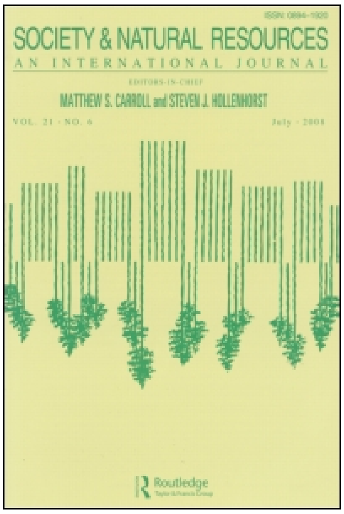

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Hierarchy Theory in Sociology, Ecology, and Resource Management: A Conceptual Model for Natural Resource or Environmental Sociology and Socioecological Systems

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This article argues that hierarchy theory can be used as a conceptual bridge to facilitate analysis of socioecological systems (SES). An SES model is proposed based on a synthesis of structuration theory in sociology and hierarchy theory in ecology. The model is process rather than component based by relating institutional processes with ecological processes at multiple scales. The model also offers a means to conceptually integrate the divide between micro and macro approaches in the fields of environmental and natural resource (E&NR) sociology.

Keywords conceptual models, ecology, ecosystem, environmental sociology, hierarchy theory, institutions, natural resource management, natural resource sociology, scale, socioecological, social structure, structuration

Hierarchy theory is extensively used in the fields of ecology and resource management (e.g., Foster et al. 2003; Kates et al. 2001; King 1993; Kratz et al. 2003; Holling 1996; Martin and Lemon 2001; Odum 1996; O'Neill et al. 1986; Pattee 1973; Rastetter et al. 2003; Samson and Knopf 1996; Simon 1973; Sneddon 2002; Woodley et al. 1993), and structuration and "new institutional" theory manifest the same conceptual scheme as hierarchy theory (Allen and Hoekstra 1992; Friedland and Alford 1991; O'Neill et al. 1986; Sewell 1992). Structuration approaches to social structure conceptualize "structure" in terms of process, and see society as composed of multiple, scalar, and conflicting institutional realms, with the concept of "freedom within constraint" used to explicate the "agency–structure" dichotomy extant in much of contemporary social theory (Friedland and Alford 1991; Giddens 1981; 1984; Sewell 1992).

Several scholars (e.g., Costanza et al. 1996; Eckhardt 1998; Field et al. 2003; Fight et al. 2000; Heemskerk et al. 2003; Holling et al. 2002a; 2002b; Naveh 2000; Norton and Ulanowicz 1996; NSF Advisory Committee 2003; Peterson 2000; Sneddon et al. 2002) have suggested (urged) incorporating the notion of scale in socioecological models, in the management of socioecological systems, and in environmental and natural resource

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(E&NR) sociology. Structuration theory has been suggested as a means to foster the inclusion of scale and to address the need for a process orientation to socioecological theory (Luzadis et al. 2002; Rudel 1999; Scoones 1999). Scoones (1999), for example, suggests that current sociological models lack a link to the dynamics of ecological change, especially to the nonequilibrium paradigm in ecology. Scoones (1999) calls for new models that "link dynamic structural analysis of environmental processes with an appreciation of human agency in environmental transformation, as part of a 'structuration' approach" (2).

> Environments are dynamically and recursively created in a nonlinear, nondeterministic, and contingent fashion. Social, political, economic, and ecological processes interact dynamically, requiring analysis to be sensitive to the interaction of structural features and human agency across a range of scales from the local to the global. (Scoones 1999, 492)

In particular, the Luzadis et al. (2002) critique of the Machlis et al. (1997) human ecosystem model (HEM) calls for precisely the type of improvements offered by the model proposed here—incorporation of a structuration/hierarchical approach to interpreting socioecological systems. "The HEM [human ecosystem model]...lack[s] integration of biophysical and social *processes*....The HEM in its current form does not model *process*" (91; emphasis added). Rudel (1999) similarly criticizes the Machlis et al. (1997) model for not "putting people as knowledgeable agents at the center of ecosystems" (258) (something that incorporating structuration theory would accomplish), and, along with Scoones (1999), suggests that the missing ingredient in the model is structuration theory. As a result, Rudel (1999) states that the "dynamic nature of the interaction between agents and structures is missing from its [the Machlis et al. model] analysis" and as such the analysis does not address the issue of scale in socioecological systems. The model proposed here offers solutions to the deficiencies in the Machlis et al. (1997) model, as well as other component or "box and arrow" models of socioecological systems (e.g., Alberti et al. 2003; Bennett 1976; Beus 1993; Ehrlich and Holdren 1971; Fight et al. 2000; Michaelidou et al. 2002; Naveh 2000; Nyhus et al. 2002), by employing scalar process analysis of socioecological systems using structuration/hierarchy theory as a conceptual basis.

The conceptual approach provided by structuration/hierarchy theory has direct practical application to the analysis of policy and management issues as well. For example, Bromley (1990) has used a hierarchical understanding of formal institutions to analyze the public policy process, and Dietz et al. (2003) suggest the development of resource management institutions that have the appropriate scalar "fit" to the ecological and social contexts that are the focus of management, the lack of which Andrews (1997) referred to as "institutional blanks." Pritchard and Sanderson (2002) make the same point.

> One of the fundamental problems of social science in environmental issues has been to find the "right scale" of adaptation to and management of nature (Folke, Pritchard et al. 1998).... The importance of this problem has been reinforced by attention to scale in natural systems. Some decisions are best devolved to local authorities, or communities, or even individuals, depending on who had the best information.... *That*

> *is, ecological scale and social scale [and their interrelationship] are both important*. (151; emphasis added)

Scale has also been employed in a more static sense by anthropologists to explain social inequality, with the observation that as social systems increase in physical scale, inequality and social injustice increase through greater concentration and disparity of political and economic power (Bodley 1994; 1999; 2003).

In the following discussion, hierarchy/structuration theory is employed to produce a conceptual model that organizes socioecological systems in a way that (1) highlights relationships based on differences in scale; (2) provides a conceptual framework for relating ecological and institutional process; (3) maintains the micro level of sociological analysis of individual social agents and their schemas of resource use; but (4) links these schemas and behaviors with social institutions at larger scales; and (5) emphasizes the dynamic (process) nature of socioecological systems. First, I point out how the employment of structuration theory has the added benefit of providing a means of linking micro and macro concerns within E&NR sociology. Finally, I point out the conceptual consistency between structuration theory in sociology and hierarchy theory as it is used in natural resource ecology, and then I illustrate how this consistency could be the basis for fostering better ways of exploring the relationships between social and ecological systems in management and research.

Why a New Model for Socioecological Systems?

The first need for an integrative socioecological model is to overcome the disjunct between micro and macro approaches within the disciplines of environmental and natural resource (E&NR) sociology (Beus 1993; Buttel 1987; 1996; Goldblatt 1996; Hannigan 1995; Nyhus et al. 2002; Michaelidou et al. 2002; Redclift and Benton 1994; Redclift and Woodgate 1994; Spaargaren and Mol 1992). For example, Buttel (1987) points out that current theory in the field of environmental sociology is largely structural and does not address the "micro" elements of "subjectivity and agency," while the empirical work done in the field is "exclusively subjectivist and micro-sociological and could benefit from a "macro-structural orientation" (484). Scoones (1999) makes the same argument by criticizing what he calls the decontextualized approaches that dominate the study of socioecological systems and his advocacy of attention to context:

> Such largely micro-level studies are usefully complemented by a wider appreciation of the institutional and political processes that mediate the relationship between agency and structure across multiple scales in the processes of environmental and social change. (15)

To better understand the origins of public beliefs and attitudes regarding environmental and natural resource policy issues, the relationship of individual schemas (Sewell 1992) to large-scale structural patterns needs to be considered. Recognizing the link between macro and micro social dynamics within E&NR sociology could facilitate understanding of how different institutional processes influence both one another and ecological phenomena at various scales of space, time, and organizational complexity. Natural resource managers continually encounter institutional constraints in the form of regulation and law, and in the cultural perceptions of resource stakeholders. Explicit incorporation of institutional constraints in ecosystem management analysis is needed to avoid either inadvertently removing constraints that provide system stability (O'Neill et al. 1986), or repeatedly dealing with localized issues while ignoring the systemic institutional structures that precipitate them.

> If adaptive management is to be truly adaptive, it should take into account not only the particular, concrete conflicts of interest involved in a given land use controversy, but also the larger societal mechanisms that these conflicts enter into.... To understand the driving forces behind these disputes, it is therefore necessary to have a broader scope. (Skogen 2003, 448)

The next issue that needs to be addressed is how the disciplines of ecology, resource management, and sociology can be integrated to analyze socioecological systems as a unity—a task considered to be of major import by many (Alberti et al. 2003; Beus 1993; Eckhardt 1998; Field et al. 2003; Fight et al. 2000; Heemskerk et al. 2003; Karr 1994; Kates et al. 2001; Lubchenco et al. 1991; Luzadis et al. 2002; Machlis et al. 1997; Michaelidou et al. 2002; Naveh 1994; 2000; NSB 2000; NSF 2000; Rosa 1999; Rosa and Machlis 2002; Scheffer et al. 2002; Stern 1993). For example, the NSF report "Developing a Research Agenda for Linking Biogeophysical and Socioeconomic Systems" strongly recommends integrated research and "developing coupled models of social and ecological systems" (2000):

> All participants affirmed that a bold departure from the status quo of disciplinary science was needed to address pressing national needs. Interdisciplinary research will represent one of the frontiers of the scientific inquiry in the 21st century, as scientists *elucidate the dynamics of complex and interdependent social and natural systems, and extend existing, discipline-based theories and paradigms to new conditions and circumstances* (1). Research in this area should focus on changes in ecological dynamics under human intervention—particularly changes in the "*spatial and temporal*" signatures of those dynamics—and how those changes relate to characteristics (*spatial and temporal structure*) of human institutions. (20; emphasis added)

The emerging concept of "sustainability science" is directly focused on the integrated study of ecosystems and social institutions across "the full range of scales from local to global" (Dietz et al. 2003; Holling et al. 2002a; 2002b; Kates et al. 2001; NCSE 2000). Similarly, Field et al. (2003) state that E&NR sociologists "recommend the inclusion of biophysical variables within a comprehensive integrated social biophysical framework" (357–358) and agree with Grove and Burch (1997) that such comprehensive models must focus "on patterns and processes at different scales" [such as the hierarchical/structuration approach offered here], and that such a conceptual framework promotes "shared biosocial vocabularies and measures" (Grove and Burch 1997, in Field et al. 2003, 358). Others (Eckhardt 1998; Heemskerk et al. 2003; Michaelidou et al. 2002; Nyhus et al. 2002) have similarly voiced the need for shared concepts between the social and biophysical disciplines for socioecological analysis and governance.

> To better understand and manage complex socialecological systems, social scientists and ecologists must collaborate. However, issues related to language and research approaches can make it hard for researchers in different fields to work together.... Researchers can improve interdisciplinary science through the use of conceptual models as a communication tool. (Heemskerk et al. 2003, 1)

> We need new conceptual frameworks; new theories that would make it possible to think in terms of the larger picture. (Eckhardt 1998, 2)

Some biological ecologists, natural resource scientists, and conservation biologists already recognize the "tight linkage" between social and ecological phenomenon. For example, some see a direct institutional conflict between neoclassical economics, property institutions, and conservation (Czech 2000a; Czech 2000b; Czech et al. 2000; Dasgupta et al. 2000; Hall et al. 2000; Naveh 2000; Yaffee 1996), and have asserted that biodiversity loss will be unpreventable by traditional natural resource management approaches unless the social (i.e., institutional) constraints on ecological systems are addressed (Czech 2000a; Czech 2000b).

Perhaps the most developed attempt to form a socioecological model is that elaborated in Holling et al. (2002b). This is a further explication of hierarchy theory, but adds a new moniker (panarchy) to take away the linear "top-down" control implication in the word "hierarchy." Hierarchy theory is also modified to emphasize the patchiness and nonlinear uncertainty inherent in both ecological and sociocultural "systems."[1] The socioecological systems (SES) model proposed here is similar in that it represents an application of hierarchy theory, but differs significantly from Holling et al. (2002b) in its focus on social theory, and the use of structuration theory (especially that of Sewell 1992) to demonstrate how large-scale institutions inform the micro sociological reality that is a focus within much of E&NR sociology (and in turn, how small-scale sociological phenomena produce—enact—structure at larger scales). The SES model proposed here is thus directed more to E&NR sociologists than biological and human ecologists as the Holling et al. (2002b) model; however, the importance of scale and process is key to both approaches.

In the following presentation of the SES model I focus on its use for linking interpretive or micro approaches with social and ecological dynamics at larger scales. I see the failure to recognize this linkage as a weakness in much of human dimensions research and practice.

> Such largely micro-level studies are usefully complemented by a wider appreciation of the institutional and political processes that mediate the relationship between agency and structure across multiple scales in the processes of environmental and social change. (Scoones 1999, 15)

Developing a Socioecological Systems (SES) Model

The model proposed here is simply the combination of two models already in existence (with slight modification): structuration theory in sociology—especially as elaborated by Sewell (1992)—and hierarchy theory as used in ecology and resource management (e.g., Allen and Hoekstra 1992; O'Neill et al. 1986). The SES model illustrates how structuration theory and hierarchy theory are both "hierarchy theories" that apply to very similar complex and interconnected systems, and suggests that socioecological systems can be fruitfully conceptualized, like all complex systems, as a hierarchical system of dynamic processes (rather than components) (O'Neill et al. 1986). The major difference, of course, is the cultural element of human social systems whose "internal" scalar dimension of "cultural schemas" is a part of Sewell's (1992) structuration approach. No similar mental models, entelechy, intentionality, or teleology are assumed for the (exclusively) nonhuman processes in socioecological systems—hierarchically structured or otherwise. However, incorporating the notion of schemas in the SES model is a means to include the (human) cognitive component of socioecological systems as an integral driver of socioecological evolution.

Structuration theory (Giddens 1981; 1984; Sewell 1992), institutional theory (Friedland and Alford 1991), and Bourdieu's concept of *habitus* (Bourdieu 1989, 1990; Brubacker 1985) are all attempts to breach the agency–structure dichotomy in social theory and methodology, a dichotomy that Buttel (1987) pointed out as a problem in the context of environmental sociology. Individual actions produce large-scale structure even as such actions are recursively shaped by structure.

> Structures shape people's practices, but it is also people's practices that constitute (and reproduce) structures. Rather than opposing one another, human agency and structure *presuppose* each other. (Sewell 1992, 4; emphasis added).

> Let me return again to the differentiation between micro- and macro-sociological analysis. ... There can be no theoretical defense for supposing that the personal encounters of day-to-day life can be conceptually separated from the long term institutional development of society. (Giddens 1981, 342)

Individuals use their knowledge (schemas) of institutional beliefs and practices to strategize appropriate actions in the expression of human agency. Thus, social "structure" becomes both a constraint and a resource for humans. Structuration theory envisions social structure as a *process*, seeks to bridge the micro–macro dichotomy in social research and theory, considers agency as a constituent of structure, and conversely views structure as *empowering* social actors as well as constraining them (e.g., the knowledge of structure gives people the capability to strategically act in a social environment).

This concept of "freedom within constraint" is fundamental to structuration and hierarchy theory (as well as information theory) (Allen and Hoekstra 1992; Giddens 1984; Ingram and Clay 2000; O'Neill et al. 1986; Sewell 1992).

> Asymmetric relationships occur between hierarchical levels and are called "constraints." ... This constraint is a natural consequence of the asymmetry in rate constants. The rates always become slower as one ascends the hierarchy and, therefore, the lower levels are constrained. (O'Neill et al. 1986, 95)

The asymmetry in process rates is what produces the "structuration" aspect of both social and ecological systems.

> Hierarchical organizations actually involve a double asymmetry. Lower-level behaviors are essential to the functioning and persistence of higher-

> level structure that, in turn, constrains the behavioral flexibility of all lower-level objects. (O'Neill et al. 1986, 95)

Or, in Sewell's (1992) words,

> Historical agents' thoughts, motives, and intentions are constituted by the cultures and social institutions into which they are born . . . these cultures and institutions are reproduced by the structurally shaped and constrained actions of those agents. (5)

Ingram and Clay (2000) point out that without institutional constraints (patterns of social interaction), the "transaction costs" of social interaction would be prohibitive. Perhaps the most familiar illustration of this aspect of hierarchy/structuration theory is language (Giddens 1981; Sewell 1992), which is "constrained" by rules of grammar and other conventions, yet within these constraints a seemingly unlimited variety of creative expressions can be formed. In fact, without such constraints there would be no information content, in language or other complex systems. Complete freedom (no structure) is chaos and unintelligibility, while total constraint obviates creativity and novelty (Holling et al. 2002b).

> In order to "bring off" . . . interaction, [social agents] make use of the institutional order in which they are involved in such a way as to render their interchange "meaningful" . . . *there is no other way for participants in interaction to render what they do intelligible and coherent to one another.* (Giddens 1984, 331; emphasis added)

The other important aspect of "freedom within constraint" is the scale dependence of process rates elaborated by O'Neill et al. (1986). Put simply, in both structuration theory and hierarchy theory, large-scale processes are "big" and "slow," while small-scale processes are local (small, idiosyncratic) and ephemeral (rapid, flux). Veblan's concept of institutional lag, for example, reflects the truism in sociology that large-scale institutional formations are usually slow to change and innovate, while the small-scale, face-to-face interactions and activities of individuals change frequently in space–time. Similarly, in resource management ecology, O'Neill et al. (1986) give the example of "individual tree leaves respond[ing] rapidly to momentary changes in light intensity, [and] CO_2 concentration . . . [while] the growth of the tree responds more slowly," dampening the signal of small-scale fluctuations in the expression of higher scale phenomena, while "changes in the [entire] . . . forest occur even more slowly," at the scale of decades or centuries (76). Such constraints confer stability in both social and ecological systems (Giddens 1984; O'Neill et al. 1986).

In the case of social institutions, these constraints—or structures—have both external and internal components. External components consist, for example, of written legal codes and their enforcement or technology ("resources" in Sewell's terminology), while the internal components are the deep schemas (or mental models) of socially, historically, and culturally positioned social actors (Sewell 1992; Westley et al. 2002). While the structurally shaped actions of social actors recursively provide the mechanisms for higher scale phenomena, actors can innovate by applying schemas learned in one institutional realm to "resources" in other (new) institutional realms (a mechanism Sewell [1992] refers to as the ''transposability of schemas''), thus furthering agency as well as social and institutional change (Sewell 1992).

Lifeworld formation in terms of Sewell's (1992) model can be described by considering preexisting structures as constituting a ''smorgasbord'' of available schemas and resources that the individual appropriates (intentionally or unintentionally), depending on his or her particular social, cultural, and historical location, and the social power differentials influencing the degree of assertion—or negation—of the various schemas in society; however, these schemas can be creatively ''transposed'' onto new resources to create novel structures. Sewell (1992) defines ''structures'' as a dyad of ''schemas'' and the ''resources'' to which they apply.

Figure 1 is a graphic illustration of the SES model, and is adapted from the scalar model of ecological criteria in Allen and Hoekstra (1992, 53). The cones in the figure represent holons[2] and are used to illustrate scale as a relational term and that there can be multiple scales of analysis (i.e., scalar phenomena are continuous and nested, while discreet scalar levels are defined in the context of a specific analysis.). By *relational* I mean that any given scale of observation is only ''large'' or ''small'' relative to phenomena that exist at scales outside the analysis. The large end of the cones represent large-scale phenomena, which are fewer (but larger in extent) than the more numerous smaller scale processes nested within them, which provide the ''mechanism'' for the larger scale phenomena (Allen and Hoekstra 1992). Although the holons representing the scalar nature of both ecological criteria and social institutions interact with one another on multiple scales, lines linking the holons are omitted to emphasize the process nature of the model, and to point out that interactions between different institutional and ecological realms are multiple, synchronic, and span differentials in interaction frequency (both within and among holons) that create the ''fuzzy'' boundaries (symbolized by the dashed lines) between these phenomena (O'Neill et al. 1986). Specific relationships between (or within) holons (ecological and/or institutional) are defined by a particular analysis.

Holons include ecological criteria such as biological community, ecosystem, landscape, and population. The social component of socioecological systems is expressed in terms of its constituent institutions, which include both the internal cognitive dimension of human ideation (schemas) and the external component of human social behavior and cultural resources. The biophysical (e.g., genetic, physiological, morphological) nature of *Homo sapiens* is captured by the ecological criteria in the model (not all criteria are illustrated), as are ''natural'' resources such as forests (which make up the resource component of social structures along with the schemas that apply to them). Although we are a biological species, the human ''social construction'' of the world so envelops us, and so influences biophysical processes, that for heuristic purposes at least, social processes defy being subsumed within ecological criteria (developed with the false assumption that somehow humans are external to ecological systems). However, in doing so the SES model retains much of the dualism between humans and ecological systems that it tries to address.

Socioecological systems (SES) can be conceived as consisting of four principal ''dimensions.'' Two dimensions of the SES model are vertical scale and horizontal ''categories'' of socioecological phenomena (social institutions and ecological criteria). The ''vertical'' dimension of scale encompasses spatial and temporal extent, degree of organizational complexity, and Sewell's notion of cultural depth. The ''horizontal'' dimension refers to the various groupings within which humans place reality, either nominally or empirically based (based on process rate boundaries)

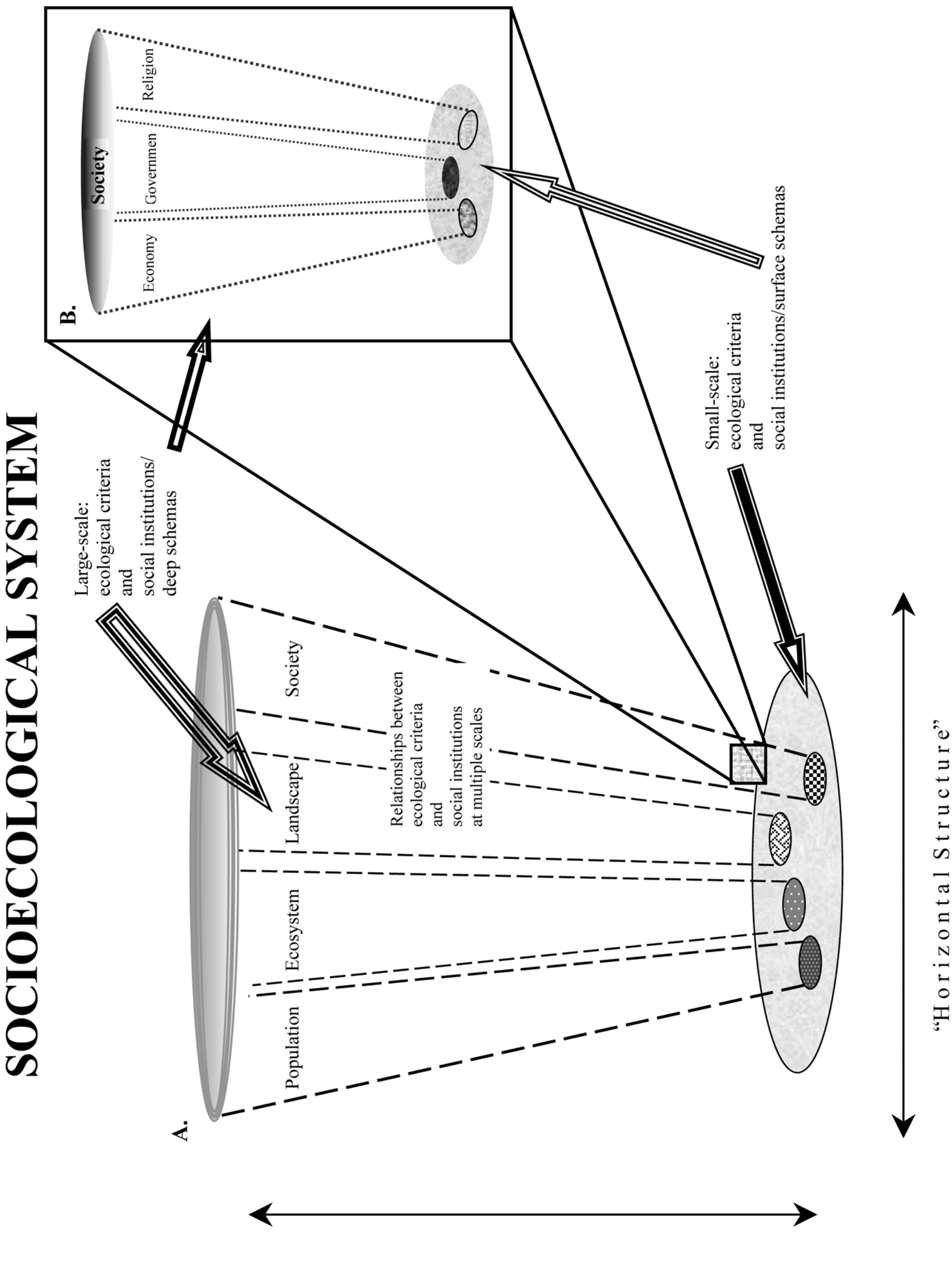

Figure 1. Socioecological systems (SES) model adapted from Allen and Hoekstra (1992, 53). (A) Cones indicate holons corresponding to examples of ecological criteria and society. Dotted lines symbolize the multiple, continuous, and synchronic relationships between scalar processes. (B) Blowup of society holon with examples of social institutions.

(O'Neill et al. 1986)—for example, social institutions such as family, church, and state, and ecological criteria such as community, population, and ecosystem. O'Neill et al. (1986) explain the empirically based demarcation of horizontal structure represented by separate holons:

> Strongly interacting components form a specific holon and are delimited from other holons at that level. The strong interactions within a holon reflect fast rates of exchange between components. Fast rates of exchange may be seen as high-frequency activity within the holon. The rate change that occurs at a surface reflects the decoupling of components within one holon from components of other holons. (95)

The other two dimensions of the SES model are "external" and "internal." The external dimension consists of the resources and behaviors that constitute social institutions and ecological criteria, such as written laws and their enforcement, technology, and forests, while the internal dimension consists of the schemas, mental models, institutional logics, or concepts in the human mind that inform action and give meaning to resources.

Unlike many "box and arrow" models, the cones in the SES model emphasize scalar processes, rather than static components. Social structure is enacted (Giddens 1984). Similarly, ecological criteria such as community and ecosystem connote suites of processes such as competition and predation in the case of community, and carbon cycling and trophic structure in the case of ecosystems (Allen and Hoekstra 1992; O'Neill et al. 1986).

Multiple schemas and institutional logics, along with their associated behaviors and resources, make up a given society and interact differentially, at various scalar combinations, with the different ecological criteria that make up the nonhuman component of socioecological systems. Social institutions interact with ecological phenomena (or criteria) throughout their respective scalar ranges, resulting in multiple relationships of interaction between social institutions and ecological criteria at all possible scales.

The SES model is an improvement over existing models for three primary reasons: (1) It incorporates scale as a means of organizing socioecological systems, and by demonstrating the conceptual identity between structuration theory and hierarchy theory provides a common conceptual framework for socioecological investigation. (2) By incorporating Sewell's (1992) structuration approach the model provides a means of integrating micro–macro socioecological analysis. (3) The SES model provides an "engine" for component-based models by focusing on the dynamic nature of social and ecological phenomena as captured in structuration and hierarchy theory.

Applications

Like the conceptual models ("theories") upon which the SES framework is based (Allen and Hoekstra 1992; Friedland and Alford 1991; Giddens 1984; O'Neill et al. 1986; Sewell 1992), the SES model is not intended to represent a falsifiable hypothetico-deductive model. Rather, it is an interpretive model that provides a conceptual scheme to enhance interdisciplinary communication and promote scholarly discourse and research on holistically conceived socioecological systems, just as do most of the component models that have been cited in this article.

Giddens (1984), for example, criticizes the notion that

> The only theory [is that which is] expressible as a set of deductively related laws or generalizations. . . . That sort of notion has turned out to be of quite limited application even within the natural sciences. . . . Much of what passes for social theory consists of conceptual schemes rather than explanatory propositions of a generalizing type. (xviii)

I see this as an advantage of the SES model, because it does not automatically exclude other causally based models and hypotheses from being constructed within its framework, and it can entertain a variety of methodological approaches.

Hermeneutically, the model is a means for relating the schemas expressed by informants in a particular case study to larger institutional structures—both internal and external. Doing so allows both a better understanding of how these larger "deep structures" in the internal dimension of socioecological systems influence local natural resource debates, but also how such structures are used by agents in various ways to promote their own agendas. Without such consideration of context, case-study work becomes anecdotal, cut off from the institutions within which agents exist, draw from, and reproduce. The SES model proposed here provides a general framework to locate such research and analysis within its larger social and ecological context.

Although at this stage of development the SES model is principally a qualitative or interpretive guide for conceptually organizing socioecological systems, it does have some specific practical applications for resource management planning. For example, resource managers and policymakers, as well as practitioners working in environmental or natural resource dispute resolution, are continually confronted with institutional limitations (e.g., Moote and Becker 2003). These limitations take the form of both external institutional constraints at higher scales, such as national environmental laws and policies, but also large-scale "internal" institutional constraints in the form of "deep schemas" or "institutional logics" held by individuals contesting resource management decisions (Friedland and Alford 1991; Hurley et al. 2002; Sewell 1992). These schemas can include notions of property, social legitimacy, "nature," etc., from which individuals' positions on particular natural resource controversies draw from (McFarlane and Boxall 2000; Skogen 2001; 2003; Wilson 1997). Thus, issues in natural resource policy are related to more fundamental cultural fracturing in society manifest through competing "institutional logics" (Friedland and Alford 1991). Resource policy debates are thus "bounded" within these "taken for granted" structural underpinnings, and therefore represent only a specific example of systemic cultural conflict within society.

> Socioeconomic systems, like biophysical systems, exist at a hierarchy of scales. Ecological processes, whether socioeconomic or biophysical, cannot be fully understood by examining a system at a single scale. This is particularly true for socioeconomic processes; the socioeconomic influences on the biophysical aspects of a forested watershed usually come from socioeconomic systems at (several) larger scales and result in influences that ripple out across several smaller scales. (Fight et al. 2000, 3)

Awareness of higher scale constraints and coordinating the scale of analysis or policy with the scale of the resource problem are essential for management.

Identifying higher scale constraints on the management system allows greater predictability of system behavior under various management scenarios (Allen and Hoekstra 1992; O'Neill et al. 1986).

> Whenever the scientist approaches the natural world with a particular purpose in mind, he or she must select the scale appropriate for that purpose. ... Isolating the relevant scale of dynamics is a critical step in setting up any problem. ... The scale of observation then determines that major attention must be focused at a particular organizational level. Higher-level behaviors occur slowly and appear in the description as constants. (O'Neill et al. 1986, 82)

Changing constraints on a system results in "lumpiness" (Holling et al. 2002b) or destabilization of a system, with a resulting loss of predictability (Allen and Hoekstra 1992). Local resource policy considerations do not always take into account these important aspects of higher level social or ecological constraints, and thus ignore a critical determinate of the system they are trying to manage, literally, "out of context."

Considering natural resource policy at the national and international scale, there is increasing awareness of the need to create the appropriate institutional forms that are sensitive to specific contexts and the various scales that resource management problems manifest (Dietz et al. 2003; Peterson 2000; Scoones 1999). "Sustainability science" (Dietz et al. 2003) does this by proposing the development of resource management institutions that are "tailor-made" to the specific scale of resource management systems from local to global scales. Such a shift in approaches is a response to the perceived failure of centralized "command and control" resource management (Kemmis 2001; Rossman 2003; Wily 1999; Zanetell and Knuth 2002), and recognition that different institutional forms are needed to best match each particular resource management situation.

Fight et al. (2000) relate an example from the Columbia Basin of the Northwest United States that illustrates the importance of considering and modeling the scalar interrelationships between ecosystems and human institutions:

> Looking at the socioeconomic system operating at the scale of an unpopulated, headwaters watershed common to much of the Pacific Northwest, we would see few human residents and few changes to the watershed overall caused by those residents. But, at a multicounty region scale, the socioeconomic system is active in the watershed with industries that use resources from its forests, lands, and waters, and with recreationists who desire certain qualities and experiences from their visits to the watershed. At a national scale, the socioeconomic system also influences the ecosystem of the watershed with a national market for wood, minerals, and energy; national sentiments about how it should look and be protected; and national laws, regulations, and policies about air and water quality, fish and wildlife habitat, and forest management. (4, 5)

In response to such scalar socioecological variations, Sneddon et al. (2002) "advocate an integrative approach to analyzing human-water dynamics and water conflicts that remains cognizant of physical, ecological, and social processes operating at different geographical and temporal scales" (666), which they apply to a case study of river basin management in Thailand (Sneddon 2002). Naveh (1994) also expresses the need for synchronic analysis of scalar dimensions of institutional and ecological relationships:

> Approaching biodiversity from a holistic view of landscapes as complex natural and cultural gestalt systems of the total human ecosystem, the strictly biological connotations of biodiversity can be expanded into a broader trans-disciplinary concept of landscape ecodiversity. This concept incorporates the biological, ecological, and cultural landscape heterogeneity at different spatial and perceptional scales.... Innovative methods will be necessary, transcending the realms of natural sciences into those of human ecology and overruling conventional mechanistic, scientific paradigms. (204)

Resource managers need a planning model that promotes consideration of institutional as well as ecological forcing mechanisms at scales beyond their immediate management purview, and additionally, one that promotes a cognizance that actions taken at the local level serve to either maintain (reproduce) or promote deinstitutionalization of larger scale social formations. I believe the SES model can serve as a metatheoretical framework to "spin off" such planning models.

Although some natural resource scientists (e.g. Czech 2000a; 2000b; Czech et al. 2000) are increasingly recognizing these institutional forces, they are easily overlooked in the narrow focus of managers to local policy and ecolgical problematics (Michaelidou et al. 2002; Warren and Rollins 2003).

> Larger social, economic, and political processes that originate far from local communities may also pose a threat to the local natural environment and culture (Wells et al. 1992; Barrett and Arcese 1995; Brandon 1997; Larson et al. 1998; Newmark and Hough 2000). Failing to address the external forces that impact natural areas and local communities may negatively affect ecosystem and community viability. Despite their impact, external [institutional] forces have often been ignored by conservation and development initiatives to date (Brandon 1997). Thus, any guide or theoretical framework needs to include a third dimension, *external forces*. (Michaelidou et al. 2002, 603; original emphasis)

One example of how social and ecological realms intersect in scalar dimensions of ecosystem analysis is the current interest in describing historical ecosystems based on how past (premodern) human cultures influenced heretofore considered "pristine" landscapes (Foster et al. 2003; Naveh 1994; Scheffer et al. 2002). In this realm both the temporal dimension of human institutions and "natural" ecosystem dynamics influence one another in complex ways that belie the simplistic notion that to restore ecosystem "health" we need merely to recreate premodern conditions. Consideration of the temporal scale of human institutions and their affect on landscapes at different scales is an emerging focus of study in natural resource management (Askins 2000; Carroll et al. 2002; Laliberte and Ripple 2003; Owen 2002).

Another application of the SES model is the incorporation of social power in resource management planning and collaboration. Sewell's (1992) structuration approach characterizes social power as the capability to produce or reproduce a structure or set of structures to one's advantage. In terms of natural resource debates, advocates of a particular schema, set of schemas, or institutional logic applied to a particular resource seek to advance their structure of the resource problematic against other competing structures. No adequate understanding of natural resource conflict is possible without considering the "warping" of idealized (fair, just, and legitimate) institutional "space–time" by the differential distribution of social power among the various contestants in natural resource controversies. By employing one or more of the four principal sources of social power—ideological, military, political, and economic (Mann 1986; 1993)—individuals and groups impose their "structures" on others: metaphorically, a "survival of the fittest" among competing schemas of social and ecological reality, a competition for what Bird (1987) has characterized as the "power to name the world." And of course, resource management agencies and institutions are not—as often pictured—neutral arbiters of this contest, but are themselves political actors seeking to impose their own schemas of appropriate natural resource management and "nature" on the rest of society (Busch 2000; Fischer 2000; Held 1980; Lyotard 1984).

> The fundamentally political issues of structural relations of power and domination over environmental resources have been seen by a variety of scholars as critical to understanding the relationships of social, political, and environmental processes. (Scoones 1999, 6)

The SES model gives natural resource managers and human dimensions scholars a conceptual framework to relate the values and assumptions of natural resource policy advocates to the larger scale (both internal and external) institutional realms from which they derive (and recursively maintain), giving greater meaning and relevance to micro-sociological investigations in E&NR sociology, and prompting managers to consider both institutional and ecological constraints on potential management solutions. Higher scale ecological and institutional phenomena provide context, and socioecological processes at smaller scales provide the mechanisms to the specific socioecological systems that are the focus of management and policy.

A structuration approach promotes a socioecological analysis that considers the deep cultural schemas that shape and direct specific attitudes, positions, and behaviors relevant to a specific natural resource problematic, as well as how these deep schemas are enacted in specific resource management controversies. The SES model also gives an explicit form to considering the influences between social institutions—at various levels of time, space, and organizational complexity—and landscapes or ecosystems, thus permitting examination of the historical interaction between a changing and multi-institutional human civilization and the nonhuman realm of physical, chemical, and biological processes.

However, "each theoretical perspective has places it cannot see, territory it cannot map" (Friedland and Alford 1991, 10), and the model proposed here is no different. Models, after all, are intended to be simplifications of reality to help us understand, and are not to be confused with reality itself. A model's merits are based not solely on its "accuracy" in terms of some representation of the "real world," but rather on the degree to which it allows us to arrange the world in a way that gives new insights, to ask new questions, and to see further.

Conclusion

I've argued that the conceptual identity between hierarchy theory (as used in ecology and natural resource management) and structuration theory can be used as a basis for a unified process model of socio-ecological systems. That both social and ecological systems can be conceptualized using hierarchy theory also points to their similarities as thermodynamically open complex systems, and to additional ways in which socioecological analysis may be integrated. Structuration theory is also important in that it is a means whereby micro–macro bifurcation in sociological analysis can be bridged to make micro-level case studies in E&NR sociology relevant to greater understanding of larger scale institutional dynamics in society, and, conversely, how these larger sociocultural currents manifest themselves in the more focused realm of natural resource controversies. Perhaps most important, the SES model emphasizes society as part of "nature." Human ideation and the institutions that our mental models inform are an inherent component of the world's ecological systems. Social structure must be addressed at the multiple scales at which institutional forces are manifest to increase our understanding of the changing human relationship to biophysical phenomena.

Notes

1. The term "system" is problematic in discussing social and ecological phenomena because it implies strong linkages between components, stability or equilibrium, and feedback mechanisms. Socioecological "systems" rarely (if ever) exhibit such characteristics except when considered on trivially small scales, but for want of another term I retain the use of "system" in this article.
2. "Holon" is a term in hierarchy theory that refers to a phenomenon or process that exists as a scalar subsystem (e.g., ecosystem criteria, human institutions).

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