

Paradigms and Problems: The Practice of Social Science in Natural Resource Management

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Increasingly, natural resource management is seeing calls for new paradigms. These calls pose challenges that have implications not only for planning and management, but also for the practice of science. As a consequence, the profession needs to deepen its understanding of the nature of science by exploring recent advances in the philosophy of science. We believe that one of the problems inhibiting a better understanding of science is a strongly ingrained belief that science is about methodology. This perspective is reflected in Hetherington, Daniel, and Brown's (1994) recent criticism of Bengtson's (1994) methodological pluralism. To initiate discussions that may help bring about a reconsideration of the nature of science, we offer a two-part definition of science. The first portrays science as a systematic endeavor that shares a common process without mandating a common methodology. The second part is an attempt to highlight and promote an exploration of the normative structure that underlies science.

Keywords epistemology, ontology, paradigms, philosophy of science, pluralism, relativism, worldview

Within natural resource management, calls for new paradigms are becoming increasingly prevalent. For example, a recent review of U.S. Forest Service land management planning concluded that the "technical and systematic process that was designed to reach the 'right' answer" employed by the agency over the past decade is inadequate (Larsen et al. 1990, 3). And, on a broader scale, the Forest Service is attempting to articulate and implement the Ecosystem Management Initiative. In wildlife management, Clark (1992, 1993) has criticized traditional approaches to planning and instead has called for a policy sciences approach. Conservation biologists have begun to debate the importance and implications of issues such as deconstructionism and the social construction of nature (Soule and Lease 1994). And, in fisheries management, there is growing interest in anthropology and the concept of local knowledge as a basis for understanding and managing natural resources (Dyer and McGoodwin 1994).

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These calls for new paradigms have implications not only for the nature of planning, policy, and management of natural resources, but also for the nature and process of science which informs these activities. For example, the Forest Service is currently struggling with the issue of defining social science's role in the Ecosystem Management Initiative. Fortmann and Fairfax (1992) have gone so far as to argue that the new role will go beyond simply filling some "social data gap." Instead, they see social science as re-defining the nature and substance of the policy process. Ultimately then, these calls for new paradigms require a critical evaluation of the nature of science as applied in natural resource management.

Unfortunately, as a discipline, we are largely uninformed about the philosophy of science. In wildlife management, for example, Romesburg's (1981) classic discussion of induction, retrodution, and hypothetico-deduction set the standard for the field (Nudds and Morrison 1991; Romesburg 1991). While this may well be a suitable basis for exploring research conducted within the natural sciences, this framework does not reflect advances in the philosophy of science over the past 30 years that are relevant to understanding the nature of social science. For example, the logical flaws and historical failures of "critical tests" central to the hypothetico-deductive method have not been given adequate attention in the wildlife literature. Also, those familiar with the broader range of normative approaches to science would argue that induction and hypothetico-deduction are both direct descendants of positivism, are more readily characterized by their similarities than their differences, and that Romesburg's typology fails to recognize a large family of interpretive approaches to science. More recently, the debate about forest values between Bengston (1994) and Hetherington, Daniel, and Brown (1994) concerning epistemological assumptions underlying methodological pluralism versus critical multiplism reflects greater awareness of advances in the philosophy of science, bringing into the discussion such figures as Thomas Kuhn and Paul Feyerabend. However, Bengston's (1994) discussion of methodological pluralism centers on a single substantive issue, the question of forest values, and lacked specific direction concerning what his epistemological position entails. In contrast, Hetherington, Daniel, and Brown's (1994) alternative (critical multiplism) largely reflects a methodological discussion grounded within the dominant epistemological tradition (positivism) that is currently being challenged in natural resource management.

Our lack of attention to epistemological issues underlying the philosophy of science is cause for concern for several reasons. First, failure to critically examine epistemological assumptions and make necessary changes in methodology may lead to a failure to achieve the stated goals for a discipline (Malm 1993). This is a dilemma that some have argued currently faces cognitive psychology nearly 40 years after its inception (Bruner 1990; Malm 1993) and appears to be one issue underlying the calls for new paradigms in natural resource management. A second reason for concern regarding the failure to adequately explore philosophy of science in natural resource management is that what we do not know about phenomena is partly a function of the way that we approach them (Weissinger 1990). Our approach to research is determined by the philosophical foundations underlying our approach to science. We have largely taken these foundations for granted, adopting a single research tradition modeled after the physical sciences that is broadly labeled "the scientific method." If we fail to examine the commitments underlying this research tradition and limit ourselves to a single approach to science, then our knowledge about natural resource phenomena will be equally limited.

A final reason for concern regarding our failure to explore the philosophy of science is that we may become isolated from other human science disciplines addressing related

phenomena. For example, over the past 15 years, consumer research has focused extensively on topics in philosophy of science, has started to hire faculty whose primary focus is on philosophy of science, has explored alternatives to the traditional approaches to science, and has attempted to deal with the difficult issues necessary to establish an adequate peer review process for research grounded in nontraditional scientific paradigms (cf. Lutz 1989). Similar trends are also apparent in environmental psychology, education, human geography, and the policy sciences to name a few related disciplines. If we continue to ignore these issues, our students will lose valuable opportunities for cross-disciplinary interaction.

The goal of the current article is to begin addressing the concerns described above. The specific purposes are to identify some of the common themes underlying challenges to current paradigms in resource management, to identify the challenges that they pose for the practice of science in natural resource management, and to introduce a model from the philosophy of science that can be used to help clarify and structure discussions about social science in natural resource management that we believe are necessary to successfully respond to these challenges.

Challenges from the Field

Calls for change have been most prevalent in forestry. Following significant public controversies such as the Monongahela dispute, legislative acts of the 1970s required the Forest Service to complete land management plans every 10 to 15 years and to employ public participation techniques as part of the planning process. The goals of these acts were, in part, to provide an appropriate avenue for incorporating the public's desires and for educating the public concerning Forest Service activities in hopes of reducing controversy. However, controversy has remained a very visible part of the process. For example, a 1989 survey revealed that 811 appeals had been filed on 96 national forests which had completed land management plans (Gericke, Sullivan, and Wellman 1992).

After the first decade of land management planning under the National Forest Management Act (NFMA), the Forest Service conducted a review and critique of the process (Larsen et al. 1990). This critique, though complimenting the Forest Service for a dedicated and sincere effort to meet both the "spirit and intent of NFMA," pointed to several challenges to which Forest Service planning needs to respond in the future (Larsen et al. 1990). Among these challenges is the need to develop a better match between "the analytical tools and the questions at hand" (p. 4).

A similar point was raised in an earlier discussion of public forest management by Allen and Gould (1986). These authors made a distinction between complex and wicked problems. Traditionally, they argued, science views the world as a set of complex problems. Complex problems occur in systems where interactions among a large number of variables make relationships hard to identify and understand. For example, trying to manage a forest to achieve maximum sustainable yield of timber is a complex problem. Traditional models of scientific rationality are designed to address this type of problem. In addition to complex problems, Allen and Gould argued that managers are also faced with wicked problems such as trying to decide how a public forest is to be managed. Wicked problems have two characteristics that distinguish them from complex problems. First, there is more than one correct formulation of the problem. That is, "the definition [of the problem] is in the mind of the beholder" (p. 22). Second, such problems involve groups of variables that may be unique in time and space. In the case of wicked problems, Allen and Gould argued that analysis and solutions cannot be standardized into general laws or

theories. Further, they maintained that such problems cannot be resolved through traditional analytical models of science.

Calls for change in conservation biology and wildlife management have been most thoroughly articulated by Clark (1992, 1993). From a starting point that conservation problems nearly always have their roots in social systems, Clark also questioned the suitability of traditional models of science. He made a distinction between the problems that science tries to tackle and the problems that managers face. Scientists address independent, fragmented problems from disciplines such as operations research, applied economics, and biology in an attempt to inform a policy process viewed as being based on a rational, objective decision-making process. Clark (1993) referred to this as a positivistic perspective on essentially a postpositivist social process. In contrast to independent and fragmented problems, managers manage "messes." Messes are complex and dynamic situations of changing and interdependent problems. As a consequence, there is a discrepancy between the problems that scientists try to answer and the problems that managers must address. If the profession is to successfully conserve biodiversity, Clark maintained this discrepancy must be overcome. To accomplish this, he called for a policy sciences orientation which he described as "a postpositivist epistemology that is a fundamental way of thinking and acting differently from the reductionistic traditions of modern science" (Clark 1992, 424).

Overall, these and similar calls for change share several common themes. First, they address management and policy problems rooted, not in natural systems (complex problems), but in social systems and values (wicked problems). Second, they question traditional ideas about what knowledge is, how it is attained, and how it can be used. And finally, they also pose a challenge: Traditional approaches to science do not always work, particularly with respect to problems grounded in social systems. The following section briefly reviews possible responses to these challenges.

Responding to Emerging Challenges to Science

For some, it may be tempting to view the challenges posed above as originating from esoteric philosophies (consider, for example, Clark's [1993] reference to postpositivist epistemologies) which have little bearing on real-world issues and therefore require no response. However, this represents a misunderstanding of the source of the critiques, an issue that can be clarified by briefly characterizing the domains in the research process. Research is commonly characterized as a dichotomy (basic vs. applied). However, a more useful and less adversarial representation of the research process is to think of science as characterized by three interrelated domains: the conceptual, methodological, and substantive (Brinberg and Hirschman 1986). The conceptual domain refers not only to theories and constructs, but also to normative philosophical commitments guiding research. The methodological domain deals with the procedures and techniques used to study phenomena. The substantive domain encompasses real-world systems and phenomena. The nature of each of the former two domains will be explained more fully throughout the rest of the article. The important point for the "no response" alternative is that the critiques presented above originate from the substantive domain. For example, the Forest Service's internal critique of its planning process indicates that science as currently practiced is not working. Thus, many of the challenges originate from "real-world" policy and management concerns rather than from purely philosophical debates.

A second response frequently seen is one that focuses on the need to add new methodology to our scientific tool kits. Commentaries representing this alternative reflect

the belief that the challenges call for simply the development of new techniques within the methodological domain to be incorporated into science as we know it. This response represents a misunderstanding either of the nature of the challenges or of the nature of science. With respect to misunderstanding the nature of the challenges, the mistake is in assuming that the problem lies solely in the methodological domain. While there are methodological implications, these challenges are more directly linked to the substantive and conceptual domains. Increasingly, we are recognizing that scientists and planners are encountering a new class of problems (wicked) whose characteristics are not amenable to solutions by traditional approaches to science.

The second mistake reflected in a "new methods" response is a misunderstanding of the nature of science. Underlying this response is the belief that science equals methodology (e.g., a deeply ingrained belief in the existence of something called "*the scientific method*"). For example, many who face the challenges described above are interested in exploring the possibility of adding qualitative methods to our tool kits. However, science is far more than simply methodology, a point we will illustrate by briefly expanding Lancy's (1993) discussion of the problem inherent in discussing qualitative methods. The root of the problem is that discussions concerning qualitative methods are often filled with miscommunication and confusion, because this concept has multiple meanings which are often confused or unrecognized in discussions. At the most basic level, the term "qualitative" refers to the manner in which data are represented. Within natural resource management, data are most commonly represented and analyzed in quantitative (numerical) form. In contrast, at this level of meaning, qualitative refers to data represented and analyzed in nonnumerical form (usually as text). At the second level of meaning, the phrase "qualitative methods" may refer to a set of nonnumerical, but otherwise unrelated, techniques for collecting, representing, or analyzing data (e.g., in-depth interviews, participant observation, content analysis).

Individuals advocating adding new methodology as a response to the challenges described earlier generally view and discuss "qualitative methods" in relation to the second level of meaning presented above. However, in doing so, they ignore a third level of meaning associated with the term, the one most closely associated with the nature of science. At this level, "qualitative method" refers to a scientific paradigm. We believe that understanding this third level of meaning (i.e., what scientific paradigms are) provides the basis for the third and most appropriate response to the challenges raised above.

Reframing the Nature of Science

The third possible response to current challenges requires the field of natural resource management to reconsider the nature of science. The term "paradigm" and suggestion that we reconsider the nature of science may bring to mind Thomas Kuhn (1962). Most researchers in the field have heard of Kuhn and have at least some understanding of his discussion of scientific revolutions in which a new paradigm challenges and ultimately replaces the existing paradigm. However, we do not believe a revolution in the Kuhnian sense of the concept is necessary or even useful. While we believe the issue underlying the challenges is a question of paradigms, the philosophy of science has moved beyond Kuhn's ideas of revolutions.

More recent discussions in the philosophy of science focus instead on the concept of pluralism—the idea that different scientific paradigms can and should coexist within a field or discipline. The concept of pluralism is based on the recognition that all paradigms have inherent boundaries and limitations which define and limit the domains (types of

problems) for which they are applicable. While this idea is clearly reflected in Bengtson's (1994) and Hetherington, Daniel, and Brown's (1994) recent exchange concerning contrasting epistemological traditions, unfortunately as a field we lack a framework for structuring such epistemological debates. As a consequence, it is difficult to comprehend, evaluate, and assess the implications of contrasting epistemological positions. To address this problem, the remainder of the article focuses on the question of how we can characterize, study, and discuss alternative epistemological traditions in a way that allows us to choose the one that seems appropriate for the specific problems we are addressing at any given moment.

Defining Science

For the purposes of this discussion, science will be characterized using a two-part definition. Science is (1) a systematic set of empirical activities for constructing, representing, and analyzing knowledge about phenomena being studied (Brunner 1982; Nespor and Barylske 1991), which is guided by (2) a set of normative philosophical commitments shared by a community of scholars. The first part of the definition is a rather traditional conception of science which emphasizes the idea that science is systematic and empirical. The second part of the definition is less traditional and perhaps more controversial. It implies that science is not so much about truth (or its approximation) determined by some existent reality, but instead is something more like an issue of social consensus. It states that science has a normative structure. That is, when you practice science in a particular way, you are "buying into" something; specifically, a set of normative philosophical commitments. What is more, this part of the definition implies that there may be more than one set of normative commitments; more than one community of scholars that calls its collection of commitments and practices, science.

To some, the discussion of different communities of scholars may bring to mind the distinction between qualitative and quantitative methods raised above. However, this basic dichotomy is too simplistic for two reasons. First, because discussions of qualitative methodology often focus on the first two levels of meaning underlying this dichotomy, the phrase holds little meaning with respect to the normative structure of science. Second, even when the discussion occurs at the third level of meaning, it erroneously promotes the perception that there is a high degree of convergence among what, in reality, is a rather large array of widely divergent approaches to science.

Much of the recent work in the philosophy of science has focused on more appropriate ways of characterizing and making explicit the normative philosophical commitments scientists "buy into." In fact, it is with respect to this question that Kuhn made his most important and longest lasting contributions: (1) He was one of the first philosophers of science to study the actual practice of science rather than idealized systems of logic which describe what science should be, and (2) he defined the appropriate unit of analysis in the study of an epistemological tradition as its macrostructure (Anderson 1986).

The macrostructure of science is comprised of normative philosophical commitments concerning issues such as the nature of reality, the overriding goals of science, and the limits and methods of knowledge that are accepted in a research tradition without direct empirical support (Hudson and Ozanne 1988). Different research traditions are distinguished on the basis of differences in these underlying commitments. However, characterizing and comparing specific research traditions is difficult due to the holistic nature of the interdependent commitments, the existence of different levels of specificity with which the macrostructure can be described, and the lack of standard terminology for de-

scribing the macrostructure (e.g., Kuhn used the term "paradigm" at least 21 different ways [Masterman 1970]). The model of the macrostructure of science presented in the following section attempts to overcome these limitations so that different epistemological traditions can be characterized, compared, and contrasted.

The Macrostructure of Science

The macrostructure of science is comprised of three levels: worldviews, paradigms, and research programs (Figure 1). The broadest and most general level is the worldview. The worldview deals with "rules" in science and the concept of validity at a very broad level and can be thought of as a continuum ranging from rationalism/foundationalism to relativism/antifoundationalism. At one extreme are rationalist/foundationalist perspectives which maintain that there is a single timeless, universal set of rules for distinguishing science from nonscience and truth from nontruth (Chalmers 1982; Thompson 1990). As a result, rationalist research traditions are largely concerned with epistemological and methodological issues (defining and refining the rules and methods of science). For example, attempts to define "*the scientific method*" fall within this extreme end of the continuum. Broadly speaking, this range of the continuum can be labeled, positivism. Within the social sciences, the concept of validity at this end of the continuum traditionally has been addressed by focusing on measurement and establishing rules for ensuring content and construct validity (e.g., Churchill 1979; Hetherington, Daniel, and Brown 1994).

The spectrum of the continuum represented by relativistic/antifoundationalist philosophies is often broadly labeled, interpretivism. Relativists maintain that there is no universal, ahistorical set of rules for judging science (Chalmers 1982). Instead, they argue that the criteria for judging science are dependent on the values or goals of the scientific community evaluating them. There is a tendency for antifoundationalists to focus on ontological issues (nature of reality, human nature) rather than methodological issues (Thompson 1990). The beneficial aspect of this tendency is a stronger focus on defining the nature of the problem (as opposed to rationalists' relatively greater emphasis on mechanically generating the answer through application of existing methodology). However, the negative side is the failure to adequately address the issue of "how to do it." The most extreme antifoundationalists tend to eschew the notion that rules or methods for conducting science can ever be prespecified. However, some of the more moderate antifoundationalists (e.g., Mishler 1990) advocate the development of "exemplars" as a means of addressing the issue of "how to do it" while avoiding establishment (or institutionalization) of compulsory, foundationalist-like algorithms.

Across the relativist/antifoundationalist range of the continuum, there has been no widespread consensus about the concept of validity. In part, this is because (1) validity assessments are seen as being based on judgments of the importance of different goals and threats to validity; (2) different goals may conflict with one another and threats to validity may be weighted differently; and (3) as a consequence, no single algorithm or set of standardized rules for assuring a valid interpretation can be defined (Kuhn 1977; Mishler 1990). The perspective on validity within this range of the continuum perhaps has been best summarized by Holt's (1991, 59) statement that "the credibility of an interpretation cannot be inferred separate from its reading." Thus, rather than relying primarily on antecedent methodological procedures to ensure the quality of research, antifoundationalists focus instead on the product itself. For example, Mishler (1990) emphasized functional criteria: Can other researchers determine how findings and interpretations were produced and whether the findings are relied on for future work? A different (though not necessar-

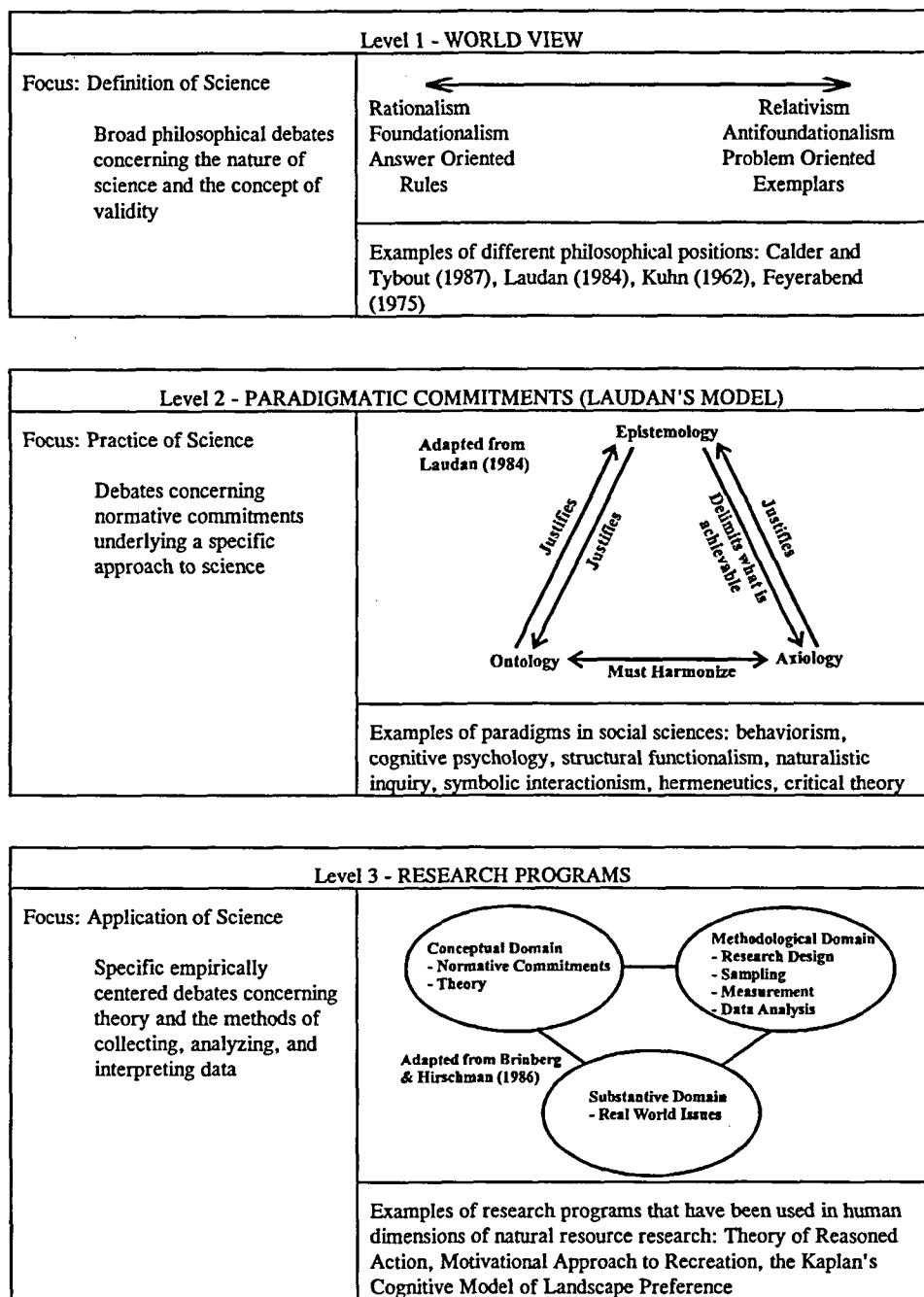


Figure 1. Model of the macrostructure of scientific research traditions.

ily contradictory) perspective has been outlined by Thompson (1990) who emphasized the concept of insight as a means of evaluating research. Both of these represent a shift from a concern for truth versus nontruth, which predominates rationalist discussions of validity, toward a predominant concern for the practical utility of findings.

Though the typical researcher rarely is active at this level in the macrostructure of science, preferring to apply the rules of science defined by someone else, those who have entered the debate concerning the nature of science can be positioned along this continuum. For example, in characterizing a falsificationist perspective (a worldview similar to Romesburg's [1981] hypothetico-deductive method) which maintained that interpretivist knowledge can be "provocative and entertaining reading . . . but must stand apart from science," Calder and Tybout (1987, 139–140) reflect a modern but rather extreme rationalist perspective. On the other hand, Paul Feyerabend's "anything goes" reflects an extreme relativist view. Kuhn's model of science, based on stages ranging from normal science to revolutions, represents something of a midpoint along this continuum. Kuhn's belief that, during the normal science stage, there are established rules to be followed reflects a rationalist perspective. On the other hand, the revolution stage represents a relativistic perspective because Kuhn maintained that there is no logical basis for choosing among competing approaches to science; choice instead is likened to a religious conversion and requires a leap of faith. Finally, Larry Laudan (1984), whose model of science serves as the basis for the second level within the macrostructure of science (Figure 1), represents a less relativist position than Kuhn because the model maintained that one can rationally choose among paradigms. At the same time, Laudan's philosophy displays a relativist perspective in that it maintained that several different approaches to science can legitimately coexist.

As described above, normative commitments at the worldview level shape the predominant philosophical and normative concerns of a research tradition (i.e., a rationalist concern for rules of evidence vs. a relativist emphasis on the nature of reality). However, because of the difference in focus among worldviews (the emphasis on different types of normative commitments) and the fact that worldviews tend to be somewhat nebulous and hard to pin down, this level alone is an inadequate basis for thoroughly characterizing a research tradition. In contrast, the second level in the map of the macrostructure of science presented in Figure 1 (paradigmatic level) permits a more thorough and detailed characterization of a research tradition because paradigms are less abstract, more coherent statements about the practice of science. This level also provides greater opportunity for comparing and contrasting alternatives because all paradigms are seen as being definable on the basis of three core normative philosophical commitments.

Examples of paradigms in social science include: behaviorism, cognitive psychology, structural functionalism, naturalistic inquiry, symbolic interactionism, hermeneutics, feminism, and critical theory. The proposed basis for characterizing, evaluating, and contrasting these paradigmatic research traditions is Laudan's (1984) Reticulated Model of Scientific Rationality (Figure 1). Laudan's model suggests that scientific paradigms are comprised of three interrelated sets of normative philosophical commitments (ontology, epistemology, and axiology). Ontology refers to normative commitments about the nature of reality, human nature, and the nature of human experience. Examples of somewhat contrasting ontological commitments are presented in Table 1. We believe that understanding the nature and implications of contrasting ontological commitments underlying paradigms is a necessary step to understanding and responding to challenges posed by wicked problems. Unfortunately, past research often has been conducted without explicitly considering underlying ontological commitments, largely because a rationalist worldview has dominated research in the field of natural resource management. While discussions of different ontologies have increased as a result of renewed interest in interpretivist approaches to science, at the current time, such discussions are filled with confusion and misunderstanding, particularly with respect to the relationship between ontology and epistemology.

Table 1
Examples of different types of normative commitments
which underlie scientific paradigms

Ontological commitments	
1. Nature of reality	Objectivist ontologies: Maintain the existence of a single, freestanding reality waiting to be discovered (Howard 1991). Constructivist ontologies: Maintain that humans actively construct identities, reality, and knowledge (Howard 1991; Nespor and Barylske 1991).
2. Nature of human experience	Deterministic ontologies: Philosophies that view psychological functioning (e.g., satisfaction, aesthetic response, and behavior) as outcome variables dependent on or caused by isolatable environmental and personal variables (Anderson 1986; Hudson and Ozanne 1988). Narrative ontologies: Philosophies that assert human experience is more like an emergent narrative than an outcome predictable on the basis of isolatable antecedent environmental and personal variables (Arnould and Price 1993).
3. Human nature	Information based models of human nature: Those models of human behavior that treat individuals as rational, analytic, goal-driven information processors. Meaning-based models of human nature: Those models of human behavior which portray individuals as actively engaged in the construction of meaning as opposed to processing information that exists in the environment (Mick and Buhl 1992).
Epistemological commitments	
1. Relationship between researcher and phenomenon observed	Dualism: The researcher is detached and separate from (has no influence on) the phenomenon observed; scientific observation is an act of description. Fusion of horizons: Observer is not separate from the phenomenon; observation is an interpretive act, observer therefore coproduces rather than describes knowledge.
2. Research process and type of knowledge generated	Linear process: Yields the answer, usually in the form of universal or generalizable laws. Hermeneutic circle: May express the understanding at the moment—this understanding is subject to revision; knowledge is contextual and time bound.
Axiological commitments	
1. Terminal goals: The ultimate aims of science.	"Positivist" paradigms: Explanation, prediction, control. "Interpretivist" paradigms: Understanding, communication.
2. Instrumental goals: The criteria by which research is evaluated as an acceptable or unacceptable scientific product in a peer review process.	"Foundationalist" criteria: Internal consistency reliability, generalizability, discriminant validity, convergent validity. "Antifoundationalist" criteria: Persuasiveness, insightfulness, use in future research.

Epistemology refers to the methods, limits, and nature of human knowledge. For example, at the paradigmatic level of the macrostructure of science, epistemological commitments deal with issues such as the relationship of the observer to the phenomenon being observed, the nature of the research process, and the type of knowledge generated. Differing perspectives on aspects of epistemology are illustrated in Table 1.

As suggested above, a fundamental issue with regard to characterizing paradigms using Laudan's model is the relationship between philosophical assumptions about reality (ontology) and methods used to study reality (epistemology). Malm (1993), for example, attempted to illustrate the adverse consequences which may occur when epistemology is not consistent ontology. Within human dimensions research in natural resource management, it seems increasingly popular to claim ontological beliefs characteristic of interpretivist paradigms. However, many who make these claims continue to use traditional epistemological commitments (rules and methods) that are inconsistent with these beliefs. Thus, our failure to become conversant in the concepts of the philosophy of science places us in danger of experiencing the same dilemma that Malm currently believes faces cognitive psychology.

Axiology, the third paradigmatic component of Laudan's model (Figure 1), refers to goals underlying a particular approach to science. There are two types of goals: terminal and instrumental (Table 1). Terminal goals refer to the ultimate aims of a specific paradigm (e.g., universal laws of human functioning, predictive explanation, understanding). In contrast, instrumental goals refer to the criteria by which specific research efforts will be evaluated as good or bad science (e.g., for acceptability for publication in a peer reviewed journal). Instrumental goals from various paradigms include concepts such as generalizability, reliability, predictive validity, persuasiveness, and insightfulness.

With respect to axiology, it is important to recognize that part of the incommensurability (failure to communicate) between positivist paradigms and interpretivist paradigms is due to the fact that they do not share the same goals. Many who criticize one approach or another either fail to recognize this or fail to understand the nature of the differences. Adherents to each side of the controversy are guilty of this shortcoming. As a final note with respect to this issue, it is also important to recognize that not all positivist paradigms share the same goals (e.g., behaviorism vs. cognitive psychology). Similarly, not all interpretivist paradigms share the same goals (e.g., hermeneutics vs. naturalistic inquiry).

A second issue to note with respect to axiology and epistemology deals with the apparent overlap between the two. For example, one could consider "type of knowledge generated" as being an axiological rather than an epistemological commitment. However, we have defined it as an epistemological commitment because it deals with the limits of human knowledge. Some "interpretivist" paradigms *believe* it is not possible to identify universal laws of behavior (or at least it is not possible in the case of the phenomena they study). This reflects ontological commitments such as the belief in a reality that changes across time, cultures, and individuals and the belief that human experience is not deterministic in nature. Consequently, production of universal laws cannot be a goal of their research. This example briefly illustrates the interdependence of philosophical commitments within paradigms.

In fact, the issue just raised reflects an important contribution of Laudan's model which distinguishes it from more relativistic worldviews. From Laudan's perspective, acceptance or rejection of different research paradigms does not require Kuhn's leap of faith. Instead, one can evaluate a paradigm and the research produced within that paradigm according to the internal consistency of its axiology, ontology, and epistemology. Considering the diversity of paradigms from which to choose (those presented above rep-

resent only a partial listing), a potentially important contribution of Laudan's model is the framework it provides for making paradigmatic commitments explicit so that they may serve both as a guide for the peer review process and as a means of helping researchers choose among alternative approaches. Several papers in consumer research serve as exemplars of how the logic of Laudan's model can be used as the basis for characterizing different scientific paradigms (Anderson 1986; Holt 1991; Larsen and Wright 1993; Murray and Ozanne 1991).

The third and final level in the map of the macrostructure of science is research programs (Figure 1). This is the level where (1) science links directly with substantive (real-world or managerial) problems; (2) specific theories, conceptual models, constructs, and propositions are dealt with; and (3) specific methodologies are adopted to generate empirical data. This level reflects the first part of the definition of science presented above and portrays the application of science as a systematic endeavor that shares a common process without mandating a common methodology. Examples of research programs include Fishbein and Ajzen's (1975) theory of reasoned action, Driver and Tocher's (1970) motivational approach to recreation experiences, and the Kaplans' (1989) cognitive model of landscape preference.

Classification of research traditions at the level of research programs does not take on the characteristics of classic taxonomies which are composed of independent, mutually exclusive categories with distinct boundaries. For example, consider the relationship of Driver and Tocher's motivational approach to the theory of reasoned action (i.e., the motivational approach owes its conceptual foundations to the same expectancy-valence theories in psychology that gave rise to the theory of reasoned action). This is because several distinct research programs may evolve out of a preexisting research program and also because initially distinct programs may merge into a single program (Anderson 1986). As the previous statements suggest, research programs are in a constant state of flux and change because this is the realm in which the community of scientists is most active.

Unlike the paradigmatic level of the macrostructure of science in which it is possible to compare all paradigms on the basis of a few broad themes (ontology, epistemology, axiology), at the level of research programs, it is impossible to define a single set of attributes by which all research programs can be compared. This is because the diversity of phenomena dealt with is so broad and varied. However, it is often possible to define a set of attributes that are useful for distinguishing among different research programs addressing the same phenomenon. Daniel and Vining's (1983) grouping of different approaches to landscape quality assessment is one example of an attempt to do this for several research programs, while Driver et al.'s (1987) paper is an excellent example of an effort to do this for a single research program.

Finally, while research programs are grounded in normative commitments established at the paradigmatic level, in a few cases, it may be difficult to characterize specific research programs with respect to the broader level of paradigms. In some cases, this difficulty in classifying research programs may be due to the fact that a research program may originate under one set of commitments, but adopt a different set of commitments as it evolves. For example, Bem's self-perception theory was originally constructed using ontological commitments of radical behaviorism (cf. Bem 1964). However, by 1970, Bem (1970) had dropped behavioristic ontology in his presentation of self-perception theory (Anderson 1986). In this process of evolution, classification of research programs with respect to paradigmatic commitments may be further complicated by the fact that changes in some commitments (e.g., ontology) may outpace corresponding changes in

another set of commitments (e.g., epistemology). Also, at times, some research programs may mistakenly mix incompatible sets of normative commitments from different research paradigms. However, while this makes classification problematic, it opens research programs to the same type of critical evaluation that Laudan suggested should be conducted at the paradigmatic level.

Implications of the Proposed Model of Science

This article began by reviewing challenges currently facing the practice of social science in natural resource management. We have adopted the position that responding to these challenges requires that resource management, as a field, deepen and broaden our understanding of the nature of science by exploring recent advances in the philosophy of science. We believe that one of the problems inhibiting a better understanding of science in the field is a strongly ingrained belief that science is about methodology. This perspective arises from a rationalist worldview which serves as the predominant philosophy in our discipline and is reflected in Hetherington, Daniel, and Brown's (1994) criticism of Bengston's (1994) methodological pluralism. In order to initiate a discussion to help bring about a reconsideration of the nature of science, we have offered a two-part definition of science. The first part is an attempt to portray science as a systematic endeavor that shares a common process without mandating a common methodology. The second part of the definition is an attempt to highlight and promote an exploration of the normative structure that underlies science. An understanding of this aspect of science is necessary if we are to effectively deal with and incorporate new approaches to science in response to the challenges currently facing us.

The discussion of the normative structure of science presented in the previous section focused on presenting a model of the macrostructure of science that can be used to study, understand, and critique different approaches to science. This aspect of evaluation is part of the conceptual domain of science. Because researchers are more familiar with a second aspect of the conceptual domain—theory, we will briefly illustrate the importance of understanding these more philosophical issues by discussing the relationship between theory and normative commitments. As stated above, normative commitments deal with philosophical assumptions that are accepted in a research tradition without direct empirical support. In contrast, the concept of theory implies three themes, all of which are linked to empirical data: Theory (1) is a guide for defining what types of observations (variables) need to be made to understand a phenomenon, (2) is a guide for interpreting observations—it explains relationships among observations (variables), and (3) implies the possibility of a "test" (this is the strongest distinguishing characteristic relative to normative commitments). However, beyond these themes, it is not possible to offer a single, more specific, definition of theory because more specific definitions reflect normative commitments which differ across research traditions.

For example, positivist paradigms search for those abstract, universal laws which explain many occurrences of a phenomenon (cf., Sellitz et al. 1967). In contrast, some paradigms have no interest in abstraction or universal laws. For example, critical theorists believe that "it is the ongoing, daily struggle that interests the critical researcher, not abstraction" (Murray and Ozanne 1991, 136). In fact, many (though by no means all) interpretivist paradigms see theory more as a metaphor (cf. Kelly 1987) or starting point to help approach or map a certain class of phenomena while seeking to remain open and sensitive to the newness in the specific occurrence of the phenomenon being examined (Brunner 1982; Gadamer 1975).

The above illustrations represent differences in how theory is defined due to differences in epistemology (normative commitments concerning the type of knowledge generated). However, different conceptions of theory also reflect other types of normative commitments. For example, Atlan (1993, 143–145) used static electricity to illustrate this point. At one point in history, this phenomenon was explained by invoking the concept of demons, an ontological reality of the time. However, as disbelief in the reality of demons increased, so did disbelief in the phenomenon. That is, the question of demons became mixed with the question of the real or illusory nature of the phenomenon of static electricity. However, the ultimate acceptance and explanation of the phenomenon did not prove the existence of demons. With the discovery of electricity, observations of static shock were confirmed without appealing to a theoretical context involving demons. Demon based explanations of phenomena would not be acceptable in science today because demons are not part of modern ontology. While this illustration may seem somewhat outlandish today, Atlan went on to point out current examples of the role that ontological assumptions play within theoretical contexts (e.g., a belief in extrasensory perception (ESP) or psychokinesis or the beneficial effects of acupuncture).

Axiological commitments also influence the definition of theory within a paradigm. For example, critical theory's terminal goal of changing and creating a better society (Murray and Ozanne 1991) encourages an emphasis on context specific, time bound research rather than the development of universal laws.

Ultimately, the view of science we present in this article is relativistic in nature. For some, this requires a change in thinking at the worldview level in the macrostructure of science. It is at the worldview level that we believe attacks against "positivism" (e.g., Clark [1993] presented above) have merit. While we believe that science does share a common process, we believe that we need to abandon the positivist worldview (extreme rationality)—the idea that there is a single epistemology and set of evaluative criteria by which "scientific" knowledge must be judged. Instead, we need to recognize that no single methodology can address all potential threats to validity (e.g., statistical generalizability vs. richness of information). In fact, studies in the history and sociology of science show that the notion that a standardized set of rules (algorithms) underlies science is a fictional account of science (Mishler 1990). Hence, philosophers of science argue that, as a normative guide, worldview-level positivism is meaningless because it does not provide an accurate account of how science is actually practiced (Chalmers 1982). While, at some level, modern positivists recognize the idealistic nature of standardized "algorithms" in their own practice (cf. Mishler 1990; Chalmers 1982), they tend to forget their deviations from the rules when evaluating approaches to science which are openly relativistic. As a result, they attempt to criticize interpretivist research for not living up to the very standards that they do not live up to.

There is also a tendency for worldview-level positivism to not make a distinction between the nature of problems (e.g., complex vs. wicked). As a consequence, either no distinctions are made in the epistemological approaches used to study them (e.g., the same assumptions and rules of evidence used to study physiological responses are seen as being appropriate for the study of meaning or values) or, at best, differences in approaches are seen simply as differences in methodology (e.g., quantitative vs. qualitative). Such a perspective is not adequate for addressing the challenges currently facing social science in resource management. Instead, we need to adopt a worldview in which the normative commitments employed in any given situation are shaped by the questions asked and the phenomena being studied (Polkinghorne 1983). As Terwee (1990) suggested, we should never start measuring before we have devoted careful thought to the

phenomenon being explored. For instance, is it a highly repeatable phenomenon that is structurally similar across time and individuals (complexity) or is it highly individual and unique, a problem that is continuously restructured (wickedness)? In other words, critical evaluation should not be limited to the level of empirical data or even the theoretical level in the conceptual domain. It must extend all the way to the normative commitments guiding our approach to science.

To achieve this goal, science as applied in natural resource management must broaden its traditional focus on disciplinary divisions (e.g., environmental psychology, sociology) to include a focus on alternative scientific paradigms as well. That is, in addition to gaining an understanding of disciplines, we need to begin to explore nontraditional approaches to science (e.g., hermeneutics, semiotics, grounded theory). To accomplish this, we need to close the gap between the philosophy of science and the practice of science. Consumer researchers' attempts to establish a "critical pluralist" perspective that employs the logic of Laudan's model (the paradigmatic level in the macrostructure of science) (Anderson 1986; Hunt 1991; Murray and Ozanne 1991) can serve as a valuable model for developing ways of guiding and evaluating research produced using alternative approaches to science.

Hunt (1991, 41) gives the following definition of critical pluralism: "The 'pluralism' part reminds us that dogmatism is antithetical to science; we should adopt a tolerant, open posture toward new theories and methods. The 'critical' half stresses that nonevaluational, nonjudgmental, noncritical, or mindless pluralism (viewing the supposed encapsulation of rival theories and new methods as thwarting comparison and evaluation) is just as bad as dogmatism." The model of science presented in this article is an attempt to facilitate the development of this perspective by providing a framework that allows researchers the opportunity to explicitly explore, discuss, and evaluate the implications of the normative commitments underlying alternative paradigms.

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