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INTRODUCTION: A SCIENTIFIC APPROACH TO GEOGRAPHY AND ENVIRONMENTAL STUDIES

LEARNING OBJECTIVES

- What is a scientific approach to geography and environmental studies?
- How is science both an individual and a social activity?
- What are several metaphysical beliefs characteristically held by scientists?
- What are four goals of scientific activity?
- What are the relationships of natural science, social science, and the humanities to the disciplines of geography and environmental studies, currently and throughout their history?

John was pursuing his Master's degree in a department of geography and environmental studies.[1] He was interested in geographical and environmental factors that contribute to causing social ills, such as violent crime, in inner cities. Having read some of the literature on this subject, John had discovered the concepts of "associative" and "dissociative" institutions. The first are thought to create community identity and social cohesion – churches might be an example. The second are thought to destroy community identity and social cohesion – crack houses might be an example. John theorized that "social decay in the inner city is caused by a prevalence of dissociative, rather than associative, institutions." To test his theory, John looked at the city of Milwaukee (it was convenient for him). He got data from the police department on the number of suicides and homicides that had occurred in the previous ten years in Milwaukee. He also looked in the phone book Yellow

[1] While John's story is inspired by our real experiences over the years, he is fictitious and does not refer to any single real person.

Pages for the Milwaukee Metropolitan Area, which includes suburbs and peripheral areas as well as the urban core of Milwaukee. From the phone book, John counted the number of liquor stores, noting their addresses. He then organized his data into census tract units; census tracts were created by the U.S. Census Bureau, and include regions in cities at about the size of neighborhoods where about 3,000 to 8,000 people reside. Each census tract was thus assigned two numbers, the number of "wrongful deaths" and the number of liquor stores. John calculated a Pearson correlation coefficient on these two variables, a statistical index that identifies linear patterns of relationships between two metric-level variables. He found a positive correlation of .31, which suggests that census tracts with more liquor stores in his data set were somewhat more likely to have more wrongful deaths, at least within the previous ten years. John concluded that he had proven that dissociative institutions cause social decay in inner cities, and he recommended getting rid of liquor stores in inner-city areas.

Should we accept John's conclusions and agree with his recommendation? Probably not. There are numerous problems with the way his study was conceived, conducted, and interpreted. For instance, the Yellow Pages lists most businesses but not all. Why only look at liquor stores and not bars? In Wisconsin (Milwaukee's state), alcohol is often purchased in grocery stores and small markets. Shouldn't John have looked at other potentially dissociative institutions, like adult clubs, gambling parlors, or criminal organizations? His theory is about the presence of dissociative institutions relative to associative institutions, but he didn't even look at associative institutions. What about other indicators of social ills besides murder and suicide, like assault? Are there other factors that we might expect to be related to the incidence of murder and suicide that vary considerably across census tracts in Milwaukee? Potential candidates are socioeconomic status (SES), age, residential density and housing style, housing tenure (ownership status), ethnic makeup, citizenship, and immigration history. John used census tracts as the unit of analysis because of convenience, but are census tracts the proper unit of analysis for the concepts that interested him? And why Milwaukee in the first place? Are there any special characteristics of Milwaukee that makes it less representative of cities, including inner cities?

Our story about John's research and its faults and limitations provides a concrete introduction to the topic of this book: **scientific research methods**. Scientific research methods (or methodologies) are the suite of techniques and procedures for empirical scientific investigation, along with the logic and conceptual foundations that tie scientific investigations together, and connect them with substantive theory. The topic of research methods clearly touches on many issues important to researchers in all natural- and social-science disciplines, including geography and environmental studies. Research methods concern which problem domains are studied; which specific ideas within the domain are investigated; what entities are studied; what is observed or measured about the entities; how they are observed; where, when, and how many observations are collected; how the observations are analyzed (including graphing, mapping, statistical analysis, or simple tallying); what patterns are in the observations and whether the patterns can be generalized to some larger population of entities, times, or places; what explains the patterns in the observations; and even what the observations say, if anything, about solving practical problems. This is an impressive list. What's more, all of these issues are potentially relevant not only to how we carry out our own research but to how we interpret research carried out by others. The study of research methods is thus central to deciding what conclusions we can draw about the meaning of research, the contexts in which these conclusions hold, and the degree of confidence we have in these conclusions. In other words, you cannot competently carry out or critique scientific research without considerable knowledge of methods.

OVERVIEW OF THE LOGIC AND PHILOSOPHY OF SCIENCE

Let's consider what makes an activity scientific research. What is a **scientific approach**? There is no precise answer to this question. Like art or cheeseburgers (does it count when the "meat" is soy protein?), science is a somewhat vague concept that includes clear central examples but also many examples that most people would agree are more-or-less scientific, rather than clearly and definitely examples of science or not. That said, we can start with this simple and fairly inclusive definition: *Science is a personal and social human endeavor in which ideas and empirical evidence are logically applied to create and evaluate knowledge about reality*. Let's consider a few components of this definition. Science is a personal and social human endeavor because it is something humans do, as individuals and as social groups. Individual scientists learn from other scientists, work with colleagues and assistants, and act within various cultural and institutional contexts. **Empirical**[2] evidence is derived from systematic observation of the world via the senses, often aided by technology. The systematic nature of scientific empiricism crucially distinguishes it from the observations we all make informally every day. Because science aims for stable and publicly consensual truth, scientific empiricism strives to be repeatable, accumulable, and publicly observable. A necessary reliance on systematic empirical evaluation of the world is, to a large extent, the hallmark of scientific activity, as opposed to some other human enterprises that strive to understand the world (more on this below). It helps differentiate science from intuition, authority, anecdote, profitability, physical or political power, spiritual transcendence, the need for happy endings, and other approaches and motivations. Ideally, ideas and evidence are applied according to certain formal and informal logical principles in science. It is not possible to give a

[2] By the term "empiricism," we are not referring to a strong version of the philosophical position that holds that all knowledge is ultimately derived from experience after birth, but only a weak version that appreciates the ultimate value of observation as part of how we can learn about reality.

finite and complete list of these principles, but they certainly include such things as: (1) contradictions must be avoided; (2) our confidence in a phenomenon increases as our observations of it increase; and (3) past regularities will probably recur in the future.

The relationship in science between ideas and evidence deserves further comment. Ideas are used to design **studies** – units of focused observation or data collection – and to interpret their results. Scientists explain patterns in their empirical observations by reference to ideas about reality. But scientists also understand that any empirical observations can potentially be explained not just by ideas about reality but also by ideas about the way the observations were obtained or interpreted. That is, scientists consider that a pattern of observations may reflect such empirical factors as biased instruments, idiosyncratic testing environments, unusual samples, and so on – not just the phenomenon being studied. In our introductory example, John failed to think scientifically when he interpret his data only to reflect truth about the phenomena of dissociative institutions, community identity, and social cohesion, and did not consider limitations in his approach to conceptualizing and measuring these phenomena.

Notice that our definition does not restrict science to just the physical or biological world. Science is also concerned with the world of human activity, artifact, and institution. There are **natural** (biophysical) **sciences** and **social** (human) **sciences**. This is especially important to recognize in disciplines as broad as geography and environmental studies, which both involve both biophysical and human sciences; as we discuss below, they also involve humanities, arts, engineering, and craft as well. As the Preface in this and the previous edition explain, this text deals with scientific methodology for all of geography and environmental studies, including the biophysical and human domains. Therefore, we always use the generic term "science" inclusively in this text to mean both natural *and* social sciences.

Our definition also avoids claiming that science restricts itself to one specific approach to logic. The history of debates about the proper way to do science includes numerous claims that, for instance, "real" science applies hypothetico-deductive reasoning, in which prior hypotheses are used to deduce observational consequences that can then be compared to empirical evidence. Others have claimed that science is inductive in nature, relying on initial observations to generate hypotheses about reality.[3] But scientists use both **deductive** and **inductive** approaches;[4] we find it misleading to claim that one is generally more common or appropriate than the other. In fact, while our definition of science highlights logical thinking, it makes no claim

[3] In philosophical debates, idea-first vs. observation-first approaches to science were championed, respectively, by Rationalists (Plato, Descartes) and Empiricists (Locke, Hume).

[4] Although deduction is sometimes defined as deriving specific truth from general truth, while induction derives general truth from specific truth, the distinction actually refers to the certitude of inferences one makes with each type of logic – deduction definitely leads to true conclusions, while induction only probably leads to true conclusions.

that scientists think exclusively in a logical manner. Like artists and other nonscientists, scientists gain insights and create new ideas in any number of different ways that would not be considered strictly logical, including intuition, fantasy, inspiration, and the like (we discuss these further in Chapter 2 when we discuss generating research ideas). Clearly, scientists often come to understand a phenomenon through a process of insight, an inferential process that seems to leap from observations to explanatory conclusions with no conscious systematic reasoning plan. This form of reasoning is sometimes called **abductive**.

Finally, while our definition points out that science includes both an idea part and an empirical part, it does not claim that every individual scientist or laboratory must engage in both parts equally. While a science such as physics has become so specialized that some physicists describe themselves as "theoretical" and others as "empirical," all physicists recognize that the full activity of physics includes both theory and empirical observation. For example, Albert Einstein's theories of relativity in the early twentieth century made sense (at least to some people) logically and mathematically, but achieved much more acceptance over the ensuing decades as other scientists were able to generate empirical evidence for them, much of it after Einstein's death. Scientists believe that empirical observations are produced in order to evaluate and generate ideas about reality, and they believe that the ultimate truth of ideas about reality needs to be empirically evaluated by someone, eventually. Looked at another way, ideas about reality suggest studies to conduct and ways to explain the observations that result from those studies. The "theoretical" scientist may not collect and analyze empirical observations, but he or she believes it is important that someone does. In other words, as we stated above, the dual components of science describe a *social* activity, not just an individual enterprise.

Characteristic Metaphysical Beliefs of Scientists

In addition to our short definition of science, we believe it is useful to identify a set of characteristic metaphysical beliefs or intellectual preferences held by most scientists. As we said above, it is probably impossible for anyone to give a strict definition of the scientific enterprise that everyone would agree actually succeeds at including all instances of scientific activity (past, present, future) while excluding all activities that are not scientific. Delimiting the meaning of a concept like science depends on the nature of human conceptualization and social relations (including financial and political relations), not just the actual reality to which the concept refers. Furthermore, the human activity called science has evolved over the centuries (if not longer) in a somewhat haphazard way – it was not defined and implemented by an overarching "creator of science." Thus, over time fairly different activities have been considered better or worse examples of scientific activity. However, we believe that characteristic beliefs can be identified that help us understand what is more scientific than not, and when someone probably is or is not doing science. These are metaphysical because they concern beliefs about the ultimate nature of reality (**ontology**) and how scientists can know about it (**epistemology**). We think these beliefs are held by a majority of practicing scientists but don't consider them essential to the definition of science. For example, we would not claim that a person who does not believe in the existence of a world independent of sentient minds could not be doing scientific research, but we do believe that such a scientist is rare. We also call these beliefs "preferences" because they are just that – personal or cultural preferences or intuitions. They have not been proven, nor are they likely to be provable, to be the best possible avenues to truth; that is, they are elements of faith!

1. *Realist philosophy*. Nearly all scientists at least implicitly accept a philosophy of **realism**. They believe the universe actually exists, independently of **sentient** (thinking, feeling) beings, as matter and energy patterned in space and time. The matter and energy coheres into meaningful pieces (entities and events) but is also organized into meaningful pieces by sentient beings, like us humans.
2. *Only continuously connected and forward causality*. This might be thought of as an extension of the belief in realism, but we find it valuable to note it separately. Scientists tend to insist that causes and effects are continuously connected in space and time, and only in a temporally forward direction. That is, cause A can only bring about effect B if A's influence can move forward "densely" in space and time; the space and time between A and B is continuously filled with causal connections that transmit the cause to the effect. Put another way, the patterned matter and energy that is the physical instantiation of causal influence cannot get from A to B without traveling continuously between the space and time separating the two. In Chapter 2 we discuss philosophical and scientific ideas about causality in greater detail, including issues surrounding its forward and continuously connected nature.
3. *Simplicity*. Scientists prefer the simplest explanation that is adequate. This is often called the principle of **parsimony**;[5] it is also largely captured by the notion that scientists like ideas that are "elegant." Because of their preference for simplicity, scientists prefer general-purpose truths to idiosyncratic truths. We return to this issue in Chapter 8 in our discussion of "nomothetic" (general, law-like) vs. "idiographic" (specific, idiosyncratic) approaches, but we note here that extremely idiographic approaches are essentially nonscientific, however true or valuable they may be. It must be stressed that parsimony still requires explanations to be adequate, in terms of fitting with observations and other ideas that are already accepted. That is, interpreting the principle of parsimony as a blind requirement to pick the simplest idea in all cases is quite a mistaken interpretation. We also note that while relative simplicity is often

[5] The principle of parsimony is often referred to by the charming name "Occam's Razor." William of Ockham was a medieval English philosopher and Franciscan monk who favored minimalism in life, a view expressed in his famous dictum that "plurality should not be posited without necessity."

fairly obvious (a model with three parameters is simpler than one with five parameters), in other cases it may be a deep intellectual question as to what constitutes greater simplicity.

4. *Skepticism*. Although scientists are searching for truth, they doubt they will find it in absolute form. Theories, for instance, are considered provisional even when widely and repeatedly supported by empirical evidence. Partially because of their skepticism, scientists dislike ideas that cannot potentially be falsified by evidence or inconsistency with other ideas.[6] Also in line with their skepticism, scientists typically entertain *chance* as a first explanation for patterns in their observations; chance must be discarded first before more substantive explanations warrant attention. This logic of falsification and the entertainment of chance are fundamental to the statistical analysis of data, to which we return in Chapter 10.
5. *Quantitative thinking*. Scientists apply observations and logical thought in order to achieve understanding. To this end, they like precision, of both ideas and observations (precision and accuracy are defined and compared in Chapter 2). In order to increase the precision of ideas and observations, scientists often turn to mathematics and computation. When feasible, they often express theories as mathematical equations, for instance. They also attempt to carry out observations of the world very carefully, avoiding distorting effects as much as possible. One way they satisfy these preferences is to develop new technologies of observation (procedures, tools) that can extend the ability of the senses to observe the world. Such new technologies have historically extended the reach of scientific observation and hence advanced scientific ideas; they include the telescope, the computer, the chromatograph, and the methods of psychophysics (by which people's perceptual responses can be quantified). We note, however, that while the use of mathematics and technology is desirable to scientists, it is not required in order for some activity to be rightly classified as scientific. Less developed disciplines or those whose problem domains are more complex may still be scientific even if they rely on relatively little sophisticated mathematics and technology. In fact, we think that some scientific disciplines, especially in the social sciences, sometimes use quantitative methods excessively, without the underlying conceptual and theoretical understanding of their subject matter that would be required to make the use of such methods appropriate. This may sometimes be motivated by social and political concerns, such as the desire to be seen as deserving of research funding.

[6] The twentieth-century philosopher Karl Popper offered extensive arguments for why we need to rely on falsifying wrong ideas and not on confirming true ones. His work is part of a larger tradition of philosophical debate about scientific epistemology. As a point of history, however, we do not believe scientists have ever or will ever stick only to falsification or disconfirmation as an epistemological strategy, nor do we believe they need to. Nonetheless, whatever logical value falsification has over confirmation, we believe scientists' preference for skepticism leads them to value disproving somewhat more than proving.

Nonscientific Ways of Knowing

Taken together, our definition of science and list of characteristic beliefs of scientists can be contrasted with various nonscientific ways of knowing. At most liberal arts colleges or universities, the major nonscientific approaches to knowing are applied in the **humanities**, traditionally including history, philosophy, languages and literature, art history, and so on. Below we discuss the fact that much geographic and environmental research is carried out in the tradition of the humanities. The humanities are like science in their logical application of ideas in order to understand reality, specifically the reality of human existence and activity, but for the most part do not employ systematic empirical observation of reality in the same way as science does. Instead, they typically interpret the semantics of texts and other symbolic artifacts of human thought, activity, and culture, and they tend not to systematically code and count such material the way we discuss in Chapter 6. The humanities are thus rarely mathematical in their work.[7] Perhaps scholarship in the humanities is even more distinctive because of a difference in the type of understanding for which it strives. While scientists want general truth, as reflected in their faith in simplicity as a guiding principle, scholars of the humanities usually want specific truth about people or societies in particular places and times. The humanities have no general preference for simple or elegant explanations and may even promote the value of complicating our understanding as a goal of scholarship. Finally, humanities scholars are often concerned with exploring ideas about human values and morality that may not be studied very effectively with only scientific approaches (see below). We return to these stylistic differences in Chapter 8.

A variety of other approaches to knowing are nonscientific because they do not pursue general knowledge of reality, do not apply systematic empiricism, and/or strongly oppose one or more of the characteristic beliefs of scientists. Artists (in the visual arts, music, dance) arguably do aim for general knowledge but are not systematically empirical in their methods, nor are they generally likely to endorse many of the characteristic metaphysical beliefs of scientists. Various crafts and vocations do not have general knowledge as their aim; they are typically about doing something or producing tangible products, rather than knowing something. Like the arts, a variety of approaches to knowing that might be called *spiritual* (religion, mysticism) do not typically employ systematic empiricism, nor do they embrace the characteristic beliefs of scientists. In particular, they tend to take explicit issue with the realist philosophy and skepticism of most scientists. Finally, practitioners of the "paranormal" (astrology, tarot, extra-sensory perception) often eschew systematic empirical evidence, but even when they welcome it, they tend to lack skeptical attitudes about their beliefs. That said, genuine scientific

[7] The huge exception is mathematics itself, which in traditional form is quantitative logic rather than science. Mathematics is a common language of science but is itself primarily a branch of the philosophy of logic (some recent approaches in mathematics are empirical, however).

research has been carried out on psychic phenomena. Evaluations of the meaning of this research are mixed, and skepticism about it is quite strong, perhaps mostly because many paranormal ideas so clearly violate principles of forward connected causality.

However, these claims about the nature of nonscientific ways of knowing must be appreciated in the context of certain limits we see to scientific understanding. First is that our description of science is an ideal that is rarely or never completely reached in practice. Scientists are human beings acting within social, institutional, and cultural contexts. They have imperfect personalities and are sometimes motivated by greed, egotism, or prejudice. Although scientists as a group endorse skepticism, individual scientists sometimes fail to apply adequate skepticism to their own ideas. But here again is where the social nature of science is critical. Social mechanisms, such as peer review of scientific reports (see Chapter 3), serve to blunt the distorting effects of individual human qualities on scientific research.

However, we see another limit to scientific understanding as more fundamental. That is simply that one can accept the value of a scientific approach without believing science is the *only* valid and useful way of knowing, or the best way of answering any question (such an extreme view is called **scientism**). An approach to knowing that is nonscientific is not necessarily wrong or useless or irrelevant. Many of the most important questions of interest to humans cannot or should not be answered scientifically, though they may sometimes be informed by scientific results. What is the meaning of human existence? Why is it wrong to hurt people and right to help them? What is beautiful to me? Is there a God? What is the best form of government? Why should I get out of bed in the morning? Do I want chocolate or vanilla? We believe some overzealous promoters of a scientific approach might occasionally fail to stress this adequately. We also believe some critics of scientific approaches, especially when applied to the study of humans, fail to appreciate that reasonable promoters of a scientific approach recognize that it has limits. We think of science as an interesting and useful way to grasp some truth about reality, including human reality, and we recognize that we pursue it in part because we personally enjoy scientific thinking. We do not, however, consider it the royal road to all truth and enlightenment.

Goals of Science

According to our definition, the purpose of science is "to create and evaluate knowledge about reality." This purpose can be elaborated in terms of four goals toward which different sciences and scientists strive, to various degrees. The goals are intellectually progressive in that goals further down the list presuppose some mastery of those above them. The goals have also largely been historically progressive in that scientific disciplines have tended to focus more on goals further down the list as their ideas and empirical techniques developed over time – as they matured. The four goals, ordered progressively, are:

1. **Description**. Whatever their domain of interest, scientists must distinguish and describe the basic phenomena (entities and events) within that domain. This is essentially the intellectual act of classification (categorization) common to all sentient creatures but often carried out especially systematically by scientists.
2. **Prediction**. Given that they know something of the content of their domain, scientists want to be able to predict phenomena about which they cannot learn simply by direct observation. These predictions are often about the future, but can also concern facts about phenomena from the present or the past that are not yet known. The most powerful tools for prediction available to scientists are statistical (probabilistic) inferences (both extrapolations and interpolations) from patterns of observations. These inferences take advantage of mathematical precision while exploiting the logical principle that observed regularities will probably hold in other situations not yet observed. The statistical logic of prediction is discussed further in Chapter 10.
3. **Explanation**. Once scientists can describe and then predict, they want to explain *why* some described and predicted pattern exists. This requires the explication of causal relations among entities and events. As we mentioned above, we discuss the logic and philosophy of causality more in Chapter 2; in Chapter 10, we consider the relation of causality to prediction in the context of data analysis; in Chapters 8 and 12, we discuss how research designs and techniques strengthen or weaken conclusions about causality in empirical studies.
4. **Control**. Finally, being able to describe, predict, and explain phenomena within their domain of interest, scientists (and those who fund scientists) typically want to apply this knowledge in order to control the phenomena – to bring about desired changes in the phenomena. Now that I understand erosion, can I prevent it? Now that I understand the development of a globalized economy, can I make sure it happens in a way that preserves economic fairness and environmental health?

A distinction is often made between basic and applied science research. Basic research focuses on understanding reality for its own sake; it is primarily an expression of human curiosity and the desire for intellectual mastery. In terms of the goals of science, basic research is very concerned with description, prediction, and explanation, but not much with control. In contrast, applied research focuses on control, in addition to the first three goals, for the purpose of making some object or procedure that will help meet specific practical needs or solve specific problems. Although engineering is often contrasted with science, because it is concerned more with making something work (or work better) than with understanding how something works, we can see that engineering might aptly be considered applied science. Similarly, much medical and educational research is applied science. Both basic and applied foci are prevalent in geographic and environmental research; below, we discuss the fact that advocacy for the health of the environment is widely seen as intrinsic to environmental studies as an academic field. Like the definition of science itself, however, the distinction between basic and applied science is somewhat vague and should not be overstressed. Many scientists work in both arenas to various degrees, and some move between the two so seamlessly in their work that the distinction becomes completely blurred. Optimally, there is interplay between basic and applied science in which the results and needs of each inform and motivate the other.

Before leaving our discussion of the goals of science, we need to mention a few caveats. The first is that the progressive quality of the goals is sometimes violated. While later goals presuppose earlier goals, this need only be partially true. For instance, explanation requires prediction but not anything like perfect prediction – it only has to be at least better than chance prediction. Or to take another instance, a certain amount of practical control can be exerted over phenomena without having a complete explanation for them; applied sciences like engineering often focus on successful control to the point of happily applying trial-and-error approaches that can lead to control without understanding. Our second caveat about the goals is that scientists may be able to predict phenomena at some scale of analysis but not at others that are smaller or larger, in spite of the fact they may feel they have a fairly complete explanation of the phenomenon. This is especially relevant to geography and environmental studies, concerned as they are with phenomena that exist and interact at a wide range of scales (the concept of scale is discussed in Chapter 2; problems of analysis related to scale are discussed in Chapter 10). Finally, an understanding of the ultimate limits of prediction was one of the great intellectual achievements of the twentieth century, when it was recognized that very small events have the power to radically alter the future (the "butterfly wing effect"). Thus, prediction in complex systems has ultimate limits because of the possibility the system will enter into "chaotic" states that cannot be predicted, even with complete prior knowledge. Our ability to predict weather will apparently always be limited in this way, for example. A related intellectual achievement of the twentieth century concerns ideas developed by quantum physicists concerning limits to the traditional notion of causality (more in Chapter 2).

HISTORY AND PHILOSOPHICAL SYSTEMS OF GEOGRAPHY AND ENVIRONMENTAL STUDIES: NATURAL SCIENCE, SOCIAL SCIENCE, AND HUMANITIES

The Discipline of Geography

We finish this chapter with short overviews of the history and philosophical systems of the disciplines of geography and environmental studies, and their relation to scientific and other approaches to knowing. Let us consider geography first. Traditionally one might define **geography** as *the study of the earth as the home of humanity* (the word's literal meaning is "earth writing"). A more modern and impressive sounding definition is that geography is *the study of the distribution of human and natural structures and processes over the* *earth's surface, and the role of space and place in understanding these human and natural structures and processes*. Like other disciplines, the domain, methods, and philosophical foundations of geography have changed over the centuries. In fact, geography has arguably gone through even more intellectual changes than other traditional disciplines, especially during the twentieth century. The result of all this is that geography is an extremely broad and heterogeneous discipline. Many books discuss these changes (see Bibliography at the end of the chapter), and we only touch upon them briefly here. We heartily recommend that students of geography read these books, and take a course on the history and philosophical systems of geography.

Geographical thought perhaps began when humans first recognized that different places have different characteristics ("areal differentiation"): the land surface varies, plants vary, people look and sound different, and so on. Surely this occurred long before writing first appeared. A more formal study of geography is often said to have begun in the ancient worlds of Africa, the Middle East, and the Far East, as part of astronomy and land surveying. From these early days, military activity was also a major impetus for the development of geographic knowledge of all kinds, including the measurement of the earth (**geodesy**), and the description of its human and natural variation; the military motivation for geography continues to this day. Trade was another early motivation for accumulating geographic knowledge. And the logs and diaries kept by travelers and explorers over the centuries provided a rich source of descriptions (occasionally accurate) of far away places. These early intellectual endeavors provided the seeds for the diverse approaches of modern geography. Thus, geographers from the beginning applied a mixture of linguistic, graphic (including cartographic), and mathematical approaches as part of their intellectual activity. Although the relative mixture of the three has shifted over the history of the discipline, all three are still applied today.

By the time geography emerged as a separate academic discipline in the nineteenth century, it had developed a venerable tradition of characterizing places and regions in terms of the totality of their natural (geomorphological, climatological, botanical, and so on) and human (cultural, economic, political, and so on) characteristics. This approach is called **regional geography**. Regional geography is still a part of the discipline, of course, and it is perhaps what most lay people think primarily constitutes the subject matter of geography; it is sometimes called the "National Geographic Approach." But during the nineteenth century, as academic specialization flowered, a different approach began within geography. This approach focused on particular topical areas or "systems" within the domain of geography, trying to describe and, even more, explain the workings of these systems wherever they found expression on the earth. Practitioners of **systematic geography** might therefore study rivers or urban structure anywhere they occur, or at least apply their knowledge of these systems anywhere they occur, even if they actually do research with data that come only from a specific place.

Many scholars who championed the systematic approach during the early twentieth century felt it made geography look more like other sciences, which were continuing to develop depth (perhaps at the expense of breadth). A penchant for applying mathematics and the application of a strict interpretation of positivist philosophy also characterized this quest for scientific respectability. It also contributed to the division in geography between those who specialized in the natural aspects of the earth and those who specialized in the human aspects. This all culminated in the so-called "quantitative revolution" of the mid-twentieth century. Statistics, geometry, calculus, computers, airplane and satellite remote sensing, and then (a little later) geographic information systems (GIS) were championed by particular scholars and departments as the "right" way to do geography, whether biophysical or human.

But almost as soon as a quantitative revolution was recognized, a counterrevolutionary response criticized what it saw as limits of quantitative approaches. To shorten a complicated story, these criticisms charged especially that **positivist** geographers oversimplified human experience and activity to the point of caricature. Instead of the clean and precise abstractions of scientific modeling and analysis, these critics called for approaches that recognized a messier, more subjective and solipsistic geographic reality. Furthermore, according to these critics, geographic reality was often the expression of unequal power relations among various stakeholders. These **post-positivist** critiques were served in a large variety of flavors during the later twentieth century, including phenomenology, Marxism, feminism, social theory, deconstructionism, and postmodernism. There are important differences among these positions, of course; the Bibliography at the end of the chapter provides some relevant readings.

The situation today is that of a pluralistic geography. Both regional and systematic approaches are evident. Linguistic, cartographic, and mathematical methods are applied in a bewildering array of combinations. This is especially true within **human geography**, where the study of human experience, activity, society, and culture is carried out from the perspectives of a plethora of disciplines, both social science and humanities. Across the breadth of geography, scholars study an enormous assortment of specific topics. Human geographers investigate transportation, migration, population, cultural distribution and diffusion, communication, economic activity (production, consumption, buying and selling), regional development, recreation and tourism, place perception and identification, spatial and environmental thought, urban structure and change, and resources and hazards. Researchers in **physical geography** investigate landform formation and change, soils and minerals, lakes and rivers, groundwater, climate and atmosphere, plant and animal distribution, glaciers and ice fields, and ocean and coastal processes. Yet other geographers specialize in the refinement and development of new geographic information methods and techniques that cut across the human/physical distinction, including GIS, database design, cartography and visualization, remote sensing, geostatistics, and spatial theory and analysis.

Given its very broad subject matter and pluralistic nature, geography in the early twenty-first century is remarkably **multidisciplinary** and **interdisciplinary**.[8] Physical geography overlaps with most of the physical and life sciences, especially the earth and environmental sciences (more below) of geology, biology, ecology, oceanography, hydrology, climatology, and atmospheric science. Human geography overlaps with most of the social and behavioral sciences, especially sociology, economics, anthropology, psychology, and political science. Alternatively, a great deal of human geography overlaps with the humanities and arts, especially history, literature, philosophy, film and visual arts, and cultural studies. Various technical specialties within geography overlap with engineering of several kinds, as well as mathematics and computer science. Last but not least, some areas of geography focus on the expression of "geographic craft" such as mapmaking and geographic information system design (more in Chapter 13). But it is still the case today that for many geographers, the real promise of the field is the integration of the natural, human, and technical aspects of "the study of the earth as the home of humanity."

The Discipline of Environmental Studies

Let us turn now to the history and systems of the discipline of environmental studies. Environmental studies – as a distinct academic field of study – is much newer than geography, having emerged formally only in the 1960s.[9] However, political, societal, and administrative concern over the impact of human activity on the environment goes back much further, with natural resource (forests, wildlife, fisheries) management and the conservation movement originating during the nineteenth century in the U.S.[10] and earlier in other parts of the world. And also unlike geography, the emergence of environmental studies as an academic field may have depended as much on certain public events and circumstances as on anything that happened within academia (although the 1960s also saw the emergence or rapid expansion of many new areas of study at universities, such as media studies, feminist studies, and modern history of science). These included human-caused (**anthropogenic**) environmental accidents and disasters, such as the oil spill off the coast of Santa Barbara in 1969; the burning of the Cuyahoga River in Cleveland, Ohio, also in 1969 (which was not the first time that flammable compounds in that river had caught fire); recognition of the increasing and increasingly evident pollution of air, land, and water by human activity;

[8] The distinction between multi- and inter-disciplinary being the degree to which a collection of multiple disciplines, each with its own concepts, vocabulary, and methods, is integrated into a single hybrid "interdiscipline."

[9] The first college degree program in environmental studies in the U.S. started in 1965 at Middlebury College in Vermont.

[10] The earliest U.S. university programs in forestry were those that started around 1900 at Cornell, Minnesota, and Yale.

and recognition of the continued destruction of wilderness habitats around the world and the concomitant loss of biodiversity. In response to events like these, public interest in and concern for human health and impacts on nature increased, and governments of developed countries started to enact legislation to regulate human actions that had consequences for the natural environment (for example, laws requiring an environmental impact assessment when modifying land cover and use). Particular popular books were also very influential in stimulating the genesis of environmental studies as a field; some prominent examples include *Walden* (1854) by Henry David Thoreau, *A Sand County Almanac* (1949) by Aldo Leopold, *Silent Spring* (1962) by Rachel Carson, and *The Population Bomb* (1968) by Paul Ehrlich (with Anne Ehrlich).

Thus, from its beginning, environmental studies has always been an academic field that embraces a philosophy of **advocacy**, in which research promotes particular values such as the ethical value of environmental conservation. According to advocacy in environmental studies, research should not only teach us how the world works, it should help us reduce our detrimental impacts on the environment (including plants and other animals) and increase our beneficial impacts. This, in turn, will benefit humankind itself. Alternatively, we should advocate for the benign treatment of the natural world because it has ethical rights and deserves moral treatment in and of itself. Either way, by promoting for or against particular changes to places, people, and institutions, advocacy can be understood as an expression of control, the fourth goal of research (that is, advocacy in this context is about trying to use science to influence society and the environment). The tradition of environmental advocacy is another of the main factors that distinguishes environmental studies as an academic field from geography.[11] We return to issues of ethics and the environment in Chapter 14.

We can define **environmental studies** simply as *the study of human–environment relations*. Of course, this is very reminiscent of geography's study of the earth as the home of humanity, and "human–environment relations" is the name of a popular subfield of geography. Both environmental studies and geography are interested in both the natural and the human (built or cultural) environment, but environmental studies especially emphasizes the natural biophysical environment. And both disciplines consider the relationship between humans and the environment to be mutual or reciprocal: human activity influences the environment and the environment influences human activity. But again, environmental studies differs a little in that it tends to focus more on the influence of human activity on the environment, especially the natural environment. This is consistent with its origin in concern over environmental degradation and the promotion of environmental advocacy.

[11] Of course, many individual geographers and some subfields within the discipline do incorporate advocacy for the natural environment or other causes (e.g., minority cultural groups, greenhouse gas reduction, urban mass transit) in their approach to research.

We noted above that geography is very multidisciplinary and interdisciplinary. Environmental studies may be even more pluralistic and integrative, and that is really saying something. It incorporates the biophysical sciences of the earth and environment, just as geography does. It incorporates the social and behavioral sciences, just as geography does. And it incorporates the humanities and the arts, just as geography does (environmental studies focuses relatively more than geography on the study of law, policy, and media and communication). Environmental studies is also concerned with technical and engineering issues, especially those surrounding the monitoring and restoration of the natural environment. In sum, environmental studies embodies exceptional disciplinary diversity as an academic field. In fact, given this great disciplinary diversity and the field's recent historical origin in response to real-world issues rather than just academic traditions, some researchers in environmental studies do not consider it to be a single, unitary discipline but a collection of people from various disciplines who hold a common worldview – that the environment, particularly the natural environment, is interesting, important, and worth protecting. Geography is disciplinarily diverse as well, as we have seen, but it does have over a century of history as a unitary academic discipline and much longer as a fundamental component of basic academic training.

Both geography and environmental studies have a common focus on earth and environmental topics. That and their mutual multidisciplinarity, especially across the biophysical and social sciences, provides our rationale for a textbook on research methods that integrates geography and environmental studies. Like geography, research in environmental studies looks at earth–sun relationships; biophysical earth systems (Chapter 5) and the cycling of energy and matter through those systems; resources (energy, water, mineral, fisheries, timber, and so on); environmental health and risk (including hazards and toxicology); waste and pollution; climate change; conservation and environmental preservation; population; food and agriculture; land use; urbanization; tourism and recreation; environmental ethics and spirituality; and sustainability. Like geography, environmental studies appreciates that understanding environmental issues must occur within the mutual contexts of space, place, and time.

We finish Chapter 1 with a final observation about environmental studies and science. Many people refer to the study of biophysical aspects of environments as **environmental science**, which, like physical geography, often includes simultaneous consideration of physical, chemical, and biological processes.[12] However, we mostly avoid the term "environmental science" in this book, as one of our fundamental premises is that the social-science research within environmental studies is also environmental science – the scientific study of human–environment relations. As we explained above,

[12] A central concept and approach within environmental science (and studies) is **ecology**, the study of the interrelationships among living plants and animals, and the organic and inorganic matter and energy that make up their environments. Environmental studies and other disciplines sometimes extend the concept of ecology to apply to humans and their socio-cultural environments.

whether discussing geography or environmental studies, we use the generic term "science" inclusively in this text to mean both natural *and* social sciences.

REVIEW QUESTIONS

- To what does the term "scientific research methods" refer, and why is attention to methods important for conducting and interpreting research?

Overview of the Logic and Philosophy of Science

- What are some characteristics of a scientific approach to geography and environmental studies? What is scientific empirical observation, and how does it differ from everyday, informal empirical observation?
- What are the following "characteristic metaphysical beliefs" held by scientists: realism, continuously connected and forward causality, simplicity, skepticism, quantitative thinking?
- What are some common types of nonscientific ways of knowing, and how are they nonscientific?
- What are some important limitations of a scientific approach to knowing?

Goals of Science

- What are the four scientific goals of description, prediction, explanation, and control, and how do they relate to each other?
- What are basic and applied science, and how is this distinction relevant to geographic and environmental research?

History and Philosophical Systems of Geography and Environmental Studies

- What is the focus of geography as a scholarly discipline, and how has this changed historically? What are the regional and systematic approaches to the discipline of geography?
- What is the focus of environmental studies as a scholarly discipline, and how was this focus stimulated historically by nonacademic events?
- What is multidisciplinarity and interdisciplinarity, and how do they play out in both geography and environmental studies?
- As academic fields, how are geography and environmental studies similar, and how are they different?

KEY TERMS

abduction: a type of implicitly logical reasoning that can lead to true conclusions without systematic reasoning from explicit premises

advocacy: philosophical approach to research that embraces the promotion of particular value-based views, such as views involving ethical or political values, as an intrinsic goal of research

anthropogenic: human-caused, as in fires caused by arsonists rather than lightning strikes

applied science: a style of scientific research that focuses on understanding reality in order to control or influence it

basic science: a style of scientific research that focuses on understanding reality for the sake of understanding

control: the most mature of the four goals of science; being able to bring about desired changes in the phenomena within a scientific domain for practical purposes

deduction: a type of explicitly logical reasoning in which premises definitely lead to true conclusions

description: the least mature of the four goals of science; distinguishing and characterizing the phenomena within a scientific domain, typically by classifying

ecology: the study of the interrelationships among living plants and animals, and the organic and inorganic matter and energy that make up their environments

empirical: evidence derived from systematic observation of the world via the senses, often aided by technology

environmental science term often used to refer to the natural-science approach within environmental studies; like physical geography, it focuses on the biophysical world and is part of the earth sciences

environmental studies: the study of human–environment relations, with a special focus on the natural environment

epistemology: the philosophical study of how people, including scientists, can acquire knowledge about reality; together with ontology, it makes up the study of metaphysics

explanation: the third most mature of the four goals of science, before control; explicating causal relations in order to answer the question of why some phenomenon is the way it is

geodesy: the theory and technology of measuring the size and shape of the earth and the spatial distribution of features on its surface

geography: the study of the earth as the home of humanity, it literally means "earth writing"

goals of science: four specific ways that scientists strive to attain their ultimate goal of understanding reality, including description, prediction, explanation, and control; the goals are intellectually progressive from least to most mature

human geography: the collection of social-science and humanities approaches within systematic geography; focuses on the human world, including social, cultural, behavioral, economic, and political phenomena

humanities: nonscientific disciplines that study the human world of individual and social activity, artifact, and institution; they include such disciplines as history, philosophy, languages and literature, art history, and much of human geography and the study of humans within environmental studies

induction: a type of explicitly logical reasoning in which premises probably lead to true conclusions

interdisciplinary: an approach to scholarship that combines two or more traditional disciplines by integrating their concepts, vocabularies, or methods into a new hybrid discipline

multidisciplinary: an approach to scholarship that combines two or more traditional disciplines without integrating their concepts, vocabularies, or methods

natural sciences: scientific disciplines that study the natural, or biophysical, world; they include such disciplines as atmospheric science, biology, chemistry, geology, oceanography, physics, physical geography, and natural-science approaches within environmental studies, often referred to as environmental science

ontology: the philosophical study of the ultimate nature of reality; together with epistemology, it makes up the study of metaphysics

parsimony: a belief widely held by scientists that the simplest adequate explanations are the best

physical geography: the collection of natural-science approaches within systematic geography; like environmental science, it focuses on the biophysical world and is part of the earth sciences

positivism: a philosophical crystallization in the late nineteenth and twentieth centuries of much of traditional scientific belief, explicitly advocating the rationality of such things as mind-independent reality, publicly observable truths that are objectively measurable, and so on

post-positivism: various diverse philosophies developed in the mid and late twentieth century that criticize aspects of positivist philosophy as a model of how science is done and should be done

prediction: the second least mature of the four goals of science, after description; guessing unknown phenomena within a scientific domain at better than chance level

realism: a belief widely held by scientists that the material universe actually exists, independently of sentient beings

regional geography: a traditional approach to geographic inquiry in which places and regions are studied in terms of the totality of their natural and human characteristics; in contrast to systematic geography

scientific approach: a personal and social human endeavor in which ideas and empirical evidence are logically applied to create and evaluate knowledge about reality

scientific research methods: the suite of techniques and procedures for empirical scientific investigation, along with the logic and conceptual foundations that tie scientific investigations together, and connect them with substantive theory

scientism: the inappropriate view that a scientific approach is the most valid and useful way to understand anything, or even the only way

sentient: entities that think and feel, including at least humans and many other animals; sentience has implications in scientific research for how we collect, interpret, and communicate data, and for various ethical considerations

social sciences: scientific disciplines that study the human world of individual and social activity, artifact, and institution; they include such disciplines as anthropology, communication, economics, political science, psychology, sociology, and much of human geography and the study of humans within environmental studies

studies: units of focused observation or data collection

systematic geography: an approach to geographic inquiry emerging in the nineteenth century in which particular topical areas or "systems" within geography are studied wherever they operate on the earth; in contrast to regional geography

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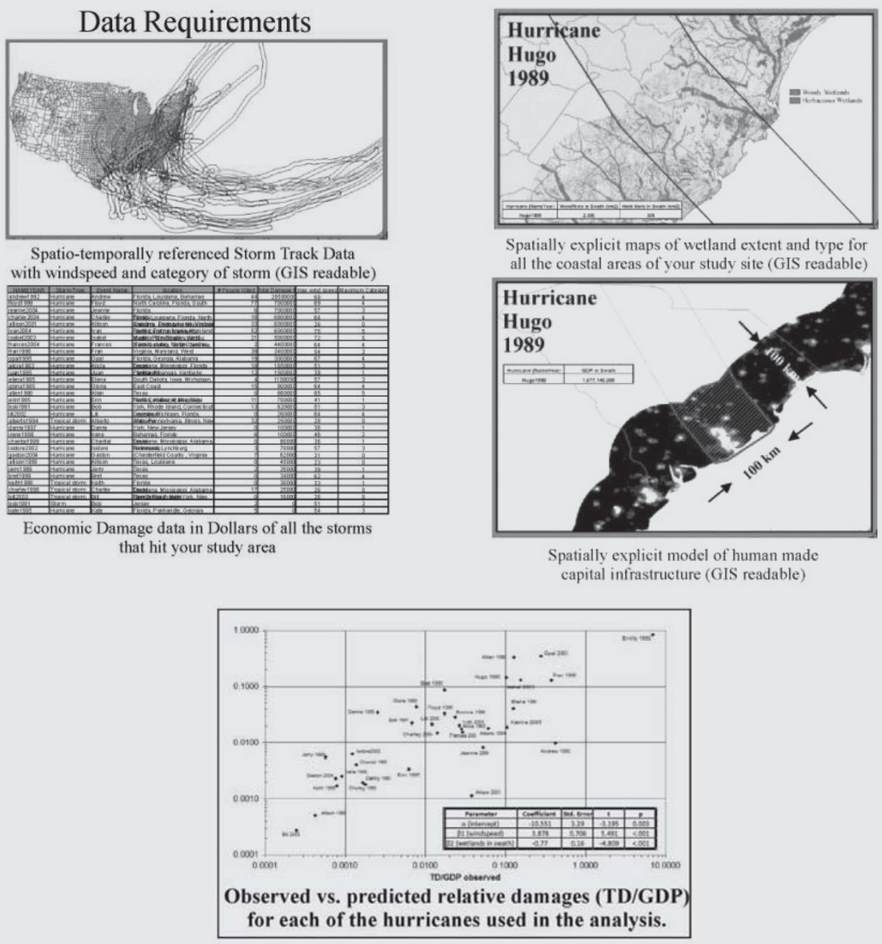
Research Vignette #1: Coastal Wetlands and Storm Protection

Before you read this, conduct a thought experiment in which you design an analysis to estimate the dollar value of the storm protection services provided by coastal wetlands. What data would you need and how would you conduct the analysis?

Imagine you have read about ecosystem services and how they can provide significant non-market goods and services to humanity (Daily, 1997). You read an article in a prominent scientific journal (Costanza et al., 1997) that estimates the global value of the world's ecosystem services and natural capital to be larger than the global GDP. You read the claim that "*A wetland is a wetland is a wetland*," by which the authors mean that the valuation of ecosystem services carried out in their paper uses a "benefits transfer model" in which the results of one or more specific wetland studies are extrapolated to all the wetlands of the world; they do not include a spatially explicit component to their economic valuation of ecosystem services. You decide that this is almost certainly a limitation of the study, insofar as the value of a particular ecosystem service must surely vary dramatically over space and place. For example, coastal wetlands provide storm protection services, but these services are much more valuable in places where there is a lot of human capital and a high frequency of damaging storms. You begin to think about how you would go about making a spatially explicit economic valuation of this particular ecosystem service.

A rough formulation of your question may be: "What is the dollar value of the storm protection services provided by coastal wetlands in a particular location and how does that value vary spatially?" To answer this question you will need some data. You choose to narrow this inquiry to the protection of human-made capital. Thus you will need a map of human-made capital and its value in different locations. You use nighttime satellite imagery to generate



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geographically distributed measurements of the capital, reasoning that optical lights are a good proxy measure for economic development. You also need a map of coastal wetlands and a map of the history of storm tracks. Finally, you need data as to how much dollar damage storms actually caused over the time period of your study. Your GIS analysis consists of hundreds of simple buffer operations in which you extract the following information to build a table that can be analyzed with a simple linear regression model. The columns of your table will be (1) Storm name (e.g., Katrina), (2) Dollars of damage, (3) Area of wetlands in swath of storm, (4) Dollar value of infrastructure in swath, and (5) Wind speed of storm at landfall.

Your table lends itself to an analysis in which the total damage of each storm divided by the dollar value of the infrastructure in the swath of the storm can be predicted by the storm wind speed and the area of wetlands in the swath of the storm (see scatterplot on previous page).Your multiple regression model proves to be statistically significant with an $R^2 = .60$ (the total variance you can account for in the predicted variable is 60 percent). Your parameter estimate for the role of wind speed is appropriately positive (that is, higher wind speeds produce larger damage) and your parameter for wetlands is negative and significant, consistent with the idea that wetlands do indeed reduce the damage done by storms (that is, more wetlands lead to lower damages). This research supported the idea that coastal wetlands provide over 23 billion dollars worth of storm protection services in the U.S. every year. For the complete report of this research, see Costanza et al. (2008).

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