to the audience and format structure. In spite of these structural impediments associated with discipline identities, spatial science is an innovative and creative research area that has much to offer other fields. For this reason, it is essential that the work of spatial scientists be published and presented in high visibility and high quality venues.

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Chapter 8
Reflections on Proposal Writing in Spatial Science

The research process is just that, a process. In this book, we have examined the process of research design and proposal writing. Yet, the focus of this book—and the accompanying proposals—is how to "propose", "do", and "write" spatial science research.

Spatial science is distinct from the other social and natural sciences in that it combines components of each and allows for a unique synthesis of historically aspatial perspectives. The principle challenge facing spatial scientists is to articulate the importance of their research and the specific benefits of looking at social and physical problems from a spatial perspective. In some cases it's obvious—in others it may not be. The challenge facing spatial scientists is to clearly state the "geographies" and spatiality of their research in an accessible style that is consistent with the work of all scientists. Historically, though, the original spatial scientists—geographers—have been unable to accomplish this from time to time and the waxing and waning fortunes of the discipline demonstrate this. Today though, new technologies, as well as the traditional tools and concepts of geography transcend discipline boundaries and have infused the natural and social sciences with the language of the collective spatial sciences. The novice emerging spatial scientist stands at crossroads with a community now demanding the use of 'open access', user-friendly methods and approaches demystifying the complex aspects of our research. Therefore, today's spatial science graduate attributes demand knowledge, attitudes, skills and values befitting the global knowledge economy which will facilitate the navigation of a shifting neoliberal landscape with implications for higher education as well as future research directions for spatial science (Boyle et al. 2015; Hill et al. 2016; Rutherford 2015). To that end, the previous chapters and model proposals to follow equip researchers and students with the skill sets and knowledge necessary to prepare, propose, and present high quality research.

In Chap. 1, the scale and scope of contemporary spatial science was considered. Based on the review of the field and its thematic diversity, it should be evident that the spatial perspective is relevant and when creatively combined with emerging technologies truly on the "cutting edge" of contemporary academic research. But beyond

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academics, spatial science is increasingly used to solve practical problems. Indeed, geo-technologies are now staples found in nearly every planning and economic development office, commercial real estate development firm, soil conservation center, biology research station, and environmental protection agency.

In Chaps. 2 and 3, the nuts-and-bolts of proposal writing and research design are presented. In Chap. 2, the structural dynamics of the literature review are presented—as are practical tips on “how to” develop a literature review. The chapter begins by clearly articulating the function and importance of the literature review. Chapter 2 is useful in that it has the potential to serve as an important resource for students who often have difficulty performing effective literature reviews. Likewise, the literature discussion includes a series of suggestions concerning the style and organization of literature reviews. Chapter 3 expands on the literature review insofar as it addresses the second most important task facing researchers—the research question. The chapter effectively differentiates between research questions and hypotheses while being mindful of the many pitfalls facing researchers as they identify and articulate their research questions and hypothesis. Finally, Chap. 3 recognizes that research is a very personal experience. While the language and structure of science is often objective, research itself is a very personal experience and successful research requires that students and researchers be committed to the project and take ownership over the entire process.

Chapter 4 reviews a range of data and methodological issues facing the quantitative, as well as qualitative researcher. This chapter provides the reader with a road map that enables research questions to be answered. The chapter includes a discussion of the hierarchy of data, data collection, and data analysis. Additionally, the chapter addresses a range of ethical issues facing researchers that preserve the integrity of science and protects research subjects.

In Chap. 5, the structure of thesis and dissertation proposals is considered in greater detail and intended to provide the reader with a ready resource as they write their proposal. The intent of Chap. 5 was to provide a recipe that included a discussion of major components of a successful proposal and defense. Chapter 6 examines the challenge of securing research monies. In an era of shrinking budgets, the identification and successful receipt of grant monies are especially significant and in some cases required to perform research. The chapter examines the full range of external funding opportunities that exist including competitive research grants, sheltered competitions, and contracts. Finally, Chap. 7 reviews the full range of dissemination possibilities that are available to the contemporary researchers. The chapter defines each format and discusses the purpose, structure, and format of each.

In summary, we hope that this book will prove to be an invaluable resource for students and established researchers alike. While the treatment of the topics was not intended to be exhaustive, we believe that it should provide the novice researcher with a solid foundation for writing an effective proposal. Additionally, we endeavored to provide more complete discussion of some topics—literature reviews, research questions, grant writing, and dissemination of research—than are found in most proposal writing resources. Additionally, we endeavored to tailor the concept of proposal writing to a specialized collection of researchers and to provide a broad collection of successful model research proposals.

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Chapter 9
Model Proposals

Proposal writing is a skill that a scholar develops throughout her/his career. Indeed, writing itself is a development process. As the following model proposals illustrate, the style and prose of scholarly writing is evolutionary and as you read the sample thesis, dissertation, and grant proposals this should be apparent. That is to say, the purpose and audience of each document determines the scale, scope, and structure of any proposal. For example, master's theses demonstrate a student's capacity to "do research." In contrast, dissertation proposals define a gap in the literature and provide a road map for making a new contribution. In the case of grants, the proposal serves not only as a vehicle to propose novel research—but also serves as a tangible means of establishing the overall credibility of an applicant as an effective researcher. To that end, please remember the purposes of the various proposal types and pay special attention to the structure and organization of each of the models. While the language may vary slightly between the models (i.e., conceptual framework versus literature review), they share the same basic structure. In the case of competitive grants, the structure and format of proposals is solely determined by the funding agency and highly prescriptive.

Each of the models included in this collection has been selected as they have specific features that make them unique. In some cases, the exposition of the data or methods section, graphics, or budget features are distinct. In all cases, the unique features of each are noted in the prefatory comments and reflection. Additionally, we—the authors—have endeavored to identify a diverse collection of models from across the spatial sciences. Further, all of the proposals have been successfully defended and/or grants have been awarded. In addition to the proposals in this book, sample proposals can now be found at any number of sites on the internet. Yet, most of the sample proposals available on the internet are often from fields outside of the spatial sciences. In many cases, online samples have been posted by graduate schools to demonstrate the proper formatting procedures and/or approved citation styles. Insofar as formatting of all proposals is often critical for final approval by a graduate school central office, these samples are useful guides. Hence, online thesis

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and dissertation samples are not necessarily selected based on the overall quality of discipline based research.

In closing, we believe that students and established scholars alike can use these examples as a guide to successful proposal development as samples are often better roadmaps than texts or proposal guidelines. Indeed, it is often difficult to find relevant model proposals prepared by geographers, planners, or other allied spatial science fields. Based on our own graduate school experiences, students are often referred to completed theses or dissertations. Indeed, we have often found ourselves encouraging students to look at the first three chapters of completed theses or dissertations. Unfortunately, as we have noted earlier, completed works are seldom effective proposal development guides as research projects evolve over time. In the area of research grants, the competitive nature of funding agencies inherently limits access to sample proposals and would-be investigators are often limited to viewing public abstracts disseminated by grant agencies. Similarly, investigator requests to obtain successful sample proposals from campus based sponsored programs offices often fail to yield proposals in or near one's own research area—and in some cases no models may be available for a given program area. On a more personal note, we earnestly hope these samples will assist you as we believe our own careers would have benefited from such spatial science specific resources.

The samples are organized by general type and broad area of expertise. The models include thesis and dissertation proposal examples that investigate human systems, physical systems, human-environment interactions, and geo-techniques. The grant samples have been selected as they represent traditional research grants, instrumentation grants, and intra-mural grants.

9.1 Online Resources

As mentioned above, many online resources exist. Below, we have identified a few that may be useful to review in conjunction with this volume's examples. In fact, many online resources are especially useful relative to assisting with the mechanics and structure of proposals.

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University of Westminster. 2019. How to write your research proposal. https://www.westminster.ac.uk/study/postgraduate/research-degrees/entry-requirements/how-to-write-your-research-proposal

Chapter 10
Thesis I: Human Systems

Eric W. LaFary

This proposal is an example of an integrated GIScience approach to investigating urban social issues. Additionally, the proposal demonstrates that a thesis proposal is just that—a proposal. Whereas some thesis proposals may appear to be nearly completed works, this proposal is an example of a common—but effective—research proposal. The proposal identifies the key issues, methods, and study area and sketches the core theoretical framework that informs the study. As this is a master's thesis, the proposal focuses heavily on data and methods to demonstrate the author's understanding of the research process.

The exploration of urban-environmental changes and how those transformations co-vary with observed socio-economic realities is currently a major research initiative in geography. To that end, I propose developing an urban-environmental assessment regime that examines how environmental change co-varies with observed socio-economic conditions. Research has demonstrated existing linkages between observed SES conditions and a particular greenness index, as represented by, normal difference vegetation index (NDVI). However, a gap within the literature has been discovered concerning the current methodologies that propose to predict SES from a remotely sensed image and the resulting classification. Therefore, it is my intent to address this gap within the related literature, providing a solution that can subsequently be generalized to urban systems distinct from the study area—Evansville, IN. Further, this project will explore the observed relationship between socio-economics (e.g. race, class, and income) and observed urban-environmental change.

Spatially-dependent socioeconomic differences within many cities are evident. However, not so clearly visible are the social inequities that co-vary with the urban forest and greenness more generally. This research will examine the average amount of greenness present at the block group level. Statistical analysis will be performed to determine the significance of covariance between NDVI and indicators of urban quality of life (UQL), namely, socioeconomic characteristics of the Evansville, IN study area. Geographically weighted regression (GWR) and ordinary least squares (OLS) regression will be utilized to determine the significance of discovered covariance among population density, mean NDVI, minimum NDVI, standard deviation

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for NDVI, range of NDVI, and for an interaction term defined by the mean NDVI multiplied by the population density of each block group. Six distinct variables that demonstrate socio-economic realities present in the study area will be used as proxies for UQL. Subsequently, ArcMap will be employed to develop maps representing the values produced by the various techniques to further explore the spatial make-up of greenness and socio-economic covariance.

10.1 Research Questions

(1) Does a relationship exist between urban quality of life (UQL) and normalized difference vegetation index (NDVI)?
(2) How do the performance of geographically weighted regression (GWR) models vary relative to models tested using ordinary least squares regression (OLS)?
(3) What can the combination of applied RS/GIS techniques and socioeconomic data lend to the urban planning process?

10.2 Evansville and Green Policy

Green initiatives have demonstrated the added value to the quality of life for residents (Gatrell and Jensen 2002). Therefore, to understand potential findings from this research, practices on the ground in regards to green initiatives must be accounted for. The Department of Parks and Recreation (DPR) controls 65 parks and 21 special facilities with holdings of more than 2,300 acres of land within Vanderburgh County (City of Evansville\Vanderburgh County). The mission of the DPR is "creating quality of life opportunities by providing safe environments and affordable programs to enhance fun, fitness, and education for residents of all ages in [the] community" (City of Evansville\Vanderburgh County). However, the mission of the DPR should be examined critically as it is loaded with relative language such as "affordable…for all residents" (City of Evansville\Vanderburgh County). Access to parks and publicly owned facilities can be and often is restricted by barriers in regards to costs associated with travel and entry into said facilities. Indeed, Evansville, IN has an ordinance established to focus energies and attentions toward the preservation of green spaces located within the city limits. In particular, a tree board was established to oversee and enforce the characteristics of the policy aimed at protecting existing trees. Specifically, Evansville has ordered that trees located upon city property are protected from destruction or removal. In addition to trees on publicly held property, the urban forest canopy is sheltered from haphazard pruning or removal. Evansville requires that any activity involving the removal or pruning of trees must be carried out by a licensed professional—in this case an aborist. There have also been intermittent efforts to give away trees through Keep Evansville Beautiful. While it is evident that trees currently inhabiting Evansville are protected, just as important to urban quality of life is new investment and the expansion of existing facilities. Again, the mission of the DPR is to increase the quality of life for residents of the local community. Ironically, the project heralded at the head of the DPR website will at best tangentially effect life for the residents of Vanderburgh County. The Pigeon Creek Greenway Passage is a section of land located along Pigeon Creek and extending to the Ohio River. While this anticipated $2.2 million dollar project is expected to give visitors an overview of the area's history—the passage will function as a scenic route for visitors of Vanderburgh County attending the local riverboat casino and therefore will be less likely to directly benefit the citizenry of the municipality. Of course, the quandary represented is one often revisited in local politics—discovering the equilibrium that will continue to encourage private investment while increasing the urban quality of life for residents of the immediate locale. In this instance, it remains to be seen which direction the scales of policy are tipping.

10.3 Literature Review

10.3.1 Human-Environment Interactions

The complex interrelations of natural and social materials and the products of the interactions between and among those systems and their consequences of human alterations on the urban landscape are the foci of this research and a major interest to geographers. An understanding of the characteristics of water, the urban canopy, agricultural spaces, and the built environment are key to developing an appropriate methodology toward the study of these systems. However, it is the amalgamate of all these distinct urban morphological behaviors that will facilitate a better understanding of how to examine the environment housing much of human populations throughout the world. Literature in this sub-discipline is currently sparse; however, a handful of articles have begun to elucidate the inter-disciplinary structure of human-environmental processes.

The discovery of connections that exist among socio-demographic phenomena and observed vegetative indices has, for many researchers, proven rather difficult. Muller and Gossette (2005) developed a study to determine whether one is able to discern the urban quality of life (UQL) from the sole data of a remotely sensed space-borne image. Limitations of Census data were defined, while the varying spatial resolutions of census data were noted as a particularly promising attribute of the data set. Furthermore, the resolution of census tract data does not accurately reflect the temporal dynamic that is characteristic of much social and structural reorganization within urban environments. In contrast to census data, satellite imagery is routinely updated thus, presenting a more accurate portrayal of urban morphological transformation and a better representation of urban change. Census tract data are utilized for this study. This research addresses the overabundance of available census data by performing principal component analysis to delineate the variable combinations most likely to explain covariance within the data set. Moreover, normalized difference vegetation index (NDVI) was employed to categorize the amount of green vegetation visible in the satellite imagery. The results produced by the particular methodology used for this study were mixed. That is, while UQL was not shown to statistically co-vary with housing density, the covariance discovered among NDVI values and other socio-demographic factors resulted in findings that demonstrate the need for further research.

Radeloff et al. (2000), working with similar data sets as those examined by Muller and Gossette set out to view the proposed interconnectedness of census data and land use and land cover (LULC) classifications. The posited outcome of this research is unique insofar as most studies investigating the combination of Census data and remotely sensed imagery have been to enhance the classification and not to draw causal inferences. Census block data were extracted and subsequently employed. Housing densities were calculated and census blocks were placed into one of seven density classes. The significance of identifying and ultimately classifying water blocks was discussed. Water blocks are areas that are unable to contain human population thus, it is important that they are kept separate from blocks without housing units for reasons obvious to analysis. A LULC classification was produced from the satellite image and census blocks depicting housing densities were superimposed to facilitate comparison. One hurdle that had to be overcome was the reality that the spatial resolution of census data did not mirror the 28.5 m $\times$ 28.5 m resolution exhibited by the Landsat image. Modifications were made, by converting the raster image to coverage and subsequently manipulating pixel size to match the superimposed image. This particular study, while not directly addressing any causal relationships, provided the framework from which causal hypotheses could be constructed. Further stated was that the relationship between housing density and a particular biomass index is not one sided, but, in fact, an interactive relationship that must be examined from various perspectives was evident. Therefore, a staging area from which research aiming to marry census data with remotely sensed imagery can launch. Ultimately, constructing a scientific basis on which future research may be anchored.

Jensen (2004) studied the covariance associated with leaf area index (LAI) and population density. Jensen elected to examine LAI as it co-varies with population density, rather than using housing density, as did previous studies. The study was further expanded to include median housing values as well as median income. The parameters proposed for this particular body of research have been developed to address the growing concern of equitable distribution of natural resources within the urban environment. Furthermore, detailing the implications associated with the distance one may live from urban green spaces was discussed. Previous research has determined that socioeconomic conditions and the availability of urban forestry have been linked to a full range of observed conditions (see Heynen and Lindsey 2003; Jensen 2004). Ultimately these patterns suggest that the closer one lives to an urban green space the more likely it is one has obtained higher education and overall elevated social status. Also elucidated, is the effect of distance decay for property values as area increases between green spaces and personal property. Numerous health and environmental factors are cited as evidence to support these findings

(Jensen 2004). To facilitate the modeling of socio-economic characteristics as co-varied with LAI the expansion method was utilized to statistically account for variance not directly modeled by the variables used in the construction of the OLS regression model (Cassetti 1972). The findings for this work were that, at least in part, socio-spatial characteristics of the urban environment could be effectively modeled and predicted from observed leaf area index. The statistically significant covariances of a biomass index and socio-economic characteristics as recorded by the Census have been demonstrated by a handful of researchers, including Jensen (2004). Gatrell and Jensen (2002) take what is intuitively the next logical step, the creation of public policy, aimed at addressing the socio-economic conditions as they relate to the urban forest canopy and addressed by the previous studies.

Programs created to advance the level of a community's quality of life have centered upon sustained and enhanced economic development. Often, forest amenities do not enter into the dialogue of city planners and others involved in the planning process (see Gatrell and Jensen 2002). However, increased urban forest canopy cover has been demonstrated to increase a number of factors that influence not only a community's economic viability, but also the overall quality of life. Informing both traditional and 'greener' economic agendas, this paper has the goal of developing a smart- growth agenda that embraces the needs of the disparate political camps involved (i.e. pro-growth, no-growth, and smart-growth) (see Gatrell and Jensen 2002). The smart-growth agenda proposed identifies such economic benefits as lower utility costs, increased property values, and reduced expenditures in many arenas of public infrastructure maintenance; furthermore, ecological benefits include reduced levels of airborne pollutants, less dependency on fossil fuels, and fixing carbon dioxide from the atmosphere (see Gatrell and Jensen 2002). This study further demonstrated, through the comparison of two cities with distinct economic programs, that 'greener' economic policies produce tangible as well as indirect positive results for residents. Ultimately, this particular study illustrates the need within geography to develop more sophisticated techniques of studying the urban forest and its interactions with the surrounding municipality.

10.3.2 Supervised Classification

Supervised classification is a widely used and accepted technique of delineating boundaries owned by various land cover types. This particular method of classifying the often disparate land covers and uses within a remotely sensed scene has proven effective in the land cover classification in diverse areas such as agricultural land, forest cover, as well as, within the urban environment. For instance, Harris (2003), aiming to discover the agricultural land use change in Oman, compared the effectiveness of both supervised and unsupervised methods of classification. Employing a seven-vegetative-class scheme, the author found that supervised classification was more effective in separating the different agricultural crops (Harris 2003).

Supervised classification has also been shown as an effective classification approach for demarcating tropical vegetation in Thailand. Trisurat et al. (2000), developed a strategy to discover whether supervised or unsupervised classification was a more highly effective technique. Supervised classification is the process of the GIS user manually selecting classification kernels based upon knowledge of the study area as well as individual experience. Unsupervised classification, on the other hand, is the process whereby the user commands the software to select earth surface features or classes with similar spectral characteristics and subsequently group those classes into an arbitrarily selected number of groups. This study demonstrated by means of accuracy assessments that supervised classification was better able to discriminate vegetation types than was unsupervised classification (Trisurat et al. 2000).

Weber et al. (2005) implemented a methodology aimed at examining the movement of settlements within the metropolitan area of Athens, Greece. Multiple modes of inquiry were employed to discover the most accurate technique to locate, classify, and subsequently track the movement of defined settlement zones in the study region. The method identified as having the most accurate results at determining the settlement zones was a combination of visual inspection of a remotely sensed scene in combination with supervised classification of the image (Weber et al. 2005). The results of the three previously mentioned studies clearly demonstrate the utility and posited accuracy of supervised classification of a remotely sensed image.

10.3.3 Normalized Difference Vegetation Index

Normalized Difference Vegetation Index (NDVI) is a technique of determining the amount of vegetation within a remotely sensed image. The method gives an average for each pixel located in the study area. NDVI is a widely used and accepted technique of evaluating greenness in both rural and urban regions. Calculating the difference between the short-wave infrared band and the near infrared band and then dividing that by the sum of the same two bands produces the value. The values fall between -1 and 1. With -1 representing no vegetation for that pixel and a value of 1 discerning a pixel with an abundance of green foliage. NDVI has been utilized for a variety of studies and has been shown to be one of the most effective vegetative indices currently available.

Sato and Tateishi (2004) determined the effectiveness of NDVI to elucidate the interactions between the atmosphere and earth surface objects. This study focused upon diverse areas consisting of vegetation from lush to very sparse. Basic NDVI was slightly modified by taking into account the number of months when reflectance values of the short-wave band were higher than reflectance for near-infrared. The modified form of NDVI was found to be more effective when classifying non or sparsely vegetated areas; thus, illustrating both the effectiveness and versatility of the NDVI technique.

NDVI has also been shown accurate when classifying grasslands in Victoria, Australia (Dilley et al. 2004). In this instance, NDVI is employed to improve a technique used to determine the level of fire risk for dry-grasslands. Commonly accepted to determine the likelihood a fire will occur has been the Fuel Moisture Content (FMC) scheme. The authors proposed pairing NDVI with the Grassland Curing Index (GCI) anticipating the result of a more accurate classification of grassland fires. This study demonstrates the effectiveness of NDVI to accurately determine the amount of vegetation present in a remotely sensed scene by using the index to develop a better method of assessing fire risk.

10.3.4 Regression Analysis

A core assumption of normal linear regression is that data are uniformly distributed across the modeled area. However, in geo-statistics, much of the data mapped within linear regression schemes are, in fact, non-stationary (Fotheringham 1998,1999). That is, it is unlikely that a particular set of findings within a study area apply equally to the entire data set. Another impetus to create a modeling scheme that can statistically address those areally contingent occurrences is the reality that many relationships likely do not display discontinuity (Fotheringham 1999). More specifically, the phenomena under examination are not necessarily constricted by the boundaries of polygons under review. Thus, one potential solution to this issue is geographically weighted regression (GWR). GWR is essentially a modified form of the normal linear regression model. The GWR model, however, allows for the parameters of the equation to vary spatially. Thereby, the inherent spatial non-stationarity of the data set is accounted for. This statistical approach reverses the traditional vantage point of geo-statistics by approaching the research from a local, rather than a global perspective (Fotheringham 1997). GWR places more weight on observations occurring nearest the specified location with descending weights placed as distance is added from that locale. The combination of modeling a local perspective of the data as well as allowing the weight of the parameter to vary spatially adds an element of 'realism' to the examination of the spatial study of localities (Fotheringham 1998). Two valuable products of GWR are that it "provides one of the few explicitly spatial visualization techniques and that the output from GWR is a set of maps of parameter variation over space" (Fotheringham 1999). GWR has been implemented on a handful of studies yielding results that are quite promising for spatial studies.

Huang and Leung (2002) used geographically weighted regression to examine the spatial structure of the industrialization process occurring in Jiangsu Province, China. The authors stated that using an ordinary least squares regression (OLS) model would misrepresent the observed phenomena by not allowing the parameters to vary spatially. That is, OLS assumes that regardless of population density, geographic phenomena occur evenly across space. More specifically, that poverty is found in similar distributions across any particular area of interest. Moreover, employing

GWR will model data in a manner consistent with actual geographic and economic observations. The findings from this study demonstrated that models created by the modified GWR algorithm were significantly more accurate than those from the OLS formula. One further study implementing GWR was that of Hanham and Spiker (2005).

Hanham and Spiker (2005) attempted to alleviate the difficulties associated with applying non-spatial methods to the spatial study of urban sprawl. More specifically, they "explore the potential for using geographically weighted regression (GWR) to modify image regression change detection technique to account for the spatial structure of the data generated by satellite imagery" (Hanham and Spiker 2005). This study produced results for GWR models that were significantly better than more commonly used a-spatial regression models such as OLS; thus, providing further impetus for the continued use of GWR to explore the non-stationarity inherent to geographical research.

In addition to GWR, other methodological schemas have been developed to address the concerns inherent to traditional regression most appropriate for data exhibiting stationarity. For instance, the expansion method attempted to account for spatial variance in observed phenomena by modifying the OLS model (Casetti 1972). During my research, I will collect data from a variety of sources. Working with the categories established by Yin for case study evidence, I will turn to the following sources for this study (1994).

10.4 Study Area

The study area is Vanderburgh County, Indiana, USA. Vanderburgh County, founded in 1818 and currently at 171,889 residents is the 7th most populous county in Indiana. Vanderburgh County is 234.6 square miles resulting in a population density of 732.7 residents per mile squared. Nearly 90% white, Vanderburgh County is 15% less racially diverse than the national average. Slightly more than 8% of the county is African American and 1.1% of 2000 Census respondents reported ancestry of two or more races. At 11.2%, the county has a lower poverty rate than the U.S. average. However, the median household income is five-thousand dollars less than the "average" American family. The county seat and largest municipality, Evansville, contains more than 117,000 of the counties inhabitants.

10.5 Methods and Analysis

Census data from the 2000 census were downloaded for the 159 block-groups of Vanderburgh County, Indiana. Literature was reviewed and UQL proxy variables were extracted. The variables showing the greatest impact on the dependent variables (e.g. mean NDVI) are percent of population white, median household income, percent in poverty, number of vacant homes, median year structure was built, the 2000 median home value, population density, and the interaction term population density multiplied by the mean NDVI for each distinct block-group. Results obtained from OLS (Fig. 2) regression will be compared to a more novel function of analysis, geographically weighted regression (GWR). The OLS regression model is shown as:

$$Y = \beta_0 + \beta_1 X_1 + \varepsilon \tag{10.1}$$

where y is the dependent variable, X_1 is the independent variable, β_0 and β_1, are the parameters to be estimated, and e is a random error term, assumed to be normally distributed (Clark and Hosking 1986).

GWR, unlike OLS, assumes that geographic phenomena do not necessarily co-vary evenly across space taking into account spatial nonstationarity. GWR is facilitated by means of modifying the OLS regression model's fixed parameters to parameters that vary. GWR is shown as:

$$Y(u,v) = \beta_0(u,v) + \beta_1(u,v)X_1 + \varepsilon(u,v) \tag{10.2}$$

This equation uses coordinate points (u,v) to allow for spatially varying parameters. More specifically, (u,v) are generally the points at which data are gathered; thereby, calculating a localized and independent estimate of parameters (Fotheringham 1999).

This study will use the 159 Census block-groups that are represented as 159 distinct polygons within the GIS. The parameter weighting is accomplished by selecting a point within the polygon at which the weight of the parameter is one. In the case of this study, the centroid of each block-group polygon is determined by the point at which the weighting of the parameter is equal to one. In addition, population density will be used as the weighting variable. From the centroid, the weight of the parameter depletes as distance is added between the centroid and the locale of each particular observance.

10.5.1 Remote Sensing

10.5.1.1 Image Acquisition

The acquired scene is an Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) image. The ASTER sensor has a swath of 60 km and captures images in three distinct spectral regions. However, the spatial resolution varies, in some instances dramatically, from one region to the next. The highest spatial resolution is Thermal Infrared (TIR). The telescope associated with TIR relays images at a 90 m resolution. A clearer representation of earth's surface features can be captured by short-wave infrared (SWIR) images. SWIR has a spatial resolution of 30 m. However, as previously mentioned the Terra platform contains three distinct spectral band classes; the final, visible and near infrared has the smallest spatial resolution at 15 m. This study will use images taken from ASTER's VNIR telescope. The spatial resolution of 15 m commingled with the spectral bands associated with VNIR will best illuminate urban foliage.

10.5.1.2 Image Reprojection

Numerous processes were involved in the processing of the acquired ASTER image. The first step in preprocessing is to geometrically correct the ASTER image so that the coordinate system attached to the image can be married to "real world" coordinate systems such as Universal Transverse Mercator (UTM) coordinates. Originally, ASTER images have a unique system that begins with a value of zero in the top-left corner of the image. This value then increases as the cursor is dragged either right or down. While useful when the scene is used alone, to import the image into a geographical information system (GIS) a universally accepted coordinate system is necessary.

The geo-correction process can begin as soon as re-projection is complete and the images now have corresponding coordinate systems. Ground Control Points (GCPs), precise locations located upon the image, are selected on both the ASTER image as well as the topographic reference maps. Initially, four points are chosen. Those first points should be as close to each of the corners of the scene as is feasible. This will allow for the software to geo-link the image with the topographic reference maps. The geo-link application will allow the software user to decide upon a GCP on either image and then will automatically demarcate the same point on the corresponding image. After geo-link has been enacted as many as 30 to 40 additional GCP's are to be selected. Once all of the points are decided upon, the root mean square (RMS) of each must be adjusted through moving the correlating point until the RMS has a total value of <0.5 pixel. This process resulted in an RMS value of 0.41 pixel for the Vanderburgh County, Indiana, USA image selected for this project.

10.5.1.3 Supervised Classification

There are two main types of classifications available within the ERDAS software package: unsupervised and supervised. Unsupervised is the application of an algorithm by the software to automatically group clusters of earth surface features that have the same or similar spectral characteristics. Supervised classification is the process of deciding upon spectral classes, primarily by means of first-hand knowledge of the area by the image processor. The five spectral classes used for this classification are urban, agricultural, residential, forestry, and water bodies. The distinct training sites for each spectral class are selected. After ensuring the accuracy of each location in accordance with the spectral signature and characteristics of each the three independent sites selected for each class are espoused; consequently, creating a unique spectral class for each of the five that is the product of various sites. Discriminating colors are arbitrarily selected for each spectral class to further demarcate nuances existing between each respective class.

10.5.1.4 Normalized Difference Vegetation Index

Normalized difference vegetation index (NDVI) will be calculated from the corrected scene to determine the amount of vegetation within the context of the observed urban canopy. NDVI yields a value of (–1) to 1 with (–1) representing a complete lack of vegetation and 1 demonstrating that the pixel for that value is replete with observed vegetation. The algorithm used to generate NDVI is:

$$\begin{matrix} Ch_3 - Ch_2 \\ Ch_3 + Ch_2 \end{matrix} \tag{10.3}$$

Channel 3 of the Terra platform on board the ASTER satellite captures near-infrared radiation; whereas, channel 2 records energies from short-wave infrared frequencies. ERDAS Imagine software's subset function will be utilized to create a subset of the NDVI image to reduce the size of the acquired image to that of the study area.

10.5.2 GIS

A Census block-group map of Vanderburgh County, IN, USA was obtained and opened in ArcMap. The subset NDVI image was clipped with the block group map. The executed clip function pared the NDVI image to the same dimensions as the block group map; thereby, all portions of the image not included within the study area were removed.

10.5.2.1 Zonal Attributes

The zonal attribute function marries attributes of one coverage to that of another. In this instance, the NDVI values from the classified ASTER image were combined with socioeconomic data embedded within the U.S. Census block group map. This process combined fields from the distinct attribute tables; thereby, producing NDVI values for each of the 159 block-groups in Vanderburgh County. The K* algorithm defined as:

$$1 + 3.3\left[(\mathrm{N})\log_{10}\right] \qquad (10.4)$$

where N is the number of observations was utilized to demarcate the appropriate number of classes for each map. ArcMap will be used to create maps displaying the spatial relationships inherent to NDVI, OLS kappa, and GWR kappa.

10.5.2.2 Geo-Coding

Furthermore, geocoding is utilized so that the spatial characteristics owned by payday lenders, rent-to-own furniture stores, pawnshops, and blood plasma donation centers can be spatially analyzed. This process will be utilized by entering the address specific to each identified business and subsequently adding a symbol representing each firm to be mapped.

10.6 Expected Results

Based on the results of earlier research (Gatrell and Jensen 2002; Jensen 2004; Radeloff et al. 2000; Hanham and Spiker 2005) this research will demonstrate the significant covariances of NDVI to indicators of UQL. The marriage of remote sensing, GIS, and socio-economics will prove a useful tool in determining the geographies of poverty, race, and class. Furthermore, this research has the potential to shed light on the silent, yet underlying covariances existing among urban forestry and Urban Quality of Life. Ultimately, this research will inform public policy, allowing government officials to base funding and public investment on empirically demonstrated results.

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Refelection

This proposal’s strength is its clarity with respect to the methods. The methods section is supported by a literature review that includes the application of relevant (or related) methodologies observed in the literature. Unfortunately, many literature reviews seldom integrate or separately address the methods used previously and tend *to focus solely on "concepts". Further, the paper defines the data to be collected, how it will be analysed, and identifies the study area. Based on the literature reviewed, the paper clearly articulates research questions that can be reasonably answered based on the data to be collected. For example, can a relationship be observed between two variables? Y or N. Further, the thesis explores the observed efficacy of two approaches: GWR and OLS. The proposal closes with an explication of expected results based on the literature.*

Chapter 11
Thesis II: Human Systems-Mixed Methods

Robin A. Lewis

This is one of the few proposals that have been in all three editions of this book. It is included as it is an example of a post-structuralist research design that incorporates a mixed methodological approach that draws on both quantitative and qualitative data. Additionally, the interdisciplinary proposal is a policy-oriented case study that effectively integrates fieldwork, content analysis, and government documents to explain and compare historical and contemporary policies in Malaysia.

11.1 Understanding Forestry Policies in Malaysia

Contemporary Malaysia is the world's largest exporter of timber and timber-based products (BERNAMA 2000, 2004; MTCC 2004b). In 2000, Malaysia exported a total of 6.8 million cubic meters of logs and 2.9 million cubic meters of sawn timber (MTCC 2004a), accounting for six percent of Malaysia's export receipts (BERNAMA 2000). Between 1990 and 2000, a total of 237,000 hectares of forested lands were newly logged in Malaysia (FAO 2003). Malaysia's government insists that its forestry management is in line with Agenda 21 (UNDPCSD 1997) and that forestry policies carefully consider aspects of sustainability, biodiversity, and logging in their natural resource policies and through government programs, such as the Malaysian Timber Certification Council (MTCC 2004b).

However, large-scale logging poses significant threats to species diversity and the livelihoods of indigenous peoples. In recent years, the primacy of the logging industries, and the large-scale exports of timber and timber-based products, have catapulted Malaysia into the center of global media attention. International environmental organizations, such as *Greenpeace International*, question the dedication of the Malaysian government to addressing environmental issues of global concern, deeming Malaysia's government "sustainable certification imposters" (BERNAMA 2004).

Amidst the global concerns about the impact of accelerated globalization on sustainability, biodiversity, deforestation, and the livelihoods of indigenous minority

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populations, Malaysia presents a prime case of the tension developing countries face between economic development and ecological conservation. My research examines the way that forestry policies are formulated and implemented in Malaysia, paying special attention to how forestry policies have changed over time. Drawing on scholarship in political ecology, I address how Malaysia formulates and implements its forestry policies at different geographic scales, and how forestry policies are embedded in larger economic, political, and social processes at different levels.

I argue that a careful textual analysis of Malaysia's forestry policies is needed in order to gain a comprehensive understanding of how these policies address the need to continue economic development while adequately addressing issues of ecological sustainability.

11.2 Conceptual Framework

Political ecology focuses on the interactive relationship between people and their environment (Black 1990). Unlike other modes of analysis concerned with human-environment interactions, political ecology provides a framework that combines "the concerns of ecology" and "a broadly defined political economy" (Blaikie and Brookfield 1987, p. 17). Moreover, political ecology approaches human-environment interactions from a multiple, interrelated cause and effect perspective (Bassett and Koli Bi 2000; Bassett 1988; Black 1990; Bryant and Bailey 1997; Carney 1996; Grossman 1993; Moore 1993; Nightingale 2003; Rangan 1996; Robbins 1998; Rocheleau et al. 1996; Schroeder 1993, 1997; Schroeder and Suryanata 1996).

Political ecology approaches the concerns of ecology through explicitly focusing on resource-use patterns, and society's influence on these patterns, at various spatial and temporal scales (Grossman 1993). Furthermore, it views the relationship between these resources and society as dialectic in nature (Black 1990; Escobar 1999), in which "society and land-based resources are mutually causal" in inducing ecological degradation. More importantly, ecological degradation is viewed as *social* in origin.

Drawing on a political economy framework allows political ecologists to take into account the effects of class, state power, and wider economic processes and developments on ecological degradation and the environment more broadly (Escobar 1996). Moreover, a political economy approach allows for the conceptualization of social relations of economic production and their consequences for the environment within larger socio-political and socio-economic conditions. A political economy oriented approach further considers the effects of changes in society at different scales on people and their productive activities (Blaikie and Brookfield 1987).

Due to this unique combination in which ecological degradation is viewed as social in origin, and is situated within dynamic political-economic processes, political ecology is an ideal framework to analyze human-environment interactions in a rapidly globalizing world (Bassett and Koli Bi 2000; Bassett 1988; Black 1990; Bryant and Bailey 1997; Carney 1996; Grossman 1993; Moore 1993; Nightingale 2003; Rangan 1996; Robbins 1998; Rocheleau et al 1996; Schroeder 1993, 1997; Schroeder and Suryanata 1996).

Before Blaikie and Brookfield coined the term ‘political ecology’ in 1987, many scholars were conducting studies on human-environment interactions utilizing either political economy or cultural ecology conceptual frameworks (Bryant 1998; Bryant and Bailey 1997). According to Becker (2001), the political economy framework emphasizes the social construction of natural resources as having market values, leading to increasing commodification of nature throughout time. Cultural ecology, on the other hand, focuses less on the market value of natural resources and more on how cultural forms are created within the larger environmental management schemes (Bryant 1998). Due to the increasingly complex nature of human-environment relationships, political ecologists sought to provide a stronger conceptual linkage between the “anthropological-style” (Bryant 1998, p. 81) of cultural ecology while maintaining the context of studies of local resource use within the larger political and economic structures. Thus, political ecology provides one approach to uncovering the diverse and dynamic effects of people, as well as their productive activities, on their environment (Blaikie and Brookfield 1987).

From the late 1970s until the late 1980s, political ecologists primarily focused on “disasters and hazards” (Bryant 1998) through critical analysis of economic and political structures. Influenced by Marxist theory, political ecology studies reflected the need to interpret ecological degradation in terms of how structures external to rural society influence people’s relationship to the environment. In other words, Marxist-influenced political ecology focuses heavily on the role of economic and political structures in human-environment relationships while all but ignoring how human agency could affect these relationships. According to Moore (1993), this ‘structural’ approach lead to a downplaying of the role of local politics in mediating resource access and control. Moreover, it presented an overly simplistic discussion of the people (actors) involved.

With the publication of *The Political Economy of Soil Erosion in Developing Countries* and *Land Degradation and Society* (Blaikie and Brookfield 1987), political ecology shifted its focus from the role of external structures in ecological degradation to demonstrating the complex nature of how different individuals or institutions interact and mediate human-environmental interactions (Bryant 1998; Moore 1993). Discussions emerged on the potential power of grassroots movements in challenging state discourses (Rangan 1996). Furthermore, feminist scholars emphasize the gendered dynamics of resource access and control (Carney 1996; Carney and Watts 1991; Rocheleau et al. 1996; Schroeder 1993, 1997; Schroeder and Suryanata 1996, Shields et al. 1996). In addition, other scholars consider the role of the state in environmental conservation *and* degradation (Becker 2001; Nightingale 2003; Rangan 1997; Robbins 1998). Overall, these studies enhance political ecology by inserting human agency as an equally important factor that influences human-environment interactions.

Scholarship increasingly draws upon post-structuralism and discourse theory "to map the ways in which knowledge and power may be interrelated" (Bryant 1998). Political ecology engages with these theories in hopes of better interpreting role of knowledge/power in political-ecological outcomes (Carney 1996; Escobar 1996). These studies further integrate economic, political, social, cultural, and ecological factors within a deeply intricate web of power relations, focusing on the roles of various actors at various spatial and temporal scales (Bassett and Koli Bi 2000; Bassett 1988; Black 1990; Bryant and Bailey 1997; Carney 1996; Grossman 1993; Moore 1993; Nightingale 2003; Rangan 1996; Robbins 1998; Rocheleau et al. 1996; Schroeder 1993, 1997; Schroeder and Suryanata 1996).

A central theme of political ecology is the 'politicized environment' (Bryant 1998, p. 82). For example, Bryant and Bailey (1997) argue that increased recognition of ecological degradation cannot be understood in "isolation from the political and ecological contexts that created them" (p.28). In addressing the environment as 'politicized,' research typically highlights the individuals and/or institutions involved (actors), interactions between actors (power relations), and the multiple levels of interaction (scale).

As defined by Bryant and Bailey (1997), the actor is a person or group of persons who have a vested interest in the physical environment. Examples of actors are local women's tree planting groups, grassroots groups, the state, transnational corporations, and international development agencies. Any actor's interests are rarely limited to one dimension (i.e., ecological, economic, political or social) of human-environment interactions. Moreover, it is often the more powerful actors (i.e., the state and international development agencies), when faced with a problem or opportunity, who initialize the association of meaning within given environmental situations (Bryant and Bailey 1997; Escobar 1996, 1998, 1999). Therefore, through creating and reproducing meaning, the actors exert power, while further marginalizing less powerful actors in the process (Carney 1996; Escobar 1996; Peet and Watts 1996; Rocheleau et al. 1996).

Robbins (1998) explores the role of actors in resource management in northwest India by addressing the following question: "How do institutions influence environmental outcomes?" (p.410). Each institution involved has a highly complex and vaguely defined relationship with one another, which Robbins (1998) characterizes as "multiple, contending institutions governing resources in a state of legal pluralism" (p.410). Moreover, although the authority of such institutions is not often disputed, Robbins (1998) notes that the presence of external actors further complicate the already complex institutional network (p.412). External actors include local communities, farmers and herders, state and federal bureaucrats, non-governmental organizations, and development authorities. Overall, Robbins (1998) argues that each actor should be examined individually because each "operates differently and to a different effect" (p.429) than every other. Furthermore, Robbins (1998) calls for the recognition that all resource management schemes are nested within each other and should be examined as such (p.429).

Power also plays an important role in studies of the politicized environment (Bryant 1998). Power is the ability of an actor, or a group of actors, to control their own and others' interactions within the environment (Bryant and Bailey 1997). For example, the state often has a narrow view of the relationship of indigenous populations to the environment and exerts this viewpoint through creating environmental policies that favor economic development over livelihood needs of indigenous peoples. Power relations are the interactions of actors at various spatial and temporal scales. A single actor rarely holds all the power; yet, the effects of unequal power relations translate into physical manifestations across the landscape, which can be experienced by all actors. Like actors, power relations are not always readily identifiable; however, power itself can be identified through a critical examination of both the 'public transcripts' produced by powerful actors and the 'hidden transcripts' created by marginalized actors participating in a 'culture of resistance' (Bryant and Bailey 1997). The interests of powerful actors, such as the state and international development agencies, are promoted over those of more marginalized groups, such as indigenous peoples and minority ethnic groups.

For example, Becker (2001) identifies what he terms "today's divergent forestry discourses" (p.511) as being rooted in current unequal power relations. He attributes these to Mali's colonial past in which colonial officials established a centralized state authority that valued resource extraction and local elites' desires over ecological conservation and the rights of ethnic minorities (p.504). Colonial environmental policies focused entirely on scientific forestry practices, which induced rapid and unequal degradation across Mali's landscape. Unfortunately the legacy of colonial occupation lives on in Mali through current forestry policies that still include *so-called* scientific forestry practices and unequal participation in policy development and implementation.

Scale plays an essential role in understanding the role of certain actors and the relations between any given set of actors. Political ecology studies consider each scale as nested within both larger and containing smaller scales, thus the international/global, regional, national, and local scales all play an important role in environmental degradation *and* conservation, economic development strategies, and environmental policy initiatives (Bryant 1998; Peet and Watts 1996; Robbins 1998).

Ichikawa (2003) situates the land-use change occurring in one small village (Nakat) in Sarawak, Malaysia in relation to the larger regional scale (Southeast Asia) and a rapidly globalizing Malaysian economy. As discussed by Ichikawa (2003), the forest formerly played the largest role in providing income to the villagers. Because of increasing local and regional demand for rice, the economic activities of Nakat have shifted away from non-timber forest products to commercial production of rice. The people of Nakat increasingly log their remaining forests to have enough suitable land for dry and wetland rice production in order to remain integrated in the regional market. Thus, the effects of regional scale demands transformed the economy of a formerly small and isolated village into a local economic development success story.

Scholars have noted that it is important to critically examine concepts such as 'sustainability,' 'biodiversity,' 'environment,' and 'nature.' As discussed by Escobar (1996), examination of such concepts is essential because meanings are socially constructed and often mean different things to different people at different times. Scholars note that land managers, the state, and international development agencies often use concepts of 'sustainability' and 'biodiversity' in order to advance their capitalist interests in economic gain (Bassett and Koli Bi 2000; Carney 1996; Escobar 1996, 1998, 1999). Through utilizing the language of sustainable development, these actors promote agendas that present economic development and ecological sustainability as having equal value. However, when carefully examined, these same actors focus more heavily on what Escobar (1996) terms "economism and developmentalism" (p.52), marginalizing concerns surrounding ecological sustainability in their efforts to compete in the globalizing world.

A number of scholars argue that such theoretical conceptualizations and studies in political ecology often lack "serious treatment of politics" (Peet and Watts 1996, p. 15; Black 1990; Bryant 1998). In addition, scholars call for a critical engagement with policy discourse as an integral part of the construction of human-environment relationships (Bassett and Koli Bi 2000; Escobar 1996; Peet and Watts 1996). My research will address such gaps by examining the role of politics (and power) in policy formulation and implementation in Malaysia. I will analyze forestry policy discourse to understand the ways that the Malaysian state conceives of and constructs human-environment interactions, and how these policies might reflect international development pressures and global environmental concerns.

11.3 Research Questions

My research aims to uncover how the policy environment in Malaysia is created and maintained, who is involved in the formulation and implementation of forestry policies, and how these policies might reflect concerns of local elites, the state, regional trade partners, and international development agencies at different geographic scales. In order to tease out the politics of the Malaysian forestry policy environment, I propose the following research questions:

1. What are the forestry policies of Malaysia, and how have they changed over time?
   - This question aims at examining the content and goals of forestry policies, including economic and ecological conservation interests.
2. Who are the actors involved in the formulation and implementation of forestry policies? And, relatedly, are forestry policies influenced by global discourses about sustainability?
   - This question considers how different actors (e.g., the Malaysian government, transnational corporations, nongovernmental organizations) are able to

shape forestry policies, and whether concerns of indigenous peoples or priorities formulated in UN initiatives, the Brundtland Report, and Agenda 21 are reflected in Malaysia's forestry policies.

3. How do forestry policies created at the national and state levels differ?

   - This question addresses the similarities and differences between forestry policies formulated at two different geographical scales.

11.4 Research Methods

Malaysia serves as a unique context in which to study the politics of forestry policies for two main reasons. First, Malaysia is extremely rich in biodiversity, containing ten percent of the world's total plant species (Merrill 1945; McMorrow and Talip 2001). Indeed, Conservation International (2004) recognizes the lowland forests of Malaysia as part of the Sundaland biodiversity hotspot. Secondly, Malaysia is unique in the organization of its natural resource management, in which each individual state formulates and implements its own policy while meeting the national standards put forth in the National Forestry Act and National Forestry Policy (Marsh and Greer 1992; McMorrow and Talip 2001; Moss 1996; Wickramasinghe 1994).

11.4.1 Data Collection

In order to answer my research questions, I will draw on two main types of data—state policy discourse and public responses to this discourse. Data sources will be archival data located at the libraries at University of Malaya—Kuala Lumpur and the National University of Singapore. These two libraries serve as repositories of data on forestry policy creation and implementation, including the National Forestry Policy of 1978 and its revision as well as the National Forestry Act of 1984 and its amended version, all of which will serve as the source of official state discourse. In addition, the forestry policy documents for the state of Pahang will be collected, serving as a point of comparison between federal and state forestry policies. Upon arrival at each site, I will spend a minimum of ten days collecting the available and accessible archival data and forestry policy documents held in these libraries. Data collection will include all available data produced from 1977 forward. This time frame is appropriate because it encompasses all data from the year before the first official National Forestry Policy was enacted (1978) to current discussions on Malaysian forestry policies.

In addition to archival data, I will collect newspaper articles, which will serve as a form of public discourse, created by various news media agencies in Malaysia. This public discourse will be in the form of written texts, serving as another perspective on Malaysia's forestry policies. Sources will be limited to regional, national, and local English-language newspapers (e.g., *New Straits Times* and *The Star*) publishing articles on the politics of the forestry policy environment in Malaysia.

11.4.2 Data Analysis

Two types of textual analysis will be used. Textual analysis is an appropriate method for discovering the nature of the policy environment in Malaysia because it aims at uncovering the words between the lines in any text, be it written or spoken.

Content analysis, the longest established empirical method in social research (Tischer et al. 2000), will provide quantifiable information about the central aspects and themes in Malaysian forestry policies, and how they relate to debates of globalization, sustainable development, and ecological conservation at the global level. Content analysis is a type of textual analysis that focuses on the presence or absence of certain words across or within texts (Bernard 2000). The first step of content analysis is the development of a series of keywords and phrases based on a comprehensive literature review. In my research, some of these keywords include biodiversity and sustainability; development, economic needs, and international pressure; logging area, volume, permits, and industries; and, community involvement, indigenous peoples, livelihoods, local needs, and participation. In the second step, I will systematically examine the forestry policy texts for the presence or absence of each of the keywords and phrases. I will do so through searching scanned documents with the aid of a laptop computer and word processor. Absences or presences of these keywords or phrases in the policy documents present an initial and quantifiable understanding of the influence of actors at different scales that I will further examine using discourse analysis in the next step of my analysis.

Discourse analysis focuses on "the close study of naturally occurring themes" (Bernard 2000, p.442) through a critical reading of what is said and not said in texts. Furthermore, discourse analysis serves as a tool to uncover the actors, power relations between these actors, and the importance of global development pressures and environmental concerns in the formulation and implementation of Malaysia's forestry policies.

According to Phillips and Jørgensen (2002), there are three main types of discourse analysis. These include discursive psychology, Laclau and Mouffe's discourse analysis, and critical discourse analysis. Although all three strands are forms of discourse analysis, they differ significantly in their theoretical backings (Phillips and Jørgensen 2002; Tischer et al. 2000).

Important theoretical differences arise in how each strand of discourse analysis views the role of discourse in constitution of the world, power and the subject. First, both discursive psychology and critical discourse analysis situate the role of discourse in the world as both constitutive and constituted, while Laclau and Mouffe view discourse as solely constitutive (Phillips and Jørgensen 2002). Secondly, the role of power is a point of contention between the three types of discourse analysis.

Critical discourse analysis approaches power in a more loosely prescribed manner than the other two strands that view power as "deeply embedded in the ways in which the social world can be understood" (Phillips and Jørgensen 2002, p.14). Lastly, the 'subject' is seen as "master and slave of language" (Phillips and Jørgensen 2002, p.17) in both discursive psychology and critical discourse analysis. In other words, the 'subject' of discursive psychology and critical discourse analysis is an agent that constitutes the world through discourse but is also the product of discourse. In contrast, the 'subject' of Laclau and Mouffe's discourse analysis is the product of discourse only, and is defined primarily by structures (Tischer et al. 2000).

For the purpose of my research, critical discourse analysis is the most appropriate choice. My primary reason for selecting this strand is that critical discourse analysis distinguishes between ideological and non-ideological research production, stressing that analysts should produce the latter to eschew the effects of hegemonic discourses on the research process and analyst (Tischer et al. 2000). Moreover, in contrast to the other two strands of discourse analysis, critical discourse analysis has a defined set of methods for conducting data analysis (Fairclough 1993, 1995; Phillips and Jørgensen 2002). Most importantly, critical discourse analysis is the only strand of discourse analysis that reveals the nature of change in discourses over time (Phillips and Jørgensen 2002), which is crucial in the context of my research questions.

Phillips and Jørgensen (2002) provide a summary of the methodological framework for critical discourse analysis, consisting of four main steps. These steps include: (1) choice of the research problem, (2) formulation of the research problem, (3) choice of material, and (4) analysis. The first three steps will have been completed prior to data collection, while the last stage (analysis) will be conducted during fall 2004. In sum, these methods will allow me to examine politics of the policy environment in Malaysia and to understand the issues surrounding forestry policy formulation and implementation in Malaysia.

11.5 Feasibility Assessment

Given that I will be working in countries with few formal contacts, I have established the necessary contacts to ensure a productive field season. During the current spring semester, I established contacts with both libraries and was granted access to all available information regarding forestry policies. Additionally, I will be allowed to photocopy and/or scan these documents so that I will have the documents available for data analysis in the fall of 2004. I have also been granted housing on-campus at the National University of Singapore (NUS), and am awaiting similar housing arrangements in Kuala Lumpur. I am lucky enough to have established a dialogue with Dr. Henry Wai-chung Yeung, a professor in the Department of Geography at NUS, and will arrange to meet with him during my stay. Although I cannot guarantee that my trip will go smoothly throughout, I am confident that I have made the necessary preparations and will have a successful field season.

Appendix I—Timeline

Spring Term 2004

- Literature review, focusing on the development of keywords for content analysis
- Methods development
- Initiate contact with libraries to gain access to archival materials
- Proposal preparation
- Defend proposal

May–June

- Continue literature review
- Continue preliminary data collection

June

- Continue literature review and data collection, focusing on identification of missing links and items to locate once at field site
- Begin immunizations

July 1–19

- Travel preparation

20–22 July

- Travel to Kuala Lumpur

22–25 July

- Begin on site archival data collection at UMKL Library
- Initiate contact with UMKL Geography faculty, to establish contacts for future work

26 July

- Travel to Singapore

27 July–7 August

- Continue archival data collection (NUS Central Library)
- Meet with NUS Geography faculty to informally discuss progress and strengthen connections for future work

8 August

- Return to Kuala Lumpur

9–17 August

- Complete archival data collection at UMKL Library
- Continue to build relationships with NUS Geography faculty
- Visit parks/reserves

18 August

- Return to Ohio

Fall Term 2004

- Organize archival data
- Begin content and discourse analysis
- Continue to write introduction, literature review and methods sections of thesis

Spring Term 2005

- Strengthen introduction, literature review and methods sections of thesis
- Prepare and write results and conclusion sections of thesis
- Defend thesis

Appendix II—Budget

Categoiy	Amount
Travel *(International):*	
Airfare Cincinnati-Kuala Lumpur. Malaysia. July 20–August 17, 2004	$1,366
Taxi and shuttle service; local transportation	$200
Train transportation, Kuala Lumpur-Singapore-Kuala Lumpur	$150
Accommodations:	
University of Malaya, Kuala Lumpur (UMKL), July 21–My 26, 2004 and August 8-August 17,2004	$550
National University of Singapore (NUS), July 26–August 8, 2004	$450
Food	$600
Supplies:	
Laptop computer	$1,150
Handheld document scanner	$114
Digital camera xD picture cards	$100
Tape recorder and recording tapes	$68
Photocopies	$150
Other Research Expenses:	

(continued)

(continued)

Categoiy	Amount
Research Permit, Prime Minister's Office, Malaysia	$500
UMKL External Library Membership	$50
NUS Temporary Reader's Permit	$35
Medical Expenses:	
Hospital/clinic fees	$100
Immunizations	$93
Anti-malarial medication	$80
Total	$5,756

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Reflection

Overall, this proposal is an excellent example of spatial science research in the area of political-ecology and the importance of interdisciplinary approaches. Consequently, Dr. Lewis's master's thesis proposal is representative of a large body of innovative human-environment research. The conceptual framework (or literature review) combines a diverse literature on political-ecology with practical policy literatures from the region. In terms of the methods and data section, the proposal uses a qualitative research design to answer the proposed research questions. The proposal also does an excellent job of making a complex concept—discourse analysis—accessible to the reader. In terms of the proposed research, the proposal also highlights the challenges of doing field work: scheduling, establishing local networks, and considering the overall feasibility of the project. In the end, proposals need to present "do-able" research and present the readers (most often committee members) with a realistic account of the challenges facing the researcher. This proposal's feasibility section is unique and a nice addition.

Additionally, this proposal demonstrates the importance of integrating budget requests into an MA thesis. In the case of this project, the Departments of Botany & Geography, College of Arts & Sciences, and Graduate School at Miami University funded Robin's research. The proposal also integrates a timeline into the narrative and includes it in an appendix. The timeline feature is useful as it explicitly identifies key benchmarks that can be used by committee members to determine student progress. Likewise, the timeline is a useful accountability tool for students themselves. Indeed, graduate students, particularly master's students, sometimes lose focus over the course of a significant long-term project and a timeline can sharpen their focus on outcomes and deadlines.

Chapter 12
Dissertation I: Human–Environment Interactions

Trevor K. Fuller

This proposalfocuses on human–environment interactions and the notion of environmental justice. The proposal develops a qualitative GIS methodology to investigate the relationship between place attachment and environmental activism in two study areas. By examining the political ecology of environmental hazards, the dissertation proposal nicely positions the research within an existing literature as well as makes explicit (conceptual and methodological) linkages to the field of GIScience and even sociology. Like Lewis' thesis proposal, the dissertation uses mixed methods to unlock and interpret the everyday realities of urban environmental risk in two demographically distinct Indianapolis neighborhoods.

12.1 Statement of Purpose

The purpose of this investigation is to examine the development of social movements (or lack thereof) in response to environmental hazards and why responses have varied between two different communities of Indianapolis, Indiana. The field of environmental justice offers many examples of investigators exploring the spatial correlation between environmental hazards (disamenities) and particular socioeconomic/demographic characteristics of a community, with 'community' representing anywhere from a census block group to the zip code or even county level. Such research has revealed many examples of disproportionate environmental risk being endured by particular disadvantaged or marginalized races, ethnicities or income groups (Pulido 2000; Buzzelli et al. 2003). While these analyses provide insight regarding the spatial distribution of disamenities and the proportions of population groups which may be impacted by them, questions of environmental justice activism must be investigated further. Some research has provided examples of residents reacting to the location and harmful practices of particular facilities (Chambers 2007; Checker 2008). The existing literature lacks comparative analysis of environmentally damaged communities and why one community becomes socially active while the

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other does not. Rather, the literature has examined the comparative levels of 'success' achieved between two already socially active environmental justice communities. This investigation contributes toward the environmental justice and urban political ecology literature by examining not only factors which may play a role in the varying degree of activism between communities, but also how place attachment, social capital, race, and the type of contaminated medium (i.e. the 'non-human') intersect with concerns of citizens regarding disamenities. A political–ecological approach to these communities individually and as parts of the larger urban development of Indianapolis, Indiana, will illuminate the political, social, and economic (i.e. capital) factors which have acted as forces to shape both the physical and human landscapes.

The two study areas selected for this research sit within Indianapolis, Indiana. The first area is Martindale-Brightwood, located on the near east side of Indianapolis and bounded by 16th and 30th streets, Keystone and Massachusetts avenues, and the Norfolk Southern Railroad (Monon) tracks. This area has a population of approximately 10,000 residents and is predominantly African-American. In 2004, a church organization in the neighborhood paid for an environmental site assessment to be conducted as part of an application for a loan to be used for planned church renovations. The environmental site assessment revealed historical practices in the area that indicated a potential for site contamination. As a result of this initial assessment, further investigations were conducted revealing high levels of lead (Pb) in the soil on the site, as well as in surface soil on approximately 250 residential properties in the area. Many of these properties were subsequently remediated, however some were not remediated. The lead contamination propelled some in the community to form an organization (Martindale-Brightwood Environmental Justice Coalition) to learn more about their neighborhood and push the U.S. EPA to expand its cleanup efforts. The other community proposed for this study is West Indianapolis, a highly industrialized area with heavy traffic bounded by Holt Road, Raymond Avenue, the White River, and Interstate 70. This area is comprised predominantly of Caucasian residents and a total population of approximately 11,000. The area has a history of industrial operations surrounding residential areas. While this area has been the subject of some sampling and extensive news reporting, no persistent environmental activism has or citizen organization has emerged. Because of the difference in citizen response between the two proposed study areas, this investigation may offer insight into the various drivers and forces which allow for or prevent citizen involvement in environmental justice activism.

The methodology will consist of both quantitative and qualitative analyses. Geotechnologies will be used in this investigation to visualize the potential environmental risks surrounding the neighborhoods. Qualitative data will be compiled via surveys provided to local residents and in-depth interviews with residents and local government officials. The surveys will ask residents about their perceptions of various sites in their neighborhood, as well as what factors play a role in moving citizens to act as part of an environmental justice organization and factors that act as barriers to participation. In sum the specific questions to be addressed by this investigation are captured in the following research objectives:

(1) Analyze the spatial distribution of environmental disamenities within the two study neighborhoods.
(2) Trace the ecological, economic, political, and social forces which have collaboratively produced the damaging environmental histories of both neighborhoods.
(3) Interrogate the respective roles of non-human factors, place attachment, race, and social capital in producing different interpretations and understandings of the local landscape within the two selected neighborhoods.
(4) Evaluate the role of non-human factors, place attachment, race, social capital, and state interaction in producing varying levels and types of environmental activism.

12.2 Literature Review

Among the general public environmental justice is often interpreted as ensuring that no segment of the population be subjected to a disproportionate amount of exposure, or even perceived exposure, to environmental hazards. Public concern over environmental justice arose in response to two high profile cases involving allegations by African-Americans in two communities that they were being subjected to a disproportionate risk of exposure to environmental disamenities (Bullard 1990; United Church of Christ 1987; U.S. GAO 1983). The unveiling of serious environmental contamination events such as Love Canal near Buffalo, NY ran concurrent with an increase in broader environmental awareness during the 1970s. Along with the growing public concern a growth in academic research on environmental injustices ensued (Lee 1992; Mohai and Bryant 1992; Anderton et al. 1994; Pulido 2000; Pastor et al. 2001). While the methods used to assess the spatial distribution of environmental hazards have been debated, the vast majority of studies demonstrate that minority and/or low-income populations are more often exposed to a disproportionately higher number of environmental disamenities.

12.2.1 Spatial Distribution

The area of analysis (and associated findings) within environmental justice literature has varied widely with much of the research focusing on a city-wide analysis (Mohai and Bryant 1992; Buzzelli et al. 2003; Pulido 2000). Some research has modeled environmental risk at the county, state, and even national level (Bullard 1990; Margai 2001; Pastor et al. 2001). Early environmental justice research analyzed the question of disproportionate risk by focusing on a larger area, such as the ZIP code (United Church of Christ 1987). This assessment of environmental hazards across Indianapolis will use census tracts as they are the smallest areas at which various government-produced environmental records information can be obtained.

More recently, researchers have tried to get beneath the surface of environmental justice issues to consider both the roles of economic, political and social institutions in shaping the unequal distribution of environmental hazards in particular places, and how local residents and political organizations perceive and respond to those hazards. Much of this research falls within the urban political ecology literature; however, other literatures on environmental activism and social movements are also relevant. The background literature for this dissertation focuses on three important themes. The first theme involves interrogating the macro-scale political and economic forces that shape the uneven distribution of environmental disamenities. The second theme emphasizes micro-scale processes: how people's perceptions of and responses to environmental hazards are influenced by social capital and place attachment. The third theme involves understanding how 'non-human' or ecological actors contribute toward people's perceptions and responses via a deeply interconnected process of collaboration with human forces (economic, political, social). I intend to draw these literatures closer together in order to more deeply interrogate how environmental disamenities come to be distributed unevenly, how residents perceive and respond to these disamenities, and how perceptions, social capital, place attachment, race, and the contaminated medium interact to either produce or deter environmental activism within two communities.

12.2.2 Political Ecology of Environmental Disamenities

Urban political ecology calls for historical analysis as a means to excavate the political, social, and economic (i.e. capital) forces that have collectively shaped the current uneven urban environment. Such an accounting can also reveal the interactions between residents of the areas and the physical landscape (Gandy 2003).

In *An Unnatural Metropolis* Colten (2006) walks the reader through the historic and ongoing struggle of humans to more effectively manipulate 'nature' in order to suit the needs and wants of New Orleans and its residents. Environmental disamenities were continually thrust upon the population unevenly as industries left a trail of pollution on the landscape and as the state acted to protect wealthy interests. This underlying trend of environmental inequities is revealed in different ways, from public works services initially not offered to all of the population, to the unjust results of historical processes more recently. Colten (2006) illustrated the way in which the relationship between humans and 'nature' is never static, but is a dynamic process that produces multiple uneven landscapes.

12.2.3 Social Movements

In reviewing major social movements in U.S. history, Piven and Cloward (1978) provide arguments as to why these movements succeeded and/or failed. In order to approach an investigation of a social or protest movement, a clear definition of what constitutes such a movement must be in place. Piven and Cloward define a ‘protest movement’ as ‘a transformation both of consciousness and of behavior…The change in consciousness has at least three distinct aspects’ (id, 4). First, ‘the system’ loses legitimacy among the people. Second, people who once complacently accepted their fate begin to recognize their rights and demand change. Third, people who believed they could do nothing begin to think they can in fact effect some change (id, 5). Piven and Cloward go on to argue that the change in people’s behavior evolves from first becoming defiant to ultimately acting collectively. It is the act of collective defiance that Piven and Cloward emphasize as being the key factor in their definition of a protest movement (id, 6).

Movements are often absorbed into the state apparatus where they are ‘tamed’ (Piven and Cloward). Such co-optation may be relevant in understanding the evolution of environmental activism in Martindale-Brightwood. Chaotic, defiant protests are much more effective for political response than a more formalized/organized activism (Piven and Cloward). The research proposed here will include an interrogation of the environmental justice movement (or lack thereof) within the two communities in an attempt to determine the ‘legitimacy’ of the movement as perceived by residents. While Piven and Cloward argue that the formalization of a protest movement leads to its demise, McAdam (1999) argues that such is not always the case.

In his discussion of the development of black insurgency during the twentieth century, McAdam (1999) dissects each of the major models used in examining social movements, specifically calling attention to two major faults of the classical model, those being the belief that a social movement is a reaction by a psychologically unstable citizen to a sudden ‘strain’ and that everybody shares equal access to the ‘system’ (McAdam 1999). In response, McAdam advocates a political process model which conceives of social movements as continuous and dynamic, enduring structural changes and being shaped by long-running social processes (such as urbanization or industrialization) in which the actors are recognized as being rational, motivated individuals with political leverage. McAdam sees this model as more appropriately fitting the development of black insurgency in the U.S. because it developed through historical interactions with social and spatial controls on race and the forms in which political and economic forces reconfigured race to serve the needs of the elite.

The social movements literature situates community activism in relation to broader class, race and ethnic divisions. It views such movements as framed by the uneven distribution of political and economic power and capitalist imperatives. These insights are highly relevant for my research. However, the social movements literature pays scant attention to the more localized dimensions of community response that are tied to people’s experiences of their local communities, their perceptions of environmental risks and their access to social networks and institutions. These dimensions vary, even within economically and socially disadvantaged communities, resulting in varying levels and types of environmental response. The next sections review the literatures on how people’s experiences and perceptions of environmental risks influence the development (or lack thereof) of environmental activism.

12.2.4 Environmental Activism

Gandy (2003) illustrates well how so often it is concerns of residents regarding their health and that of their children which provide the impetus for social activism. Such environmental justice movements often have deeper goals than preventing one facility being sited near a community. As Gandy illustrated, the goals of the New York City-based environmental movements were to acquire a greater ability to dictate how their ‘space’ or ‘community’ is used, or in other terms, how their physical landscape will be shaped.

When attempting to identify determinants of environmental activism Wakefield et al. (2006) offered an analytical framework consisting of composition, context, and collective ingredients. Composition refers to the individual demographics within a community, such as level of education, age, income, etc. that correlate to different levels of environmental activism. Context refers to the local ecological or environmental characteristics, such as the visibility, duration, and intensity of pollution (Wakefield et al. 2006). I propose to expand upon this role of context as a determinant of environmental action by examining how differences in the form of pollution itself (soil vs. air) may produce different responses and levels of environmental activism. The term collective is used by Wakefield et al. (2006) to describe the social networks of support existing within a community, which have been shown to be important to the potential development of local civic action (id).

Despite many residents perceiving risks from air pollution in their neighborhoods or communities, very few people choose to become active (Wakefield et al. 2001; Elliot et al. 1999). Wakefield et al. (2006) constructed the composition, context, and collective framework to join together disparate literatures (environmental health justice and political ecology) in order to deepen investigations of environmental activism. In addressing why so few residents (who are concerned about air pollution) take environmental action, Wakefield et al. (2001) argue that individual perceptions and experiences are key. Individuals often feel as if they (1) lack sufficient scientific knowledge to assess something as complex as air pollution, (2) have other priorities to deal with in life, and (3) don’t know how to go about contacting anyone in order to complain.

Residents’ concerns and perceptions derived from their experiences of their life spaces or something akin to ‘activity spaces’ (Buzzelli et al. 2005). The context includes not only the observed pollution, which calls to mind the strong role of the senses (odor in Elliot et al. 1999), but also the observed health outcomes. As Wakefield et al. (2006) argued the context is one of the strongest predictors of environmental action. Therefore, the senses can play a significant role in prompting response. Context can also include consideration of how the characteristics of an existing site and the presence of state/federal officials contributed toward citizens’ health concerns and activism (Stephan 2005).

The literature provides accounts of where environmental justice activism took place and why residents became active (Kurtz 2005; Stephan 2005), however the literature lacks a robust examination of the comparative forces (including ecological) at play between those areas where activism did take hold and those where it did not. Here the intent is to compare two different communities in the hopes of revealing what factors may have contributed toward the different responses to environmental injustices.

12.2.5 Place Attachment

Place attachment refers to a bond one develops with a particular locale or an emotional investment in an area (Wakefield et al. 2001). Place attachment has sent mixed signals throughout the environmental justice and activism literature (Wakefield et al. 2001; Brown et al. 2003). When residents give poor valuations of their neighborhood then they most likely exhibit low place attachment, however, poor valuations of a neighborhood from 'outsiders' may not at all be indicative of low place attachment. In fact, high levels of place attachment are often seen in areas classified as 'devastated' by outsiders. Wakefield et al. (2001) finds that friendships are also important (2001). Because of these various emotional attachments to an area, residents often choose to stay in communities that can be classified as environmentally damaged, in essence a tradeoff whereby residents accept the pollution in exchange for certain benefits such as affordable homes and friends (Elliot et al. 1999; Wakefield et al. 2001).

The impact of place attachment on different responses to disamenities depends on interactions of place attachment, social capital, and characteristics of the environment or context (Wakefield et al. 2006). Wakefield and Elliot (2000), in assessing the role of risk perceptions and stress associated with a landfill siting process, concluded that place attachment did play a role in residents' stress but not necessarily in action-taking. While environmental activism literature has presented variability in the role of place attachment in prompting environmental activism, this investigation positions place attachment as one of multiple forces critical in the production of locally-based environmental activism.

12.2.6 Social Capital

Social capital is important in communities facing environmental negatives (Wakefield et al. 2006). Social capital, the networks of connections and support that people possess and build can strongly influence residents' decisions to become activist even when place attachment is not strong (Wakefield et al. 2001). Wacquant (2008) addressed the potential decline in social capital among residents of the 'hyperghetto' as people develop poor valuations of their neighbors via a social-Darwinist view which labels them as failures. This view prevents residents from recognizing common concerns and offering support to the larger community.

12.2.7 Race

Research examining differences in environmental activism by ethnicity and race has produced conflicting results (Williams and Florez 2002; Mohai 2003; Stephan 2005). Williams and Florez (2002) attempted to examine a previously underexplored area of environmental justice in assessing how Mexican Americans perceive issues of 'risk, inequity, trust, and participation in civic activities' in Tucson, Arizona, a city with a history of environmental racism (303). The authors conclude that ethnicity does indeed play a strong role in influencing participation in such activities as environmental justice. Mexican Americans perceive greater inequalities in their communities and perceive a stronger association between environmental negatives and health risks than Whites in Tucson.

Mohai (2003) presents evidence refuting the previously longstanding notion that because of other priorities, such as income and daily needs, African American citizens are not concerned about environmental issues. Mohai deconstructed this notion using data indicating that more African Americans than Caucasians believe that quality of life in the U.S. is seriously threatened by environmental issues (id, 15). The difference can be explained via the greater exposure of African Americans to environmental disamenities (Mohai 2003).

The neoliberal political governance within the city of Indianapolis has produced a dramatically uneven form of development which has most negatively affected low-income African Americans (Wilson 2007). This uneven development is rooted in the goal of local growth machines to isolate and foster particular communities as 'warehouses of contaminants' (id, 30). These communities are not only isolated as neighborhoods of both 'contaminated bodies' (African-Americans) and contaminants (i.e. environmental hazards), but they can become targeted neighborhoods with which city officials and other 'outsiders' intervene in an effort to inject capital into neighborhoods ripe for redevelopment and gentrification (Hulse 2001). Municipal authorities offer up various 'neo-liberal forms of intervention' such as Community Development Corporations (CDCs), which are tied up in the belief that market mechanisms can improve a community (id, 39). Potential activism within these low-income African American communities can be muted through co-optation by the city's neo-liberal CDCs.

12.2.8 The Environment Speaks: Agency of the Non-human

In addition to place attachment, social capital, and race, non-human actors (e.g. contaminated soil vs. air) are important in shaping responses to environmental injustice. Urban political ecology offers a useful framework for examining the interactions between humans and non-humans (Heynen and Kaika 2006; Desfor and Keil 2004; Heynen et al. 2007). Environmental justice as a political project offers the notion that decades of political, cultural, and economic forces create many 'metropolitan natures' (Gandy 2005), with the various natures distributed across an urban space via the underlying power structure (Véron 2006). A form of nature devoid of noxious land uses but filled with trees and/or 'clean' air is constructed in wealthier, white areas while another form made up of disamenities and disinvestment takes shape in another part of the city. What lower-income and minority communities experience then is a nature that acts by invading the human body via contaminant transport and deposition, making its way into the lungs and pores or even minds (via perceptions) of residents to affect their health and their response to the nonhuman.

Non-human 'actors' reveal themselves and act upon us and the physical environment on a continuous basis, altering all parties, including themselves, along the way (Franklin 2006). Franklin (2006) illustrates how gum trees, despite appearing passive can dictate not only the human practices and responses but also the very form of the material environment produced. In this way, gum trees and humans both 'act' and in doing so they 'are constitutive of each other' (id). Through an analysis of the political-economic context, Robbins (2007) revealed how lawns and the larger economies and ecologies they operate within exert pressure and anxiety upon humans (Robbins 2007). For example, Robbins (2007) illustrated the way that lawns 'speak' to homeowners by way of their changes in appearance (turning brown) and this influences homeowners to fertilize and mow their lawns in order to maintain an appearance both of their lawn and themselves.

Urban political ecology literature provides examples of attempts by researchers to use the notion offered by Swyngedouw et al. (2002) that environmental and social changes co-determine each other, and as such, the classic dichotomy is dismantled to form this ever-shifting, amorphous mass made up of the social, ecological, political, economic, human, and non-human. The political, economic, social, and ecological processes acting on and through us have created a socio-ecological environment that has deeply intertwined humans and non-humans (Heynen et al. 2007) in the production of multiple symbolic and material 'natures' that are continuously in flux. The unjust environments that we encounter today in our urban formations provide ample evidence of the continuous interactions between humans, nonhumans, and the transformation/production of local environments.

In a similar fashion as Franklin (2006) and Robbins (2007) have approached trees and lawns, respectively, soil and air (Véron 2006) as non-human entities can and do influence. Robbins (2007) spoke of the role of the soil on a lawn and the way in which the biological and chemical characteristics of soils combined with the effects of various human actions such as earth-moving, chemical application, and planting regimes causing continuous shifts in the soil's form which in turn, reshape the form of the various industries, economies, and humans acting upon it in the first place (Robbins 2007).

12.2.9 Non-human Agency and Local Knowledge

In addition to the literature which has explicitly discussed the agency of nonhumans, more recent scholarly endeavors provide numerous examples of how nonhuman agency might intersect with local knowledge. Local knowledge is 'an organized body of thought based on immediacy of experience' (Corburn 2003). It is information that reflects the daily life experiences of people and the insights this regular interaction with their physical and social environments imparts upon them. Non-human agency, while not discussed as such in the literature here, can nevertheless be seen.

Scammell et al. (2009) added to the local knowledge and environmental health justice literature by offering what has been termed 'tangible evidence' as that crucial personal information derived from daily experiences that is dismissed by traditional risk assessment. Scammell et al. (2009) found that many project participants had a difficult time accepting the findings of risk assessments when they contradicted the experiences or 'local knowledge' of the residents. The nonhumans, or in this case air pollution, interacted with residents on a regular basis and produced negative responses and perceptions of health, thereby contradicting the results of the risk assessment. Researchers should pay attention to the contextual differences, or in this case, the combination of human and non-human actors, the 'built environment' as well as the various nonhuman actors such as particulate matter, odor, smoke, etc. (Scammell et al. 2009).

Related to the role of context in such investigations and how local knowledge can add 'contextual meaning' to environmental health justice issues, Lambert et al. (2006) provided an illustration where local knowledge complimented 'expert' knowledge. Physical measurements in Sydney, Nova Scotia revealed elevated levels of various metals and petroleum aromatic hydrocarbons (PAHs) in surface soil. In response to a decision only to remediate a limited area, residents sought further assessment by gathering residents' observations and experiences of this contamination in a wider area. Combining local knowledge with physical measurements showed that many more people were affected by nonhuman actors (particulate matter, smoke, odor, wind) than a traditional risk assessment would reveal.

12.3 Summary and Contributions

This research adopts an urban political ecology framework in understanding varying levels and types of environmental activism in two Indianapolis neighborhoods. The current landscape of environmental hazards is excavated to reveal the historical political, economic (explicitly the role of capital), social, and ecological factors that shape/re-shape the uneven urban environment. Urban political ecology brings to environmental justice/activism research a needed accounting of the interplay between the human (political, economic, social) and nonhuman (ecological, contaminated media). This research situates environmental activism in relation to forces at both the macro and micro scales. The macro-scale forces will be the political, social, and economic (capital) forces that have produced the environmental histories and environmentally unjust status of the two study areas. The micro-scale forces will be the individual residents' and neighborhood organizations' perceptions of and responses to local environmental hazards, how their responses are influenced by social capital and place attachment, and how the particular medium (soil vs. air) contaminated impacts their perceptions of and responses to those hazards.

In addition to these macro and micro forces, for the community in which activism is stronger (Martindale-Brightwood), this investigation also will examine the development of the local environmental justice coalition, MBEJC. This proposal does not begin with a starting presumption that the 'activism' seen in Martindale-Brightwood is 'real' grassroots activism. However, this investigation will seek a deeper understanding of the activism to date and whether it is 'bottom-up' or 'top-down' and what role local institutions play in shaping the form of action/inaction seen in both Martindale-Brightwood and West Indianapolis. This analysis will be framed by the social movements literature to determine how that coalition formed, its primary actors, the role of race and capital, as well as the potential for co-optation by the city/state. In summary, this research draws from all of these literatures in order to more deeply interrogate how environmental disamenities come to be distributed unevenly in Indianapolis, how residents perceive and respond to these disamenities, and how perceptions, social capital, place attachment, race, and the contaminated medium (nonhuman) interact to either produce or deter environmental activism within two communities, and what that activism comes to look like.

This research makes a contribution by interrogating via comparative analysis between two neighborhoods (one socially activist and the other not) how the potential form of environmental injustice, including the medium contaminated (soil or air), initiates or encourages activism. I ask whether the specific type of environmental contamination might play a role in prompting (or inhibiting) activism. Most often in environmental health investigations when residents speak of their first 'encounter' with pollution, it predominately takes place via their sense of smell or perhaps even a 'taste' in the air, i.e. 'sensory experience' (Scammell, et al 2009; Wakefield et al. 2006; Wakefield and Elliot 2000). In this way, this research will contribute by demonstrating the importance of considering ecology in urban environmental justice issues. Perhaps the regularity with which residents encounter a foul odor (poor air quality) acts to normalize the injustice, whereas a sudden event (soil contamination) triggers immediate health concerns. The perception of air as a complex entity difficult to capture or trace may produce a sense of hopelessness among residents regarding the likelihood of political efficacy. The role of non-human actors (contaminated air and soil) will be examined in relation to residents' perceptions of health risks as well as social and economic factors that may produce activist residents/communities. In doing so, this research will expand upon the concern with nonhuman actors in urban political ecology while enriching the environmental justice literature.

This research also responds to the call in urban political ecology for a greater role of capital in environmental justice studies through an examination of the historical, ecological, economic, political, and social forces that have shaped the discursive and material landscapes (i.e. natures) of the two Indianapolis communities. In addition, this investigation will assess residents' perceptions of these landscapes and how those perceptions, combined with place attachment, race, social capital, and contaminated media, and local government produce two markedly different responses from the study areas. This will also contribute to the broader environmental justice literature by echoing more recent arguments for a greater place for perceptions with regards to questions of environmental injustice, moving beyond the often stagnant division between distributive and procedural forms of equity. Here both will be considered as both neighborhoods suffer from the burden of inequitable distribution of disamenities relative to the rest of Indianapolis.

Finally, as a methodological contribution, this project will offer a unique qualitative GIS component to depict and visualize differences in residents' environmental perceptions and experiences between the two communities (Knigge and Cope 2006; Pavlovskaya 2006). Qualitative GIS enables 'grounded visualization', in which local ethnographic research findings regarding the views, perceptions, and attitudes of local residents are considered, taking into account 'people's subjective experiences of everyday life' (Knigge and Cope 2006, p. 2025). Built upon Kwan's notion of 'body-mapping' (Kwan 2002), the qualitative GIS will reveal geographic variation in residents' physical encounters (sight, smell, touch, etc.) with disamenities and their recorded perceptions of those encounters. In this way, perceptions of disamenities and the form of encountering those disamenities may vary spatially and temporally on a daily basis.

12.3.1 Hypotheses

In sum the specific objectives of the investigation are captured in the following proposed hypotheses:

(1) The spatial distribution of environmental disamenities is disproportionately dense within the two aforementioned communities as compared to the greater metropolitan Indianapolis area.
(2) The two study areas share similar extensive and damaging environmental histories.
(3) Differences in environmental activism are associated with differences in place attachment, social capital and the medium contaminated.
(4) Local social institutions and the activities of local business interests and governmental agencies are important in shaping differences in environmental activism.
(5) A qualitative GIS produced via the 'body mapping' of residents in each community will reveal a difference between the two study communities in terms of residents' perceptions and experiences of disamenities.

12.4 Data and Methodology

Quantitative and qualitative methods will be used in this investigation. The use of GIS as well as interviews to explore the proposed questions provides a suitable framework for a mixed methodology. Environmental activism, with its distributional and procedural equity branches, is well-suited to both quantitative and qualitative analyses.

12.4.1 Study Areas

Both study areas share a long history of environmental contamination and are the home of numerous hazardous sites. Both are low-income areas however Martindale-Brightwood's population is predominately African American and West Indianapolis is predominately Caucasian. Martindale-Brightwood has some collective environmental activism while West Indianapolis has none.

12.4.2 Quantitative Analysis: GIS and Environmental Justice

An initial GIS-based assessment will be performed for both study areas in order to visualize the environmental disamenities in and around the study areas. GIS will be used not only to visualize the distribution of disamenities but to gather and statistically analyze the quantitative properties of the disamenities including frequency and levels of toxic releases. This will provide quantitative data describing the presence and levels of disamenities in the two study communities in comparison to Indianapolis as a whole.

12.4.3 Environmental Disamenities

Since the 1970s when much of U.S. environmental policy was developed and institutionalized, the United States Environmental Protection Agency (U.S. EPA) has required reporting of information from facilities/sites handling or processing particular wastes or emissions. The Toxics Release Inventory (TRI) contains data for each reporting facility on the levels and types of hazardous chemicals released. Information on regulatory compliance and the release and storage of hazardous materials provides both the public and academe with a database for investigating environmental quality and questions of environmental injustice. The Indiana Department of Environmental Management (IDEM) holds such data for all of Indiana, including the City of Indianapolis. The proximity of a disproportionate number of such facilities to particular communities is interpreted by many researchers as an indication of environmental risk (i.e. injustice).

Maps showing the locations and types of environmental disamenities in the two communities will be constructed in ArcGIS. In order to most effectively compare communities of Indianapolis, a limited number/type of disamenities will be selected for assessment. This will include the use of variables which have been historically utilized in environmental justice distributional research (Anderton et al. 1994; Atlas 2002; Buzzelli et al. 2003). The variables proposed for use are the following: Brownfields, Large Quantity Generators of Industrial Waste, U.S. EPA Toxics Release Inventory (TRI), Treatment, Storage, and Disposal Facilities (TSDF), and Superfund sites.

12.4.4 Qualitative Analyses: Historical Assessment of Study Areas

The social, political, and economic forces that have shaped and altered the political economies of the two communities will be assessed via analysis of local government policies and socioeconomic demographics. Data on past hazardous facilities will be collected from Sanborn maps. In addition, articles from local newspapers and magazines will be analyzed to capture the occurrence of contamination 'events' and residents' reactions to these 'events'. This work will be directed at compiling and historicizing the development of the two communities in question. Archival information will provide insights as to how and when the two areas underwent periods of growth. The aforementioned data will include historical aerial photographs, Sanborn maps, and an inventory of businesses in both communities.

12.4.5 Perceptions of Risks and Health Outcomes

Qualitative methods (surveys and interviews) will be utilized to assess how residents perceive various facilities/sites in their neighborhood. A survey will be conducted of approximately 40 residents of each community. The survey will attempt to gather individual measurements of residents' perceptions to determine the potential contextual factors that may be contributing toward the different responses to environmental disamenities among the two communities. Residents will be asked for their perceptions of disamenities, including particular facilities/sites, and whether they associate such disamenities with actual or potential health risks. Questions will also attempt to determine the potential influence (if any) of the particular form of contamination (soil or air) in producing different perceptions. The survey will also attempt to measure residents' place attachment and social capital with regards to the neighborhood.

12.4.6 Drivers of Activism

This study seeks to understand what factors play a role in moving citizens to act as part of an environmental justice organization. Questions asked during in-depth interviews with residents and local officials from each study area will determine what forces work to convince residents to act collectively in response to environmental disamenities and also forces that discourage environmental activism. Forces of interest include: social capital, place attachment, political efficacy, residents' perceptions of health concerns, race, and perceptions of the medium contaminated. Data gathered from the interviews will be coded for textual analysis using a qualitative data analytical software package.

12.4.7 Qualitative Geographic Information Systems

A qualitative GIS is a GIS that incorporates such qualitative information as photographs, attitudes, perceptions, videos and oral histories (McLafferty 2002). GIS will be used to produce this visualization based on residents' perceptions and observations during their daily pathways. They will rate facilities and places in their community according to a scale (unknown, no concern, little concern, significant concern, danger). Participants will also be provided with a blank map, illustrating only streets and street names, and they will be asked to mark/draw areas of environmental concern, whether those be operating facilities, abandoned facilities, or vacant areas in which dumping/polluting occurs. I also propose to ask participants to identify areas where regulatory involvement is strong, weak, or absent. The daily environmental experiences of residents will be recorded in order to visualize perceptions of and interactions with disamenities. This may reveal differences among residents of the two communities, their frequency of physical encounters with disamenities, the types of disamenities most often encountered and the medium, as well as the ways in which residents perceive these sites and come to imagine their daily landscapes. Residents will be asked to record their daily routes and interactions with disamenities including encounters with sites, odors, smoke, liquids and the like. Each resident (4–5 per community) will be given a camera and notepad and asked to document their daily interactions with disamenities.

12.5 Expected Results

12.5.1 Non-human Factors

In this study, I hypothesize that a key nonhuman factor is the particular form of environmental contamination. In West Indianapolis, air pollution predominates, so residents are (and have historically been) faced with the smell of the various contaminants released to the local atmosphere. Hazardous air pollution is well-documented in that part of the city. On the other hand, residents in Martindale-Brightwood have predominately encountered pollution as something they are told is present in their yards or soil. The nonhuman actors in this community can include the presence of Pb in/on residential lawns. It is this difference in the nature and medium of contamination and how that may affect residents' perceptions and activism that this research will address. This study hypothesizes that this route of exposure to a resident does trigger different responses and processes than when a resident is informed of pollution via manifested health issues or observation of government officials assessing/remediating a site.

12.5.2 Perceptions, Place, Race, and Social Capital

This study is also expected to reveal that differences in environmental activism between the two communities relate to the strength and nature of social capital and place attachment, in people's relations with local government and industries, and in their efforts to blunt local activism. These are likely to vary socially with race, ethnicity, and age and in relation to particular economic and historical circumstances. These processes play out differently in each community resulting in varying types and degrees of response to local environmental disamenities. Initial fieldwork in the study areas indicates that some residents associate disamenities in their neighborhoods with past or existing health outcomes. While residents in both communities associate environmental risks and personal health, it becomes critical to understand why different responses emerge via activism or acquiescence.

12.6 Implications

Environmental injustice and activism research can offer information critical to the development of more effective policy within urban environments. The research proposed here will provide much-needed 'local knowledge' that may challenge traditional 'professional' environmental assessment methodologies. This research will also illuminate the role (if any) of social capital and/or place attachment that can contribute toward a re-visiting of existing and longstanding urban redevelopment approaches. In addition, policy will be well-served by findings which provide insight as to if/how the particular form of contamination (medium-soil, air, water) may foster different resident responses and actions.

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Reflection

This proposal synthesizes a vast and diverse collection of literature across multiple fields to identify a gap in the existing literature (place attachment) to understand perceptions of environmental risk, activism, and complex (but inherently fuzzy) concepts such as social capital. The methods section is especially clear and well defined. In the case of more qualitative proposals, the methods section is critical to a *successful proposal. In this case, definitions of qualitative GIS and local knowledge are positioned within well defined boundaries to avoid the excessive "fuzzy-ness" that sometimes accompanies qualitative research. Additionally, this research and the methods are also grounded in empirically observed environmental data.*

Chapter 13
Dissertation II: Geo-Techniques

Genong Yu

This proposal is an example of a technique driven proposal. The proposal is a fine example of the use of graphics to simplify complex methods of analysis and the effectiveness of graphics to convey such information. Additionally, the literature review clearly defines the contribution of the research and is presented in a straightforward fashion using a table structure.

13.1 Accuracy of Neural Network Classifiers in Humid Tropical Areas

Accurate tropical land cover characterization is important to model, monitor, and predict terrestrial ecosystem processes and global climate change patterns, and accurate classification of secondary forest and forest age is important to accurately assess the carbon budget in tropical forests (Kimes et al. 1999). Deriving accurate land cover information using remote sensing techniques is critical to understand links between land cover and environmental changes (Foody and Boyd 1999). However, many issues remain unanswered concerning the classification of remotely sensed data. For example, in recent years, many studies have been dedicated to developing more accurate classification techniques, and neural networks have emerged as an accurate method. In fact, research has shown the potential of neural networks in information extraction of remotely sensed data (Muchoney and Williamson 2001; Frizzelle and Moody 2001; Tatem et al. 2001). This potential motivated the proposed study of neural networks and their prospects in improving the accuracy of tropical land cover classification. This study will lead to a robust classifier with hybrid properties of different classification approaches, typically Gaussian and non-parametric classifiers.

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13.1.1 Problem Statement

Many classifiers have been developed for the retrieval of land cover information from remotely sensed data. These include statistical classifiers (parallelepiped, distance and maximum likelihood, and Bayesian), neural network classifiers (multiple layered perceptron, self-organized map, adaptive resonance technology MAP), decision tree, texture, contexture, semivariograms and segment, and variations with ancillary data (Mather 1999a, b; Paola and Schowengerdt 1995a, b). These classifiers have been employed in applications for forest monitoring (Ranson et al. 1997; Ranson and Sun 1997; Meyer et al. 1996; Treitz and Howarth 2000), land cover (Price et al. 1997), and geologic studies.All remotely sensed classifiers have limitations, but alternative methods can be developed to address these limitations. This study tests the ability of neural networks to address tropical land cover characterization, scale effects, and linear feature extraction.

13.1.2 Limitations of Current Classifiers

According to their assumptions, remotely sensed classifiers can be grouped into two categories. One category is parametric, and a maximum likelihood classifier is the most popular parametric classifier. The Maximum likelihood classifier has been proven the most reliable statistical classifier (Mather 1999a, b; Brisco and Brown 1995; Huang and Mausel 1994). However, the results from this classifier are unsatisfactory when applied to multiple sources and multiple scale data because weighting strategies must be used if the maximum likelihood classifier incorporates ancillary data (Maselli et al. 1995). These weights require a priori knowledge of the study area, which is often difficult to acquire. The other classification category is non-parametric, and neural network classifiers are among the most commonly used.

13.1.3 Alternative Classifiers

Neural network classifiers have been used in remote sensing data since the early 1990s. Neural network classifiers use the principles of artificial neural networks (ANN) and artificial intelligence by simulating the workings of the brain through composing sets of linked processing units and using them to solve problems (Mather 1999a, b). Usually, a neural network is an interconnected assembly of sample processing elements, units, nodes, or neurons, whose functionality attempts to simulate the animal neuron. Its processing capability is stored in weights learned from a set of training patterns (Gurney 1997, p. 234; Bischof et al. 1992).

Neural network classifiers are non-parametric and have demonstrated remarkable accuracy in dealing with multiple sourced data (Benediktsson et al. 1997; Gong 1996; Bruzzone et al. 1997). This accuracy contrasts the weakness of the maximum likelihood classifier. For example, ancillary data, such as DEMs and historical thematic data are typically used to improve land cover classification accuracy.

13.1.4 Special Feature Extraction

Linear features in remotely sensed data are important for classification and visual interpretation. For example, a visual interpreter could start with the interpretation of linear features and use these features to geo-reference the image and infer further information, such as slope aspect and ground target position. This ability to infer information is important for improving classification schemes.

Currently, remotely sensed image classification relies mostly on radiometric information, and does not often use ancillary information, including geometric, topological, and contextual information, from a remotely sensed image. The extracted linear features can be used as an input to a knowledge-based classifier by providing information other than radiometric data.

However, linear features do not often maintain the normal distribution assumption that forms the basis of most parametric classifiers. Therefore, neural networks, which make no assumption of normality, may be better in detecting these features than parametric classifiers. The potential of neural networks for edge detection and linear feature extraction will be tested in this study.

13.1.5 Adaptation to New Sensors

Advances in technology have created new classifiers and remote sensing data at a variety of scales. For example, new satellite sensors, such as IKONOS, provide high spatial resolution data. Past studies on the effects of scale on the land-cover/land-use classification (Latty and Hoffer 1981; Markham and Townshend 1981; Irons et al. 1985) have shown that conventional parametric classifiers resulted in a lower overall classification accuracy with the use of higher spatial resolution data because the spectral variability within a class confused the conventional classifier (Marceau and Hay 1999). Therefore, the responses of neural networks to scale from conventional classifiers will be examined.

13.1.6 Objectives and Hypotheses

The goal of this study is to work towards a robust classification approach for tropical land cover characterization. To achieve this goal, the study will investigate the performance of neural networks under different conditions to see where its greatest potentials lie. The following aspects will be examined.

(1) Response of neural networks to ancillary data: The ancillary data will be digital elevation data and its derivatives.
(2) Response of neural networks to scale: Remotely sensed data at high (4 m), moderate (15 and 30 m) and low (250 and 500 m) spatial resolution will be used to test the accuracy of neural network classifiers.
(3) Linear feature extraction with neural networks: This study will test the ability of neural networks to detect linear features, such as rivers and roads.
(4) Hybrid classification approaches: Alternative hybrid approaches through combinations of different classification schemes, parametric and non-parametric, will be evaluated to create an improved method for tropical land cover characterization.

Specifically, the following hypotheses will be tested.

(1) Neural network classifiers are more accurate than parametric classifiers when incorporating ancillary data.
(2) The accuracy of neural network classification changes with sensor resolution, but NN accuracy is superior to parametric classifiers.
(3) Neural networks yield better results in linear feature extraction.
    a. Neural networks perform better in edge detection compared to maximum likelihood classification.
    b. Neural network architecture affects edge detection results. Generally, the more neurons the neural network has, the less generalization the neural network has.
    c. The image resolution has significant effect on the detection of linear features. At a certain resolution, some linear features are more easily identified.
(4) The hybrid approach, compensating for the weaknesses of individual classifiers, will result in more accurate classifications.

13.1.7 Development of Neural Networks

The first perceptron was developed in 1952 by Rosenblatt at Cornell University. In 1959, Bernard Widrow and Marcian Hoff of Stanford developed ADALINE and MADALINE (Multiple ADAptive LINear Elements) that were the first neural networks to be applied in telephone's echo elimination (Anderson and McNeil 1992). However, disappointments from the exaggerated potential of neural networks from these early successes stunted the growth of neural network research until 1980s (Anderson and McNeil 1992). The development of neural networks increased since the development of multiple layered perceptrons (MLP) in 1986 (Olmsted 1999a, b). The first application of NN in remote sensing was completed in 1988 (Kanellopoulos and Wilkinson 1997), and the first published papers occurred one or two years later (Key et al. 1989; Benediktsson et al. 1990; Lee et al. 1990) (Table 13.1).

13.1.8 Previous Knowledge of Neural Network Classifiers

With the development of multi-layered perceptron (MLP) and the growing popularity of neural networks (NN) in remote sensing studies during the 1990s, neural networks have been applied extensively in classification of remotely sensed data with different adaptations. Some of these adaptations include integrating disparate and ancillary data, like topographic information (Benediktsson et al. 1990; Kimes et al. 1996) and measures of texture (Bischof et al. 1992; Tian et al. 1999; Bruzzone et al. 1997). Others studies have applied neural network classifiers incorporating other methods, such as fuzzy logic (Chen et al. 1998), sub-pixel (Foschi and Smith 1997), decision tree (Dai and Khorran 1999; Kung and Taur 1996), and expert systems (Tag et al. 2000).

Three major advantages have been identified for the use of NN classifiers with remote sensing data. First, an NN classifier is easy to construct theoretically since it has been proven that a three-layer neural network approximation with enough hidden units and sigmoid function is able to solve all the possible formations of decision boundaries in feature space that determines class membership (Hornik and Sejnowski 1988; Lippmann 1987; Paola and Schowengerdt 1995a, b). Most of the NN classifiers applied in remote sensing were often layered (Paola and Schowengerdt 1995a, b).

Second, most NN classifiers are non-parametric and do not require a Gaussian distribution (Lippmann 1987; Paola and Schowengerdt 1995a, b). In contrast, most common statistically based probability classifiers, like the maximum likelihood classifier, require that the data for each ground cover class be approximately normally distributed (Jensen 1986). This property of NN classifiers enables them to function as multi-source classifiers, since most non-remotely sensed data do not hold the assumption of a normal distribution (Benediktsson et al. 1993; Benediktsson and Sveinsson 1997; Kimes et al. 1998). NN classifiers were more accurate when the feature space was complex, the source data had different statistical distributions, and the datasets were nominal or categorical (Benediktsson et al. 1990, 1993). The classifier can easily incorporate more complicated input data by using multiple pixels or windows, like textural measures (Bischof et al. 1992). The incorporation of a priori knowledge becomes more logical and accurate (Foody 1995a), and a priori knowledge and physical factors could be easily incorporated into the analysis (Foody 1995a, b).

Finally, neural network classifiers can deal with some degree of noise because of the property of graceful degradation, (Gurney 1997), where the level of error tolerance is linked to the number of layers of neurons (Mather 1999a, b).

Table 13.1 Historical events during the development of neural network computing (Olmsted 1999a, b)

Events	Scientists	Date	Works
First NN theory	Alexander Bain (1818–1903)	1873	Mind and Body. Theories of Their Relation. Henry King, London
American first restatement of NN theory	William James	1890	Principles of Psychology, Henry Holt, New York
First neural logic	Rashevsky, N	1938	Mathematical Biophysics. University of Chicago Press, Chicago, Illinois
First randomly connected reverberatory networks theory	Donald Hebb	1949	The Organization Of Behavior. John Wiley & Sons, New York
First simulated Hebbian networks	B. Faley and W. A. Clark	1954	Simulation of self-organizing systems by digital computer. IRE Transactions on Information Theory, 4:76–84
First reverbatory network showing self-assembly	N. Rochester, J. H. Holland, L. H. Haibt and W. L. Duda	1956	Tests on a cell assembly theory of the action of the brain using a large digital computer. IRE Transaction of Information Theory IT, 2:80–93
The first perceptron	Frank Rosenblatt	1958	The perceptron: a probabilistic model for information storage and organization in the brain. Psychological Review, 65:386–408
ADALINE	Bernard Widrow and Marcian Hoff	1960	Adaptive switching circuits. 1960 IRE WESCON convention record. IRE, New York. pp. 96–104
Classic perceptrons	Frank Rosenblatt	1962	Principles of Neurodynmaics: perceptrons and the theory of brain mechanisms. Spartan Books, Washington, DC
The association network of Kohonen	Teuvo Kohonen	1972	Correlation matrix memories. IEEE Transaction on computers, C-21:353–359
The association network of Anderson	James A. Anderson	1972	A simple neural network generating an interactive memory. Mathematical Biosciences, 14:197–220

(continued)

Table 13.1 (continued)

Events	Scientists	Date	Works
The cognitron—first multilayered NN Kunihiko Fukushima	Kunihiko Fukushima	1975	Cognitron: a self-organizing multilayered neural network. Biological Cybernetics, 20:121–136
The Hopfield association network	John Hopfield	1982	Neural networks and physical systems with emergent collective computational abilities. Proceedings of the National Academy of Sciences, 79:2554–2558
The first hybrid network	Doug Reilly, Leon Cooper and Charles Elbaum	1982	A neural model for category learning. Biological Cybernetics, 45:35–41
The multi-layered back propagation association networks	Paul Werbos	1974	Beyond regression: new tools for prediction and analysis in the behavioural sciences. Ph.D. Thesis, Harvard University, Cambridge, MA
First multi-layered back propagation perceptrons	D. B. Parker	1986	A comparison of algorithms for neuron-like cells. In Neural networks for computing (J. S. Denker, Ed.), American Institute of Physics, New York
	David D. Rumelhart, Geoffrey E. Hinton and Ronald J. Williams	1986	Learning representations by back-propagating errors. Nature, 323:533–536
	Y. Le Cun	1986	
The adaptive resonance (ART) networks	Gail A. Carpenter and Stephen Grossberg	1987	1. A massively parallel architecture for a self-organizing neural pattern recognition machine, Comput. Vision Graphics Image Processing, 37:54 2. ART 2: Self- organization of stable category recognition codes for analog input patterns, Applied Optics, 26:4919–30

(continued)

Table 13.1 (continued)

Events	Scientists	Date	Works
The first multivalued logic neural network	David Olmsted	1990	The reticular formation as a multi-valued logic neural network. In International Joint Conference on Neural Networks, IEEE Neural Networks Council, 1:619–24

However, several disadvantages of neural networks have discouraged many potential users from adopting this classifier in remotely sensed data processing. The most significant problem with the neural network classifier is its training time and complexity (Paola and Schowengerdt 1995a, b). The neural network classifier is fast at the stage of feed-forwarding (Heermann and Khazenie 1992), but the iterative process required to produce the weights for the feed-forward processing is both time and computation intensive (Paola and Schowengerdt 1995a, b). This process depends on the learning rate and the proper initial assignment of weights. How well the neural network performs in solving a problem therefore depends on how well the function was developed during learning of the training set (Dowla and Rogers 1995). Second, the mechanisms behind a classification are difficult to discern, since they are different from statistical theory and usually never explain how outputs depend on inputs or how they are weighted (Dowla and Rogers 1995; Key et al. 1989; Paola and Schowengerdt 1995a, b). This disguises the exact relationships between inputs and outputs. Finally, the NN classifier may lead to a local minimum instead of a global minimum (Mather 1999a, b). For example, during training the error is reduced to below a preset threshold. The global minimum represents the smallest error that can be reached. However, the network may never proceed to the global minimum if a local minimum that is significantly worse than the global minimum is encountered. The iteration stops and the training algorithm fail to further reduce error. Differences in the initial weights may result in a different local minimum and thus different classification accuracies (Ardo et al. 1997; Skidmore et al. 1997).

13.1.9 Applications of Neural Networks in Tropical Land Cover Study

Applications of neural networks in the context of tropical land cover study are limited. Kimes et al. (1999) applied neural networks to discriminate between primary forest, secondary forest, and deforested pixels in the tropical area of Rondonia, Brazil by using SPOT HRV (High Resolution Visible) images, and texture measures. Their results showed that the neural network classifier with textual measures was able to classify the three categories with 95% accuracy. The textual measures increased the accuracy by 6.4%. The neural network classifier was able to better predict forest age when multi-temporal images were used. Bandibas (1998) compared the results of maximum likelihood classifier and neural network in Philippines. The neural network showed a higher overall accuracy (86%) when compared to the accuracy (76%) obtained using the maximum likelihood classifier. Fauzi et al. (2001) reported that a neural network classifier was superior to maximum likelihood classifier in an Indonesian rainforest study. Foody and Boyd (1996) attempted to use the fuzzy mapping capability of neural networks in dealing pixel-mixing of NOAA AVHRR images in West Africa.

13.1.10 Study Area

The study area used is located in Altamira, in the eastern Amazon, Brazil (Fig. 13.1). The dominant vegetation is mature rainforest and liana forest (Mausel et al. 1993), and typical soils are Alfisols (Mausel et al. 1993). Annual precipitation is about

Fig. 13.1 Study area: Altamira, Brazil

1700 mm, with a four-month dry season occurring June through September (Mausel et al. 1993). Grazing and swidden agriculture are the most common agricultural activities in the area (Moran et al. 1994; Skole et al. 1994).

13.1.11 Remotely Sensed Data

Four remote sensing datasets will be used in this study: Landsat TM (May 26, 1996), ASTER (October 14, 2000), IKONOS (July 29, 2000) and MODIS (July 4, 2000). IKONOS data are available in four multi-spectral bands: blue (0.45–0.53 μm), green (0.52–0.61 μm), red (0.64–0.72 μm) and near infrared (0.77–0.88 μm) at resolution of 4 m, and one panchromatic band (0.3–0.7 μm) at a resolution of 1 m. MODIS data have 12 bit radiometric resolution and 36 spectral bands between 0.5 and 14.4 μm. In this study, the first seven bands will be used. The spatial resolution of the first two bands, 0.62–0.67 and 0.841–0.876 μm, are 250 m. That of the other five bands, 0.459–0.479, 0.545–0.565, 1.23–1.25, 1.628–1.652 and 2.105–2.155 μm, are 500 m. There are three other informational bands associated with the MODIS data obtained from EOSDIS, i.e. solar zenith, view zenith and relative azimuth. Landsat TM has six bands with 30 m spatial resolution. Their spectral resolution is 0.450–0.515, 0.525–0.605, 0.630–0.690, 0.750–0.900, 1.55–1.75, and 2.09–2.35 μm. The ASTER image was acquired on July 29, 2000. ASTER has 5 bands, including three visible near infrared (VNIR) bands, six shortwave infrared (SWIR) bands, and five thermal infrared (TIR) bands. Three VNIR bands in 15 m spatial resolution are used which are 0.52–0.60, 0.63–0.69 and 0.76–0.86 μm.

These datasets represent six different spatial resolutions: 1, 4, 15, 30, 250 and 500 m. These datasets will allow the comparative study of neural networks in the context of multiple scales. The actual area used will be a small subset of each dataset to enable the fast processing. Figure 13.2 shows the original datasets.

Classifiers

In this research, two neural network classifiers will be used and maximum likelihood classifier will be used for comparison.

The approach to implementing the two neural network classifiers is object-oriented design (OOD). There are several advantages to this approach: (1) Economic versioning management; (2) Effortless team-cooperation with the proper framework; (3) Easy distribution to web and other applications; and (4) Flexible extension support.

Multiple Layered Perceptron

A multi-layered back propagation neural network will be implemented using OOD approach. It is also called as a multi-layer feed forward network. A unit or processing element in a neural network can be considered as a simple processor with many different input connections from other units in the network and one output which is sent to many other units (Bischof et al. 1992). Every unit at the hidden layer or the output layer has all the weighted input from the previous layer and two actions. One action is the sum of the weighted input as performed by using Eq. (13.1). The other is the transformation by using an activation function. This function (Eq. 13.2) is a sigmoid function used to ensure the nonlinear transformation and the simplicity of computing implementation (Zurada 1992). The output of this unit is derived through these two steps. Figure 13.2 shows the typical structure of a neuron, or a unit.

$$I_i = \sum_{j=1}^{n} \varpi_{ij} x_j \tag{13.1}$$

where, I_i is the input value of the neuron i, x_j is the value of each unit in the previous layer, and w_{ij} is the weight for each unit in the previous layer in the case of the neuron i.

$$f(I) = \frac{1}{1 + e^{-I}} \tag{13.2}$$

where, $f(I)$ is the sigmoid activation function, and I is the input value of a neuron.

The algorithm for the multiple layered feed-forward network classifier has seven steps in one training cycle (Zurada 1992). This cycle loops for all training samples

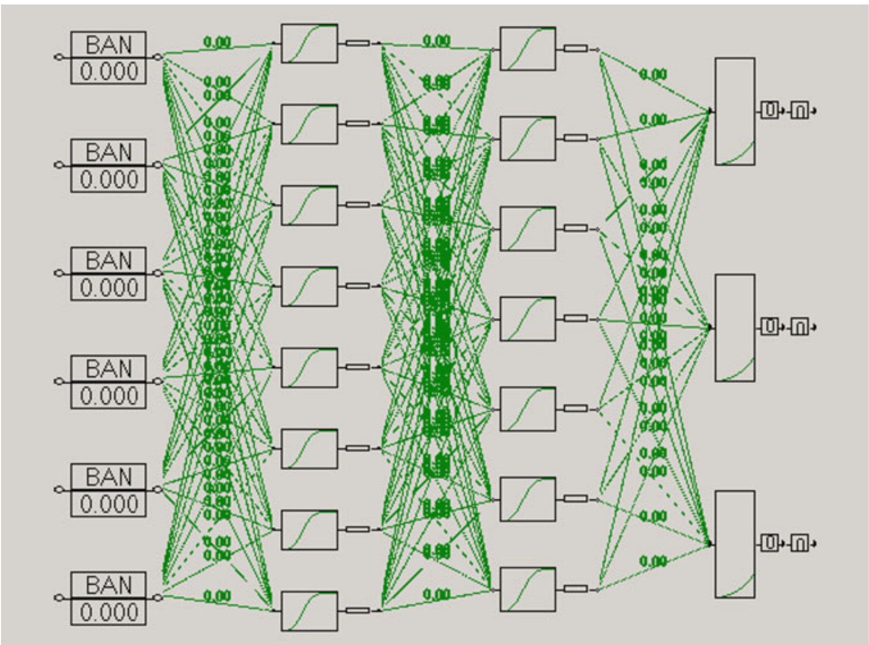
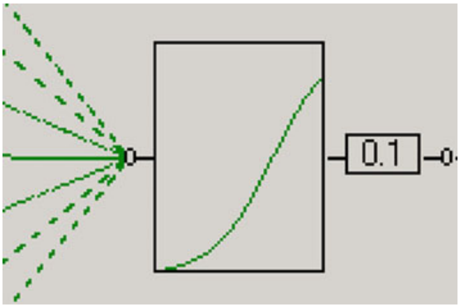


Fig. 13.2 An example of neural network architecture

Fig. 13.3 A neuron



until the required criterion to terminate the recursion is met. The termination conditions could be a maximum error or the maximum iterations given by the user. Figure 13.3 shows the algorithm flowchart. In the developed classifier, the termination conditions are to check: (1) if the allowed maximum error is met; and (2) if the overall neural network error has improved after another iteration over all the training samples.

With the classifier, the outputs of the neural network represent one class each and are trained to have 'high' values for their given class. The classifier uses a simple class extracting strategy that assigns the class of the output node the highest value (Cromp 1991; Paola and Schowengerdt 1995a, b).

A normalizing routine is embedded to keep the pixel value of the remotely sensed data within the range of 0 to 1, which ensure the NN error within 0 to 1.

Adaptive Resonance Theory Map

Adaptive resonance theory, or ART, refers to self-organizing neural architectures that cluster the pattern space which overcomes the plasticity-stability dilemma. In other words, a network remains open to new learning (plastic) without wiping out previously learned codes (stability) (Gurney 1997; Carpenter and Grossberg 1987).

ARTMAP, a supervised learning by a self-organizing neural network, combines two ARTs with MAP fields that learn input–output pairs (x, y) (Gurney 1997). The fuzzy extension of the ARTMAP allows the processing of analogue data and results in fuzzy ARTMAP architecture (Carpenter and Grossberg 1992). In this study, a fuzzy ARTMAP will be implemented.

Land Cover Classification Schemes

This study will focus on comparing the performances of each classifier on a level one-land use/land cover classification system considering the comparison of multi-resolution images. In the study area, the major categories are water surface, cultivated land, forest, and built-up area. Alternative feature categories may be considered in the examination of the classifiers, such as linear features. Road and rivers are the two major linear features in the study area.

Data Pre-processing

Tasks for the data pre-processing include the following.

- Analysis of field data collected.
- Data fusion and geographical registration.
- Set up and analyze the spectral library.

Enhancement or feature selection/extraction, especially for linear features (Fig. 13.4).

Data Analyses

A series of evaluations of the responses of classifiers are necessary to build a thorough understanding of the neural networks and their potential in improving the accuracy of tropical land cover classification. These analyses will be designed to optimize the architecture upon data sources, data scales and information targets.

Architecture Optimization

A series of comparisons will be made to find the optimal neural network architecture for tropical land cover characterization. In this study, the performance of each classifier will be examined in three aspects: an internal examination by setting different parameters, an evaluation by choosing different inputs and outputs, and an external comparison with the maximum likelihood classifier.

Ancillary Data Inclusion

Digital elevation data (DEM) and its derivatives, slope and aspect, will be used as ancillary data to see if they improve classification accuracy. The different responses between neural network and maximum likelihood classifier will be compared.

Scale Effect Examination

The responses of the neural networks to different resolution images and their scaling will be assessed. The tasks are: (1) To examine scales at which land cover classes can be mapped as detected by remotely sensed imagery. Focus will be given to the characterization of land cover across spatial (4 m–500 pixel spatial resolution) scales. (2) To compare the performances of maximum likelihood classifier (MLC) and multi-layered perceptron (MLP). (3) To verify that there is a need to collect data at a variety of spatial scales for multiple scale study of land cover.

Linear Feature Extraction

The main objectives will be to verify if the neural network edge detector performs well over a range of images, and will be compared to two conventional approaches in extracting linear features: Canny edge operator and direct classification using maximum likelihood classifier. Canny edge detector is considered an optimal edge detector for pictures with noise that works in a multi-stage process (Canny 1986): (1) Directional gradients are computed by smoothing the image and numerically

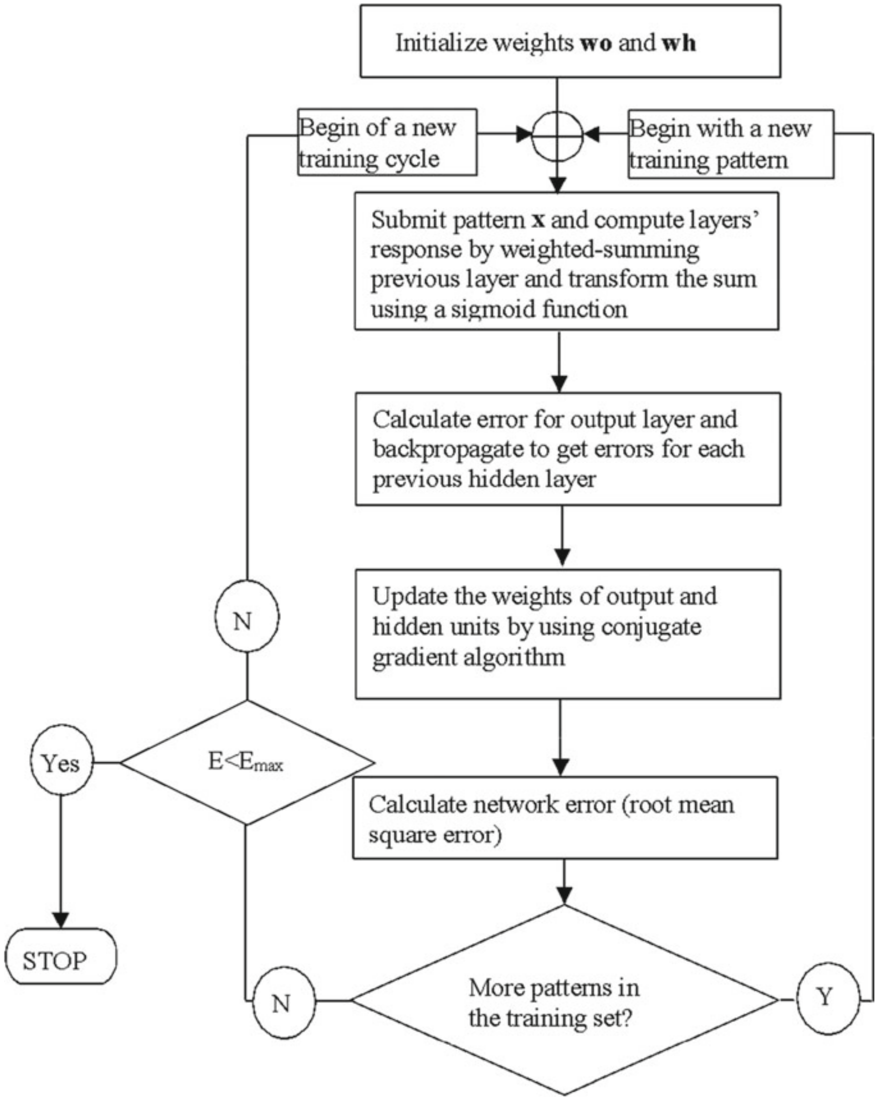


Fig. 13.4 A typical algorithm for neural network computation

differentiating the image to compute the two axial gradients; (2) Noon-maximum suppression finds peaks in the image gradient; and (3) Hysteresis thresholding locates edge strings (Fig. 13.5).

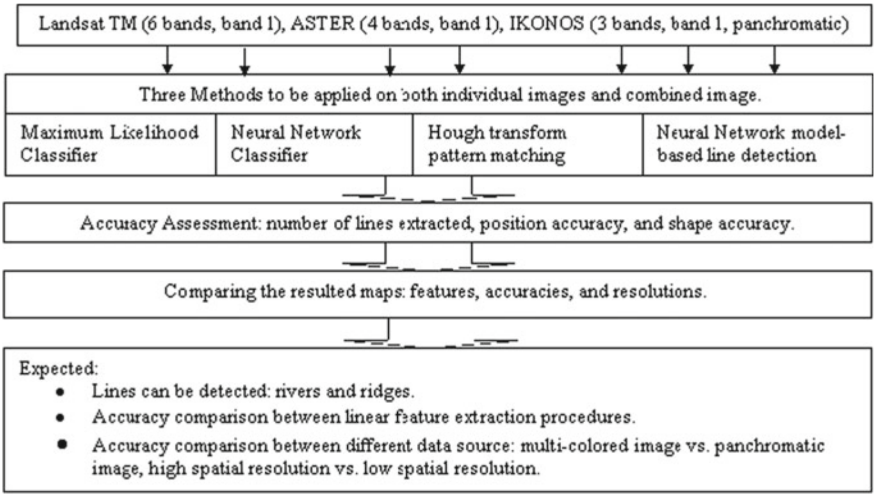


Fig. 13.5 Linear feature extraction

13.1.12 Hybridized Approach

This study will determine if combining multiple neural network classifiers improves the accuracy of the land cover classification. Each land cover type will be trained and classified independently using a neural network classifier. The classification results will then be merged. This will help save training time if there is a need for adjustment of training samples.

A hybridized approach with both non-parametric and parametric classifiers will also be explored.

Accuracy Assessment

High-resolution satellite data (1 m panchromatic image) and aerial photos, in conjunction with field data, will be used to assess accuracy. Accuracy assessment in this project will examine two aspects. One is to calculate the accuracy of classification at different scales. A fixed set of reference pixels will be randomly selected and used to calculate producer's accuracy, user's accuracy, overall accuracy, and Kappa coefficients. The same set of reference pixels will be used to enable the consistent comparison between the results from different datasets.

The other dimension to accuracy assessment is to examine the scale effect by looking at the aggregation of pixels. This helps to understand multiscale image processing by overlaying pixels at different scales to derive a cross table of mixing pixels.

13.1.13 Expected Results

The results and discussions concerning the following are expected through corresponding experiments.

1. Test if NN is superior to MLC on tropical land cover classification when ancillary data are used.
   a. DEM
   b. Different derivatives
2. Determine if NN is superior to MLC on scaling and mixed images.
   a. IKONOS, Landsat TM, ASTER and MODIS data
   b. Up-scaling
3. Determine if NN is superior to MLC on linear feature extraction. But MLC is superior to NN in most cases for non-linear feature extraction.
   a. Rivers and roads
   b. Edges
4. OOD provides the flexibility. Parallel makes possible for large nets.
   a. Objects binding data and procedure
   b. Speed and resource by parallel computing
5. The hybridized approach improves in some aspects.
   a. Multiple use of neural networks
   b. Multiple classifiers.

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Reflection

After more than one year of research, the Ph.D. dissertation was completed and defended. The proposal proved to be a good blueprint for the research. Indeed, this proposal is unique in that the proposed research and end product were nearly identical. While this example is one of the most efficient examples we have seen in over the course of our careers, most projects evolve in response to various challenges or methodological complications. Even under ideal situations, the end product's literature review and methods for most dissertations change, if only as a result of the normal writing (and revision) process. For that reason, research proposals represent only an initial step in an inherently developmental process. As a result, research proposals and the final work products may vary in a variety of ways—particularly if the expected results are not achieved.

Finally, this sample dissertation proposal presents a comprehensive summary of the technical literature using a table. While the table approach is efficient, the table is very complex. That is to say, a great deal of content is contained in a single feature. Insofar as this is a highly technical research initiative, the major shortcoming of the proposal is its overall accessibility to the general spatial science community.

Having said that, the proposal was written for a very specific audience—a dissertation committee comprised of geotechnical expects—and the prose was appropriate in this case. However, the proposal writers must be mindful of the expectations of his/her entire committee—the audience.

Chapter 14
Dissertation III: Physical Systems

Michael Jurmu

This proposal has four unique features. First, the literature section distills complex research in geomorphology into easily understood concepts. Second, the author explicitly cites the works from which the hypotheses are derived. This technique serves to situate the proposed research squarely in the existing literature and by implication defines the "gap." Third, the methods section of this proposal provides a solid example how research methodologies are inherently linked to the literature review. Fourth, the author nicely describes the initial field work (i.e., process) used to obtain the study data. Finally, the proposal's introduction and explanation of the methods and associated equations is both economical and effective.

14.1 Variation in Wetland Stream Morphology

The recent discovery of wetland importance to the diversity of Earth's ecosystem has caused an increase in wetland restoration and creation projects over the last several decades (Vance 1987; Gildersleeve et al. 1989; Garlo 1990; Rhoads and Miller 1990; Lefor and Gadwa 1995). The replication of such environments is complex and can be very difficult to duplicate exactly. Although one of the most important components for successful wetland construction is hydrology (Carter 1986; Mitsch and Cronk 1992; Mitsch and Gooselink 1993), a hydraulic aspect apparently overlooked is the function of streams traversing wetland areas. The fact that many wetland projects design streams to replicate features typically found in non-wetland alluvial settings reflects the assumption that wetland streams are similar in morphology, and therefore function. If wetland environments are unique biologically and aquatically, it follows that factors affecting streams within these areas might also be distinct and create different morphological features. Research has failed to investigate how these unique aspects of wetlands could influence stream morphology and thus the function of the system itself.

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This study intends to identify and compare morphological features of streams traversing wetland areas to those parameters normally associated with streams in non-wetland alluvial environments. The specific features being investigated are bank full flow, bends, pools and riffles, thalweg location, straight reaches, and cross-sectional shape. Where differences exist, explanations will be presented to describe why they might occur. The overall objective is to aid in restoration/creation of these environments by supplying a more accurate representation of actual wetland streams.

14.2 Literature Review

The benefits of wetlands are well documented and include habitats for various biotic communities, the maintenance of water quality and recycling of nutrients, protection of shorelines, removal of sediment and chemicals from wastewater along with providing recreational activities for humans (Bardecki 1984; Callahan et al. 1992; Mitsch and Gooselink 1993). Historically, wetlands have been filled or drained for development (Callahan et al. 1992) causing a dramatic rate of loss until the 1970s when the goal of "no overall net loss" was suggested by the National Wetland Policy Forum (NWPF) (Mitsch and Cronk 1992). Since then mitigation and restoration projects have increased annually through programs under such acts as the Federal Water Pollution Control Act Amendment of 1972 and the Wetland Protection and Flood Plain Management Executive Order of 1977.

The restoration or replication of wetlands is complicated, yet recent research has aided designers in establishing construction specifications for successful projects (Cooke 1995; Lefor et al. 1995; Rich and Murray 1995). While researchers acknowledge poorly designed hydrology is the leading cause of failed wetland projects (Mitsch and Cronk 1992), little attention has been given to one hydrologic aspect; streams in wetland areas. Few researchers believe streams need special consideration in wetland projects (Vance 1987; Lowry 1990), and when streams are identified as critical to wetland planning, little information is provided on optimal designs (Kusler and Kentula 1989). If hydrology is a critical factor in wetland restoration and creation, and streams are an aspect of wetland hydrology, further research is needed to better understand how streams function in wetland environments, and this research should include the physical features within streams that are associated with wetland controls.

In 1992, the National Research Council's Committee on the Restoration of Aquatic Ecosystems (1992) suggested a massive program of wetland restoration to gain 10 million acres of additional wetlands within the U.S. by the year 2010. This indicates the government's commitment to wetland development, and ensures the trend of increasing wetland restoration projects will continue. If these projects are to be successful, it is imperative that the critical factor in wetland functioning, hydrology be duplicated as close to natural as possible. Because streams traversing wetlands are a portion of a wetland's hydrology, it is also important to replicate these features to ensure projects restoring or creating wetlands are successful, yet there is an apparent lack of research specifically involving streams, especially stream morphology. If wetlands contain unique plant life, have distinct hydrology, and function unlike any other environment, will the morphology of streams within these environments also be different than in non-wetland alluvial environments?

The term *morphology* encompasses a variety of features regarding streams, and to suggest all morphological features of streams in wetland areas are different would be erroneous. It is probable hydraulic factors work to produce certain channel features regardless of the surrounding environment. Yet little research has been conducted on wetland stream morphology to determine ***if*** there are differences, ***which*** features differ, and to what ***extent***. Therefore several research hypotheses are proposed to study wetland stream morphology based on accepted models of river hydrology generated from alluvial environments:

H_1: The basic planform morphology (sinuosity) of wetland streams in this research differs in relationships to bed material and Form Ratio (F) from models proposed by Schumm (1963).

H_2: The cross sectional morphology (form) of wetland streams in this research differs in relationship to bed material from a model proposed by Schumm (1960).

H_3: The channel bed morphology (profile) of wetland streams in this research differs in relationship to bed material and drainage basin area from a model proposed by Hack (1957).

The use of these models will aid in demonstrating differences in wetland stream morphology by linking this research to accepted empirical equations. Along with these morphological models, additional comparisons will be made with other standard relationships found in the literature and often cited in text books concerning rivers to further support the findings. The classification of features into specific categories allows more detailed analysis of each feature as it relates to the form of a stream. The exact characteristics within each category will be outlined further in the *Methods* section.

As expressed by Jurmu and Andrle (1997), the term "wetland stream" will be used in this study to signify the coherent study stream traversing a wetland area not specifically classified as a riverine wetland. All streams and adjacent periphery can be classified as some type of riverine wetland and the streams of interest in this research are those traveling through broader wetland areas (such as palustrine wetlands). The standard wetland classification (Cowardin et al. 1979) does not provide a separate class for streams within freshwater wetlands not classified as riverine. The use of the term "wetland stream" in this research indicates the stream of interest is located within a wetland of another type (palustrine, lacustrine), and not a riverine wetland.

14.2.1 The Kankakee Watershed

The Kankakee River Watershed is a sub-basin of the Illinois River Basin, both included within the Upper Mississippi River drainage system (State of Indiana 1990). Most of the Kankakee basin is located within 100 miles of Chicago, Illinois. Starting near South Bend, Indiana as the Dixon West Place drainage ditch, the Kankakee River flows west about 104 miles to near Kankakee, Illinois where it joins with the Iroquois River, then travels northwest another 36 miles to merge with the Des Plaines River to form the Illinois River. The basin drains approximately 5165 mi^2 within Indiana and Illinois with a small portion in Michigan (State of Indiana 1990). Groundwater resources are relatively good throughout most of the basin and while a large percentage of total soil loss occurs in the north and east peripheries of the basin, the Kankakee River has a lower suspended sediment content than any other stream in Indiana (State of Indiana 1990).

Much of the Indiana portion of the Kankakee River and its tributaries were channelized early in the century to aid in drainage for agricultural use (Bhowmik and Bonini 1981). The Kankakee River itself was straightened reducing its length from 250 miles to approximately 82 miles (Bhowmik 1989). Besides this earlier channelization and several maintenance projects on minor upstream reaches, the Indiana section of the Kankakee River has basically remained untouched for over fifty years (State of Indiana 1976).

14.2.2 Identification of Possible Study Streams

Initial site identification began with the production of an NWI map of the Kankakee Basin in Indiana using available land cover data and ERDAS Imagine software (ERDAS 1995) to locate all possible wetlands. Stream size most applicable for this investigation range between 5 and 10 m in width and are most often found near the headwaters of streams. Areas where wetlands exist in the upper reaches of a stream were first identified along with their corresponding county locations. Soil survey books for these counties were obtained and each selected location was reviewed for hydric (organic) soils and channel planform shape. The planform of a stream refers to the pattern of the stream from the vertical view and can initially indicate several factors relevant to this study. Extremely long straight reaches of a stream with perpendicular bends connecting to other similar reaches often denote extensive human modification (channelization or ditching) and are not desirable for this research. Based on the initial review, 14 stream reaches on 6 different rivers were determined suitable for further investigation; 3 on Mill Creek, 2 on Kingsbury Creek, one each on the Little Kankakee, Fish Creek, and Pine Creek, and 6 on the Yellow River.

To further evaluate the sites, a set of criteria were established where values could be assigned to characteristics of a site based on feature importance in defining a suitable study location. Values could be summed to obtain an overall score for the site and aid in final site selection. Features evaluated included wetland type and extent, stream morphology and flow, soils, surrounding environment, accessibility, and distance from Indiana State University. Table 14.1 shows the complete criteria and possible values. A site visit was conducted on October 11, 1996 to each of the identified locations deemed suitable from the initial review of the soil surveys. From

Table 14.1 Wetland stream criteria and values

Wetland		Soils	
Type	5-PEM 4-PSS 3-PFO 2-Riverine 1-not classified	Drainage	5-very poorly drained 4-poorly drained 3-somewhat poorly drained 2-some drainage 1-drained
		Accessibility	
Configuration	5-basin (oval/circular) 4-valley w/extensive fringe 3-valley w/narrow fringe 2-narrow w/ patches 1-narrow or patchy	Equipment input and parking	5-excellent 4-very good 3-good 2-poor 1-no access
Stream		**Agricultural encroachment**	
Width	5-5 to 8 m 4-8 to 11 m 3-11 to 14 m 2-0 to 5 m Over 15 m	Distance from wetland	5-over 200 m 4-135 to 200 m 3-70 to 135 m 2-5 to 70 m 1-within 5 m
		Surrounding environment	
Morphology	5-high meandering 4-meandering 3-some meandering 2-limited meandering 1-straight	Study site found in	5-extensive weltland 4-rural residential 3-rural agricultural 2-urban residential 1-urban
		Distance from ISU	
Flow	5-low 4-variable 3-stagnant 2-medium 1-high	Time to study site	5-with 0.5 h 4-0.5 to 1.0 h 3-1.0 to 3.0 h 2-3.0 to 5.0 h 1-over 5.0 h
Length	5-over 500 m 4-300 to 400 m 3-200 to 300 m 2-100 to 200 m 1-less than 100 m		

viewing the streams at different bridge locations, each site was evaluated based on the criteria. Photographs for later review were also taken where possible and applicable. In several incidences, individual reaches on a single stream were very similar. To avoid excessive replication in evaluation, 11 stops were made to evaluate the 14 initial stream reaches. In several cases (Mill Creek and Kingsbury Creek) multiple reaches were combined into one stop. Although Fish Creek and the Little Kankakee River initially had one reach, two stops were made at each stream to better evaluate their features. The Yellow River had different characteristics above and below the town of Plymouth, and the evaluation was therefore split between the two locations with 4 stops total. The results of the evaluation are provided in Table 14.2.

By the fall of 1997, access to the stream reaches of interest were only available for the Little Kankakee (private landowner) and Fish Creek (The Nature Conservancy [TNC]). Both sites were visited on October 4–5, 1997 to further evaluate stream characteristics by canoeing the stretches. A canoe was borrowed from ISU's Department of Sports and Recreation for the site visits. The author and his spouse traversed the stretches and reviewed each stream for appropriate morphology, wetland extent, channel characteristics, and overall acceptable features. The Little Kankakee was bordered by mostly forested buffer areas adjacent to agricultural lands. The stream was wide and very shallow with relatively quick flow. Because of these reasons and the lack of extensive open areas to conduct a survey from, it was determined the Little Kankakee would not be suitable for this study.

In contrast Fish Creek provided excellent features worthy of study including stream morphology, distinct boundary between vegetation and the open channel, and minimal stream flow. The extent to which continuous surveying could be conducted along a reach was in question because the inundation of the wetland provided few areas for locating surveying equipment. Because of the typical wetland features found along Fish Creek, it was determined surveying would be conducted to the maximum extent allowed by stream conditions. The wetland characteristics along Fish Creek will accurately depict a classic wetland environment and wetland stream in the Kankakee watershed.

14.2.3 Site One: Fish Creek

One initial study stream currently identified and partially surveyed is Fish Creek. This stream is located in northwestern Indiana in LaPorte County and found in the Stillwell Quadrangle. The reach being surveyed is located on connecting properties; the northern section privately owned and the southern portion owned by TNC. The wetland is adjacent to agricultural fields to the west on a ridge approximately 25 m above the wetland valley. The south end is bordered by railroad tracks where three large culverts allow unimpeded drainage beneath the tracks to Upper Fish Lake. The soils of the Fish Creek wetland are deep histosols (Hh) and aquolls. They exist on nearly level surfaces or in depressions on low-lying lake plains, outwash plains, till plains or moraines. These soils are very poorly drained with some covered by shallow water most of the year. The histosols of LaPorte County exist in small areas, usually less than 10 acres.

The National Wetlands Inventory (NWI) classification identifies this wetland as palustrine with various sections within the wetland boundary of emergent vegetation (PEM), scrub-shrub (PSS), forested (PFO), and unconsolidated bottom (PUB). Wet meadow vegetation composes most of the area with a distinct boundary between

Table 14.2 Evaluation Table of Kankakee Watershed Streams

Stop no.	Stream name-location	Wetland type	Weltland configuration	Stream Width	Stream morphology	Stream flow	Stream length	Soils	Access	Agriculture encroachment	Surrounding environment	Distance from ISU	Total
1, 2, 3	**Yellow River**; s.w. of Plymouth; trends east-west	3.0	3.0	1.0	4.0	5.0	5.0	3.0	3.0	4.0	3.0	2.0	37.0
4	**Yellow River**; east of Plymouth; at ben to north	4.5	2.0	1.0	4.0	5.0	5.0	3.0	4.0	3.0	3.0	2.0	36.5
5	**Pine Creek**; west of Walkerton	5.0	1.0	5.0	2.0	2.0	5.0	5.0	3.0	2.0	25	2.0	34.5
6, 7	**Fish Creek**; north of Fish Lake	4.5	3.5	5.0	5.0	5.0	5.0	5.0	5.0	3.0	3.0	2.0	46.0
8, 9	**Little Kankakee River**; north of RT. 4 to headwaters	4.5	3.0	3.0	5.0	1.0	5.0	5.0	2.0	2.0	3.0	2.0	35.5

(continued)

Table 14.2 (continued)

Stop no.	Stream name-location	Wetland type	Weltland configuration	Stream Width	Stream morphology	Stream flow	Stream length	Soils	Access	Agriculture encroachment	Surrounding environment	Distance from ISU	Total
10	**Kingsbury Creek**; north and south of Kingsbury	4.5	2.0	2.0	5.0	2.0	5.0	5.0	2.0	4.0	2.5	2.0	36.0
11	**Mill Creek**; from RT. 6 to RT. 39 through Union Mills	5.0	2.0	4.0	5.0	3.5	5.0	5.0	2.5	4.0	2.5	2.0	40.5

the vegetation and the open-water channel. A relative new beaver dam exists approximately half way between the railroad tracks and the north property boundary.

14.3 Methods

14.3.1 Field Surveying of Streams

Each stream segment investigated will require extensive surveying similar to the procedures described here conducted on the Fish Creek study stream. A survey of Fish Creek was conducted over two weekends (October 31–November 2, and November 14–16, 1997) using standard surveying equipment provided by ISU's Department of Geography, Geology, and Anthropology. The survey was designed to take measurements of the channel cross section at increments approximate to the mean channel width. Channel measurements could not be taken by standing in the stream because this would disturb the fine-grained material composing the bed and thus the cross sectional shape. By using the canoe and strapping it to aluminum conduits inserted in the bed perpendicular to the flow, measurements across the channel could be taken from within the canoe without disturbing the bed formation. The only disadvantage the author has found using this method is the movement from one cross section to another. The process of unstrapping the canoe, removing the conduits, canoeing to the next cross section location, reinserting the conduits, and securing the canoe does require considerable time. The average number of cross sections surveyed per hour was 4 to 5. Although this method is often tedious and requires extreme balance, there is no other procedure known to the author that would allow cross section survey without disruption of the bed, and this might explain why extensive studies on wetland stream morphology do not currently exist.

Wet meadow vegetation can often grow over 2 m tall inhibiting the view to the rod during surveying. It is then desirable to locate the level in such a way to maximize the measuring distance of the channel reach and minimize sight obstructions. This avoids having to setup the level again every few cross sections. Another problem associated with wetland surveying is the inundation of adjacent surfaces to the stream. Because the area surrounding Fish Creek was often inundated and minimal room was available to locate the level, only specific reaches longer than 50 m could be continuously surveyed. The lower reaches of Fish Creek below the beaver dam provided the best possible location for setup. Another location upstream of the dam was also surveyed to possibly compare the differences associated with the channel at these two locations. Level measurements of upper stadia, lower stadia, and azimuth from north were recorded. Field notes were also collected concerning distinct features or noteworthy characteristics observed.

Raw survey data were entered into a Microsoft Excel spreadsheet for preprocessing and quicker manipulation. Distance to each point and depth from water level were initially calculated. Using the Laws of Sine and Cosine, spreadsheet formulas were developed to calculate surveyed cross section width, channel width, and distance from left bank so initial cross sections could be generated.

Spreadsheet usage was originally believed to be the most productive and efficient method to produce cross sections with survey data. After this preliminary work, it is obvious the author needs to pursue other methods for further manipulation of the data. A more efficient and robust software package is needed that provides better manipulation of cross sections, planform composition of the surveyed reaches, and possible incorporation of GPS, remote sensing, or other digital databases for further analysis. The author has been working with ArcView version 3.0a (ESRI 1996) and Arc/Info version 7.0.4 (ESRI 1995) to develop a procedure to process the raw survey data into several final products. ArcView is a user-friendly software that can be utilized for initial survey point input, planform maps, and simple geometric calculations. This system will also be used for digitizing additional information such as watershed boundaries, infrastructure, and soil surveys. Arc/Info is a more robust software that provides mapping and cross-sectional capabilities for illustrating surveyed data, along with features to develop bed topography graphics that can be used to analyze bed bars and pools and riffles. This software will be used to produce a TIN of the channel that can then be used to generate cross sections and bankfull widths needed for comparison, and 3-D perspectives of the entire stream for visual analysis and description.

14.4 Specific Morphological Feature Comparisons

Several features noted as typical in alluvial streams will be compared to the same features found in the surveyed study streams. These morphological characteristics will be similar to those compared by Jurmu and Andrle (1997) on one wetland stream reach in Connecticut. Since only one stream was involved in their study, statistical analysis was limited. With additional stream features from this study, more statistical analysis can be conducted to validate the findings. Analysis of Variance (ANOVA) between the means of the wetland streams and typical alluvial streams will be calculated where applicable to determine if, and to what degree, several features differ. Regressions will also be applied to establish correlation between features within wetland streams where applicable. As stated in the hypotheses, the morphological features being analyzed have been classified into three sections; planform, cross-section, and bed.

14.4.1 Planform Morphology

Using data from 43 streams from the Great Plain region of the U.S., Schumm (1963) determined stream sinuosity (P) is related to the weighted percent of silt and clay (M) on the channel banks and bed. He proposed the equation

$$P = 0.94M^{0.25}$$

Along with channel material, Schumm (1963) also found the Form Ratio (*F*) of a channel related to sinuosity (*P*) by the equation

$$P = 3.5F^{-0.27}$$

Analysis of bed sediment samples and Form Ratios of the wetland streams in this study will be conducted and used to compare how accurate Schumm's equations fit these reaches. Original data from Schumm (1963) and additional data from other research will be used to produce other regression equations that might be more applicable.

14.4.2 Additional Planform Morphology Relationships

Bends In streams with high degrees of meandering, bends are often measured between the inflection points and the bend apex to determine the radius of curvature. The degree of curvature in wetland streams is often restricted by stabilization of the banks by vegetation and the low energy of normal stream flow. This causes longer straight reaches between bends and if inflection points are used to calculate radius of curvature in wetland streams, the values will be greatly exaggerated. Bend definition and measurement for this study will be similar to those described by O'Neill and Abrahams (1986).

The ratio radius of curvature (r_m) to channel width (w) has been found to be between 2.0 and 3.0. Leopold and Wolman (1960) determined a typical value for the 50 rivers they studied was 2.3 while Hickin (1974) found a mean r_m/w value of 2.11. Bagnold (1960) determined from pipe flow that minimum resistance occurred between the 2.0 and 3.0 range of r_m/w. Radius of curvature to width ratios for Roaring Brook in Connecticut was between 1.57 and 1.88 (Jurmu and Andrle 1997). These lower values might be indicative of wetland streams and will be evaluated on the streams in this proposed study by using the original data of Leopold and Wolman (1960) and Hickin (1974) to determine how features in wetland streams compare.

Another feature associated with radius of curvature is the relationship between axial wavelength (L) of a stream and channel width. Leopold and Wolman (1960) determined L was approximately 7–10 channel widths and is considered standard for streams. Jurmu and Andrle (1997) found the L on their study wetland stream was over 32 channel widths. This indicates channel width will not increase dramatically downstream demonstrating the stability of the banks and the influence of longer straight reaches. The axial wavelength to channel width relationship will be investigated on the study streams of this research.

Straight Reaches The occurrence of lengthy straight reaches in any type of stream is rare yet they most often occur in low-energy settings associated with minimal channel gradients (Richards 1982). Some researchers consider a straight reach over

20 times the mean channel width uncommon (Leopold 1994) while others believe that straight reaches over 10 times the mean channel width are unique (Richards 1982). One lengthy straight reach in the Connecticut wetland stream (Jurmu and Andrle 1997) was 14.89 channel widths; considered long by some but not unusual by others. The straight reaches in the study streams will be compared to these values along with the frequency of straight reaches occurring that could possibly aid in determining if straight reaches are significantly different for wetland streams.

14.4.3 Cross-Section Morphology

The width-to-depth ratio, also known as the Form Ratio F (Richards 1982), is important in assessing variations in channel form (Beschta and Platts 1986). The shape of a channel section is influenced by the type and composition of the channel material water moves against. Schumm developed a weighted mean percentage equation for silt and clay to determine if bed material was related to channel form. The weighted mean percentage value (M) is found by

$$\mathrm{M} = \frac{(Sb * W) + 2(Sc * d)}{W + 2d}$$

where; Sb = percent silt and clay in banks
Sc = percent silt and clay on channel bed
d = channel depth (max)
W = channel width
Using 90 cross sections, Schumm (1960) then found the relationship

$$\mathrm{F} = 255\mathrm{M}^{-1.08}$$

This relation will by investigated on the wetland streams by using original data from Schumm (1960) to create the regression and analysis where study stream values fit into this model (whether they are within standard error values).

14.4.4 Additional Cross-Section Morphology Relationships

Form Ratio Form Ratios under 10 are often associated with straight streams while values over 10 and up to 100 tend to occur in meandering streams (Parker 1976). The mean F for the wetland stream in Connecticut is 7.70 indicating a straight stream, yet the sinuosity of the study reach (1.56) classifies it as a meandering stream. This existence of a narrow and deep channel probably results from the bank stabilizing, as any change in the channel will occur vertically, not laterally. The Form Ratio of all cross sections surveyed in the study streams will be calculated to determine if narrow and deep channels also exist in the wetland streams of the Kankakee watershed. These ratios will then be statistically tested against data from the literature using an ANVOA to determine the significance of the difference.

Cross-Sectional Shape Cross sectional shape of a channel will also vary along a stream. Trapezoidal shapes tend to exist in straight reaches where more asymmetrical, triangular shapes occur in bends (Richards 1982; Leopold 1994) as the stream deposits sediment on the convex bank creating a point bar. Cross sections from the Connecticut wetland stream (Jurmu and Andrle 1997) found only one bend where this point bar development was occurring. The other seven bends had irregular shapes associated with the location of the thalweg. It is possible the low-energy gradient typical in wetland streams does not create sufficient or sustained flows necessary to maintain erosional concave and depositional convex banks. The cross-sectional shape of the bends and straight reaches in the channels surveyed for this study will be compared to typical non-wetland alluvial cross sections and those found in Connecticut. Although this aspect cannot be tested statistically, it is important to note any differences that could be applied to wetland stream creation. These variations will be presented in the *Discussion* section.

Width The consistency of channel width through a bend has been cited as typical for alluvial streams (Chang 1984) where the range in width through a bend divided by the mean width was 11.45%. Bends in the study reaches will be compared to this value to determine if width through bends in wetland channels are also consistent. Langbein and Leopold (1966, H11) excluded channel width in their analysis because they believed width "…has no characteristic that distinguishes it between curved and straight reaches." This assumption that width does not vary between straight and meandering sections of alluvial non-wetland streams will be tested on each wetland stream in the study. Because sample sizes for this aspect will probably be small, statistical procedures would not produce significant result, therefore only a straight comparison between Chang's (1984) study and the wetland streams of this research will be conducted.

Bankfull Many designations of bankfull for a stream have been proposed, including the bench index (Riley 1972) and the minimum Form Ratio suggested by Wolman (1955), yet none have been developed based on wetland streams. The concept of bankfull might be less applicable for streams in wetland environments because bank height relates less closely to bankfull flow by virtue of beaver dams, thick vegetation, and the normal inundation above the banks associated with wetland streams (Jurmu and Andrle 1997). Defining bankfull is critical for evaluating channel cross sections because the width of the channel at bankfull is usually the standard dimension for stream width used in determining channel area and Form Ratio.

Although Jurmu and Andrle (1997) define bankfull for their study stream as the ground level boundary between open water and wet-meadow grasses, this definition has not been applied to any other stream. The accuracy and usefulness of such a bankfull definition will be tested for the wetland streams of the Kankakee watershed. Although this definition is not directly comparable to bankfull definitions currently applied in non-wetland, alluvial streams, this topic will be explored in further detail in the *Discussion* section. Another aspect that will be addressed in the *Discussion* is how the extensive growth of bed vegetation and development of medial bars caused by agriculturally induced runoff and sedimentation has altered the water carrying capacity of the channel, thus causing continual inundation of the surrounding surface.

14.4.5 Bed Morphology

Using median grain size of channel bed material and the area of the watershed basin a stream drains, Hack (1957) determined

$$s = 18\left(\frac{M}{A}\right)^{0.6}$$

where; s = channel slope (ft/sq. mi.)
M = median grain size (mm)
A = drainage area (sq. mi.)

To determine if this relation applies to wetland streams, the original data will be used to re-generate a regression and analyze how well the study streams fit this model.

14.4.6 Additional Bed Morphology Relationships

Pools and Riffles Pools and riffles are fundamental topographical features on streambeds, yet the identification of these features has often been subjective. The bed form differencing technique (O'Neill and Abrahams 1984) will be employed on the study streams to more objectively identify where pools and riffles occur. This method uses a tolerance for identifying pools and riffles based on a percentage of the standard deviation of the difference in high and low points along the bed. Once pools and riffles have been identified, the sequential spacing will be compared to intervals found in alluvial non-wetland streams. Typical pool-riffle sequences in alluvial non-wetland streams range from 5 to 7 channel widths (Leopold et al 1964; Keller and Melhorn 1978). Spacing in a wetland stream in Connecticut (Jurmu and Andrle 1997) ranged from 5.71 to 6.43 channel widths depending upon the standard deviation used in identifying pools and riffles.

Richard (1976, 1978) found channel widths at riffles of non-wetland streams were between 12 and 15% wider than at pools and that maximum width occurred directly downstream from the riffle. Although mean riffle widths in a wetland stream (Jurmu and Andrle 1997) were 12.9% greater than in pools, the maximum width was not always directly downstream of the riffle and in several cases the pool width was actually wider than the riffle section. Richard (1976) also found that the depth differences between pools and riffles in bends were greater than in straight reaches.

Similar differences were also found in the Connecticut wetland stream (Jurmu and Andrle 1997) although it was minimal (0.48 m in bends and 0.43 m in straight reaches). Even though several of these typical pool-riffle features were found to be similar to the wetland stream in Connecticut, all these aspects of pools and riffles will be compared to those in the wetland streams studied in the Kankakee watershed.

Thalweg The thalweg of a stream is a line connecting the deepest points in the channel (Mangelsdorf et al. 1990). Thalwegs in meandering streams will usually be located near the eroding concave bank in bends and for straight reaches, thalwegs tend to meander from bank to bank through pools and riffles and around side-channel bars. In only one bend of the Connecticut wetland stream did Jurmu and Andrle (1997) find the thalweg near the concave bank while the thalweg was inconsistent in straight reaches. They suggest the pattern is related to lack of point bar generation and triangular cross sectional shape for these bends, and that the stabilization of banks by vegetation has caused these features to persist in the wetland stream. Further investigations will be conducted on the streams in this study to determine if the thalwegs have similar configurations to the wetland stream in Connecticut or conform to more typical non-wetland alluvial streams.

14.5 Evaluation Procedure

Each research hypothesis will be tested by applying the current standard model to the data obtained on the study wetland streams. Original data for these models will be used and the study data will be employed to determine if wetland stream variables differ or how well they fit the equations. The results of this analysis will determine if each hypothesis has been proven. Additional individual features for each classification of morphology will also be analyzed, yet statistical methods might not be applicable. This does not degrade the importance of such information for future detailed research and should be noted within this dissertation. How each individual variable is analyzed will be determined by the available original data, sample size of the feature, and method most appropriate for accurate and clear presentation.

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Reflection

The primary strength of this proposal is the methods section and the articulation of the hypotheses. The proposed methodology clearly maps the entire research process and demonstrates the importance of forming clear and concise hypotheses. As mentioned in the introduction, this example also discusses field work. In the case of this research, the proposed research demonstrates that pilot studies and/or a degree of field work (data collection) may occur prior to the actual proposal. This early or initial primary data collection is often required in physically oriented studies as pilot studies often determine the overall feasibility of a dissertation. Additionally, dissertations that investigate the spatial dynamics of physical systems often expand on earlier efforts using data collected as part of a larger, often team based, research initiative. Finally, the proposal honestly articulates "open questions" facing the author as well as the potential limits of the data.

Chapter 15
Extramural Grant I: Collaborative Research and Outreach

Kevin Czajkowski, Alison Spongberg, and Mark Templin

The following proposal was funded by the National Science Foundation and the overall budget was $381,000. The project combines research in applied climatology with k-12 education. This funded project—which is part of a larger national GLOBE initiative—combines academic research, instrumentation, curriculum development, and k-12 outreach. Given the emphasis on STEM disciplines across society, research proposals that emphasize collaboration and outreach are inherently competitive.

15.1 Earth and Energy Systems: GLOBE Protocol Research and Outreach, NSF GLOBE Program

Although the United States is the most technologically advanced country in the world and technology helps support our high standard of living, the number of students proficient in science and pursuing careers in science is not high enough to meet the needs of our country (Gehring 2001). A specific shortcoming in students' knowledge is in their understanding of Global Warming since students often have misconceptions about Earth Science (DeLaughter et al. 1998).

The threat of global climate change and record global warmth this decade have prompted action by world governments through meetings such as the Kyoto conference in Japan. The scientific community is faced with a daunting task of collecting global data to assess rapid and slow changes in ecosystems, the energy cycle and water cycle. The GLOBE observation program is adding to the observational database of the Earth and has the potential to assist with many aspects of the Global Climate Change scientific inquiry. For instance, meteorological station measurements have shown global temperature increases over the last century of 0.6 °C (Karl et al. 1993). However, there are many problems associated with ground station observations including local effects of urban development and the lack of measurements in many parts of the world. NASA continues to launch a series of satellites to monitor

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the Earth's environment and changes. GLOBE data offers a unique, spatially disaggregate and temporally intensive data set that can be used to validate satellite algorithms for many parameters valuable for our understanding of global climate change, including cloud cover, snow cover, air temperature and land cover change.

Our experienced team of scientists and educators at the University of Toledo have been working together for almost six years on projects to promote science education in K-12 teaching. We have experience working with students, teachers and developing publishable research with the students' data. Therefore, we are proposing to take the lead on a set of GLOBE protocols for the study of the Earth's Energy Cycle and its relationship with global climate change, to modify those protocols if needed and to add a new surface temperature protocol.

15.2 Objectives

- Take responsibility for existing GLOBE protocols related to the energy cycle.
- Develop a new protocol for surface temperature (the key variable of the energy cycle).
- Modify existing protocols to address comments by teachers and students.
- Perform scientific investigations using student GLOBE data focused on validation of satellite data and global climate change research.
- Develop student scientific investigations using energy cycle and related protocols.

15.3 Background

15.3.1 Our Team

Our team consists of three earth scientists who have different academic backgrounds, an accomplished teacher k-12 teacher and a member of the science education faculty. This balance allows us to make a significant contribution to the GLOBE program. All five team members have been GLOBE trained in "Train-the-trainer" basic workshops and two members have received advanced protocol training.

15.3.2 Global Change and Remote Sensing Workshop and Student Observation Program

The University of Toledo has hosted a NASA sponsored workshop during both the summers of 2000 and 2001 called "Global Change and Remote Sensing Seminar" for teachers in grades 4–12. Thus far, fifty teachers from Ohio, Michigan and Pennsylvania with varied backgrounds have participated in the workshops. This included teachers with science as their major to teachers that did not have any science in college. The teachers expanded their science content knowledge on topics such as the electromagnetic spectrum, solar radiation, energy budget, weather observing techniques and analysis, greenhouse gases and their effects, satellite imagery, Global Warming issues, and human dimensions of global change.

The seminar was held at the University of Toledo's Lake Erie Center (LEC). The seminar was funded by two grants: a New Investigator Program from NASA and the OhioView Consortium, allowing the teachers to attend at no cost to them. In addition, 15 of the teachers each of the years received scholarships from the OhioView Consortium for 3 graduate credits. The teachers investigated curriculum and pedagogical issues (Fig. 15.1). A university educator and teaching consultants from the Ohio Geographic Alliance modeled good, effective science and geography teaching. In addition, a local TV meteorologist spoke to the participants about weather and weather forecasting.

At the workshop, the teachers received training in weather observing techniques, the threat of Global Warming and remote sensing. The teachers received practical hands-on lessons that they can use in their classes. Teachers explored education pedagogical issues, such as the national standards for science and geography, constructivist theory, and the 5 E Learning Cycle (Engage, Explain, Explore, Extend and Evaluate). Each teacher developed three lesson plans using the 5E model that addressed a topic covered in the workshop. Then these lessons were implemented and revised.

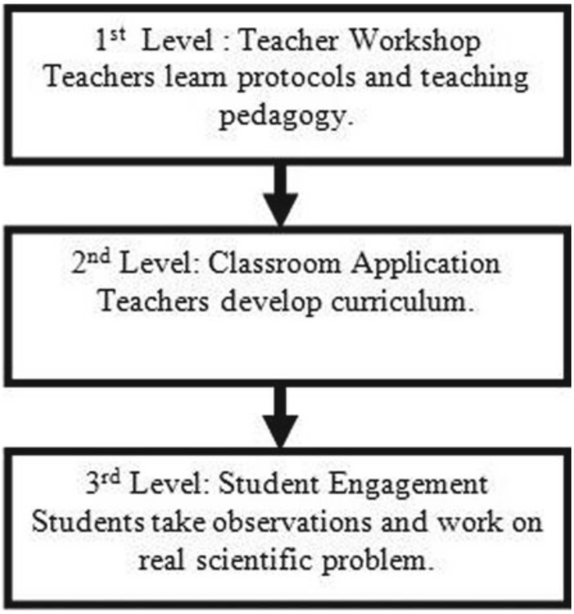


Fig. 15.1 Flowchart of Global Warming and Remote Sensing Outreach Program at the University of Toledo

After each lesson is reviewed, it will be posted on the department's Global Change and Remote Sensing website (http://www.utoledogis.org/education/teacher_wkshp/lesson.htm) making them accessible to all teachers. The teachers also participated in a web course receiving up-to-date information from the university, discussing pedagogical issues and sharing their strategies on what is being done in their classes.

The third phase of the program engaged students as scientists through an observation program in which the students took cloud and snow observations from December 4–12, 2000 Jan. 29 to February 9, 2001, December 3–14, 2001 and January 28 to February 8, 2002 to develop a validation data set for cloud/snow distinction. Teachers had their students identify cloud type and percent sky cover, 24 h snow accumulation, 24 h snow water equivalent, total snow depth and total snow water equivalent. Over 1,500 students took part in this first year of observation. The scientists are in the process of comparing the data, to satellite imagery, to assist in the validation of remote sensing algorithms. An example of comparison between student observations and imagery from the Advanced Very High Resolution Radiometer (AVHRR) is shown in Fig. 15.2. The images have been imported into ArcView and then displayed with AVHRR and MODIS satellite imagery for each day of the observation period. The results are posted on the university's web site for the students to use. http://www.utoledogis.org/student_observations.html.

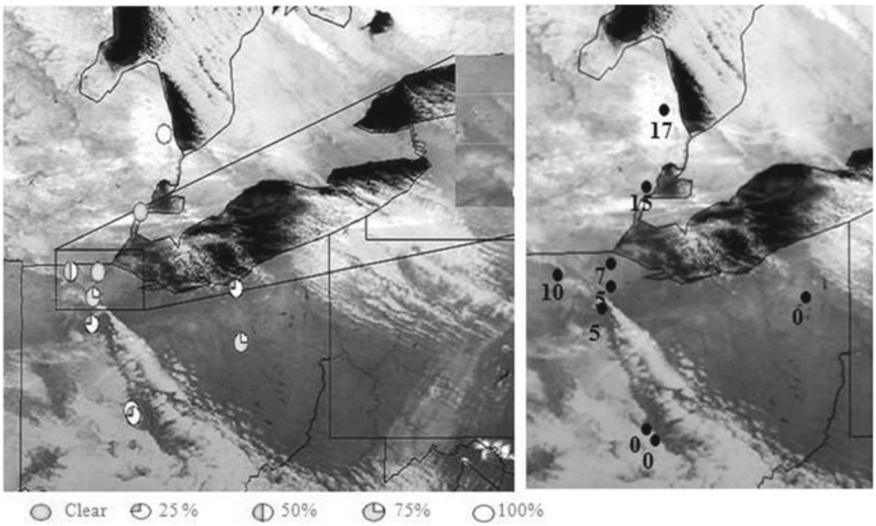


Fig. 15.2 Comparison of student cloud and snow observations with AVHRR satellite imagery

15.3.3 Cloud Awareness Webcast

On November 29, 2001, NASA Glenn Research Center, Cleveland, Ohio, hosted a Cloud Awareness Day Webcast for K-12 students and teachers working on a NASA funded project with the University of Toledo (UT) (Czajkowski 2002). Teachers participating in the webcast had attended one of two summer workshops held at the University of Toledo's Lake Erie Center. To follow-up with teachers who had taken the workshop and whose students were going to take cloud and snow observations, we visited every school (28) in the program in 2000. During the visits, we would introduce the program to the students, explain the purpose for taking the observations, and work with students to properly identify cloud type and cloud cover. Teachers love to have scientists visit their classes. Although visiting individual schools is an excellent way to engage students and teachers, it is quite a burden to visit every school. In 2001, a total of fifty-five schools from Michigan, Ohio, Pennsylvania and New York are participating in observation programs.

The University of Toledo was offered the opportunity to make a Webcast from NASA Glenn Research Center. It was a very attractive alternative to visiting each school. The Webcast was broadcast over the Internet by NASA Glenn using their Mobile Television Unit (MTU). Prior to the broadcast, teachers were given specific access instructions to NASA Glenn's Internet Broadcasting webpage. A studio audience of 12 students from Cleveland Heights High School helped by answering questions and doing demonstrations during the broadcast. We will use the lessons from this webcast to improve future programs. We hope that webcasts will be a useful way for us to communicate to many GLOBE schools simultaneously. A nice aspect of webcasts is that the video can be archived on the web and schools can play it at any time.

We propose to link several existing GLOBE protocols and add a new one, surface temperature, that are all part of the energy cycle of the Earth. We believe that by linking them, the scientific as well as educational goals of GLOBE can be better met. Scientifically, the energy cycle begins with incoming solar radiation that is affected by cloud cover and type and by the albedo of the surface that is affected by snow cover. The second part of the energy cycle is the partition of this incident energy into latent and sensible heat flux from the surface and heat transfer into the ground. This part of the energy cycle is affected by soil moisture. At the heart of the energy cycle is surface temperature. All aspects of the energy budget contribute or are affected by it. Clouds, snow and soil moisture affect the surface temperature while soil temperature is affected by the surface temperature.

Table 15.1 shows the protocols that we will take responsibility for under this grant with the related research that we will carry out and the questions that student can address. We have extensive experience performing research in these areas, we have used GLOBE data in the past to address these issues and all of the research is publishable in scientific journals. The student questions will be developed under this grant. We will test them using several GLOBE schools as testbeds for feedback. We have already tested the surface temperature protocol with several schools.

Table 15.1 Protocols that we will take responsibility for, the scientific questions we will do research on as well as the student questions that can be addressed in the classroom

Protocol	Scientific questions	Student questions
Snow	• Validation of snow algorithms from satellites; specifically MODIS	• Investigate relationship between snow cover and surface temperature • Investigate relationships between snow cover and soil moisture
Cloud cover and cloud type	• Validate cloud screening algorithms for satellites; specifically MODIS	• Investigate the relationship between cloud cover and type with surface temperature
Air temperature	• Urban Heat Island Contribution to Global Temperature Trend	• Urban heat Island effect • Relationship with cloud, snow, soil moisture, surface temp. and soil temp
Surface temperature	• Validate surface temperature from satellite • Urban Heat Island Contribution to Global Temperature Trend	• Urban heat Island effect • Investigate changes in reflectance and color on surface temperature
Soil temperature	• Investigate effects of climate change on soil temperature changes	• Investigate the transfer of heat into the ground
Soil moisture	• Investigate relationships between soil moisture and surface temperature change	• Investigate relationship between surface temperature and soil moisture • Investigate relationship between soil moisture and precipitation
Advanced: continuous air temp & soil temp using Hobo loggers	• Urban Heat Island Contribution to Global Temperature Trend	• Urban heat Island effect • Diurnal versus seasonal changes in air and soil temperature

15.4 Scientific Investigations

15.4.1 Surface Temperatures

Satellites offer an alternative approach to determination of climate change. The large area coverage of the data compared to ground observations means that all areas of the globe can be sampled nearly continuously. Recent studies using the Microwave Sounding Unit (MSU) have produced temperature trends that show a slight cooling of the lower atmosphere and land surface over the last twenty years directly contradicting ground station observations (Spencer and Christy 1992). A controversy over the MSU data set has since erupted with the publication of an article by Wentz

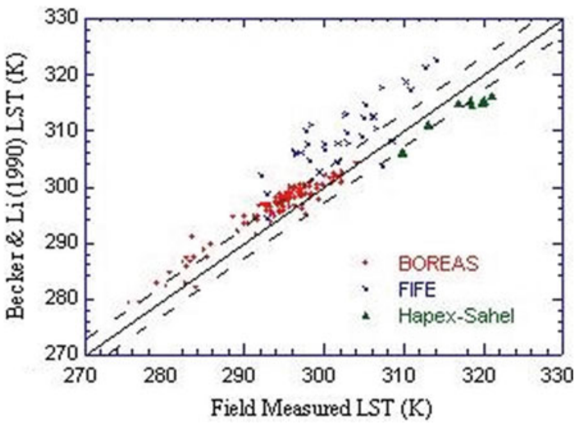


Fig. 15.3 Comparison of ground-based LST measurements from IRT's with LST estimated using the split window technique of Becker and Li (1990)

and Schabel (1998) showing that satellite orbital decay may be the source of the temperature cooling.

Extensive work has gone into the development of algorithms to estimate land surface temperature (LST) from satellite imagery. The radiometric signal observed by satellite thermal sensors is a combination of the complex interactions between energy emitted by the surface, its subsequent absorption by water vapor in the atmosphere, and atmospheric emission. Figure 15.3 shows validation of AVHRR estimations of surface temperature using the Becker and Li (1990) algorithm with "ground truth" observations from tower-mounted Infrared Radiative Thermometer (IRT's) at FIFE, Hapex-Sahel, and BOREAS (Goetz et al. 1995; Czajkowski et al. 1997; Prince et al. 1998). The source of errors in these comparisons originates from a number of sources including (i) changes in filter functions between satellites if they are not taken into account, (ii) assumptions used to derive the split window equations, (iii) unknown variations in spectral emissivity, and (iv) mismatches between ground observations and the satellite field of view (Czajkowski et al. 2000).

In 1999, Dr. Czajkowski received a grant from NASA under its New Investigator Program (NAG-5-8671) to investigate new ways to validate surface temperature derived from satellites. The GLOBE schools offer an excellent source of ground truth information. The schools are located over large areas which is conducive to satellite validation. A particularly important reason to use school observations is that all previous studies have looked at LST estimation during the warm weather when snow cover is not present (Czajkowski et al. 1997). This is primarily due to the teaching responsibilities of the scientists conducting the studies. It is every field scientists' dream to have thousands of hands helping them. Our goal is to validate MODIS, AVHRR and Geostationary Operational Environmental Satellite (GOES) observations.

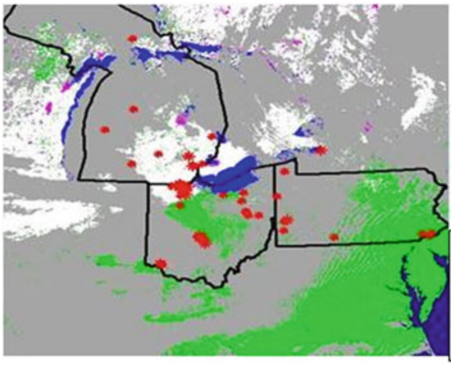
15.4.2 Clouds

Many cloud screening techniques in remote sensing under-estimate the amount of cloud contamination in any given satellite scene (Czajkowski et al. 2000). In particular, cirrus clouds can have a significant impact on any remote sensing application. Very little research has been conducted on cirrus contamination although it was discussed as a major limitation to thermal remote sensing at the International LST Workshop (Snyder et al. 1997). We will use GLOBE data to validate cloud screening techniques.

15.4.3 Cloud Cover Versus Snow Cover

Delineation between cloud cover and snow cover is a limitation to the use of TIR data during the winter months at mid and high latitudes. Global studies of climate change will need to produce temperatures over snow and ice covered regions. In fact, a limitation of passive microwave sensors and thus a limitation of the studies performed by Spencer and Christy (1992) is that the emissivity of snow at microwave wavelengths renders microwave data inadequate to estimate surface temperature. Often, the areas that are snow covered but have clear skies are screened along with clouds by traditional screening techniques (Cihlar 1996; Czajkowski et al. 1997).

Figure 15.4 shows the MODIS snow product for December 12, 2000 along with the locations of schools from our program and GLOBE. Even with only 14 observations, we can see that the snow product is not 100% accurate and needs further validation. We plan to publish this work after we have analyzed more satellite images. The National Ice and Snow Information Center in Boulder, CO is currently working on



		MODIS Snow Product	
		Snow	No Snow
Student Observa tions	Snow	5	1
	No Snow	3	5

Fig. 15.4 **a** Location of student observations (red asterisks) used to validate the MODIS snow product for December 12, 2000. White is snow cover, gray are clouds, green is land not snow covered and blue is water. Seven of the observations for snow in this validation are from GLOBE schools. **b** Matrix showing the comparison between student observation and MODIS snow product

a news story for NASA's Earth Observatory about this project. The next step is to validate the cloud screening algorithm in conjunction with the snow algorithm.

15.4.4 Soil Temperature and Soil Moisture

With student soil temperature observations we will be able to research interannual soil temperature variations at a site and the variation in heat and energy storage. Temperatures recorded at solar noon over a period of time easily show the expected seasonal fluctuations. The temperature range of each annual cycle decreases with depth in an approximately exponential fashion. Peaks are delayed with depth and appear over 1 month later at 120 cm than at 10 cm. Perhaps a little less widely appreciated is the high degree of interannual stability in the timing and magnitude of soil temperature. As climate changes from year to year we hope to accumulate data on how the energy storage is affected and how this affects yearly crop growth, frost dates, etc.

Soil water content markedly impacts soil temperature changes through its effect on the specific heat or heat capacity of a soil (Fig. 15.5). Specific heat is defined as the number of calories required to raise the temperature of 1.0 g of moist soil by 1 °C. The specific heat or heat capacity of moist soils can be calculated with a simple mathematical equation. Water has a specific heat of 1.0 cal/g, while most dry mineral soils have a specific heat of 0.2 cal/g. The equation is a simple weighted average specific heat of a mixture of these substances:

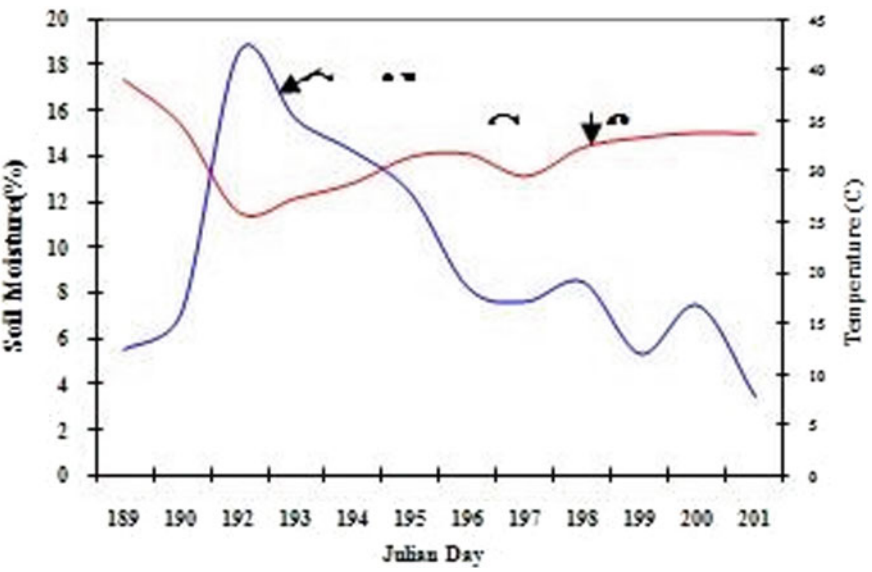


Fig. 15.5 Relationship of surface temperature with soil moisture over a 13 day period

$$c_{\text{moist soil}}, = c_{\text{soil}} m_{\text{soil}} + c_{\text{water}} m_{\text{water}} / m_{\text{soil}} + m_{\text{water}}$$

where c is the specific heat and m is the mass of the dry soil or water.

Surface energy balance, which supplies an important and often poorly described feedback to atmospheric forcings, is also directly related to soil temperature. These data allow a variety of analyses of processes related to soil temperature over time in different environments. For example, soil temperature has added significance in relatively high-latitude or high-elevation locations because of the impact of soil freezing on hydrologic processes. Of particular interest in high latitude environments is soil freezing because of implications for hydrology.

15.5 Student Observations

Many of the GLOBE protocols are not appropriate for inner-city schools. We have worked closely with several inner-city schools in Toledo including an instructor at Central Catholic High School in Toledo, OH. The instructor, Mrs. Hedley, was one of the first teachers to join the GLOBE program at its inception. She has over twenty years of teaching experience. She purchased the weather shelter, however it was vandalized within one day. She tried to move it to the roof, however, students are not given access to the roof. She does not do the soil protocol because there is not any substantial fields in which she can digs holes. This is especially difficult for inner-city elementary schools that often have only paved playgrounds. She cannot do the land cover protocol because there is no nearby natural environment. Given all of these constraints, she has only been doing the snow and cloud protocol for GLOBE, despite her interest in the other protocols. The Central Catholic High School teacher said that the surface temperature protocol is exactly what she needs because her students can investigate the influence of humans on the urban environment around the school. They can take the temperature of the parking lot, football field, sidewalk and bushes and investigate the influence of the cover type on the temperature.

15.5.1 Cloud Cover and Cloud Type

As stated above, we plan to use the cloud cover and cloud type protocol for validation of cloud screening algorithms. Through this grant we will explore possible improvements to the protocol to make the data more useful for scientific investigation. We will use the experience we have gained through conducting our own student observation program over the last two years and by looking at the S'cool program that Lyn Chambers directs for the CIRES satellite.

15.5.2 Snow

Having used snow observations from the GLOBE database, we are confident in saying that they meet the needs of the scientific community. We do not plan to change these.

15.5.3 Air Temperature

It is our understanding that a new thermometer is being developed for the air temperature protocol. We will test this sensor and monitor comments from students and teachers to see its effectiveness. At this time we anticipate the new sensor will meet scientific rigor.

15.5.4 Surface Temperature

The surface temperature concept was piloted in 2000 and the students loved it. This was encouraging to us and contributed to us proposing it here. We have found that it is easy for students to use the hand-held infrared thermometers and the press is interested in the types of research projects that include students.

For the surface temperature protocol that we propose, we will investigate various hand-held infrared thermometers. Currently, we use the ST20 Infrared Thermal Thermometer (IRT) by Raytek. The ST20 Pro is a lightweight, hand-held, easy to use instrument for recording surface temperatures. This model is equipped with an infrared sensor and a large LCD display. The user just aims, pulls the trigger, and reads the temperature on the LCD display allowing a non-contact reading to be acquired. Temperature readings can be shown in Fahrenheit or Celsius. The unit includes a rugged overmolding for durability. weatherproof and drop-proof to five feet. This instrument's temperature range is –32° to +400° Fahrenheit allowing data acquisition of various cover types throughout the year. The ST20 Pro's accuracy is within ±1 degree C Fahrenheit, and it costs $179. Our assessments of the accuracy of the ST20's have confirmed the specs given by the company of within ±1 °C. A rapport with Bob Bader, Director of Sales, of Raytek, Inc. has been established regarding our proposed new protocol, and Raytek, Inc.

When data are submitted for this protocol, a data log will be designed for use in the field in order to assure that the data submitted are of useable format and quality. Once the data is collected, students will enter the data onto the GLOBE website. On the web page will be validation checks for all appropriate fields to minimize any data quality issues. An important aspect of the land surface temperature protocol is that the land cover for each observation is needed. The MUC for the observation or a modified version of it will be needed to ensure useful data. Also, we may ask the students to take observations of surface temperature of several different cover types to broaden the scientific and educational use of the data.

15.5.5 Soil Protocols

The Soils Investigation in the existing Globe protocol collects valuable data for any soil scientist interested in temporal and/or global variations in soil physical properties. Participating schools essentially follow two protocols. The first is a one-time evaluation of the study site in which the physical characteristics of the soil with depth are evaluated by digging a pit or auguring several deep holes. Changes in these properties with depth are recorded and can then be used along with the temporal data to be collected in Part II to evaluate the soil's capability to sustain crops, etc. Part I of the protocol, the Soil Characterization, evaluates changes in bulk density, texture, structure, color consistence, root density, and the presence of carbonates. These protocols are very good and valuable as they are currently written. Other than the time and 'mess' our experience with Globe teachers has shown no major deterrent in performing this exercise.

In Part II of the Soils investigation, soil moisture data are obtained 12 times a year at either weekly, monthly or biweekly intervals along a transect or star pattern. Two depths are measured, 0–5 and 10 cm with some locations being sampled in triplicate for quality assurance. A third advanced option of sampling five depths from surface to 90 cm either with an augur or gypsum blocks is also available. All samples are analyzed using the gravimetric technique. Through our Northwest Ohio training sessions we have heard repeated comments about the inconvenience of taking the soil moisture data due both to the lack of drying ovens in our schools and the size of the required samples. Soils are often compressed during collection as the metal container is pushed into the soil. Soil must be removed from the currently used metal containers and dried in a microwave oven. Instructions for doing this are vague and the large compressed samples often are not thoroughly dried. Often the dried sample is 'brick hard' and difficult to disaggregate

15.5.6 Soil Temperature

The current protocol for soil temperature requires taking measurements near the soil moisture location, which is, in turn, near the Atmosphere Study Site at solar noon at 0–5 and 10 cm, weekly throughout the year. Four times a year the temperatures are taken every two hours for two days.

Soil temperature rarely varies significantly within the first 10 cm. However, we are proposing that with minimal additional low cost instrumentation (less than $50) greater soil depths could be measured, allowing the students and researchers to see the variation with depth associated with seasonal changes. The temperature of the soil at any time depends on the ratio of the energy absorbed to that being lost. The constant change in this relationship is reflected in the seasonal, monthly, and daily temperatures. For example, in a subhumid temperate region in the northern hemisphere, the surface temperatures will be lowest in January and highest in July. However, the temperatures will increase with depth in the January samples, and decrease in the July samples. Variation will be only about 1–2 °C within the top 10 cm. This is why sampling at a greater depth is imperative.

15.5.7 Soil Moisture

Soil moisture is independent of sample size. Therefore, we propose to investigate and develop an alternative protocol that uses a smaller sample size and materials that can be used directly in the microwave oven. Using crucibles made of Pyrex, glass or porcelain, we would like to investigate the optimum size sample to be efficiently dried in a microwave, while obtaining reproducible results. An alternative option, which we have investigated briefly, is the use of smaller samples collected in pre-weighed plastic containers, with very small holes that can be directly placed in the microwave oven. The smaller sample size will dry quicker and the container will allow more thorough and uniform drying.

15.5.8 Advanced: Continuous Air Temperature and Soil Temperature Monitoring

GLOBE has initiated a new advanced protocol using HOBO H8 Pro Temperature Logger from the Onset Computer Corporation. The sensors work well as a stand-alone, automatic unit that can be deployed onto the object in which surface temperature readings are wanted. This data logger is equipped with a microprocessor, data storage, and sensor. The user presets the sampling intervals, start date, time, etc. by using the accompanying computer software. The unit is about the size of a hockey puck, and it is weatherproof and drop-proof to five feet (A big bonus considering K-12 usage.) This instrument's temperature range is –22° to +122° Fahrenheit allowing data acquisition of various cover types throughout the year. The HOBO H8 accuracy is within ±1° Fahrenheit, and it costs $129. The logger is brought back to the school's personal computer to have the data downloaded. The accompanying computer software (Windows-based) costs $14, is installed in less than five minutes, and is easy to operate. The Macintosh version is available on Onset's website at no charge.

We have extensive experience using the HOBO probes and data loggers in the field for our research. During the NASA sponsored Southern Great Plains Experiment (SGP99), Dr. Czajkowski used 30 Hobo's as a surface/soil temperature observation grid to help validate the thermal signal from satellite images. This data is shown below in Fig. 10. Subsequently he has used them in Oklahoma and in Toledo to monitor surface temperature. We found that the sensors and loggers performed well under most conditions. Under very hot conditions, they had problems with their batteries and we had trouble with wild life eating the cords or sensors. The most difficult part of using the sensors/loggers is to place them correctly to measure what you want. For instance, placing them in the soil disturbs the soil and vegetation which ultimately changes the soil's thermal characteristics.

Discussions with Rich Marvin from Onset's iScienceProject (www.iscienceproject.com) has been established, and Onset Computer Corporation will loan our team any number of data loggers to be used/tested for up to 2 months at a time. Onset currently supports the GLOBE project's mission, and Mr. Marvin is very interested in continuing and enhancing GLOBE's outreach. The iScienceProject, also, has opportunities for teachers and students to use Free HOBO data loggers through contests and labs.

15.5.9 Evaluation of New and Modified Protocols

We will test any new protocols or protocol changes in the field and laboratory setting and in school implementation. As the scientists develop the protocols, there will be an ongoing collaboration with the Educators to ensure ease and accuracy of implementation into K-12 classes/curriculum. We have commitments from five GLOBE teachers representing grades 4 to 12 from Bowling Green, Central Catholic and Toledo Public School District who will be our beta testers (see Supplemental Documents for their commitment letters). The principal from Kenwood Elementary has pledged his full support for our activities. In return for their help, we will provide them with the instrumentation free of charge. We have included these costs in our budget.

A number of different methodologies for data collection will be experimented with to determine the most effective, efficient, and easiest technique to adopt. Questions regarding scientific validity will be addressed by analyzing the instrumentation and the methodologies developed. Once the protocol is established, any/all questions and concerns will be directed to the Research Associate and/or the PI.

15.6 Educational Observations

Our project of focusing on the flow of heat energy as measured by clouds, snow, surface temperature, air temperature, soil temperature and moisture the surface temperatures cuts across important learning outcomes for students. With the materials we develop, students will inquire into transformations of energy and flow of energy through systems. The American Association for the Advancement of Science

Table 15.2 Concepts from the NSES that we address (in bold italics)

SYSTEMS	***ORDER***	ORGANIZATIO*N*
EVIDENCE	***MODELS***	***EXPLANATION***
CONSTANCY	***CHANG***	***MEASUREMENT***
EVOLUTION	***EQUILIBRIUM***	FORM
FUNCTION		

(1989) recommends investigations focusing on these topics as essential components of a curriculum that promotes the scientific literacy of students.

Table 15.2 identifies the unifying concepts and processes that underlie the Content Standard: K-12, of the National Science Education Standards (NSES) (National Research Council, 1996). Bold italics denote unifying concepts and processes integral to the proposed project:

As this list demonstrates, the proposed project will enable students to use, construct, and reflect upon 9 of the 13 unifying concepts and processes of science.

15.6.1 Relevance to School Curriculum at Selected Grade Levels

An analysis of the National Science Content Standards: Grades 5–8 of the NSES (NRC, 1996); shows the Content Standards: Grades 9–12 of the NSES (NRC, 1996) reveals several strengths of using the energy cycle as a focus of our project. First, the energy cycle is important subject matter appropriate for students in grades 5–12 such as the properties of matter, the transfer of energy in a system, the structure of the earth system, conservation of energy, entropy, energy in the earth system, and geochemical cycles. Second, the energy cycle provides a context for students to conduct a scientific inquiry; thereby honing their abilities to conduct a scientific investigation and improving their understanding of the nature of science and scientific inquiry. Third, the energy cycle has content specificity. That is, it does not attempt to "do the whole job" of teaching all areas of science but rather focuses in-depth on the properties of matter as applied to understanding certain key aspects of the dynamics of environmental systems. Fourth, our project helps students understand remote sensing technology and how such innovations can be used to solve problems of interest to society. Various states are in the process of aligning their science curricula to these standards (e.g., The State of Ohio). Thus, our proposed project is relevant to school science curricula in most states and will grow even more relevant in the foreseeable future as state-level alignment with the NSES progresses.

15.6.2 Expected Learning Outcomes

With our participation in the GLOBE program, our goal is for students in Grades 5–12 to:

(1) hone science process skills, using the NSES unifying concepts and conduct authentic inquiries of energy cycle (or components thereof) and change in their community;
(2) increase depth of science knowledge by working to understand the following science concepts: heat versus temperature, specific heat, conduction, convection, and radiation of heat, differences in capacity of objects to radiate energy, surface temperature versus core temperature, and structure of matter;
(3) integrate science understanding by developing a knowledge of the interconnections among science concepts related to energy and the flow of energy;
(4) develop an enhanced scientific literacy by applying their knowledge of science concepts related to energy and energy flow to understand issues in the following application areas:

Issue area	Related science content
Health	Perspiring, thermal stress, thermal shock
Environment	Diurnal patterns of temperature change, transpiration, energy budget
Society	Impacts of the built environment on the environment

15.6.3 NSF Results from Prior Support

In 1999, the principal investigator was awarded a grant through NSF's Research Experience for Undergraduates (REU) program (SES-9988038). Students participated in interdisciplinary research projects at the University of Toledo's Lake Erie Center. The purpose of the program is to encourage the students to pursue a career in environmental sciences. Faculty from Geography, Public Policy, Biology, Ecology, Geology, Environmental Engineering, Remote Sensing, and Environmental Law have worked with REU students over the last two year on projects ranging from agricultural remote sensing to phytoremediation. Twelve of the students in the program have done GIS and/or remote sensing projects. Twenty-two students have gone through the program and many have either gone on to graduate school or are working in the environmental field.

In the fall of 2001, the University of Toledo received an NSF Major Research instrumentation (MRI) grant to support GIS and remote sensing research in the Department of Geography and Planning to establish a Geographic Information Science and Applied Geographics (GISAG) applied research lab. Through this grant, the University of Toledo is in the process of outfitting an entire computer lab including a server, large storage devices, large format printer, LCD projector, GPS units and micrometeorological stations. There are no results from this grant as of yet because it was just awarded. The powerful computers as well as the audiovisual devises will be used in this GLOBE project.

15.6.4 Management Plan and Timeline

This project will be directed by the principal investigator (PI). The PI and a Co-PI1 senior personnel will share responsibility as project scientist for each protocol that we are taking responsibility for. The PI will primarily be responsible for clouds, snow, air temperature, surface temperature while Co-PI1 will be responsible for soil temperature, soil moisture and the advanced continuous air temperature and soil temperature protocol with the Hobos. The PI and Co-PI2 are also responsible for research using GLOBE observations in their area of expertise (PI: remote sensing, atmosphere and snow, Co-PI1: soils and energy exchange). Co-PI2 is responsible for developing activities (student centered research projects) that are appropriate for each grade level. He will work with the PI and Co-PI1 to ensure that protocol changes work well in the school setting. As the full time scientist on this proposal, Co-PI2 will attend train the trainer workshops, correspond with students and teachers and organize outreach activities for our group including webcasts. Co-PI2 will also perform much of the research to be carried out with student data. The grant will also have a research assistant (senior personnel) that will assist both Co-PI4 and Co-PI2 with outreach activities. In addition, research assistant (senior personnel) will organize the five GLOBE schools working with us.

Throughout entire project	Conduct research using GLOBE data. Respond to student and teacher questions regarding protocols we are responsible for.
August, 2002–August, 2003	Research, develop, and write the basic protocols. Continue cloud and snow satellite detection validation.
March–August, 2003	Develop Learning Activities to complement protocols.
Fall, 2003	Initial training and testing with five area. GLOBE teachers.
School year 2003–2004	Test protocols with five area GLOBE teachers and their schools.
January, 2004	Revise protocols using teacher suggestions.
Summer, 2004	Expand use of new and modified protocols to GLOBE teachers. Provide support for a group of ten GLOBE teachers to do second phase testing. Start surface temperature validation research. Start energy budget (soil temperature/moisture) research using modified protocols.
Fall, 2004	Solicit feedback from trainers on how well the implementation of the basic protocol is taking place.

(continued)

(continued)

January, 2005	Meet all GLOBE teachers via the internet in a chat room. Obtain feedback. Revisions are made if needed on both protocols.
School year 2005–6	Expand new and modified protocols to all GLOBE schools. Provide teacher and student support for all schools. Mentor students interested in using the data.

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Reflection

This project was funded in 2002. As part of the project, Dr. Kevin Czajkowski became a GLOBE scientist and runs the GLOBE Partnership at the University of Toledo. The GLOBE project remains active and is funded through the NASA Science Activation

*Program called GLOBE Mission EARTH and continues to advance STEM in k-12 schools (*https://www.globe.gov/*). The educational outreach part of the project involves an Urban Heat Island Student Research Campaign, a blog, web pages and students presenting at conferences each year. As a result of this initial grant, Kevin and members of his team have published or presented more than 20 papers derived or extending from this initial initiative.*

Chapter 16
Extramural Grant II: Instrumentation

Ryan R. Jensen, Jay D. Gatrell, Susan Berta, John Jensen, and Paul Mausel

The following proposal was submitted to the National Science Foundation's Major Research Instrumentation program (NSF#0,319,145). The proposal was a collaborative initiative that built on the existing strengths of an entire academic unit and explicitly details how an award would complement current departmental infrastructures and expand existing initiatives. The key for instrumentation grants is to avoid writing proposals that appear to be "wish lists" that indicate what researchers "might" do with a new toy. Instead, instrumentation grants must be closely associated with current research, unit infrastructures, and individual (as well as unit) capacities. Beyond the current research agenda, this proposal clearly identifies linkages between research and the undergraduate and graduate curriculum. Additionally, the proposal also outlines an outreach component and provides for public data sharing.

While this proposal was funded, it was funded on the third submission. Ironically, the subsequent submissions were revised only slightly. While some grant writers would have significantly re-tooled their applications in response to reviewer and panel feedback, the structure of NSF programs is such that every competition is a new competition with a restructured panel and often entirely new reviewers. For this reason, the authors believed the original submission was competitive and chose to only slightly revise the later two submissions. The revisions were minor in nature and included only staffing and figure updates. This approach was successful in that each competition is new, NSF programs are fund dependent, and the prevailing principle is "first past the post." That is to say, NSF does not approach grant competitions as developmental exercises. However, not all grant competitions are the same and grant writers should be attentive to the policies, procedures, and practices of agencies and foundations.

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16.1 Acquisition of AISA+ Hyperspectral Sensor

The following proposal outlines: (1) the importance of remote sensing technologies; (2) the history of remote sensing at Indiana State University; (3) implications for the institution; (4) major research clusters with on-going remote sensing activities; (5) the instrument; and (6) a proposed instrument 'utilization' plan.

16.1.1 Remote Sensing Technologies

As anthropogenic and natural environmental changes continue to increase, the ability to map and monitor these changes using remote sensing data must improve. Traditionally, multispectral satellite remote sensors such as Landsat Thematic Mapper (TM) Multispectral Scanner (MSS), and SPOT have been effectively used to map and monitor changes in the biosphere. However, while these sensors have proven robust for many applications they often lack the spatial and spectral resolution necessary to differentiate very small characteristics of earth's surface vital for their discrimination.

Landsat TM measures only seven discrete portions of the electromagnetic spectrum, and SPOT only measures in four discrete portions of the spectrum. Because of this, new hyperspectral imaging systems have been developed that acquire images throughout the visible and near-infrared portions of the spectrum from airborne platforms with wavebands as small as a few nanometers that facilitate higher discrimination between vegetation types, crops, and other earthly features (Gong et al. 1992). These sensors record spectral signatures with sufficient sampling to allow identification of ground targets and quantitative analysis of subtle spectral changes.

The narrow bandwidths of a hyperspectral sensor are sensitive to subtle variations in reflection. These same reflectance characteristics are lost within the relatively coarse bandwidths in conventional multispectral scanners (e.g. MSS, Landsat TM). Thus, conventional multispectral sensors under-sample the information content available by making only a few samples in spectral bands up to several hundred nanometers wide (Jensen 2000a, b). For example, through laboratory and field studies, numerous narrow spectral band features have been shown to be related to changes in some vegetation biophysical variables (Treitz and Howarth 1999) such as chlorophyll amount and type (Yoder and Pettigrew-Crosby 1995) and canopy chemical characteristics and their relation to carbon cycling (Gao and Goetz 1995).

The large number of very narrow bands enable remote sensing data collection to replace data collection that was previously limited to field site surveys or laboratory testing. Analysis of hyperspectral data allows extraction of detailed spectrum for each picture element in the image. Such spectra allow direct identification of specific materials based upon their spectral characteristics, including minerals, atmospheric gases, vegetation, dissolved material in water bodies, agricultural crop yield, and soil characteristics (Jensen 2000a, b).

Government agencies and private companies have developed scores of hyperspectral remote sensing systems. These sensors are often designed to answer specific research questions. One of the more robust systems that were developed to address many research questions is the AISA+ hyperspectral system. This hyperspectral sensor is a proven instrument that allows for outstanding user control over bands and bandwidths and can be placed in virtually any aircraft throughout the world.

16.1.2 Remote Sensing at Indiana State University

In addition to research benefits of a new hyper-spectral instrument, the instrument would enhance graduate and undergraduate education at Indiana State University across the collaborating departments and the entire campus. ISU is a unique institution that emphasizes undergraduate education while seeking to develop and maintain strong graduate programs in numerous departments. Indeed, the Department of Geography, Geology and Anthropology enrolls thousands of students in general education courses that would specifically benefit from hyper-spectral images, in general, and local case studies, specifically. For these reasons, the MRI award would immediately enhance on-going ISU projects and facilitate new collaborations between departments and other institutions (see Fig. 16.1).

ISU is partnering in research with University of Texas-Pan American (with its 86% Hispanic population) and Indiana University-Bloomington (IU), and we will be doing so in remote sensing and environmental studies at both the graduate and undergraduate levels. ISU is helping UTPA develop an undergraduate geography

Fig. 16.1 Listing of proposed Indiana State University hyperspectral consortium

program that will emphasize environmental geography using geotechniques which is under consideration that will impact many students there.

In addition to the instrument's immediate and positive impact in the area of research, the instrument will provide students with the opportunity to participate—as active learners—in the application of remote sensing technologies. In the area of graduate studies, life science, geography, geology and anthropology students will learn the 'nuts and bolts' of data acquisition, processing, and applying hyper-spectral data in real-world situations. In the undergraduate population, ISU has developed an active collection of undergraduate research initiatives—that like their graduate counterparts—enables undergraduates to experience the research process.

Yet, the benefits of the instrument in the area of education are not limited to the 'research experience'. The acquired data will enable students in introductory courses to obtain a local and real world perspective on global environmental change, economic development or any number of courses within the cluster and disciplines identified in Fig. 16.1. Finally, the hyperspectral sensor would enable a collection of students within the College of Technology to experience real world aero-technology applications.

Finally, by partnering with Dr. John Jensen in the Department of Geography at the University of South Carolina, we will continue to strengthen the remote sensing program at ISU. Dr. John Jensen's record of scholarship in remote sensing studies will benefit our undergraduate and graduate students by incorporating them in future hyperspectral remote sensing projects, and we anticipate extensive cooperation on graduate student committees between the two universities.

16.1.3 Current Research at Indiana State University

Below is a list of existing 'research strengths' at Indiana State University. In each of these clusters, contributing personnel are actively engaged in the application of remote sensing technologies to tackle a range of research questions. In each of these areas, the proposed instrument would provide researchers and students with an important tool.

Forest Ecosystem Modeling

Forests develop through the dynamic relationships between physical and biological site characteristics and history. Forest studies within ecosystems and ecological processes provide additional information about the relationships between forests and their environments (Treitz and Howarth 1999). Remote sensing data and techniques have demonstrated wide applicability in estimating and mapping physical and structural forest features.

Hyperspectral sensors have many applications within the broad category of forest ecosystem modeling. With the availability of hyperspectral sensors, data has come with the expectation that if spectral measurements are made with adequate spatial resolution to avoid spectral mixing, most types of rocks, soils, and vegetation should be identifiable (Cochrane 2000). For example, Franklin et al. (1991) used hyperspectral data to classify forestland in southern Alberta and achieved 96% map accuracy. Hyperspectral data was used by Gong et al. (1995) to estimate coniferous forest leaf area index along the Oregon Transect. The researchers used several leaf area index (LAI) estimation methods that resulted in low root mean square errors. In addition, hyperspectral data were proven to be highly correlated with LAI of Ponderosa Pine in the Cascade Mountains in west-central Oregon (Gong et al. 1992). The authors concluded that hyperspectral data is very effective in mapping forest biophysical variables. Airborne Visible and Infrared Imaging Spectrometer (AVIRIS) hyperspectral data were used to estimate the percentage of green vegetation cover in cultivated Monterey Pine stands in the Jasper Ridge Biological Preserve in California. Percent green vegetation cover ranged from 2.0 to 31.9% and the chlorophyll red edge was detected for green vegetation cover as low as 4.8% (Elvidge et al. 1993).

At Indiana State University, a group of researchers within geography and other disciplines are engaged in the study of forest biophysical variables such as LAI, diameter breast height, biomass, and species distribution. For example, researchers in the Department of Geography, Geology, and Anthropology at ISU have investigated the ability of remotely sensed data to estimate secondary growth in Brazil's Amazon Basin (Mausel, et al. 1993; Moran et al. 1994), quantified terrestrial carbon sinks along the Guapore/Itenez River (Jensen and Binford 2001), quantified longleaf pine sandhill loss in a Florida preserve (Jensen and Carson 2001), examined the relationship between longleaf pine LAI and succession to southern mixed hardwood forests (Jensen 2002a, b), and derived new methods of estimating LAI using artificial neural networks (Jensen 2000a, b). Finally, researchers at ISU have many articles in review that estimate or measure biophysical characteristics of forests using remotely sensed data and techniques.

Dr. John Jensen has studied the predictive modeling of coniferous forest age using artificial neural network approaches with remote sensing data (Jensen et al. 2000). He has quantified environmental changes using an ecosystem degradation index and remote sensing data (Jackson and Jensen 2001).

A new research cluster involving state park forests will be created in 2003. This cluster, composed primarily by Dr. Daniel McLean and Dr. Ryan Jensen, will use the sensor as a tool to quantify the forest biophysical variables in state parks throughout the Midwest. Hyperspectral data will allow them to more accurately quantify biophysical variables and analyze forest changes (https://www.naspd.org/).

Urban and Economic Applications of Hyperspectral Remote Sensing

Remote sensing technologies have many potential applications in the broad category of regional development and planning. At Indiana State University, a group of researchers within geography are actively engaged in the study and practice of regional and local economic development issues at numerous scales. In fact, the majority of students enrolled in the Department of Geography, Geology and Anthropology's Ph.D. program in Geography are enrolled in the regional-economic geography track. To that end, many of the department's recent Ph.D. dissertations have explicitly addressed human-regional development issues vis-à-vis targeted geo-technical applications (e.g., Al 1993). Similarly, MA theses have used remote sensing technologies to examine the intersection of various human and natural systems—with an emphasis on the wider 'development' process (e.g., Rudibaugh 1995; Nam 1996).

While students and faculty at ISU have long used remote sensing technologies to investigate land-use change and land cover, a wide array of human applications have been developed. For example, Larson and Carnahan's (1997) study of the urban heat island effect successfully utilized remotely sensed images for the purpose of investigating the thermal characteristics of Indianapolis. Likewise, Gatrell and Jensen (2002) built on Jensen's earlier LAI research (Jensen 2000a, b) to develop a set of economic development indicators that demonstrated the utility of implementing 'green' economic development strategies as vehicles for future urban growth. Jensen et al. ((a) in review) examines the impact of urban leaf area on household energy consumption in Terre Haute, Indiana, and Jensen et al. ((b) in review) analyzes the issue of environmental justice and the urban forest in Terre Haute. Also, Dr. Jensen is supervising two graduate students who are currently completing urban forest studies that use remote sensing data. Through the acquisition of the hyperspectral instrument, ISU researchers will be able to expand current economic development projects by further integrating the Department of Geography, Geology and Anthropology's strong human and geo-technical traditions. In a similar fashion, the expansion of urban-economic applications has the potential to establish ISU as a national center for urban-economic remote sensing capabilities. Dr. John Jensen has also published on remote sensing capabilities in urban areas (Jensen and Cowen 1999).

As these two cases demonstrate, faculty throughout the Department of Geography, Geology and Anthropology are actively involved in inter-disciplinary research that would directly benefit from the availability of new instrumentation. With the availability of a high resolution hyperspectral scanner, the urban and regional research group and cluster of graduate students will be better equipped to uncover and investigate new facets of economic development and urbanization.

NASA LBA Ecology Program

ISU has been partnering with colleagues at Indiana University and other institutions in the Brazilian led NASA LBA (Large-Scale Biosphere-Atmosphere Experiment) Ecology Program that deals with ecological issues in the Brazilian Amazon Basin. Indiana University and Indiana State University recently received a three year grant in the NASA/INPE LBA Ecology program for a project entitled "Human and Physical Dimensions of Land Use/Cover Change in Amazonia: Forest Regeneration and Landscape Structure" and has received three years of additional NASA funding (through 2005) for "Human and Physical Dimensions of Land Use/Cover Change in Amazonia: Toward a Multi-scale Synthesis." One of several project objectives is to develop a spectral library, based on airborne hyperspectral data, for vegetation and other features important in carbon modeling and vegetation succession research in five Amazon study sites. In addition, these hyperspectral data were to be used to identify narrow spectral bands most critical to land use change/vegetation succession classification. The project's co-PIs responsible for these research elements of research are

Dr. Ryan Jensen and Dr. Paul W. Mausel. Dr. Emilio Moran, Director, Anthropology Center for Training and Research on Global Environmental Change, Indiana University, Bloomington is overall PI/PA of the IU/ISU/IMPE project strongly supports the use of hyperspectral data in aspects of LBA research and will provide the detailed field data needed to integrate with hyperspectral data to achieve project goals. The anticipated hyperspectral data for this project was to be from NASA's AVIRIS sensor; however, logistics and a heavy demand for this instrument elsewhere made it impossible for NASA to acquire airborne hyperspectral data for the project's study sites or study sites of other LBA project PI's who also wanted hyperspectral data. The hyperspectral sensor will be available for this research and also for other LBA colleagues who have indicated a need for such data in their research.

This proposal has the support of Dr. Mike Keller, National LBA Projects Coordinator, to use the instrument in the Brazilian Amazon. In addition to the partnership that is shared with IU, we have contacts with many other principal investigators in the many studies that LBA supports. It is anticipated that the instrument will be loaned for use in LBA projects for up to three months each year. The sensor will enhance LBA projects by providing higher spectral and spatial resolution data to examine many of the biotic and abiotic properties of the Amazon. The foci of LBA research include carbon dynamics in vegetation and soils, carbon dioxide exchange between forest canopy and the atmosphere, land use/land cover change, fire ecology, biogeochemical cycling, modeling to examine nutrient dynamics throughout the region, and human dimensions of land use/land cover changes.

Water and Wetlands Studies

ISU is currently partnering with the United States Department of Agriculture and the University of Texas—Pan American to assess water quality and water quantity, and sea grass degradation using hyperspectral/multispectral remote sensing data in the Lower Rio Grande Valley and Laguna Madre. This project is still in its preliminary stages, but hyperspectral data would be a valuable supplement in both preliminary and later stage work as funding increases. In addition, Dr. John Jensen at the University of South Carolina will use the sensor to analyze coastal wetlands areas and wetland ecology. Dr. John Jensen has studied coastal areas extensively (e.g. Jensen et al. 1998), and he plans on continuing these studies in the future.

Description of the Research Instrument

AISA+, built by Specim, Inc in Finland and distributed in United States by Galileo Group, Inc, is one of the smallest and least expensive airborne hyperspectral instruments in the world (https://www.specim.fi/products-aisa.html). Its small size makes it portable for use in various aircraft because the instrument can be mounted on a plate that is compatible with a standard aerial camera mount, available in virtually any airplane throughout the world. Another advantage of AISA+ over other hyperspectral sensors is the flexibility in selecting the sensor's spatial and spectral resolution characteristics. For example, simple ASCII text files that can be written and loaded at any time control the sensor settings, bandwidth selections, and integration time. Multiple configuration files are loaded on the controlling computer and used interchangeably throughout the flight depending on the image targets or mission goals (https://www.3dicorp.com/rem-hyper-aisa.html; https://www.specim.fi/products-aisa.html).

Reflected light from the target below the aircraft is transmitted through a camera lens and directed to a prism-grating-prism optical system, which splits the light into its component wavelength spectra. The refractive properties of the two opposing prisms allow for a linear projection of light onto the charged coupled device (CCD) array. The two-dimensional array consists of a spatial axis of 500 detectors, and a spectral axis of 286 detectors.

Spectral and Spatial Resolution: AISA+ is capable of collecting data within a spectral range of 400–970 nm. Although AISA+ is capable of collecting up to 244 spectral channels within this range, the data rate associated with the short integration times (sampling rates) required of the sensor in most operational/flight modes, limits the number of channels. The full spectral mode, however, is useful for acquiring 244 spectral signatures of specific targets that can be used to generate pure endmembers as well as for band selection purposes (https://www.3dicorp.com/rem-hyper-aisa.html).

Downwelling Irradiance: Another unique feature of the AISA+ sensor system is the Fiber Optic Downwelling Irradiance System (FODIS). The FODIS allows for the concurrent measurement of downwelling and upwelling radiance by the AISA+ sensor head. A diffuse collector installed on the top of the plane is connected to the AISA+ head via fiber optic cable and collects downwelling irradiance in the same bandwidth configurations as the areas being imaged. The calibration of the FODIS coupled with the AISA+ sensor allows for the calculation of apparent at-platform reflectance.

Geometric Corrections and Georeferencing: In order to provide accurate location of the hyperspectral data, an Inertial Navigation System (INS) and Differential GPS (DGPS) are integrated into the AISA+ sensor. The INS and AISA+ datastreams are combined in the collection computer to provide frame-by-frame georeferencing of the imagery. Pitch, roll, and yaw are encoded with the DGPS information to provide accurate locations of areas of interest on the ground.

Data Processing: The AISA+ processing software (CaliGeo) provides for automatic geometric correction, rectification, mosaicing, and calculation of radiance or apparent at-platform reflectance (FODIS ratio). The program uses the (D)GPS and attitude information from the INS to perform the geometric, georeferencing and mosaicing operations. Automated batch processing provides for rapid turnaround times for data delivery. Using these tools, AISA+ produced a calibrated, rectified, and georeferenced hyperspectral image with an ENVI header file (https://www.specim.fi/pdf/AISA%2B_brochure1.4.pdf).

16.1.4 Impact of Infrastructure Projects

The sensor will enhance both undergraduate and graduate education at Indiana State University and other institutions. As mentioned earlier, data acquired will be used in the classroom as well as the research laboratory to demonstrate to all students the ways that geographic information can be measured and how these measurements can impact land use decisions and other factors. Professors at Indiana State University continuously seek to implement real-world data and problems to teach students theoretical and applied approaches in remote sensing (e.g., Jensen 2002a, b). An undergraduate student funded by ISU-GGA will be charged with cataloging, maintaining, and distributing sensor data to researchers via the Internet, File Transfer Protocol, or CD-ROM. To train the maximum number of undergraduate students, a different student will be assigned this duty each year.

The sensor will attract students from many socioeconomic backgrounds and enable all students to conduct hyperspectral remote sensing research without substantial external funding. The sensor (and data) will be made available to other institutions. For example, two institutions located within ten miles of ISU are St. Mary of the Woods College and Rose-Hulman Institute of Technology. St. Mary of the Woods College is an undergraduate Catholic all-women college that would directly benefit from access to the data and sensor in the classroom. Likewise, Rose-Hulman Institute of Technology would also benefit from the sensor. Rose-Hulman has received the number one ranking from U.S. News and World Report for undergraduate engineering schools for the past four years. The instrument would be made available for research and teaching for up to one month (or more) each year to the University of South Carolina and the University of Texas-Pan American.

In addition to the proposed collaboration, ISU-GGA will house a data-sharing network that will provide access to sensor data. Once sensor data has been acquired, the resulting images will be made available vis-à-vis a proposed web-based server. In particular, Wabash Valley data will be made freely available to the public through a proposed 'Wabash View' website akin to the current Ohio View (https://www.ohioview.org/) and proposed America View projects. The Department of Geography, Geology and Anthropology will house and fund the proposed Wabash View to distribute the data. If researchers do not have access to the Internet or FTP, we will distribute sensor data at cost via CD-ROM.

Geoeducation

Indiana State University received a four year $565,000 grant from NASA-Stennis to develop environmental remote sensing technology transfer materials for use in grades 7–12 to promote interest in science ("Remote Sensing Technology Transfer to Grades K-12 with a Focus on Preparation for SSTP Initiatives"). The period of development was 1997–2000 with Dr. Paul Mausel as the project PI. By 2001 three interactive multimedia CDs highlighting remote sensing and its role in environmental problems associated with wetland and land subjected to volcanic eruptions were completed. The first two CDs were submitted to NASA for peer review and in 2001 earned the

NASA Seal of Approval and Outstanding New Educational Product Award. Currently the first two CDs are in limited distribution (1000 copies of each CD), but they are expected to go into more widespread distribution during 2002. The third CD is anticipated to go into limited distribution within a year.

A beta version of the NASA CDs was shown to INPE (Brazil's NASA) by Dr. Mausel while at a NASA LBA PI/co-PI Conference. This introduction of the product eventually lead to a NASA/INPE grant awarded in October, 2001 to Dr. Mausel and Dr. Nelson Dias of Indiana State University to create two environmental remote sensing CDs focusing on Brazilian environmental problems presented in Portuguese ("Development of Educational Remote Sensing CD ROM's Using LBA Research Results: Adaptation of Existing U.S. Products to Brazilian Remote Sensing Teaching Materials"). These two CDs in Amazon environmental remote sensing funded by NASA-INPE are almost completed and will be used in Brazilian undergraduate universities starting in 2003. Additional CDs are expected to be developed and hyperspectral applications will be an element in these CDs. Both UTPA and IU are participants in the environmental science materials development proposals submitted to NSF and NASA ($2,000,000+ collectively) and, if funded, has hyperspectral incorporated in science materials development. This technology transfer product is intended for use in Brazilian universities and by the general public interested in environmental science. These CDs will be ready for distribution early to mid 2003 (Fig. 16.2).

The multimedia expertise and experience to develop multimedia technology transfer products, including graphics, animation, sound, music, interactivity, integration with web-based materials are all present at ISU. Academic/teaching materials developed for presentation in multimedia or web format have been proven to be of very high quality. Much of the results of research using hyperspectral and associated techniques in addressing environmental issues in the Amazon Basin, Lower Rio Grande Valley, agricultural areas of the Midwest, etc. suggested in this proposal are amenable to effective display and presentation to a variety of audiences using the facilities and expertise that exists at ISU.

Finally, the instrument and associated research projects will expand the current scale and scope of the Geo-Technology Education Center's (GTEC) mission. Access to hyper-spectral data and real-world case studies will enable the center to continue to develop educational materials using timely and appropriate remote sensing technologies. For this reason, the impact of the instrument on the current GTEC will provide benefits for a wide audience that would include university-level researchers, K-12 students and their teachers.

Integration with Undergraduate Curriculum at ISU

The sensor will be used as a formal component of the undergraduate curriculum in three areas. Specifically, the sensor will be used to demonstrate the scale and scope of remote sensing technologies and a range of curriculum appropriate applications in the geography, geology, and general education curriculum. The instrument and Wabash View data will be integrated into each of these classes. Specifically, the Wabash View data will be used to create hands-on laboratory assignments in the foundational courses (111L and 160L). In 115, the sensor will be used in connection

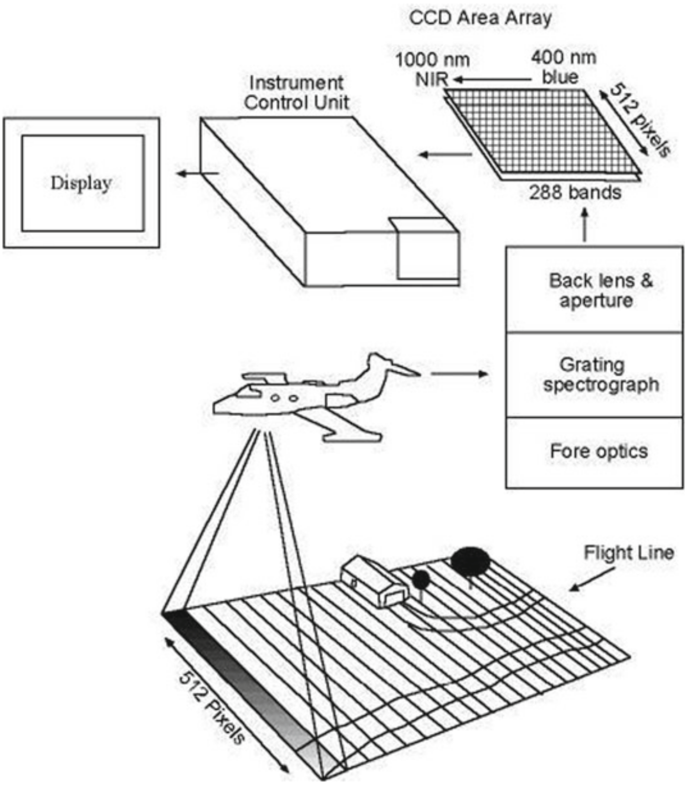

Fig. 16.2 Schematic of a hyperspectral sensor (after Jensen 2000a, b)

with a semester ‘project’ to provide students with the real world opportunity to use and explore a range of real world applications. In addition, sensor data will be used in advanced GIS, remote sensing, and cartography courses.

General Education Capstone Courses (across many disciplines)

In addition to departmental courses, the instrument will be made available to any undergraduate enrolled in a general election capstone course who may need access to it—provided she or he is working closely with a faculty member who is senior personnel associated with the instrument. These courses are intended to synthesize the core themes of the general education experience. As such, some research projects (particularly those with an environment policy focus) could clearly benefit from the availability of this unique instrument. However, priority will be given to ISU students enrolled in an appropriate capstone experience where the instrument can clearly make a major contribution to her-his research experience. In short, the instrument has the potential to greatly enhance the experience of undergraduates and improve the quality of the department, college, and university curriculum. Because the instrument will be introduced in courses associated with the university's education program, the sensor has the potential to positively influence curriculum development across the sciences—as well as expose students to the technology.

16.1.5 Utilization Plan

As the project description demonstrates, the anticipated usage rate of the hyperspectral sensor will be high. Indeed, the integration of the instrument into existing ISU and inter-institutional collaborations will result in an estimated usage rate between 2 and 3 'missions' (including maintenance and calibration 'flights') per month for the duration of the 2-year project. In addition to current projects, new and expanded multi-disciplinary projects will most likely result in a usage rate between 3 and 4 missions per month over 2-years, for a total of 5–7 expected uses per month.

Given the anticipated high demand for the instrument, current projects identified in the project description will be given the highest priority. Other priority users would include senior personnel and graduate students listed in this proposal. The final group that would be granted priority status is ISU researchers and students. The Department of Geography, Geology, and Anthropology (GGA) will be solely responsible for scheduling hyperspectral missions. The primary contacts within GGA will be the PI (R. Jensen) and Co-PIs (Berta, Gatrell, and Mausel). J. Jensen (co-PI, University of South Carolina) will have priority use of the instrument and will be consulted in scheduling as well. After two years, GGA will continue to maintain and use the sensor and allow other institutions to use the sensor. As the sensor is very easily mounted onto any plane, we could simply ship the sensor out to any location or we could drive or fly it out (Fig. 16.3).

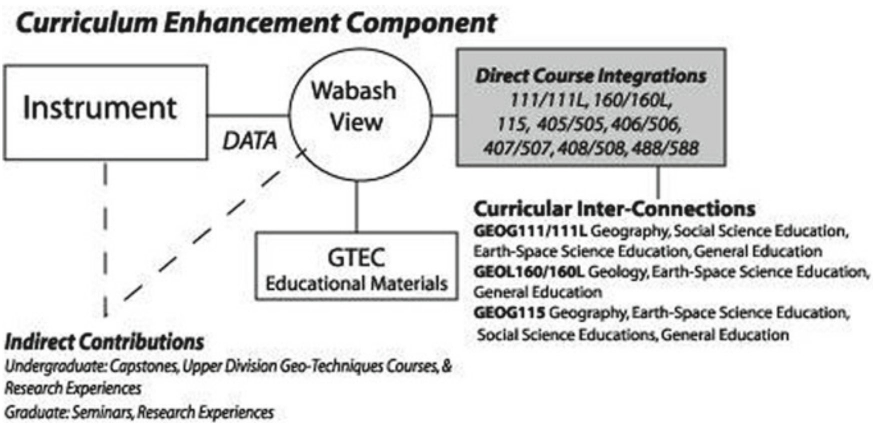

Fig. 16.3 Curriculum enhancement

The fee schedule for use of the sensor will be limited solely to direct overhead costs of each 'mission.' That is, users will be assessed a fair and reasonable charge with respect to the transit of the sensor and flight time (pilot and plane fees). The fee structure for flying time will be determined by the College of Technology's Aerospace-Technology Department and the ISU Office of Sponsored Programs. In some cases, this fee may be waived at the discretion of the ISU Office of Sponsored Programs and College of Technology. Finally, no user fees will be assessed for the instrument itself.

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Reflection

This proposal was funded in the fall of 2003. However, MRI awards are unique as they are long-term investments in scholarship and programs. To illustrate this point, the instrument was not received until the spring of 2004 and faculty, staff, and students received their initial training in the mid-summer of 2004. Test flights of the instrument occurred during the 2004–2005 academic year. The first research flights of the instrument did not occur until full leaf-on in the spring of 2005. The outreach project—WabashView—went "live" as an educational website in the summer of 2004 and was maintained through the end of the grant's no cost extension. For roughly a decade, the instrument was used as part of research collaborations with colleagues from around the nation and the world.

Chapter 17
Extramural III: Doctoral Dissertation Research Improvement Grant

James Speer

The following proposal was submitted to the National Science Foundation's (NSF) Doctoral Dissertation Research Improvement (DDRI) Grant Program (BCS 0,000,281). DDRI proposals are written in conjunction with your graduate advisor. Because NSF only awards grants to faculty, the advisor is the Principle Investigator (PI) and has responsibility for the grant. The student is the second PI and expected to contribute most of the work and intellectual input to the project. The DDRI can be submitted any time and researchers can request up to $18,000 (Solicitation 17-566).

This DDRI proposal was funded on the second submission of the proposal. The first submission was rejected but the reviewers provided relevant input for how the project could be improved. After incorporating these comments and having another year to advance the preliminary findings of the work, we were able to submit a stronger grant proposal. NSF often funds grant proposals that can defend the success of the concept in the proposal. Because of this, much of the work towards the project must be completed before a strong proposal can be submitted.

17.1 Long-Term Reconstruction of Oak Mast in the Southern Appalachian Region

Van Dersel (1940) reported that oak is utilized as a food source by more wildlife than any other genus of woody plant. Some of the more prominent game species that feed on acorns in the southeastern United States, are white-tailed deer *(Odocoileus virginianus),* turkeys *(Meleagris gallopavo),* black bear *(Ursa americanus),* and European hogs *(Sus scrofa).* Oaks *(Quercus spp.)* now serve a critical role for wildlife as producers of calorie-rich "hard" mast in late summer and fall. Historically, this role was shared by American Chestnut *(Castanea dentata)* in the Southern Appalachian region, but near-extinction of chestnut in this century has left oaks alone. Oak trees produce mast (acorns) during most years. At intervals, however, almost all individual

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trees throughout a region fruit very heavily in unison, producing what is known as an extreme mast event. A long-term record of extreme mast events could provide wildlife managers with a better understanding of natural variation in the mast cycle and insight into past fluctuations in wildlife populations. But thus far, no such record of mast cycles exists.

Schweingruber (1996) suggests that tree-ring analysis can provide a record of past fluctuations in the mast cycle. He notes that no mast reconstruction has yet been attempted, but could be if "dendroecological studies can be done on well-defined sites where the known fruiting of single trees can be compared to climatic conditions." That set of conditions now exists. The U.S. Forest Service is collecting mast data on 900 individual oak trees in an ongoing study being conducted on National Forest lands in Tennessee, North Carolina, and Georgia.

Dendrochronology—the technique of using annual growth of trees as a temporal record of all environmental variables that affect tree growth—has been used extensively in archaeology (e.g., Douglass 1929; Baillie 1982), climatology (e.g., Fritts 1976; Grissino-Mayer 1996), geomorphology (e.g., Gardner et al. 1983; Smith et al. 1994), and ecology. Ecological investigations (e.g., Abolt 1997; Swetnam and Baisan 1997; Speer 1997) have included reconstruction of insect outbreaks, fire history, stand age structure, and mast events. Tree-ring growth reduction due to known extreme mast events has been documented in beech (*Fagus sylvatica* L.), Norway spruce (*Picea abies*), Douglas fir (*Pseudotsuga mensiesii*), grand fir (*Abies grandis*), and western white pine (*Pinus monticola*) (see Holmsgaard 1958; Eis et al. 1965; Chalupka et al. 1976; Woodward et al. 1994; Nobori et al. 1996).

The methodology for reconstructing mast years is the same basic method used in reconstructing other short-term stresses such as insect outbreaks. The signal of interest is recorded in tandem with environmental factors. Once these are accounted for and their contributions to the record removed, the signal of interest remains. The result is a chronology, or continuous time series, of the events of interest. For example, insect defoliation can be identified in the host trees once confounding factors of climate and fire are removed (Speer 1997). Similarly, once the overriding signal of climate is removed from oak tree chronologies, extreme mast events should remain as a distinct signal in the ring-width record.

Oak tree-ring chronologies have not previously been studied to determine the feasibility of investigating mast-event signatures. We propose to do so, extending dendrochronological methods to a new suite of species and a new region, and breaking new ground by generating a set of records long enough and spatially diverse enough to allow rigorous investigation of temporal trends, climatic links, and spatial dynamics of mast cycles. We will document the tree-ring signature associated with extreme mast events, and then use this signature to reconstruct a mast history for the lifetime of extant trees (~200 years).

17.1.1 Background

The underlying principle of dendrochronology is that all trees in a site or region respond to a regional climate signal that affects growth in those trees similarly and synchronously. Growth includes radial stem growth, i.e. the width of annual rings. Differences in ring widths caused by annual climate variations occur synchronously in different individuals, regardless of age or condition (and to some extent, species). The chronological pattern thus recorded over many years forms a repeatable signature that allows the trees to be dated against each other. However, other information is embedded in the dendrochronologic record as well.

Any factor that limits growth will also affect tree ring width. To the extent that heavy masting by trees represents a significant tax on the energy resources of the trees, heavy masting events will be recorded as narrowed ring widths. The biomass incorporated in mast production in beech trees can equal approximately 139% of leaf production and 70% of annual wood-mass production (Nielsen 1977). This large drain on the resources of the trees has allowed dendrochronologists to document a reduction of wood volume associated with extreme mast events. Extreme mast events in beech trees were found to cause at least 40% growth suppression (Holmsgaard 1958). This severe suppression lasted only one year with a return to normal growth by the first or second year after the mast event. Eis et al. (1965) examined ring width data in conjunction with cone count records for a 28-year period, and found that heavy mast events in Douglas fir, grand fir, and western white pine result in a reduced growth ring the year(s) that the cones are on the tree. One year of suppression occurred in Douglas fir and grand fir while western white pine retained its cones for two years, yielding two years of suppressed growth. The studies of Eis et al. (1965) and Holmsgaard (1958) only documented the effect of known extreme mast events without attempting to reconstruct a history of past events.

The factor or factors most limiting to growth determine tree ring width. In most instances this is climate, but short-lived factors such as insect outbreaks or extreme mast events are occasionally limiting in those trees that experience them. Such signals are recorded along with climate, and can't be separated without independent knowledge of one or the other (however, this can be embedded in the record as a characteristic ring-series signature that identifies it). We will be looking for a mast signal, so we must control for climate.

Each species of oak has its own natural fruiting cycle. Acorns from white oak *(Quercus alba* in our study area) and chestnut oak *(Q. prinus)* mature in the first year, while acorns from red oak *(Q. rubra),* black oak *(Q. velutina),* and scarlet oak *(Q. coccinea)* mature in the second year. Each species may also have a natural masting cycle. Sork et al. (1994) studied flowering and acorn production in three oak species in east central Missouri. They monitored 14 black oaks, 12 red oaks, and 15 white oaks for the period 1981 to 1988 and found robust mast cycles specific to each species. Black oak tended to produce an extreme mast event every 2 years, red oak every 3 years, and white oak every 4 years. They hypothesize that it takes the intervening years to store the necessary starch and nutrients, and thus mast cycles are intrinsic to the species. They also found that in all three species the number of flowers produced in spring decreased the year following an extreme mast event, which they argue is evidence of an evolved mechanism for masting cycles in oaks (Sork et al. 1994).

However, climate also plays a role. Warm spring temperature during the season of fruit maturation correlated significantly with extreme mast events in all three species. Sork et al. (1994) hypothesize, from this and other weather correlates, that weather affects fruit maturation success rather than flower initiation. They conclude that weather can limit acorn production, but as long as conditions remain above a threshold then the tree's intrinsic mast cycle will control crop size.

Similar patterns seem to be present in the study area. Individual oak species tend to mast synchronously, but oaks as a whole do not. Inman (1997) studied diets of black bear during fall 1995 in the northwestern quadrant of the Great Smoky Mountains National Park (GRSM). He found that red oaks had produced an abundant acorn crop and provided 69.4% of the available food calories on his sites, while white oaks experienced mast failure and provided only 5.1%. Varying food availability on a site explains wildlife population movements that are associated with mast success (see Rogers 1976; Beecham and Pelton 1980; Garshelis 1994). During years of overall mast failure, bears move further across the landscape to find sufficient food for hibernation (Tankersley 1996), which brings them into closer contact with humans and other dangers.

17.1.2 Research Objectives

Objective 1: Determine the dendrochronological signature of masting in oaks

Using two sets of data from ongoing studies of masting in oaks, we will compare ring-width response to known masting histories at the level of individual trees at ten study sites in northern Georgia, western North Carolina, and eastern Tennessee, and at the stand level in GRSM. The physiological realities of resource allocation, and results from other tree taxa discussed above, strongly suggest that oak trees should produce reduced annual ring-widths the years that heavy acorn crops are on the trees. The first step will be to establish that this is the case among the major oak species of the Southern Appalachian region.

Objective 2: Establish the local dendroclimatic record in oaks and control species

We will create standard chronologies for each species (the 5 *Quercus sp.*, *Pinus strobus,* and *Liriodendron tulipifera)* in and adjacent to study sites, covering the period of local climate records (approximately 100 years). We will compare these data statistically with local Weather Service records for the same period, from Atlanta, GA; Asheville, NC; and Chattanooga and Knoxville, TN. This effort will yield a set of dendroclimatic records for each study site, for each species present. Respective masting cycle signals will be present as noise in the records. However, masting cycles in the control species are both minimal and different, so their combined record should reflect climate with minimal noise.

Objective 3: Remove the climate signal from the mast record

We will compare the climate signal portion of Objective 2 data with the Objective 1 data, allowing us to examine how known masting events alter the climate signal in oak species, and how the oak climate signal (with masting removed) relates to the control climate signal. That relationship, once established, will allow us to remove the climate signal from the 100-year oak chronologies, leaving mast cycles as a dominant feature of the record. We will interpret the record for each oak species at each site to generate century-scale chronologies of probable extreme mast events.

Objective 4: Extend the chronologies using the control records alone

Beyond the period of instrumental records, only proxy climate data such as dendroclimatologic records exist. We will use the relationship between the control chronology of each site and those of oak species, developed in Objective 3, to extend the records to 200 years. The dendroclimatologic record will be of interest for its own sake. The record of probable extreme mast events will provide a valuable tool to historians interested in resources used by settlers, wildlife biologists interested in the history of game populations, and climatologists interested in ecological impacts of past and future climate change.

Objective 5: Analyze the effect of climate on the mast cycle

The extent to which mast cycles are affected by climate is as yet poorly understood. Sork et al. (1994) found that spring temperature was positively correlated with extreme mast events and that summer drought was negatively correlated to mast. Studies such as this examine mast production over a few years and compare it to climate patterns during the period of study, but no century-scale data set has been analyzed. We will compare Objective 3 results with local monthly climate records to determine whether strong relationships exist between direct or lagged climatic parameters and shortening or lengthening of the cycle of extreme mast events. We recognize, however, that because of the need to ignore partial correlates remaining after removal of the climate signal from the chronologies, we may unavoidably miss very direct relationships.

Objective 6: Examine mast cycles at multiple spatial scales

Study sites for the proposed research form a nested hierarchy of individual trees, watershed-based forest stands, study sites, and the region as a whole (see below). We will compare the temporal patterns of extreme mast events (results of Objective 3) for each oak species at each spatial scale. This will allow us insight into the scale of the driving mechanisms behind the synchronous fruiting behavior of large numbers of trees that defines the mast cycle.

17.1.3 Study Area and Methods

The U.S. Forest Service's Southern Research Station (SRS), in cooperation with the National Forest system, is collecting a unique data set on annual mast crops of over 900 individual oak trees of the five regionally dominant species listed above (white, chestnut, red, black, and scarlet oak). So far they have acquired 5–7 years of data from study sites on National Forest lands in Tennessee, Georgia, and North Carolina (see map). Individual trees were selected to include a broad range of ages, slopes and aspects. The goal of the original research is to determine what physiological factors in the environment affect acorn production. However, these data on individual trees provide us with an opportunity to directly calibrate tree rings to known mast history. The research also provides us with a set of study sites that are broadly distributed spatially and are located in a variety of topographical positions.

We are cooperating with the SRS in this project. Our cores of the study trees will provide the SRS with the establishment date of each tree so that they can determine the effect of tree age on mast production. Conversely they are providing us with their data set of mast crops for the past 5–7 years so that we can correlate yearly mast production for each tree with the ring width that corresponds to that year's growth. The oak trees in the study are often over 200 years old, which will allow us to reconstruct a long-term record for reconstruction of climate and extreme mast events.

We will first core the 900 study trees that the SRS has selected. These are tagged, and we have maps of the sites so that we can locate them. We will core each tree twice on opposite sides, parallel to the slope contour to avoid the complicating effect of the tree's growth compensation for slope angle. Two cores provide a better estimate of wood allocation to stem growth than does a single radial sample. At this writing we have collected 600 cores from 300 trees at sites in the Bent Creek Experimental Forest in North Carolina.

GRSM park personnel have also collected mast data since 1979 in a stratified random sample approach designed to represent the diverse vegetation of the park. Researchers walk 28 selected trails within the park each year and record masting at sample sites spaced every 0.8 km. At each sampling site, the first available hard mast tree greater than 30.5 cm is selected and visible mast counted using binoculars. The 19 years of data provide useful stand-level and sub-regional records of those species most consistently represented.

We have obtained permission to follow the GRSM sampling methodology on the 28 designated trails. At each site we will core one of the oldest of the well-represented oak species. This set of cores will provide sub-regional chronologies for these species that can be compared with their masting records. The data will be less useful than the unique individual-tree data of the Forest Service, but they will extend the calibration period. Coring these sites will add 100 or more trees (200 or more cores) to our data set.

As a control, we will collect samples from stands of white pine *(Pinus strobus)* and tulip-poplar *(Liriodendron tulipifera)* adjacent to study sites. Ring widths from these chronologies, combined with a century of monthly precipitation and temperature data from local Weather Service stations, will allow us to develop transfer functions for predicting climatic variables from ring widths (developed and tested using random subsets of data). These species respond to the same regional climate signals as oaks, but should exhibit a different masting signal (Eis et al. 1965) from the oaks and from each other. By averaging the climate reconstructions from these two different taxa, we will be able to create climate reconstructions that are not strongly biased by either genus. This portion of the study minimally requires another 300 trees or 600 cores.

In the laboratory, all cores will be dried, mounted in wooden core mounts, and progressively surfaced with 120-, 220-, 320-, and 400-grit sandpaper. The resulting surface allows examination of individual cells. We will cross-date all cores using standard skeleton plot and memorization methods (Stokes and Smiley 1968). Precision measurements of ring widths of dated cores will be recorded using a Velmex measuring machine, and measurements standardized to remove the growth trend. Individual chronologies, each representing a single species and site, are per-year averages of standardized ring widths over all core samples from the site. Only the last 5–7 years of tree ring record (length varies by tree) of SRS study trees need to be analyzed as individual records, while studying the mast signal and its lag effects. In these, we will also study the ring structure at the cellular level to search for any distinct morphological characteristics of extreme mast events.

The trees and sites form a nested hierarchy. The region forms the top level of the hierarchy, and the combined dendroclimate record should reflect background climate that is affective at the scale of the Southern Appalachian region. Ten study sites are fairly evenly distributed throughout the region. Each site contains sub- sites (from 3 to 6) defined by watershed, and each of these sites contains from 30 to 70 individual trees. Individual trees respond to local topographic position and microsite availability of water and nutrients. We can study mast patterns at each one of these four levels. Records of subsites can be combined, and their ring-width chronologies averaged to develop higher-order chronologies, just as records of individual trees can be combined to produce stand chronologies of mean ring-widths. Mast patterns may or may not differ between each set of levels. This approach is analogous to previous spatial reconstructions of insect outbreaks (Speer 1997) and fire history (Swetnam and Baisan 1997).

17.1.4 Significance of Research

The proposed research will contribute broad methodological advances to dendrochronological technique. Documentation of extreme mast events in tree rings has been sporadically attempted in the past, but we propose to lay the groundwork for a new subfield in dendrochronology. Dendrochronology originated around 1920 as a tool for dating archaeological sites in the Southwest, and subsequently for reconstructing climate. More recently, dendrochronology has expanded to the investigation of past events and histories of events, such as fires, insect outbreaks, and floods. We will bring a new dimension to the science by defining a methodology for documenting extreme mast events.

This work will help inform theoretical inquiries into mast ecology. Mast has been studied for a long time because of its importance to wildlife populations. Foresters are collecting data on modern mast crops to gain further understanding of the mast cycle and how it fluctuates through time. The results of this and subsequent studies will quickly provide long-term mast reconstructions that will allow foresters and ecologists to better understand mast ecology.

A recent concern in ecology is the role of scale in the dynamics of natural systems. By incorporating spatial scale explicitly into our research design from the outset, as geographers, we can contribute to the understanding of the scale dynamics of masting and of climatic variation in the study area. At the conclusion of the proposed research we will have constructed many tree-ring chronologies representing over 1300 trees located on sites throughout the Southern Appalachian region. Completely apart from masting, this will constitute a very significant dendrochronological resource. Even at its most basic level, the research we propose will generate and replicate, robust information for a region where little exists.

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Reflection

This proposal was funded in December of 1999 with funding to run from April 15th 2000 to October 15th 2000. Considering the reviewers comments improved the proposal and even changed some of the author's thinking on the dissertation project as a whole. In terms of funding rates, roughly 1/3 of the DDRI proposals are funded. While the majority of proposals are not funded and the program is highly competitive, the DDRI program has one of the highest fund rates across all NSF programs. Indeed, many doctoral programs encourage their PhD students prepare and submit their dissertations proposals to the NSF DDRI program. While preparing a DDRI proposal may take additional effort, the submission process is a *good exercise, because student researchers learn to follow rigorous grant proposal guidelines and may receive funding in the process.*

With respect to the unique aspects of the proposal, the methodology section has been written in such a fashion as to assume the reader is not an expert per se. In the case of many proposal competitions, the majority of readers are trained in the general discipline—but do not necessarily have expertise in the specific area of the proposed research. As such, most proposals for extramural grants should be mindful of the audience. Additionally, funded research proposals have to credibly demonstrate that the research can be performed within a given grant period (1–3 years in most cases) and that the investigator has the skills, knowledge, and infrastructure necessary to complete the proposed project. Finally, proposals serve as writing samples that can be used to assess an investigator's capacity to disseminate research vis-à-vis the peer reviewed literature. To learn more about the NSF Geography and Spatial Sciences DDRI program, please visit: https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503621.

Chapter 18
Extramural IV: Training and Development

Ryan R. Jensen and Emanuel H. Martin

This proposal was funded by the United States Agency for International Development (USAID) in 2019 via*USAID's Protect Tanzania project (Promoting Tanzania's Environment, Conservation, and Tourism;* https://tz.usembassy.gov/u-s-government-launches-14-5-million-project-protect-tanzanias-environment-promote-conservation-tourism/*). The project focused on developing institutional capacity and key infrastructure vis-à-vis training and research collaborations. Some of the aspects of the project were revised (e.g., project timeline) based on when and how the project was funded. Also, some personal information has been removed from the proposal.*

18.1 Building Capacity for Geospatial Technologies in Tanzania: A Collaboration Between BYU and the College of African Wildlife Management

The United Republic of Tanzania is located in eastern Africa. It borders eight other countries to the north, west, and south and the Indian Ocean to the east. In 2016, the United Nations estimated the Tanzanian population at just under 56,000,000. Tanzania has abundant natural resources, and approximately 38% of its land area is protected for conservation, including the Ngorongoro Conservation Area. Tanzania's 16 National Parks include the Serengeti, Lake Manyara, Tarangire, Gombe Stream, and many others. The responsibility to map, maintain, and model these areas and Tanzania's other natural resources falls in part on government-funded colleges and universities in Tanzania, such as the College of African Wildlife Management. Geospatial technologies, such as Geographic Information Systems and Remote Sensing, can greatly assist College faculty and others to accomplish this responsibility. This proposed project seeks to build the teaching and research capacity of Geographic Information Systems (GIS) and Remote Sensing in the Tanzanian College of African Wildlife Management (CAWM). The project will be an integral part of strengthening geospatial technologies at the College. Specifically, the project

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will ultimately provide enhanced education and research opportunities through shared investment between Brigham Young University and CAWM. These opportunities will help increase spatial knowledge of Tanzania's incredible natural resources, improve natural resource and national park management, and ultimately support local and international tourism. Finally, the project will further the education statement on the United States Agency for International Development (USAID) website, 'Education is transformational for individuals and societies–it creates pathways to better health, economic growth, a sustainable environment, and peaceful, democratic societies.'

The CAWM was established in 1963; the College is a pioneer institution in the field of wildlife management training in Africa and has remained the leader in this field. Since its establishment, it has maintained a stringent academic discipline providing renowned qualifications nationally and internationally. The College has been registered and is accredited by the National Council for Technical Education (NACTE) in Tanzania (registration number REG/ANE/006). It is also recognized as a Centre of Excellence by the East African Community (EAC) and the Southern African Development Community (SADC). Part of the CAWM's charge is to 'protect and manage Africa's natural heritage.' Further, the CAWM mission **is 't**o provide the highest standards of technical training by engaging a global community and undertaking relevant research and consultancies in order to meet the needs of wildlife and tourism management in Africa.' The implementation of GIS and remote sensing will help accomplish these goals by providing state of the art tools and methods to effectively map, model, and monitor Tanzania's enormous natural resources.

Currently, CAWM has a shortage of personnel capable of teaching GIS and remote sensing in the classroom and using GIS and remote sensing in research. Also, CAWM lacks a GIS and remote sensing lab. We propose that faculty in the Department of Geography and the Geospatial Services Center at Brigham Young University help build the capacity for GIS and remote sensing teaching and research at CAWM. This will take place as part of a training program for CAWM faculty in the geographic techniques of GIS and remote sensing and the creation of a GIS and remote sensing lab on the CAWM campus. It is anticipated that the training program will consist of two different summer workshops. The first workshop will involve basic training in GIS and remote sensing at the GIS lab and GeoSpatial Services Center at Brigham Young University involving five selected participants from both BYU and CAWM. The second workshop will provide advanced training in those same subjects on-site at CAWM. The interim period between the two workshops will consist of CAWM faculty completing technological and pedagogical projects in-country while communicating with BYU faculty.

Further, two BYU geography GIS students will be selected to help provide instruction during both workshops. Finally, the project will provide participants with increased understanding of both the Tanzanian and American cultures.

Specifically, the project will provide the following outcomes to participants:

- Provide CAWM faculty and students with increased knowledge of geospatial science including cartography and technological tools such as GIS and RS to map, maintain, and model Tanzania's natural resources.
- Increase spatial knowledge and management of Tanzania's natural resources and national parks.
- Increased ability of CAWM faculty to use and teach GIS and RS software.
- Personal experience in the use of a web-based site for learning.
- Development of pedagogical strategies for the creation of teaching units that address conservation and environmental studies.
- An experiential learning opportunity to BYU students that complements BYU's recent engaged learning emphasis.
- Increased understanding of American and African cultures.
- Development of GIS lab at CAWM to be used by natural resources researchers, academic staff, and students
- Cementing strong bonds between the two institutions—CAWM and BYU.

18.2 Partnership Overview

18.2.1 Partnering Institution

Brigham Young University

Brigham Young University (BYU) is a comprehensive university offering almost 200 majors in a wide variety of areas. BYU currently enrolls 30,395 undergraduate students and 2,968 graduate students from all 50 states and 100 countries. Further, BYU employs 1,264 full-time faculty (and 486 part-time faculty). The academic training for this project will be provided by the Department of Geography at BYU, which offers introductory and advanced courses in Geographic Information Systems (GIS) and remote sensing. Geography faculty have been successful in completing funded research and workshops for the National Science Foundation (NSF), National Aeronautical and Space Administration (NASA), and the USAID Association Liaison Office. The Department focuses on applied environmental research and maintains a fully equipped GIS and remote sensing laboratory with 42 computers. The lab allows students and faculty to analyze and model environmental problems. The lab maintains large servers with digital remote sensing data, including Landsat TM and MSS data, USFWS National Wetlands Inventory data, SPOT, TIGER/Line, Eastwide Forest Inventory Database, STATSGO data, USGS land use/land cover, USGS digital elevation models (DEMs), USGS transportation, USGS digital raster graphics (DRGs), US EPA stream reach files for Indiana as well as several more specialized databases such as vegetation and soil coverages developed for specific projects, and a large aerial photography library. In addition, the project will be supported by the GeoSpatial Services Center in the Harold B. Lee Library under the direction of Dr. Mark Jackson.

College of African Wildlife Management

The College of African Wildlife Management was established in 1963 by the Act of Parliament Number 8 of 1964. The establishment of the College came after the Arusha Manifesto signed by Mwalimu Julius K. Nyerere, in September 1961 while he was the Prime Minister of Tanganyika. The manifesto highlighted, among other conservation commitments, the need for trained manpower to protect and manage Africa's natural heritage. The College of African Wildlife Management is a pioneer institution in wildlife management training in Africa. It has shaped and influenced professionalism in wildlife conservation and management in eastern, western, and southern Africa particularly in Nigeria, Gambia, Tanzania, Kenya, Uganda, Malawi, Ethiopia, Zambia and Botswana.

Since its establishment, the College has trained over 8,000 wildlife and tourism managers from Certificate to Degree levels from over 50 countries worldwide. The majority of these graduates are now working in protected area management throughout Africa. In Tanzania alone, 90% of the protected areas in Tanzania (particularly National Parks, Games Reserves and Ngorongoro Conservation Area) are managed by graduates from CAWM. Subsequently, CAWM has a strong record of accomplishment in coordinating and participating in large projects, and is actively involved in the formulation of national wildlife management policy and preparing management plans for protected areas within and outside the country. Furthermore, the college has formed a number of collaborative partnerships to provide training, conduct research, and prepare and conduct conservation projects with institutions from both within and outside the country, including WWF–Tanzania, USAID–Tanzania, Tanzania Wildlife Research Institute, Hedmark University College (Norway), University of Würzburg (Germany), Manchester Metropolitan University (U.K.), Brigham Young University (U.S.A), Saudi Wildlife Authority (Saudi Arabia), and Uganda Wildlife Authority (Uganda).

Given the extent of CAWM's reach in Tanzania's natural resource and tourism management, providing additional GIS and remote sensing skills and knowledge for use in tourism and natural resource and park management will further enhance the ability of CAWM faculty, students, and graduates to promote, protect, and in some cases expand Tanzania's natural resources and parks. For example, in tourism development and planning, GIS can help audit environmental conditions, examine tourism suitability in specific locations, help identify conflicting interests in potential locations, and model complex relationships (Bahaire and Elliott-White 1999). Further, remote sensing data and techniques and GIS can map wildlife habitat at various spatial scales to help manage animal populations and predict animal locations (Osborne et al. 2001; Tuttle et al. 2006) and map historical physical environmental factors and their influence on land use and land cover change (Mutiti et al. 2017).

18.2.2 BYU-CAWM University Relations

There is a history of connections between CAWM and BYU that is rooted in the dynamics of personal and professional associations. In May 2017, faculty accompanied four BYU undergraduate students to Tanzania for a study abroad experience. During the study abroad, students and faculty were hosted by and attended multiple short courses taught by CAWM faculty. Topics for these courses included Wildlife Hunting, Wildlife Management Areas, Wildlife Management, Wildlife Management: African Perspective, Tourism in the Northern Circuit, Tourism and Community Well-Being, African Snakes, Animal Behaviour, and several others. In addition to their academic content, these courses provided BYU students and faculty familiarity with CAWM faculty and their teaching methods. After the short courses, CAWM faculty arranged and accompanied BYU students and faculty on safari to five Tanzanian National Parks namely Serengeti, Lake Manyara, Tarangire, and Arusha and Ngorongoro Conservation Area. Finally, in January 2018, Dr. Jensen visited CAWM and provided multiple GIS and remote sensing lectures to CAWM students and faculty. The short courses, lectures, and safaris represent initial steps in the burgeoning academic and research relationship between CAWM and BYU.

Current Research Project—Mapping the Kwakuchinja Wildlife Corridor

Currently, Dr. Emanuel Martin and Dr. Ryan Jensen are working on collaborative research using geospatial technologies to map out current and historical vegetation cover around Kwakuchinja Wildlife Corridor in northern Tanzania that links Tarangire and Lake Manyara national parks. This wildlife corridor is critical to animal movement between Lake Manyara National Park and Tarangire National Park, and it forms the Tarangire-Manyara Ecosystem (Caro et al. 2009; Marttila 2011; Hariohay 2013). Dr. Martin, his colleagues at CAWM, and Dr. Jensen will create and error-check vegetation maps using Landsat satellite images from 1990, 1995, 2000, 2005, 2010, and 2015. The project will identify current and historical patterns of woodland, open woodland, bush land, Grassland, and settlement land cover categories. This will help inform short-term and long-term management strategies to responsible wildlife departments and conservation agencies in Tanzania on possible mitigation measures for the sustainable management and conservation of the Kwakuchinja Wildlife Corridor.

18.2.3 Partnership Design

BYU and CAWM will share responsibility for overall financial and administrative management of partnership activities, general coordination of training personnel and technical assistance, and reporting on the progress of project activities. The U.S. Partnership Director and the Tanzania Partnership Director will be responsible for the project's overall design, implementation and evaluation. The Project Leadership

Team will consist of the two Partnership Directors, the Project Administrative Coordinator, and the Project Academic Coordinator. BYU representatives on the Leadership Team will have responsibility for the day-to-day administration, management, and academic components of the project. While CAWM representatives on the Leadership Team will have responsibility on the actual implementations of the day-to-day activities including coordination and management. The U.S. Partnership Director (hereafter referred to as the Project Director) and his Tanzanian counterpart will be the official representatives of the partnership. For day-to-day project management, the Project Director will interact with other members of the Project Leadership Team and faculty; monitor partnership activities; coordinate effective and timely deployment of physical, financial and human resources for partnership activities; coordinate project activities; and develop and submit required report(s) to the Association Liaison Office.

18.2.4 Project Leadership Team

U.S. Partnership Director/Project Director and Project Academic Coordinator: Dr. Ryan R. Jensen, Professor and Chair of BYU's Department of Geography. Dr. Jensen has expertise in GIS and remote sensing. His primary teaching responsibilities include GIS and remote sensing, and his textbook, *Introductory Geographic Information Systems*, has been widely adopted throughout the world. Dr. Jensen's research interests are diverse and include: Geographic Information Systems and Remote Sensing Applications in Environmental Systems; Longleaf pine/turkey oak sandhill fire ecology in the southeastern coastal plains; Amazon forest succession; Urban forestry; Biogeography; and Landscape ecology. Finally, Dr. Jensen has experience in conducting projects like this one. In fact, this project is based, in part, on a similar project conducted between Indiana State University and Mzuzu University in Malawi from 2004–2007. This project was funded by the USAID Association Liason Office. Dr. Jensen was faculty at Indiana State University during the Malawi project, and he was the Project Academic Coordinator for the project.

Tanzania Partnership Director: Dr. Emanuel H. Martin, Ph.D, Lecturer and Contract Manager at CAWM. Dr. Martin has expertise in Wildlife Management. He specializes in forest mammal ecology and modelling, and protected areas planning and management. His primary teaching responsibilities include wildlife ecology, mammalogy, protected areas planning, wildlife policies, and animal systematics. Dr. Martin also has a basic knowledge of GIS and remote sensing acquired from various training organized by University of Copenhagen and Trento Museum of Natural Sciences—Italy, University of Oxford through distance learning and Glasgow University from Scotland. Dr Martin has also has experience collaborating with various scholars, which has resulted in a number of publications in various scientific journals such as *Ecography*, *Science*, and *Philosophical Transactions of the Royal Society* just to name a few. In addition, Dr. Martin has experience co-managing projects with different institutions such as Tropical Ecology Assessment Monitoring

(TEAM) project (www.teamproject.org) where he was a Site Manager for Udzungwa Mountains National Park field site from 2009–2014. Also, he has been involved in a number of collaborative projects through Tanzania National Parks (TANAPA) such as animal inventory in Rubondo and Mkomazi national parks in Tanzania. Currently, Dr. Martin is also serving as Project Investigator on a Bee Pollinator Project co-run by CAWM as a leading institution among other institutions, such as, University of Würzburg (Germany), Sokoine University of Agriculture (Tanzania) and Tanzania Wildlife Research Institute.

18.3 Collaboration Timeline

The primary goal of this collaboration is to enhance the capacity of GIS and remote sensing in teaching and research at the College of African Wildlife Management (hereafter CAWM) by providing the human and technological resources of Brigham Young University (BYU) to members of the CAWM faculty (hereafter called 'faculty fellows'), including creating and equipping a GIS lab with necessary facilities. To achieve this goal, BYU and CAWM seek to create a partnership to enhance the role of GIS and remote sensing in CAWM courses and research.

The steps designed to meet this goal are:

Phase 1: Planning-Assessment and Orientation. July 2018. U.S. Project Director will go to CAWM for two weeks to work with the CAWM Project Coordinator to assess project needs, select Faculty Fellows, and conduct a cultural orientation.

*Phase 2: Summer Training Worksho*p. This will be a three-week in-residence training for four Faculty Fellows delivered on the BYU campus in Provo, Utah during August 2018. The content areas will be introduced. BYU geography faculty and select students will participate in the instruction.

The "Interim Period" will incorporate the year between the two workshops during which time the Faculty Fellows will complete assigned technological and pedagogical projects in-country while in communication with BYU faculty.

Phase 3: Summer Training Workshop II. This will be a three-week on-site training workshop at CAWM in July/August 2019. An advanced level of content and skills in the content areas will be presented by visiting BYU faculty and two GIS students.

Phase 4: Follow Up and Close Out. The U.S. Project Director will go to CAWM for one week in October, 2019, to discuss the final project evaluation with the Tanzania Project Director and the outside evaluator.

This design allows for intensive content and skills training at BYU, followed by a period in-country to integrate and apply the learning to projects and classes, and a second intensive training to further the Faculty Fellows' learning. This integrative approach—two training workshops with an interim period of practical application—is supported by adult learning theory. Adult learning theory is primarily focused on the following four principles presented by Knowles (1984): (1) Adults should be involved in the planning and evaluation of their instruction; (2) Experience provides the basis of learning; (3) Adults are most interested in learning things that have immediate relevance and impact in their job; and (4) Adult learning is better problem-centered as opposed to content-centered (Pappas 2013). Finally, this multi-phase approach to the training also provides more opportunities for summative evaluation that will, in turn, shape the next phase to make this project more responsive to the needs of the Fellows.

A secondary goal is to promote and enhance the understanding of the American and African peoples and cultures. Informal activities such as field trips and sharing meals will give participants from both countries opportunities to hear the stories of the others and to develop greater sensitivity and appreciation.

18.4 Description of Partnership Activities

18.4.1 Workshop Content Areas and Instructional Strategies

Geographers investigate fundamental questions that relate directly to the mechanics of the earth's physical processes that can be applied to issues of conservation and the environment. In the training workshops proposed in this grant, CAWM Faculty Fellows will study GIS and remote sensing as tools for understanding environmental issues.

<u>Geographic Information Systems (GIS)</u>

GIS are important tools in earth science and spatial data analysis. This training workshop will introduce participants to the practice and theory of GIS through lectures, applied laboratory analysis, and field trips. Lectures will emphasize principles and theory in GIS and the nature of spatial data systems. Applied laboratory analysis will be oriented towards concepts discussed in lecture by using a GIS to display and analyze spatial data. Field trips will be conducted to collect field data and familiarize students with the entire GIS analysis process. At the end of the Summer Training Workshop I, participants will feel comfortable in the application of GIS to earth science issues. During the interim period, they will complete a project using the techniques learned throughout the workshop. This project will be presented at the second workshop.

<u>Remote Sensing</u>

Summer Training Workshop I will provide all-purpose instruction on fundamental issues in contemporary remote sensing. Instructional methods will combine lectures with lab and field exercises. Identification and evaluation of Earth features from images/data acquired from space will be explored. Aerial photos, Earth resources satellite images, and weather satellite images will be used to give insight into important physical, economic, and cultural features. Satellite data of Tanzania will be studied both during the first workshop and during the interim when Faculty Fellows will complete a project to be presented during the second workshop. In the Summer

Training Workshop II the techniques of digital image analysis of remotely sensed data will be presented. Workshop highlights will include: (1) The role of digital image processing in remote sensing for developing information about the Earth; and (2) An introduction to techniques of data transformations that enhance the information extracted from remotely sensed data which can then give insight into environmental issues.

18.4.2 Description of Activities

Planning- Assessment and Orientation (Phase 1- July 2018).

Dr. Ryan Jensen will visit CAWM for two weeks to meet with Dr. Martin and the CAWM rector. Together, they will assess the project needs, assess CAWM's technology level, select Faculty Fellows, collect information about the Fellows, and conduct preliminary cultural orientation.

Summer Training Workshops I and II (Phases 2 and 3, July/August 2018 and 2019)

Four Faculty Fellows will attend the workshops during three weeks at BYU, with the total number of days in the U.S. being approximately 22 days. For the first two weeks, the group will have a thorough presentation of the dominant concepts in the content areas of GIS and remote sensing. Instructional strategies will include traditional lecture format, partner-based activities, hands-on experiences with various software packages, guest speakers from the profession, and field trips. Instructors will provide written and electronic materials to augment the learning. Learning sessions will be scheduled from 9:00–12:00 and 2:00–5:00, Monday through Friday. A two-hour break will be allocated for lunch to provide time for Fellows, BYU faculty, and invited guest speakers to interact informally to help build the bridges of cultural as well as professional understanding.

The third week will be devoted to both scientific and cultural activities that may include but are not limited to: Salt Lake City (Natural History Museum), Las Vegas (cultural experience), basin and range field trip (collect data), and several national parks (probably Arches National Park and Zion National Park).

Weekends will be used for study and preparation for class, cultural activities and additional short trips to surrounding areas. Weekends will provide an excellent opportunity for the Fellows to become involved in a great array of cultural experiences, meeting students on campus, socializing with students and faculty with similar interests, learning about the American way of life, and relaxation. Weekends will also be an essential time for the Faculty Fellows to work on assigned projects, both technical and pedagogical. The GIS/RS lab will be open and available to them during the weekends.

The Interim Period (August 2018 to July 2019).

During the twelve months between the Summer Training Workshops, Fellows will complete projects in the content areas that were started during Summer Training Workshop I. They will work collaboratively in-country with communication access to the BYU faculty through a web-site.

Follow-up and Close-out Activities (Phase 4, October/November 2019).

Dr. Ryan Jensen will return to CAWM for one week in discuss the final project evaluation with Dr. Emanuel Martin to discuss the summative evaluation results and the final evaluation report.

18.5 Project Evaluation

Activities related to project evaluation will be conducted related to the three components of the training model and will include: (1) written narrative evaluations that assess the effectiveness of the Summer Training Workshops' curriculum, the teaching modules, the projects developed by the Fellows during the interim period in country; and (2) a group evaluation session in Tanzania at the conclusion of the project. An independent outside consultant from Tanzania will conduct the project evaluation. The consultant will assess the following:

(1) Is the project being conducted as planned and is progress being made toward meeting the goals?

(2) How successful is the project in reaching its goals?

The consultant will develop formative evaluation tools as well as a summative evaluation of the project. The formative evaluation will measure and describe project activities in order to inform the leadership staff about the ongoing implementation of the project. The summative evaluation will assess the extent to which the project has achieved its goals.

The consultant will coordinate his/her work with Dr. Ryan Jensen, Dr. Emanuel Martin, and the CAWM Rector. In May 2018, the consultant will meet with the team during the Phase 1 planning stage to identify the purpose and intent of the evaluation and to ensure that the appropriate questions and methods of data have been developed. At the end of Phase 2, the consultant will evaluate the 2018 Summer Training Workshop and submit a progress report. At the end of Phase 3, the consultant will evaluate the 2019 Summer Workshop and submit a final evaluation report that will be included in the final report that BYU will submit at the conclusion of the project.

18.6 Anticipated Results

- Provide CAWM faculty and students with knowledge of earth sciences including cartography and technological tools such as GIS and remote sensing.
- Increase spatial knowledge and management of Tanzania's natural resources and national parks.
- Increased ability of CAWM faculty to use and teach GIS and RS software.
- Personal experience in the use of a web-based site for learning.
- Development of pedagogical strategies for the creation of teaching units that address conservation and environmental studies.
- Increased understanding of American and African cultures.
- Development of GIS lab at CAWM to be used by natural resources researchers, academic staff and students
- Cementing strong bonds between the two institutions i.e. CAWM and BYU

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Reflection

This proposal is included in this collection as it emphasizes assessment. Program or project assessment are critical elements for many types of grants that focus on partnerships. Additionally, this project demonstrates that the scale and scope of potential funding opportunities are much broader than "research". This training or capacity building grant project facilitates not only a project; but enhances the competitiveness of research at an international partner institution.

Chapter 19
Extramural V: Non-profit Organizations

Mark Patterson and Nancy Hoalst-Pullen

This proposal was submitted to the National Geographic Society's prestigious Explorer grant program [see https://www.nationalgeographic.org/funding-opportunities/grants/]. Unlike government agencies, non-profit organizations and foundation grant programs are more streamlined application processes with an emphasis on creative ideas and concepts—not necessarily data or methods. In some cases, non-profit organizations or foundations require very limited application materials, such as an internal form with limited narrative requirements or even a simple letter of intent. As you will see, the authors seek to leverage an Explorer grant to enhance a pending NGS-supported project.

This project will produce the *National Geographic World Atlas of Beer*, which National Geographic Books and we envision being the "the most comprehensive atlas on beer". The atlas will be divided into sections by continent and will feature countries and regions within selected countries with significant beer cultures. In all there will be approximately 40 countries featured in the atlas, with a total page count of 304. A detailed chapter outline has been uploaded with this proposal. Beyond the visually rich maps, photographs, and infographics, and text expounding on the geography and history of beer for each country/region, we will be including narratives of local beer related stories. These narratives and photographs will be collected by visiting countries and talking with local brewers/patrons/pub owners. We undertook a pilot project for such data collection, traveling to Ireland, Belgium and the Netherlands in May 2015, and have been able to refine the process to increase our data compilation efficiency. This proposal seeks funding to help offset some of the travel costs we will incur. Specifically, we are requesting $20,468 for trips to Asia, South America and the Western US. To cover expenses to other countries/continents, we will redirect our book advance ($30,000) to this purpose and we have access to discretionary funds ($5,000). These data collection trips will allow us to present a more vivid and personal account of "beerscapes" around the world, something that is lacking in other beer atlases.

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19.1 World Atlas of Beer

We are writing a book for National Geographic tentatively entitled the *National Geographic World Atlas of Beer* (October 2017 anticipated publication date). Our goal with this publication is to produce the most comprehensive atlas on beer, beer styles, and beer culture. To achieve this, the atlas will contain visually rich maps, photos and infographics, along with factoids and stories. It is these stories from each pre-defined region that lend to the overall uniqueness of the atlas. Our goal is to include personal stories from the perspectives of local patrons, brewers, bar owners and the like, to engage readers and help them understand how and why beers, beer styles and beer cultures are linked to certain locations, thereby telling fuller stories of the "beerscapes" of these regions.

It goes without saying that the most common and most recognized beer regions (e.g. Germany, Belgium, USA) will be included; however, it is as important to include regions that are rarely identified, marginalized, or do not have (yet) a global reach. Such is a shortfall found in similar books, where these places are unknown, stereotyped, or overlooked. Expanding the regions to include the beers and beer cultures of Japan, China and South America, for example, will help us produce the comprehensive atlas that we envision.

Significance: In the current beer book market, there are beer reference books, regional beer books, beer and food pairing books, and beer style/tasting books. Few if any books, investigate beer from a spatial perspective - to discover the "what's here" and "why here?" of beer. Even the beer atlas that is presently on the market (World Atlas of Beer, 2012) fails to capture beer stories from around the world by way of its maps, photographs, and text.

Pilot Study: At present, we have conducted a pilot project for our interviews and have successfully interviewed and collected oral histories and modern day folklore on the beers and beer cultures of Ireland, Belgium and the Netherlands. Through our pilot study, we have become efficient at interviewing brewers, patrons, and bartenders. Our interviews have already been approved by the Institutional Review Board (IRB) on our campus, and we are both IRB certified. Furthermore, at this time, we have contacts on the ground to assist us in identifying the best potential locations and/or people for our stories.

Funding Request: This proposal requests funding to help cover the costs of traveling to countries for story collection, data for infographics and photography. Specifically, we are seeking $20,468 from the EC grant. These funds will be used to pay for travel to Asia, South America and the Western US. We are redirecting our book advance from National Geographic ($30,000) and our discretionary travel funds at our university ($5,000) to cover travel costs to Northern Europe, Southern Europe, Oceania, Eastern US and Canada.

19.2 Budget Narrative

To conduct research and data collection for the National Geographic World Atlas of Beer, we are proposing to take trips to several locations to collect stories and photos. We have divided travel into several 2 week trips in which we will visit places with major beer cultures. Specifically, we are requesting $20,468 from the EC grant program for trips for Drs. Patterson and Hoalst Pullen to travel to: Asia, South America and the Western US.

We have requested that our book advance of $30,000 be redirected to help cover travel to other regions. In addition, we have $5,000 in discretionary funds from our university that we will also use toward travel. These funds would be used for trips to Northern Europe, Southern Europe, Oceania, Canada and the eastern US.

Thus we would be contributing $35,000 toward travel and are requesting $20,468 from the EC grants program. Specifically, the itemized cost breakdown is as follows.

Item	E Grant	Additional Funds
Airfare	$8,948	$15,116
Lodging	$5,900	$9,967
Food	$3,600	$6,080
Visas	$770	$1,300
Rental car/Gas	$750	$1690
Ground Transportation	$500	$844
Total	**$20,468**	**$34,997**

19.2.1 Geographic Locations of Fieldwork

South America: Argentina (Buenos Aires, Bariloche, Córdoba), Chile (Santiago, Valparaíso), Brazil (Rio de Janeiro).

Asia: China (Beijing, Shanghai, Hong Hong), Japan (Tokyo, Yokohama).

North America: Western US (San Diego, LA, San Francisco, Portland).

Reflection

The authors' project was funded and culminated in the fall 2017 publication of the National Geographic Atlas of Beer *[*https://shop.nationalgeographic.com/products/national-geographic-atlas-of-beer*]. The National Geographic Society provided technical (photography lessons), and editorial support. In addition to the Explorer grant and atlas advance monies, Mark and Nancy also were required to write internal proposals at their home university to obtain support for the project and reduce* *teaching responsibilities. As such, the reality is this substantial research project required identifying numerous and diverse revenue and non-revenue streams to support research.*

Chapter 20
Intramural Grants

Gregory D. Bierly and Jay D. Gatrell

Internal grants are unique and the specific proposal requirements vary from institution to institution—as do the total monies available. However, the audience for internal grant proposals is often very similar. In most cases, grant proposals are reviewed by colleagues and administrators from various disciplines and these reviewers are seldom "experts" in the field. Insofar as the audience is composed of well-read generalists, it is essential that internal grant proposals be prepared with this in mind. The success or failure of this proposal was heavily dependent upon the ability to convey the unique nature of the spatial approach and how the geographical approach may yield decidedly different results relative to the earlier work of Knack. The following model proposal was submitted to the Indiana State University Research Committee (URC) and the grant was awarded. However, the budget was altered based on the availability of funds and URC's assessment of current programmatic resources.

The politics of weather, or more accurately the role weather plays in politics, has long been informed by a collective conventional wisdom that suggests inclement election day weather (i.e. rain, humidity or temperature) inhibits voter participation (Gruenwald 1994; Knack 1994). While this supposition has been taken for granted (e.g. Morton 1991; Weisberg and Grofman 1981), the weather hypothesis has not been formally or directly tested. The sole academic test of the conventional wisdom indirectly tests the weather hypothesis by posting whether 'rain helps Republicans' (Knack 1994). Based upon National Election Studies survey data for the 1984, 1986, and 1986 general elections, the Knack study concludes inclement weather does not appreciably inhibit voting. Yet, Knack does concede that the voter participation of NES respondents with low 'civic duty' does decline with poor weather.

In contrast to Knack's model of individual decision-making across a heterogeneous set of ballots from around the nation, this project proposes to test the statistical relationship between observed voter turnout and measures of election day weather conditions (hourly precipitation rates, total rainfall, statistical temperature deviation, and the CLO comfort index) for all Kentucky counties over 9 general-primary election cycles between (1999–2000). This study is significant for several reasons. First,

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the proposed research will directly test the weather hypothesis using ordinary least squares regression. Second, the project will examine both primary and general elections. Third, the research will utilize a more sophisticated comfort index to account for relative 'weather' than used in the earlier Knack. Fourth, the proposed research will examine election turnout during multiple election cycles. Fifth, the proposed research will examine statewide turnout for elections with common national and statewide 'upper' ballots. For all of the above reasons, the proposed research will make a significant and direct contribution to political science and geography (human & physical) literatures.

20.1 The Politics of Weather: Voter Turnout in Kentucky

In contrast to Knack's model of individual decision-making across a heterogeneous set of ballots from around the nation, this project proposes to test the statistical relationship between observed voter turnout and measures of election day weather conditions (hourly precipitation rates, total rainfall, statistical temperature deviation, and the CLO comfort index) for all Kentucky counties over 9 general-primary election cycles between (1999–2000). This study is significant for several reasons. First, the proposed research will directly test the weather hypothesis using ordinary least squares regression. Second, the project will examine both primary and general elections. Third, the research will utilize a more sophisticated comfort index to account for relative 'weather' than used in the earlier Knack. Fourth, the proposed research will examine election turnout during multiple election cycles. Fifth, the proposed research will examine statewide turnout for elections with common national and statewide 'upper' ballots. For all of the above reasons, the proposed research will make a significant and direct contribution to political science and geography (human & physical) literatures.

The following proposal examines: (1) the specific and general objective of the proposed pilot study; (2) reviews the theoretical landscape surrounding voter participation and weather-related behavior modification; (3) defines the study area; (4) identifies key data resources; (5) presents a model to test the proposed research question; and (6) reviews anticipated results. In addition to the proposal, a proposed budget is attached.

20.1.1 Objective

The proposed research is exploratory in nature. The goal of the research is threefold. First, the research will preliminarily establish if a statistical relationship can be observed between the dependent variable (turnout) and independent variables (weather conditions). If this pilot research project demonstrates the existence of a statistical relationship, the pilot project will be used to assess the feasibility of creating a nationwide database for both primary and general elections. Third, the research will be used as a foundational component of a larger national project to be proposed and submitted to relevant grant competitions.

20.1.2 Literature

The University of Michigan's National Election Studies (NES) data set performs pre- and post-election surveys of individual voting behavior and participation (i.e., turnout) (NES 2000).[1] Over the past several election cycles, the NES has specifically asked non-voting survey respondents why they chose not to vote and one of the 'official' responses includes 'bad weather' (NES 2000). No doubt the decision to include such a response is rooted in the many studies that document the role weather plays in promoting or inhibiting social interaction, decision-making processes and general behavior modification (for example, Katz 1993; Rotten and Cohn 2000; Cohn 1993).

Yet, no single empirical study documents if weather inhibits or promotes voter turnout. Instead, anecdotal evidence is often cited to the difference 'weather makes' (e.g. Morton 1991; Weisberg and Grofman 1981; Gruenwald 1994; Sluis 2000). Yet, even the anecdotal evidence is unclear. Whereas low turnout in Durango, CO 2000 primary election was attributed to 'bad weather' (see Sluis 2000), other anecdotes suggest weather's influence on voter turnout is highly contextual. For example, the relative importance of a single ballot issue, or interest in a specific candidate, may nullify the influence of weather completely. For example, cold 'dreary weather' apparently did not prevent voter turnout in Southfield, MI in the recent general election (Allpolitics 2000). Still other researchers, such as Dr. Curtis Gans of the Committee on the American Electorate, assert that only extreme weather deters turnout (Business Wire 2000). Given the various and sometimes-contradictory assertions associated with the weather hypothesis, the impact of inclement conditions, if any, on voter participation should be empirically tested.

While the conventional wisdom has not been directly tested, Knack's (1994) study used NES pre- and post-election survey data to examine the specific question 'does weather differentially influence individual voting behavior by party affiliation?' Despite empirical evidence that suggested weather does influence the decision making behavior of specific sub-populations of the NES sample, Knack's rejects the general 'weather hypothesis' and reiterates the basic findings of an earlier study (see Knack 1992) to conclude that overall 'civic duty' possessed by individuals and degree of social connectedness are key determinants of voter participation. In general, the work of Knack confirms the existing literature on participation rates, in

[1]The reliance upon self-reported data is somewhat suspect as many voters 'remember' voting, but do not necessarily 'remember' not voting (see Abelson 1987). As such, an analysis based upon empirically observed turnout data at a reasonable scale (i.e., the county or precinct) is important. On a related note, party identification data is also self-reported and does not represent official declared party affiliation.

general (Shields and Goidel 2000; Fain and Dworkin 1993), and party implications of turnout among peripheral voters, specifically (DeNardo 1980).[2] While the Knack study represents a significant effort to understand the role weather plays in politics, the study was based on self-reported party affiliation and participation based on pre- and post-election surveys—not observed voter turnout. Moreover, we believe the combination of the proposed Std variable and the Clo index (to be discussed later) represent an important advance in attempts to assess ‘bad weather’—relative weather conditions—within the context of the weather hypothesis. Consequently, an empirical study should be performed to more fully understand the impact of weather on observed turnout.

20.1.3 Study Area

The study area will be the entire state of Kentucky by county. Kentucky has been chosen because the Secretary of State has an established, reliable and historical data infrastructure for both primary and general elections by county. Additionally, Kentucky is increasingly referred to as a ‘bellwether’ state in terms of national politics. Kentucky has also been chosen because of the relatively large number of total county units (n = 120).

20.1.4 The Data

Data will be obtained from two primary resources: (1) the Midwest Regional Climate Center and (2) the Kentucky Secretary of State’s Election Office. Data will be collected for all statewide primary and general elections between 1990 and 2000 (n = 18). The following variables will be obtained:

(a) Hourly Rainfall Rates.
(b) Overall Rain Fall.
(c) Total Turnout [overall, republican, democrat, other].
(d) Total Registration [overall, republican, democrat, other].
(e) Mean Temperature.
(f) Minimum Temperature.
(g) Maximum Temperature.

In addition to obtained data, the following metrics will be calculated:

[2] DeNardo (1980) clearly established (and has seen re-affirmed his earlier findings) that the disparate participation rates between Republican and Democratic voters could be attributed to the lower turnout rates of ‘peripheral voters’ (Nagel and McNulty 2000; Radcliff 1994). Peripheral voters are defined as those voters with relatively ‘lower levels of civic duty’, limited experience voting and/or limited expectations within their home communities to vote. In most cases, the model proposed by DeNardo (1980, 1996) demonstrates suggests lower turnout rates among peripheral voters hurts ‘democrats’ because a higher proportion of registered democrats tend to be ‘peripheral voters’.

1. **Temperature Departures**: Our analysis features two measures of the thermal environment's potential influence on voter behavior. As November is a transitional season in the westerlies circulation across the United States (Harman 1991; Bierly and Harrington 1995), sudden shifts in temperature and precipitation are expected with increased activity of upper level disturbances. Because of the heightened variability that characterizes transition season weather, we will first use maximum and minimum daily temperatures in context with a regionalized climatological sample to calculate statistical temperature departures. By determining the statistical deviation from mean conditions, we will be better poised to discuss regional trends within the data and also to transfer the approach to the larger national study that will follow, where regional acclimatization to temperature patterns may become significant. Such an approach is also warranted over simple raw temperature measures because of the likelihood of passage of a cyclonic system on election day, a synoptic environment where temperatures may vary widely over small distances.
2. **Clo Weather Comfort Index**: The Clo Weather Comfort Index, a measure of thermal stress (Yan and Oliver 1996). The clo unit specifically calculates the amount of clothing resistance required to maintain thermal equilibrium between the body and the environment (Gagge et al. 1941). Our use of the Clo index will supplement the temperature departure data by providing a generalized, physiology-based measure of human comfort. This index is preferable to more conventional variables, such as wind-chill, because of its versatility during different weather types and its utility in non-extreme weather conditions.
3. **Pooling Metric**: To statistically account for the pooling of data, a series will be created to assign values 1–18 for specific election events. This maneuver will result in a substantial increase on the overall total cases observed ($n = 3240$).

20.1.5 The Model

The statistical relationship, if any, between turnout and weather-related variables will be tested using ordinary least squares (OLS) regression. The county data will be pooled according specific election events. The following OLS model will be used:

$$T = \alpha + \beta HR + \beta OR + \beta CLO + \beta Std + \beta P \qquad (1)$$

Where.

T is percent turnout.

HR is hourly rainfall.

OR is overall rainfall.

CLO is the obtained CLO index.

Std is the statistical temperature deviation.

P is a series to account for separate election events.

Based on the results of this model, the obtained r-square will be used to determine the statistical relationship (if any) between weather and turnout. Additionally, the obtained 'b' coefficients will be used to tease out the relative importance and specific statistical impact of variables. In addition, obtained coefficients will be used to inform future research—specifically with respect to identifying appropriate facets of the weather hypothesis to pursue as part of a national study.

20.1.6 Anticipated Results

Based on the earlier work of Knack (1994) and building on the conventional wisdom, we anticipate that local weather conditions statistically explain voter participation. We expect the model will demonstrate that the relationship conforms—at-least partially—to the conventional wisdom. That is, bad weather results in lower turnout.

Unlike Knack's decision to dismiss the empirical evidence that partially confirms the weather hypothesis, we believe our model will demonstrate that weather is a statistically significant determinant of voter participation. Yet, from our perspective the inherent value of the proposed exploratory analysis lies in the model's potential to articulate future research questions pertaining to a potential national project. For example, what are specific roles of individual variables in explaining voter turnout? How do the CLO and Std variables perform individually and together in the proposed model? Finally, the model may demonstrate that the dynamics of inclement weather are cumulative with respect to the combined influence of stress and 'rainfall'—confirming suggestions that only extreme events deter turnout.

In conclusion, we earnestly believe it is necessary to test the weather hypothesis as it informs much of contemporary 'pop cultures' understanding of voter participation. Consequently, the use of empirically observed turnout and weather data to test the weather hypothesis has clear and relatively immediate real world application. In addition to the potential to develop numerous real world applications for the data set and model, the proposed project has the potential to demonstrate the importance of identifying and cultivating research initiatives sited at the boundaries of human and physical geographies.

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Reflection

We believe the relative success of this grant proposal was heavily dependent upon the general layperson's familiarity with the "weather-hypothesis' and the proposal's ability to convey the importance of the question—not just the hypothesis' novelty. Ultimately, the proposed project resulted in several publications and continued to evolve from this initial research design. However, it was the receipt of this grant that made subsequent research possible as it enabled us to have the seed monies necessary to continue to pursue the project. For this reason, internal grants—while not necessarily "major" grants—play a crucial role in the development of a scholar's research agenda. More importantly, internal grants provide researchers with the seed monies to develop new research interests. That is to say, internal grant programs can be used to visit libraries, perform preliminary field work to determine the feasibility *of a larger project, or to purchase initial pilot data sets. In the case of this research, the project enabled two colleagues to collaborate on an entirely new project.*

To learn more about internal grant programs, several examples, accessed on May 11, 2020, are below:

Appalachian State University
https://www.orsp.appstate.edu/funding/internal
The University of Georgia
https://research.uga.edu/iga/grants/
The University of Iowa
https://dsp.research.uiowa.edu/ui-internal-funding
The University of Wisconsin-Eau Claire
https://www.uwec.edu/orsp/grants/internal-grant-programs/