Journal of Ethnobiology 29(2): 339–358 Fall/Winter 2009

# THE PARADIGM OF MANAGEMENT, MANAGEMENT SYSTEMS, AND RESOURCE STEWARDSHIP

Ken Lertzman

*The idea of ''management'' is central to our understanding of how people interact with their resources, but many challenges have arisen to traditional concepts of western, science-based resource management. Management is a set of actions taken to guide a system towards achieving desired goals and objectives. A Management System is the sum of these actions, goals and objectives, the process through which they are legitimized by social norms, and the institutions and actors involved in carrying them out. Reframing the concept from management to management system provides a tool for better understanding how social and ecological dynamics act as coupled drivers of managed ecosystems. Seen from this perspective, there are strong parallels between the traditional resource management systems of indigenous peoples and western science-based management systems. Stewardship is a western concept which resonates with the foundations of traditional resource management systems. Both systems of management can be understood on gradients of human influence on ecosystems and of management intensity. Sustainability can emerge across various locations along these gradients. Achieving an integrated understanding of the coupled dynamics of social and ecological systems is a central challenge for both managers and for researchers.*

Key words: *traditional resource management system, western science-based management system, management failure, stewardship, sustainability.*

*La idea de ''manejo'' es central para nuestro entendimiento de cómo la gente interactúa con sus recursos. Sin embargo, muchos retos han surgido a los conceptos tradicionales occidentales sobre el manejo de recursos basados en la ciencia. Manejo es un conjunto de acciones tomadas con el fin de guiar un sistema para alcanzar metas y objetivos deseados. Un Sistema de Manejo es la suma de estas acciones, sus metas y objetivos, el proceso a través del cual éstas se legitiman por normas sociales, y las instituciones y actores involucrados en llevarlas a cabo. Replantear el concepto de manejo por el de sistema de manejo proporciona una herramienta para el mejor entendimiento de cómo las dinámicas sociales y ecológicas actúan como conductores acoplados de los ecosistemas manejados. Desde esta perspectiva, existen fuertes paralelismos entre los sistemas tradicionales de manejo de recursos de los pueblos indígenas y los sistemas de manejo occidentales basados en la ciencia. Stewardship es un concepto occidental que armoniza con las bases éticas de los sistemas tradicionales del manejo de recursos. Ambos sistemas de manejo pueden ser entendidos como gradientes de influencia humana sobre los ecosistemas y la intensidad de manejo. La sustentabilidad puede emerger en varios puntos a lo largo de estos gradientes. Alcanzar un entendimiento integrado de la dinámica acoplada de los sistemas sociales y ecológicos es un reto central tanto para manejadores como para investigadores.*

## Introduction

Human populations have always interacted strongly with the ecosystems in which they participate. Traditional societies are critically dependent on the dynamics of local ecosystems and exhibit diverse, nuanced, and deep knowledge of those ecosystems (e.g., Berkes 2008; Turner and Berkes 2006). They also exhibit a diverse array of formal and informal social constraints on how people interact

Ken Lertzman, School of Resource & Environmental Management, Simon Fraser University, Burnaby, BC, V5A 1S6 CANADA (e-mail: Lertzman@sfu.ca)

with resources and ecosystems, on the distribution of rights to access, and responsibilities for stewardship. These social constraints, the knowledge they embody, and the behaviors they enable, can collectively be considered as ''management systems''. In modern industrial societies we also depend on the products and services of ecosystems. Indeed we depend on them to the extent that by 1986 we had appropriated 40% of the annual products of global photosynthesis (Vitousek et al. 1986), and by the mid-1990s we were using more than half the available freshwater on the earth, the products of industrialization and land-use change were transforming the earth's atmosphere, and we were the dominant source of global N fixation (Vitousek et al. 1997). Modern western societies have also developed intricate social constraints on how we interact with resources and ecosystems. These modern management systems are often intended to provide for sustainability and the distribution of benefits within society, a goal which is achieved variably across ecosystems and management institutions (e.g., Acheson 2006; Ludwig et al. 1993; Rosenberg et al. 1993). Though our conception of sustainability has emerged in the context of modern industrial societies, such concepts often have strong parallels in indigenous cultures—for instance the ubiquity of the idea of respect for other living things (Anderson 1996; Berkes 2008; Turner 2005; Turner and Berkes 2006).

The relationships of indigenous peoples to the ecosystems they live in not only reflects an intimate knowledge of the ecology of those systems, but the deep structure of their beliefs about their role in the world, their cosmology and values, and their social institutions and relationships (e.g., Berkes 2008; Lertzman 2006; Turner 2005; Turner and Berkes 2006; Deur, Wyndham *this volume*). Western societies also typically embody a complex mix of knowledge and beliefs in our relationships with resources. While our management systems reflect a significant base of scientific knowledge about resources and ecosystems, our relationships and patterns of use also reflect a strong imprint of our social institutions, historical precedents, and our beliefs about the nature of the world and our role in it. There are thus some significant parallels in the structure of traditional resource management systems and modern science-based resource management systems. Table 1 illustrates some of these broad similarities, such as a knowledge base that is responsive to empirical experience or management practices that require special skills and knowledge ''held'' by trained individuals (e.g., Turner and Berkes 2006).

While global society struggles with the relatively new idea of sustainability in a broad sense, concepts related to sustainability have been present as core values in human interactions with resources since before ''resource management'' became professionalized as a science-based discipline (e.g., Berkes 2008; Turner 2005; Turner and Berkes 2006). Normative values associated with ethical and sustainable treatment of nature are ubiquitous in traditional management systems. Questions of sustainability, both in terms of societal or individual intent and in what was actually achieved on the ground, have also been a substantial part of the discourse on traditional management systems (e.g., Krech 1999, 2005; Smith and Wishnie 2000; Turner and Berkes 2006).

My goal here is to examine the relationships between our concepts of ''management'' in traditional resource management systems, such as are

TABLE 1. Comparing traditional resource management systems and western science-based management.

| Attributes | Traditional Resource Management Systems | Western Science-Based Resource Management Systems |
|---|---|---|
| Incorporates empirical knowledge about species or ecosystems | Yes | Yes |
| Embodies socially accepted theory about resources and ecosystems | Yes | Yes |
| Knowledge base changes over time in relation to changing experience, knowledge base or theory | Yes | Yes |
| Knowledge held, management guided by specially trained individuals | Frequently | Frequently |
| Successes and failures of management practice can be observed | Yes | Yes |
| Rights and responsibilities for management are contingent on successful management | Often | Often |

discussed elsewhere in this issue, and those of modern science-based resource management systems. The thesis I develop is that there are many broad parallels in these systems and that it is useful to see them as a part of the same continuum of anthropogenic influence on ecosystems. I approach this from the perspective of an applied ecologist with an interest in both the science (e.g., Lertzman et al. 1996a, 2002) and policy (e.g., Lertzman et al. 1996b) contexts of modern resource management and how traditional societies understand and interact with their resources (e.g., Lepofsky et al. 1996, 2005; Lepofsky and Lertzman 2008). I base my observations on both the scholarly literature that has developed in these areas and my interaction with colleagues from various disciplines, but also on interaction over many years with management directly via policy advisory panels, resource planning exercises, professional workshops for resource managers, and time ''on the ground'' with both indigenous and non-indigenous managers.

## What the Heck Is ''Management'' Anyway?

We use the terms ''management'' or ''manager'' to refer to very different kinds of tasks or people, but they have shared features. For many people, these terms will be most familiar in the context of businesses or other institutions. There, those who plan organizational strategy and tactics and often lead the teams for carrying them out are ''management''. These managers are tasked with not only making decisions about the strategy and tactics of an institution, but with establishing the structure in which those decisions are made. They are also often responsible for shepherding the processes though which those policies and plans are articulated. In a striking parallel to what I will discuss below about failures of resource management, Mintzberg (2004, 2009a, 2009b) argues that our

current global financial crisis is less a failure of economics or our understanding of the system *per se*, than it is a failure of managers and management systems. He suggests that managers acted in such a way as to bring about the current global financial crisis because our best schools of management trained them to do so. They acted—despite other, contrasting social values—on current social norms of profit, greed, and a peculiar interpretation of leadership versus ''community-ship'' (Mintzberg's term).

For our purposes, we can define *Management* as a set of actions taken to guide a system towards achieving desired goals and objectives, usually subject to a set of externally imposed constraints (such as cost, other values to be protected, etc.). In this system, the *Managers* are those who design and/or carry out those actions. A *Management System* is the sum of these actions, the goals and objectives, the process through which they are legitimized by social norms, values, and institutions, and the actors involved in carrying them out. These definitions should apply equally to management in both modern and traditional societies. To the surprise of some people, resource and environmental management is mostly about the regulation of *human behavior* in relation to the environment, rather than direct manipulation of the environment *per se*. For instance, this typically involves issues such as harvest limits and seasons, restrictions on harvest technology, regulation of the use of water resources or release of pollutants into the water, road construction standards, and so on. Increasingly, resource management also involves managing the land-use planning processes that determine where various kinds of human activities will take place. Formalized rules about the ''right'' way to interact with resources are common in traditional societies and are direct parallels to these examples of regulation of human behavior in western societies (e.g., Berkes 2008; Turner and Berkes 2006; Deur, Turner et al., Wyndham *this volume*).

Who is a manager? Some might consider managers only as the highly trained (often professional) cadre of decision makers in the management system. I am using the term more generally here to refer to all the actors in the system. The Rarámuri children who move livestock from fields to shelters on a daily cycle so that manure can be collected as fertilizer (Wyndham, *this volume*) are managers. So are the Klamath and Modoc people who used fire, special harvesting technologies, weeding, and transplanting, to increase the productivity of black huckleberry (*Vaccinium membranaceum* Douglas ex Torr.), yellow pond lily (*Nuphar polysepalum* Engelm.), and ***yampah*** (*Perideridia* spp.; Deur, *this volume*). The broad idea of a management system as defined above suggests that we need a broad, inclusive definition of who the managers are. While the term is often applied to the professional or decision-making levels of the management system in western societies, we need to include those who are active in carrying out the decisions on the ground (or the water). It is important that our concept of ''manager'' be able to apply equally to all those involved in both making and implementing decisions across the spectrum of management contexts. Two examples illustrate this. In these two examples, the managers need to be considered not just as those who interpret social norms in a codification of acceptable practice, but also those who implement that codification in what actually happens on the ground.

First, Rosen (1995) describes the social response to environmental change in early Bronze Age Canaan. This was a complex, hierarchical, social system with elaborate agricultural practices that could be finely tuned to the year-to-year environmental variation (especially in rainfall) characteristic of the dry ecosystems in which the agriculture was practiced. Rosen ascribes the eventual collapse of the Canaanite society to its inability to effectively mobilize societal resources to deal with a more major, long-term shift towards a drier climate. Key among her explanations for this collapse is the social discontinuity between the farmers, who had management tools for adapting to drier conditions, and the social elites, whose demands for resources prevented farmers from engaging those adaptive mechanisms. Rosen concludes that the downfall of the family-farm based agricultural sector became a major threat to the stability of the society as a whole. The managerial elite, by not including the needs of the small-scale farmers in their conception of the ''management system'' engineered the rigidity of their society and its eventual demise.

Second, when I was a member of the Scientific Panel for Sustainable Forest Practices in Clayoquot Sound (e.g., Scientific Panel 1994; Lertzman 2006; Lertzman and Vredenberg 2005; see *Conclusions* for a brief description of the Panel), we did a field visit which involved driving along a newly built road that crossed steep, rocky, difficult terrain, and of which the company involved was quite proud. Clayoquot Sound is a wet temperate rainforest ecosystem and the control of the flow of water associated with cut areas and roads is a key issue related to landslides and the consequent loss of terrestrial and aquatic productivity (e.g., Scientific Panel 1995a). Over a several kilometer stretch, the road engineer on our team stopped to inspect each culvert we passed to assess its function. Most culverts were not functioning as intended, either because they had been installed improperly, had been damaged in installation, or had not been maintained since installation. Despite an enormous, detailed, and carefully designed regulatory environment, with strict standards on roads and culverts, the success of the system depended on the knowledge, skills, and commitment of the crew installing culverts along the road. Without including these people in our understanding of the management system, it is doomed to failure. Notably, subsequent, very successful changes to the management system did include ''buy-in'' from such workers as a critical element of their success (Bunnell et al. 2009). Similar parallels could be made in the relations between fisheries scientists, regulatory agencies, and the fishermen who must implement regulations about fishing gear, locations, timing, and by-catch (e.g., Cox and Kronlund 2008; Smith et al. 1999).

The goals and objectives of management systems, whether traditional or western science-based, are diverse and are determined by their societal context. They include commodities, food, trade products, technology, conservation, and ecosystem health. In both modern and traditional societies, the products of resource management are used both for personal consumption and for trade. Managers generally ''manage'' to achieve goals or targets that are set outside the management system by societal norms and values. In evaluating a management system, a key question becomes whether we should evaluate the system solely by whether those goals and objectives are successfully achieved or whether we think

the goals and objectives expressed were ''correct'' or appropriate. This question is particularly relevant to discussions of past management systems where societal norms and knowledge were different than those of today. The issue dominates discussions of whether past traditional societies' approaches to resource management qualified those people to be considered conservationists or not (e.g., Hunn et al. 2003; Krech 1999, 2005; Smith and Wishnie 2000). The question of how we evaluate past management actions, however, also applies within the context of modern, science-based management. Many practices were undertaken with the best of intentions, given current understanding, that have subsequently been shown to be ecologically damaging (e.g., removal of woody debris from stream channels or the dispersed patch cutting system in the US Pacific Northwest; Cissel et al. 1999; Sedell and Froggatt 1984).

Some may be concerned that it is inappropriate to apply modern concepts and terminology of management to traditional management systems of the present and the past. However, it is clear that the parallels between managers across societies are very strong and the empirical and adaptive aspects of knowledge development in traditional resource management systems are similar to what we expect from a science-based process (e.g., Berkes 2008; Berkes et al. 2000; Turner and Berkes 2006). Furthermore, a significant body of research on common property resources and their regulation and management emphasizes the ubiquity of formal and informal systems of social controls on how access to and use of public or community resources is regulated in various societies (e.g., Dietz et al. 2003; Feeny et al. 1990; Johannes 1981; Klee 1980; Ostrom 2009; Ostrom and Nagendra 2006; Turner et al. 2005; Williams and Hunn 1982). This literature also focuses attention on the emergence of sustainable systems from a diverse range of regulatory approaches; natural resources in traditional societies were not simply subject to degradation via Hardin's tragedy of the commons (Feeny et al. 1990). Here, I will examine concepts of management and management systems in the context of both traditional indigenous societies and those based on positivist western scientific traditions, with a focus on the parallels between the two. Consistent with Lepofsky (*this volume*), I will refer to the traditional resource and environmental management systems of indigenous peoples as TREMS. The management systems of modern, industrial societies will be referred to as Western Science Based-Management Systems (WSBMS).

## From ''Management'' to ''Management Systems'': Transformation of the Core Paradigm

If avoiding population declines, species loss, erosion of ecosystem services, and degradation of environmental quality in general are the criteria for a successful management system, then modern resource management systems cannot be considered successful. Beyond the obvious public issues such as extinction, loss of habitat for late seral species, toxic pollutants, and threatened water supplies and quality, there has been a substantial discussion in the formal literature about the failures of resource management to achieve its core objectives (Acheson 2006). Holling and Meffe (1996) characterize the ''pathology of natural resource management'' as the loss of system resilience when natural variability is

truncated by management actions—and they ascribe this loss of variability as an almost inevitable consequence of the command and control structure of modern resource management systems. Similarly, Ludwig et al. (1993) asserted that resources are almost inevitably overexploited by modern, science-based management systems through a combination of the inherent complexity of the physical and biological systems driving resource dynamics and the social and economic systems driving resource exploitation. This perspective has been supported and expanded upon by a series of more recent large-scale assessments, especially of marine systems (e.g., Hilborn et al. 2005; Jackson et al. 2001; Worm et al. 2006). This approach, however, need not only apply to modern management systems—it seems to fit well with Rosen's (1995) description of agriculture in Bronze Age Canaan (and potentially many other systems; Diamond 2003).

While modern managers have often failed to achieve even the relatively simple objective of regulating a sustainable harvest of a renewable resource, there are many cases of excellent, sustainable management of harvested populations (e.g., Hilborn et al. 2005; Rosenberg et al. 1993). However, the problems facing our modern management systems are much more challenging than just setting harvest levels for managed populations. Sustainability is not just a question of ''sustained yield'' (e.g., Ludwig et al. 1993), but of managing the ongoing trends in a much larger set of resources, environmental services, and values. A forest manager must be concerned not only with determining how many trees to cut of what kind and with what silvicultural system, but also with how to provide habitat for fish and wildlife, non-timber forest products and how to manage water quality and quantity, recreational opportunities, cultural heritage, and carbon budgets. All of this, however, is subject to differences of opinions among diverse groups of stakeholders and other variables that drive the entire context for management, such as changing climate.

This kind of management problem with multiple, often conflicting objectives, significant uncertainty in action-response causality, and complex underlying social and ecological dynamics has been characterized as a ''wicked problem'' (Ludwig 2001; Rittel and Webber 1973; Shindler and Cramer 1999; Wang 2002). In forestry, for instance, the basic methodology for determining sustainable yields is relatively straightforward (compared to, say, fisheries, where the subjects are harder to find and are mobile). However, many problems in forestry today are inherently wicked (e.g., Bunnell and Dunsworth 2009), not because of challenges in meeting the classical issues of resource productivity and harvest rates, but because of the complex background of multiple environmental and social values and services inherent in forest ecosystems—and how they are responding to complexly changing social and biophysical environments.

Collectively, these problems have led some to declare ''the era of management is over'' (Ludwig 2001) or at least to pose the question of whether this may be so (Wang 2002). However, what is really being rejected is the notion of ''management'' as a deterministic sequence of actions to achieve a simple, restricted set of goals and objectives, such as a maximum sustained yield (Ludwig et al. 1993). Instead, what is needed is closer examination of what I defined above as a Management System—the sum of all the actions, the goals and

objectives, the process through which they are legitimized by society, and the actors involved in carrying them out. In response to the critiques of the late 20th-century model of scientific management of presumed deterministic systems (Holling and Meffe 1996 Ludwig 2001; Ludwig et al. 2001; Rittel and Webber 1973), we need a view of management systems that recognizes the underlying complexity, dynamics, diversity, and stochasticity of both the biophysical systems and the social systems that are part of the problem (e.g., Ludwig et al. 2001; Folke et al. 2004; Wang 2002). We need a conception of ''management'' wherein the managers and the system being managed are seen as interacting elements of the same larger system.

This is a perspective that has been pursued vigorously by those interested in understanding the mechanisms of resilience in coupled social and ecological systems (e.g., Liu et al. 2007; Ostrom 2009; Ostrom and Nagendra 2006). It is also a perspective on the place of humans and their actions that is remarkably consonant with that of indigenous cosmology, where managers are not seen as inherently separate from the managed system and ''respect'' is due to all parts of that system irrespective of their utilitarian value (Turner and Berkes 2006). Indeed, the idea of Ecosystem Based Management (e.g., Grumbine 1994), the latest concept in WSBMS to attempt this kind of holism and integration in a management context, has been equated to the Nuu-chah-nulth concept of ''Hishuk Ish Ts'awalk'' (''everything is one''; Science Panel 1995a,b).

**Clusters of Related Concepts – Management, Conservation, and Stewardship**

There are several terms that are used in the context of both traditional and modern resource management and often form a tangle of concepts in discussions. All fall under the rubric of management systems as I have defined them—and they are differentiated on the basis of the *objectives* of management. Resource management overall is, in principle, value neutral in that it is intended to achieve goals and objectives provided to it by its societal context. The job of management is to manifest in practice the normative values of society that are reflected in policies, plans, and accepted behaviors. However, conflicts about management are frequently generated because various distinct communities in a society differ in their values in relation to natural resources and thus the management practices and approaches they desire. In societies with WSBM, these differences are reflected in the dynamics of how information is used in the policy formation process that directs management planning and practices (Lertzman et al. 1996b).

In practice, there is also significant variation among individual managers in implementing even the same set of rules, based on the training, personal values, intent, and the management context of those involved. This is true even in a highly prescriptive management context such as under the British Columbia Forest Practices Code (British Columbia Ministry of Forests 1994, 1995) and similar regulatory environments. There is always room for enthusiastic and committed practitioners to go beyond minimum standards—and for others to just barely meet those minima. We see this kind of variation reflected in the voluntary choice of corporations and individual professionals to meet rigorous externally defined environmental and social standards such as Forest Steward-

ship Council Certification (Cauley et al. 2001; Taylor 2005). There is a parallel in this pattern of variation among individuals in TREM in that there was and continues to be substantial variation in training and knowledge in traditional societies. Some individuals were/are better trained and better embody traditional values and norms than others, and thus may have the knowledge and ability to manage to a higher standard. I suspect that in all societies, management mostly inhabits the domain between the ''minimum socially acceptable standard'' and the ''best possible'' standard, as defined within their particular social context.

There is nothing inherent in the idea of ''management'' that implies an objective of sustainability or conservation. If ''management'' embodies values and norms determined by its social context, then to the extent that they follow social norms, the goals of a management system may legitimately *not* include a ''conservation'' ethic. If a society values commodity production over conservation, then we will see management systems develop that reflect this, such as the large-scale, industrial clearcutting of temperate rainforests in western North America or industrial grain farming in the mid-continent. A management system as a whole can reflect largely commodity or utilitarian values despite the fact that the loggers and farmers participating in management may be keen conservationists. Clearly, this can emerge even in societies, such as our own, that also have a conservation ethic as part of our norms (e.g. the Endangered Species Act in the US, the Species at Risk Act in Canada). We can see a similar phenomenon in traditional societies where, despite potential evidence for some kind of conservation ethic or management practices supporting sustainability, long-term environmental degradation was a consequence of the overall management system (e.g., Johnson et al. 2005; Lepofsky et al. 1996; Rosen 1995). In some cases, there is evidence that the managers on the ground, such as Rosen's Canaanite farmers, had the tools to adopt more conservation-oriented approaches, but were unable to do so because of social controls by the elites in their society.

Somewhat similarly to Mintzberg's economic managers, who by following the rules of behavior and upholding the values that society has laid out for them, have managed us into a global economic decline, resource management professionals (in the broadest sense of the term) and the institutions in which they participate have ''managed'' us into a global environmental catastrophe. This is despite the best efforts of enormous numbers of individuals to do the very best job they can as part of a management system which operates under a ''wicked'', mixed set of conflicting goals and objectives which, to some extent, must inevitably have led us along this path.

In contrast to the idea of management more generally, ''stewardship'' has a clearly implied embedded context of values in relation to the resource. While managers can ''manage'' to achieve whatever objectives society has given them, *stewards* always have an obligation to the resources or ecosystems themselves. The idea of stewardship is very consonant with traditional resource management principles (as described by Berkes 2008; Turner 2005; Turner and Berkes 2006). Professional codes of conduct for resource managers often embody stewardship as a value and professional obligation, for instance, the Association British Columbia Professional Foresters (http://www.abcfp.ca/regulating_the_profes-

sion/bylaws/code_of_ethics.asp). Stewardship implies that human uses are being managed for, but not to the exclusion of non-human elements of the ecosystem: stewardship is always concerned with conservation and sustainability. The papers in this volume provide many examples of actions in indigenous societies that, as a part of TREMS, could be considered resource stewardship (e.g., Deur, Smith, Wyndham *this volume*).

In the context of this discussion, *conservation* is one possible objective of management. Conservation is management that contributes to a goal of protecting biological diversity, ecological services, and environmental quality at any of the scales of the biological hierarchy from genes to communities to ecosystems. Most of the application of conservation science is about how we build conservation objectives into the management process, how we develop tools to achieve conservation objectives, and how we can develop policy and planning environments that support the application of those objectives and tools (look through issues of the journals *Conservation Biology*, *Ecological Applications*, or *Ecology and Society*). Conservation is always a form of management—even declaring an area to be an ecological reserve and putting up a fence to keep out people is a management action and a choice of a particular ecological trajectory. In a summary of his substantial body of work (e.g., Krech 1999) on relations between indigenous people and the environment, Krech (2005:81) states, ''*practices are conservationist not because they have sustainable consequences but because they meet intentionally formulated ends*'' (italics added for emphasis; see also Smith and Wishnie 2000 for a similar perspective). This situates his view of ''conservation'' firmly as part of a management system as I have defined it.

**Towards a Synthesis of Management Systems: The Gradient of Management**

I have argued that there are strong commonalities between management systems based on western science and traditional management systems. These commonalities are rooted in many of the fundamental attributes of both types of systems (Table 1) and can be observed in many of the issues that arise regarding the relationships between the management systems, the managers themselves, and their broader social context. TREMS and WSBMS can thus be placed on a common scale or gradient of the degree of anthropogenic modification of ecosystems, which illustrates both commonalities and differences among them (Figure 1). This suggests that TREMS and WSBMS exhibit differences in degree, not kind. They are not different kinds of things; they are different examples of the same thing.

This continuity is illustrated in Figure 1. The main axis is the lower shaded box labeled ''Gradient of Anthropogenic Influence on Ecosystems''. It extends from one archetype on the left of ''wild'' ecosystems, uninfluenced by human activity, to another archetype on the right, of completely anthropogenically determined ecosystems. Of course, we understand that both of these archetypes are unlikely. Many ecosystems that were historically thought to be ''wild'' have been shown to have had substantial human influence on their ecological dynamics—and the most intensively industrial agricultural and forest systems still have unplanned species and stochastic environmental drivers, such as fire,

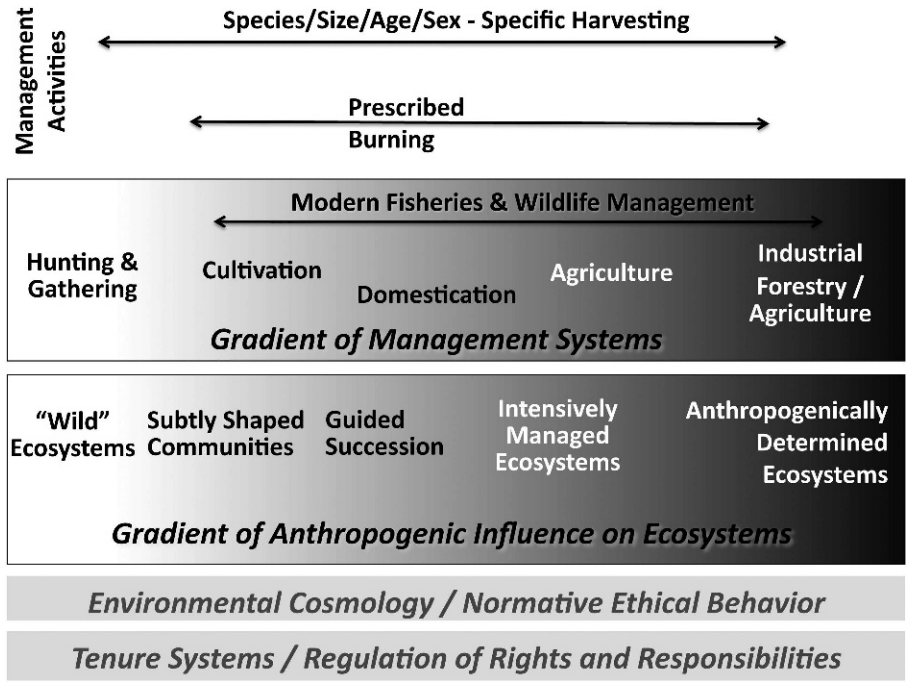


FIGURE 1. The gradients of management and anthropogenic influence.

from outside the management context (Bush and Silman 2007; Heckenberger et al. 2007; Landres et al. 1999; Swanson et al. 1993).

In between, we have a gradient from ecological communities exhibiting a mix of human and non-human drivers. On the left are those that have been so subtly shaped by human activities that visitors might not recognize they are anthropogenic. Deur's (*this volume*) description of yellow pond lily and ***yampah*** tending, transplanting and harvesting provides a good example. Lepofsky (1999) provides another good example with her description of how early European explorers incorrectly perceived the French Polynesian forest to be a ''natural paradise'' from which people had only to harvest, without management effort. To the right of this middle area are various traditional, more intensively managed agricultural systems where human intervention has significantly altered a broad range of system properties (e.g., Conklin 1963; Handy 1940; Lepofsky et al. 1996).

Figure 1 emphasizes the broad middle ground of the management gradient–the ubiquity of the semi-natural matrix (Lindenmeyer and Franklin 2002). In western society we tend to focus on a dichotomy of extremes–wilderness or factory farm–and this has been reflected in a historically dichotomous approach to conservation policy that focused on parks and protected ''wilderness'' areas vs. intensively managed commodity landscapes. We are now, however, more often emphasizing stewardship in the matrix between the extremes (Franklin 1993; Lindenmeyer and Franklin 2002). Modern western science-based fisheries and wildlife management typically inhabit this middle terrain of landscapes with both strong human influences and substantial natural elements. This is an

approach much more consistent with TREMS—in which not only is ''wilderness'' a foreign concept (Anderson 2005; Anderson and Blackburn 1993), but so is the dedication of a landscape solely to human needs. This perspective is consistent with the discussion among archaeologists of the diverse middle ground between hunting-gathering and agriculture (Smith 2001).

There are many examples of management systems that could fit at each point along the gradient of anthropogenic influence. The second shaded box, above the first, illustrates one example of such a gradient of management systems. The gradient of intensification of management and production, from hunting and gathering to domestication and agricultural systems has been discussed thoroughly (see Smith 2001 for a review) and is used here to illustrate how it sits on the gradient of anthropogenic influence—and its continuity with WSBMS. Specific examples of management practices illustrate this latter point. Prescribed fire is a land management tool that is used across nearly the entire gradient of management systems and anthropogenic influence, from classic ''hunting and gathering'' systems to industrial forest management (Boyd 1999; Pyne 1997, 2001). Indeed in understanding the role of fire historically in many ecosystems, it is difficult to separate the human from non-human signals (e.g., Heyerdahl et al. 2007). Similarly, species-, size-, age-, and sex-specific harvesting of both plants and animals are management activities that span the entire gradients of anthropogenic influence and management systems.

It is important to recognize that the ''success'' or ''failure'' of management systems from the perspective of sustainability appears not strongly correlated with either of these gradients. Reviews of diverse management institutions and governance structures have found failures across the spectrum of types, but have also found success stories across a broad spectrum of systems (Acheson 2006; Feeny et al. 1990; Krech 1999, 2005; Ostrom and Nagendra 2006; Ostrom 2009). No simple rules such as ''private is better'' or ''common property is better'' apply across the board. System stress arising from the sheer level of demand of population and per capita consumption leads to a greater challenge to sustainability from populations farther to the right along these gradients. But as Smith (*this volume*) argues, that does not mean that those to the left of the spectrum experienced sustainability merely through low population density or were not also engaging significant traditional knowledge and complex management systems to guide their stewardship and manage their overall level of impact.

Underlying human interactions with their environments across societies and across the gradients of Figure 1 is the presence of environmental cosmology and the normative rules of behavior that arise from it (illustrated at the bottom of the figure). Various authors provide excellent illustrations of this across a range of coupled social-ecological systems (Deur, Wyndham, *this volume*; Berkes 2008; Turner and Berkes 2006). Some might presume that WSBM is free from such influence, but of course our own management systems and the rules we impose on them as a society are also conditioned by the structure of our system of beliefs about right and wrong in relation to the environment. Indeed, there has been a long discussion of the cultural and ethical roots of our environmental crises (e.g., White 1967 and most of those who have disagreed with him examine the ethical

roots of western societies' behavior towards the environment) and increasingly, how such approaches might be used as a tool to bring more sustainability into human-environment relations (e.g., Nadkarni 2004; Waskow 2000). Similarly there are social institutions, systems of tenure, rules regulating rights of access and use, and management responsibility across these gradients (e.g., Johannes 1981; Trusler and Johnson 2008; Turner et al. 2005).

While TREMS and WSBMS can be logically placed on a continuum, there are significant differences in how underlying cosmologies are expressed in values about human relations with the environment. While societies generating western, science-based management systems have many core values about conservation and stewardship, as expressed in policies, legislation, and the intense public debates we have seen over the past century, they also have consistently produced management systems which focus on utilitarian values and the commodification of ecosystems. This is an approach which seems inimical to core values described in virtually all accounts of traditional resource management systems—which focus on reverence and respect for the resources being used and their environmental context (e.g., Wyndham, Turner et al., Deur, *this volume*; Berkes 2008, Turner 2005; Turner and Berkes 2006). These are differences in degree, not kind, but the degree can be large and the consequences of the differences significant.

## Conclusions

As a specialist in resource and environmental management, finding critical paths to social and environmental sustainability is my primary goal. Given this, is it useful to focus on an integrated view of traditional indigenous and western science-based management as I have here? I believe it is not only useful, but important to do so. Western science rarely has the time-depth of experience in ecological dynamics that is embodied in TREMS—and when it does, as through palaeoecological analysis, the resolution of the data is often either too broad or too fine to easily translate to direct management prescriptions (though see Landres et al. 1999). Furthermore, western managers often lack the deep cultural and personal connections to place that are the hallmark of indigenous knowledge. Alternatively, western science has available to it data, theory, and analytical tools which are not available to TREMS. A combination of modern ecological science (including palaeoecology) and traditional knowledge is likely to have more power as a tool for developing sustainability than is either alone. Indeed, managers are increasingly required to incorporate both western science-based approaches and traditional knowledge and management into their plans and practices (e.g., Horowitz 1998; Michel and Gayton 2003; Scientific Panel 1995a, 1995b). If this integration is to occur, we need a framework where the two are viewed as complementary approaches in a broad toolkit, rather than incommensurate systems of values, beliefs, and management practices. Such integration is a critical element of building management systems that are ecologically effective and socially legitimate (Pinkerton and John 2008).

In reality, managers on the ground are already making this kind of integration without worrying about its theoretical implications. For instance, one of my graduate students is working closely with an indigenous forester who

manages land for a First Nation in the southern interior of British Columbia. This forester is trained in western, science-based forest management and interacts effectively with regulatory agencies and professional organizations in that context. He also incorporates into his management strategies community concerns about the effects of forest management on culturally significant plants and animals, and he is engaged with my student in research to improve his ability to do so. Garibaldi's discussion (*this volume*) of bringing cultural keystone species into modern management reflects exactly this kind of blending of traditional and western science-based management systems. Many other such examples from various cultures and ecosystems can be found in the literature (e.g., Lertzman 2006; Lertzman and Vredenberg 2005).

Our views of management in both TREM and WSBRM contexts have been dominated by strong mythology. Western societies have tended to view many indigenous landscapes as if they were wilderness—that is, without the influence of human action and at the far extreme of the left of Figure 1. In reality, we know that many of these existed (and continue to exist) in the broad middle ground of Figure 1 where human and non-human drivers interact to produce complex, diverse, and productive landscapes. In contrast, we have imagined that western science-based management could engineer ecosystems to achieve simply defined goals and exist beyond the reach of the stochastic dynamics that dominate natural systems—at the far right of Figure 1. A significant body of research from both the social science and natural science domains has rejected this myth as a viable option (Holling and Meffe 1996; Lindenmeyer and Franklin 2002; Ludwig 2001; Ludwig et al. 1993; Ostrom 2009; Swanson et al. 1993). Instead, western science-based management is being directed towards the same broad middle ground of Figure 1 where traditional resource management systems exist: where natural variability and human agency interact (e.g., Lindenmeyerand Franklin 2002; Ostrom and Nagendra 2006).

The challenge before managers in WSBM contexts is to understand and adapt to this shift in social context, what forest managers in British Columbia refer to as the ''social license to operate'' (e.g., Bunnell and Dunsworth 2009). The opportunity it presents, if we can do so, is that problems that appear ''wicked'' from the perspective of command and control management (*sensu* Holling and Meffe 1996) may become less wicked under a management regime defined by its integrated approach to social and ecological variability. Thus I suggest that not only are there structural similarities between TREMS and WSBMS of the sort described in Table 1, and a common gradient of anthropogenic influence as in Figure 1, but the two approaches can share a common future as well.

From a research perspective, five key points emerge from this discussion:

1. What is the role of ethnobiology and ethnobiologists? We need to understand the elements of sustainability in both past and present resource management systems across a range of societies and in different environments. Ethnobiology is clearly a critical component of such an endeavor and ethnobiologists are necessary participants. Ethnobiological knowledge needs to be mobilized as a tool for building the future of both the cultures whose heritage it represents and the ecosystems on which those cultures depend.

2. We need to understand sources of variation in the quality of stewardship at different scales (individuals, communities, corporations, political jurisdictions) and how these can lead to sustainability in a broader sense. Despite the similarities I have posited, are there key differences between TREM and WSBM that account for variation in stewardship? For instance, in many societies practicing TREM, a high proportion of members were/are involved in the resource management process through food gathering, cultivation and other management practices. Does active participation in the management system and its associated knowledge base bring a greater commitment to stewardship? Is this correlated with the scale and degree of social stratification of a society?
3. One of the most significant conclusions to be drawn from the various empirical assessments of how humans actually behave in relation to their environments and resources is that we can hold a range of conflicting values and act on them variably over time. As individuals, communities, and societies, we can move back and forth along a spectrum from reverence and respect to utilitarian consumption and commodification, all the while reflecting values that are present within our social context. For instance, modern North American society clearly holds core values about conservation and stewardship, but the expression of these depends on a complex process of competing values, interests, and ideas (Lertzman et al. 1996b). This same society can, in one place and time, produce an icon of stewardship like ''A Sand County Almanac'' (Leopold 1990) and a paradigm of industrial monoculture. Similarly, indigenous peoples can hold traditional values and engage at the same time with WSBM systems that are, at least in part, in conflict with those values. We have a tendency to dichotomize discussions of these types of situations—either stewardship and conservation values are present or they are not, a society can be classed as either ''conservationist'' or not (e.g., Krech 1999, 2005). The reality is clearly much more complex. It is thus a central challenge for us as researchers to understand better the processes through which different values emerge to dominate among individuals, communities, and societies and how those values are translated into actions.
4. The scale of societies (*sensu* Smith and Wishnie 2000) is a confounding variable in much of this discussion. Is scale the real issue here? Were all large-scale societies in the past failures at sustainability? Clearly not all small-scale societies were failures, but nor were they all successes. In what ways might sustainability be inextricably linked to either the scale of a society or to the scale of polity at which management authority is allocated?
5. Sustainability is an epi-phenomenon that emerges from many cultural and ecological contexts—and fails to emerge across a range of conditions as well. Sustainability across a society is not solely a function of ecological knowledge, management practices, and the values associated with them, it is also driven by population pressure and per capita consumption, rates of environmental change, and a broad range of social dynamics only indirectly related to the environment (e.g., Homer-Dixon 2000, 2006). We need a much better understanding of the complexity of how coupled social and ecological systems develop and persist or fail (Liu et al. 2007).

From 1993 to 1995 I served on the ''Scientific Panel for Sustainable Forest Practices in Clayoquot Sound''. We had 19 members, 4 of whom were Nuu-chah-nulth elders, selected for their traditional ecological and other cultural knowledge. The rest of us represented various western scientific disciplines. We were charged with using a combination of western science and traditional knowledge to determine forest practices that supported a very high standard of stewardship. I learned many things from this process relevant to the discussion here, but I want to relate one event, in particular, from which I learned much about the relationship between values, management practices, and individual variation in their expression.

After the panel had been meeting for about six months, we were discussing aboriginal rights and title in relation to forestry. One of the scientists expressed concern based on his experience with other First Nations who had used exploitative and environmentally destructive forest practices. After some discussion among the elders, Roy Haiupis spoke for them. He acknowledged that there were indeed examples where First Nations people had done things that did not live up to their cultural standards about the environment. Similarly, he noted that it was easy to find examples of places where, based on the western science tradition, people had engaged in environmentally destructive logging practices. Roy continued, saying that he did not believe those examples represented the best of the western scientific tradition—and that the examples of destructive practices by First Nations did not represent the best of *their* tradition either. Roy concluded with what has become an article of faith for me in this kind of work. We are not here to represent the mistakes and failures of the past: ''we are here to represent the best of our traditions.''

**Acknowledgements**

I would like to thank Dana Lepofsky for her ongoing inspiration to think about these ideas and keep working on them, as well as her comments on this paper. I also appreciate thoughtful reviews by Fikret Berkes and Evelyn Pinkerton on earlier drafts of this paper. I very much appreciate Marcela Olguin and Andrés Valle-Domenech for providing the Spanish translation of the abstract. I owe a great deal to my colleagues who keep pushing the boundaries of the paradigm and the many resource managers, indigenous and not, who keep trying to do the best job they can for the lands and waters for which they are responsible.

## References Cited

Acheson, James M.
2006 Institutional failure in resource management. *Annual Review of Anthropology* 35:117–134.

Anderson, E.N.
1996 *Ecologies of the Heart: Emotion, Belief, and the Environment*. Oxford University Press, New York.

Anderson, Kat and Thomas C. Blackburn.
1993 *Before the Wilderness: Environmental Management by Native Californians*. Ballena Press Anthropological Papers, No. 40. Ballena Press, Menlo Park.

Anderson, M. Kat.
2005 *Tending the Wild: Native American Knowledge and the Management of Cali-*

*fornia's Natural Resources*. University of California Press, Berkeley.

Berkes, Fikret.
2008 *Sacred Ecology,* 2nd Ed. Routledge, New York.

Berkes, Fikret, Johan Colding, and Carl Folke.
2000 Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications* 10: 1251–62.

Boyd, Robert, ed.
1999 *Indians fire and the land in the Pacific Northwest*. Oregon State University Press, Corvallis.

British Columbia Ministry of Forests.
1994 *Forest Practices Code of British Columbia Act: Bill 40, 1994*. Government of British Columbia, Victoria, British Columbia.
1995 *Forest Practices Code of British Columbia - Regulations*. Government of British Columbia, Victoria, British Columbia.

Bunnell, Fred L., William J. Beese, and Glen B. Dunsworth.
2009 Chapter 4: Implementing the approach. *In Forestry and Biodiversity: learning how to sustain biodiversity in managed forests*, eds. F.L. Bunnell and G.B. Dunsworth, pp. 54–74. University of British Columbia Press, Vancouver.

Bunnell, Fred L. and Glen B. Dunsworth, editors.
2009 *Forestry and Biodiversity: learning how to sustain biodiversity in managed forests*. University of British Columbia Press, Vancouver.

Bush, Mark B. and Miles R. Silman.
2007 Amazonian exploitation revisited: ecological asymmetry and the policy pendulum. *Frontiers in Ecology and the Environment* 5(9):457–465.

Cauley, H.A., C.M. Peters, R.Z. Donovan, and J.M. O'Connor.
2001 Forest Stewardship Council forest certification. *Conservation Biology* 15(2): 311–312.

Cissel, John H., Frederick J. Swanson, and Peter J. Weisberg.
1999 Landscape management using historical fire regimes: Blue River, Oregon. *Ecological Applications* 9: 1217–1231.

Conklin, Harold.
1963 *The study of shifting cultivation*. Washington Technical Publications, Washington DC.

Cox, Sean P. and Allen Robert Kronlund.
2008 Practical stakeholder-driven harvest policies for groundfish fisheries in British Columbia, Canada. *Fisheries Research* 94:224–237.

Diamond, Jared.
2003 *Collapse: How Societies Choose to Succeed or Fail*. Viking, New York.

Dietz, Thomas, Elinor Ostrom, and Paul C. Stern.
2003 The struggle to govern the commons. *Science* 302:1907–1912.

Feeny, David, Fikret Berkes, Bonnie J. McCay, and James M. Acheson.
1990 The tragedy of the commons: twenty-two years later. *Human Ecology* 18:1–19.

Folke, Carl, Steve Carpenter, Brian Walker, Marten Scheffer, Thomas Elmqvist, Lance Gunderson, and C.S. Holling.
2004 Regime shifts, resilience, and biodiversity in ecosystem management. *Annual Review of Ecology Evolution and Systematics* 35:557–81.

Franklin, Jerry F.
1993 Preserving biodiversity: species, ecosystems, or landscapes? *Ecological Applications* 3:202–205.

Grumbine R. Edward.
1994 What is Ecosystem Management? *Conservation Biology* 8(1):27–38.

Handy, E.S.C.
1940 Hawaiian planter. *Bernice P. Bishop Museum Bulletin* #161.

Heckenberger, Michael J., J. Christian Russell, Joshua R. Toney, and Morgan J. Schmidt.
2007 The legacy of cultural landscapes in the Brazilian Amazon: implications for biodiversity. *Philosophical Transactions of the Royal Society B* 362:197–208.

Heyerdahl, Emily K., Ken Lertzman, and Steven Karpuk.
2007 Local-scale controls of a low-severity fire regime (1750–1950), southern British Columbia, Canada. *Ecoscience* 14:40–47.

Hilborn, Ray, J.M. (Lobo) Orensanz, and Ana M. Parma.
2005 Institutions, incentives and the future of fisheries. *Philosophical Transactions of the Royal Society B* 360:47–57.

Holling, C.S. and Gary K. Meffe.
1996 Command and control and the

pathology of natural resource management. *Conservation Biology* 10:328–337.

Homer-Dixon, Thomas.
2000 *Environment, Scarcity, and Violence*. Princeton University Press, Princeton.
2006 *The upside of down: catastrophe, creativity, and the renewal of civilization*. Vintage, Toronto.

Horowitz, Leah Sophie.
1998 Integrating Indigenous Resource Management with Wildlife Conservation: A Case Study of Batang Ai National Park, Sarawak, Malaysia. *Human Ecology* 26:371–403.

Hunn, Eugene S., Daryll R. Johnson, Priscilla N. Russel, and Thomas Thornton.
2003 Huna Tlingit Traditional Knowledge, Conservation, and the Management of a ''Wilderness'' Park. *Current Anthropology* 44(Supplement):157–69.

Jackson, Jeremy B.C., Michael X. Kirby, Wolfgang H. Berger, Karen A. Bjorndal, Louis W. Botsford, Bruce J. Bourque, Roger H. Bradbury, Richard Cooke, Jon Erlandson, James A. Estes, Terence P. Hughes, Susan Kidwell, Carina B. Lange, Hunter S. Lenihan, John M. Pandolfi, Charles H. Peterson, Robert S. Steneck, Mia J. Tegner, and Robert R. Warner.
2001 Historical Overfishing and the Recent Collapse of Coastal Ecosystems. *Science* 293:629–638.

Johannes, R.E.
1981 *Words of the Lagoon. Fishing and Marine Lore in the Palau District of Micronesia*. University of California Press, Berkeley.

Johnson, C. David, Timothy A. Kohler, and Jason Cowan.
2005 Modeling historical ecology, thinking about contemporary systems. *American Anthropologist* 107:96–107.

Klee, G., ed.
1980 *World Systems of Traditional Resource Management*. Edward Arnold, London.

Krech, Shepard III.
1999 *The ecological Indian: myth and history*. Norton, New York.
2005 Reflections on conservation, sustainability, and environmentalism in indigenous North America. *American Anthropologist* 107:78–86.

Landres, Peter B., Penelope Morgan, and Frederick J. Swanson.
1999 Overview of the use of natural variability concepts in managing ecological systems. *Ecological Applications* 9:1179–1188.

Leopold, Aldo.
1990 *A sand county almanac: with essays on conservation from Round River*. Ballantine Books, New York.

Lepofsky, Dana.
1999 Gardens of Eden? An Ethnohistoric Reconstruction of Maohi (Tahitian) Cultivation. *Ethnohistory* 46:6–22.

Lepofsky, Dana, Ken Lertzman, Douglas Hallett, and Rolf Mathewes.
2005 Climate Change and Culture Change on the Southern Coast of British Columbia 2400-1200 B.P.: An Hypothesis. *American Antiquity* 70: 267–293.

Lepofsky, Dana, Patrick V. Kirch, and Kenneth P. Lertzman.
1996 Stratigraphic and paleobotanical evidence for prehistoric human-induced environmental disturbance on Mo'orea Island, French Polynesia. *Pacific Science* 50:253–273.

Lepofsky, Dana and Ken Lertzman.
2008 Documenting ancient plant management in the Northwest of North America. *Botany* 86:129–145.

Lertzman, David Adam.
2006 Bridging Traditional Ecological Knowledge and Western Science in Sustainable Forest Management: The Case of the Clayoquot Scientific Panel. *Recherches Amérindiennes au Quebec* 36(2–3):43–58.

Lertzman, David and Harrie Vredenburg.
2005 Indigenous Peoples, Resource Extraction and Sustainable Development: An Ethical Approach. *Journal of Business Ethics* 56(3):239–254.

Lertzman, Ken, Daniel Gavin, Douglas Hallett, Linda Brubaker, Dand Lepofsky, and Rolf Mathewes.
2002 Long-term fire regime estimated from soil charcoal in coastal temperate rainforests. *Conservation Ecology* 6(2):5. Available at: http://www.consecol.org/vol6/iss2/art5 (verified 24 September 2009).

Lertzman, K.P., G. Sutherland, A. Inselberg, and S. Saunders.
1996a Canopy gaps and the landscape mosaic in a temperate rainforest. *Ecology* 77:1254–1270.

Lertzman, K.P., J. Raynor, and J. Wilson.
1996b Change in the B.C. forest policy sector: a consideration of Sabatier's advocacy coalition framework. *Canadian Journal of Political Science* XXIX: 111–133.

Lindenmayer, David and Jerry F. Franklin.
2002 *Conserving forest biodiversity: a comprehensive multiscaled approach*. Island Press, Washington, DC.

Liu, Jianguo, Thomas Dietz, Stephen R. Carpenter, Marina Alberti, Carl Folke, Emilio Moran, Alice N. Pell, Peter Deadman, Timothy Kratz, Jane Lubchenco, Elinor Ostrom, Zhiyun Ouyang, William Provencher, Charles L. Redman, Stephen H. Schneider, and William W. Taylor.
2007 Complexity of coupled human and natural systems. *Science* 317: 1513–1516.

Ludwig, Donald.
2001 The era of management is over. *Ecosystems* 4:758–764.

Ludwig, Donald, Marc Mangel, and Brent Haddad.
2001 Ecology, conservation, and public policy. *Annual Review of Ecology and Systematics* 32:481–517.

Ludwig, Donald, Ray Hilborn, and Carl Walters.
1993 Uncertainty, resource exploitation, and conservation: lessons from history. *Science* 260:17–18.

Michel, H. and D.V. Gayton, editors.
2002 *Linking indigenous peoples' knowledge and western science in natural resource management: conference proceedings*. Southern Interior Forest Extension and Research Partnership (SIFERP series # 4).

Mintzberg, Henry.
2004 *Managers Not MBAs: A Hard Look at the Soft Practice of Managing and Management Development*. Berrett-Koehler Publishers, San Fransisco.
2009a *Managing*. Berrett-Koehler Publishers, San Fransisco.
2009b America's monumental failure of management. Available at: http://vmhn.org/home/index.php?/Future-Studies-Collection/americas-monumental-failure-of-management.html (verified 24 September 24, 2009).

Nadkarni, Nalini.
2004 Not preaching to the choir: communicating the importance of forest conservation to non-traditional audiences. *Conservation Biology* 18:602–606.

Ostrom, Elinor.
2009 A general framework for analyzing sustainability of social-ecological systems. *Science* 325:419–422.

Ostrom, Elinor and Harini Nagendra.
2006 Insights on linking forests, trees, and people from the air, on the ground, and in the laboratory. *Proceedings of the National Academy of Sciences* 103: 1924–1931.

Pinkerton, Evelyn and Leonard John.
2008 Creating local management legitimacy. *Marine Policy* 32:680–691.

Pyne, Steven J.
1997 *World fire: The culture of fire on earth*. University of Washington Press, Seattle.
2001 *Fire: a brief history*. University of Washington Press, Seattle.

Rittel, Horst W.J. and Melvin M. Webber.
1973 Dilemmas in a General Theory of Planning. *Policy Sciences* 4:155–169.

Rosen, Arlene M.
1995 The social response to environmental change in early Bronze Age Canaan. *Journal of Anthropological Archaeology* 14:26–44.

Rosenberg, A.A., M.J. Fogarty, M.P. Sissenwine, J.R. Beddington, and J.G. Shepherd.
1993 Achieving sustainable use of renewable resources. *Science* 262:828–829.

Scientific Panel for Sustainable Forest Practices in Clayoquot Sound.
1994 Report of the Scientific Panel for Sustainable Forest Practices in Clayoquot Sound. Victoria, B.C.
1995a First Nations' perspectives relating to forest practices standards in Clayoquot Sound. Victoria, B.C.
1995b Sustainable ecosystem management in Clayoquot Sound: planning and practices. Victoria, B.C.

Sedell, J.R. and J.L. Froggatt.
1984 Importance of streamside forests to large rivers: the isolation of the Willamette River, Oregon, U.S.A., from its floodplain by snagging and streamside forest removal. *Verhandlungen der Internationalen Vereinigung fur Theoretische und Angewandte Limnologie* 22: 1828–1834.

Shindler, B. and L.A. Cramer.
1999 Shifting public values for forest

management: making sense of wicked problems. *Western Journal of Applied Forestry* 14:28–34.

Smith, A.D.M., K.J. Sainsbury, and R.A. Stevens.
1999 Implementing effective fisheries-management systems – management strategy evaluation and the Australian partnership approach. *ICES Journal of Marine Science* 56:967–979.

Smith, Bruce D.
2001 Low-level food production. *Journal of Archaeological Research* 9:1–43.

Smith, Eric. A. and Mark Wishnie.
2000 Conservation in small-scale societies. *Annual Review of Anthropology* 29: 493–524.

Swanson, F.J., Jones D. Wallin, and J. Cissel.
1993 Natural variability, implications for ecosystem management. In *Eastside Forest Ecosystem Health Assessment. II. Ecosystem Management Principles and Applications*, eds. M. Jensen and P. Bourgeron, pp. 89–103. United States Department of Agriculture Forest Service, Pacific Northwest, Portland.

Taylor, P.L.
2005 In the market but not of it: fair trade coffee and Forest Stewardship Council certification as market-based social change. *World Development* 33(1): 129–147.

Trusler, Scott and Leslie Main Johnson.
2008 ''Berry Patch'' as a Kind of Place – The Ethnoecology of Black Huckleberry in Northwestern Canada. *Human Ecology* 36:553–68.

Turner, Nancy J.
2005 *The Earth's Blanket: Traditional Teachings for Sustainable Living*. Douglas & McIntyre, Vancouver and University of Washington Press, Seattle.

Turner, Nancy J. and Fikret Berkes.
2006 Coming to understanding: developing conservation through incremental learning in the Pacific Northwest. *Human Ecology* 34:495–513.

Turner, Nancy J., Robin Smith, and James T. Jones.
2005 ''A Fine Line Between Two Nations'': Ownership Patterns in Plant Resources among Northwest Coast Indigenous Peoples. In *Keeping It Living: Traditions of Plant Use and Civilization on the Northwest Coast of North America*, eds. Douglas Duer and Nancy J. Turner, pp. 151–78. University of Washington Press, Seattle.

Vitousek, Peter M., Paul R. Ehrlich, Anne H. Ehrlich, and Pamela A. Matson.
1986 Human Appropriation of the Products of Photosynthesis. *BioScience* 36(6):368–373.

Vitousek, P.M., H.A. Mooney, J. Lubchenko, and J.M. Melillo.
1997 Human domination of earth's ecosystems. *Science* 277:494–499.

Wang, Sen.
2002 Wicked problems and metaforestry: is the era of management over? *The Forestry Chronicle* 78:505–510.

Waskow, Arthur, ed.
2000 *Torah of the Earth: Exploring 4,000 years of Ecology in Jewish Thought* Volumes 1 and 2. Jewish Lights Press, Woodstock, Vermont.

White, Lynn Townsend, Jr.
1967 The historical toots of our ecologic crisis. *Science* 155:1203–1207.

Williams, Nancy M. and Eugene S. Hunn, editors.
1982 *Resource Managers: North American and Australian Hunter-Gatherers*. American Association for the Advancement of Science, Washington, DC.

Worm, Boris, Edward B. Barbier, Nicola Beaumont, J. Emmett Duffy, Carl Folke, Benjamin S. Halpern, Jeremy B.C. Jackson, Heike K. Lotze, Fiorenza Micheli, Stephen R. Palumbi, Enric Sala, Kimberley A. Selkoe, John J. Stachowicz, and Reg Watson.
2006 Impacts of Biodiversity Loss on Ocean Ecosystem Services. *Science* 314: 787–790.