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Broad-scale consequences of land management: Columbia basin example

Richard W. Haynes[a,*], Thomas M. Quigley[b]

[a]*Pacific Northwest Research Station, USDA Forest Service, P.O. Box 3890, Portland, OR 97208, USA*
[b]*Racific Northwest Research Station, LaGrande, OR, USA*

Abstract

Integrating management actions to consistently achieve broad ecological and socioeconomic goals is a challenge largely unmet. The presumed or real conflict between these goals establishes a forum for debate. Broad measures are needed to describe tradeoffs, trends in conditions under varying management scenarios, and a transparent science underpinning. The Interior Columbia Basin Ecosystem Management Project in the northwestern United States provides a useful example where scientists, managers, and the public have explored these issues in depth. From a science perspective we conclude that a successful strategy for broad-scale land management will need the ability to do the following: maintain long-term sustainability of resources and ecosystems; maintain socioeconomic resiliency; continually assess results of management activities; manage risks and opportunities through consistent approaches at multiple scales; expand our knowledge base; and adaptively manage for new knowledge and assessments of resource conditions/capabilities. Published by Elsevier Science B.V.

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1. Introduction

Environmental policy discussions in the United States have been characterized by a constant tug-of-war among an “unholy alliance of ignorance, ideology, and self-interest” since the early 1970s (see Blinder (1987) and Rolston (2000) for representative discussions of the roles scientists have played). Scientists are challenged in this tug-of-war when asked to interpret the social and biophysical consequences of management alternatives to provide greater clarity around policy impacts or consequences. The shift to managing ecosystems across relatively broad spatial extents also stretches the limits of traditional science (see Lackey (1999) for a general discussion). Such bioregional assessments compile and synthesize data with less emphasis on the usual components of experimental science (see Johnson et al. (1999) for a discussion of science issues in bioregional assessments).

The Interior Columbia Basin Ecosystem Management Project (ICBEMP) is one example of a bioregional scientific assessment that was coupled with an evaluation of land management strategies. The ICBEMP developed unique sets of broad-scale science assessments that include composite measures of ecological and socioeconomic conditions (see Quigley and Arbelbide, 1997; Quigley et al., 1996). Since these assessments were completed, changes in management direction on US Department of Agriculture, Forest Service (FS) and US Department of Interior, Bureau of Land Management (BLM)

*Corresponding author.
E-mail address: rhaynes@fs.fed.us (R.W. Haynes).

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administered lands in the ICBEMP assessment area (hereafter, Basin[1]) have been proposed (see Haynes et al. (2001) and USDA and USDI (2000) for a description of the management alternatives), and effects likely to occur from implementing such direction have been projected both spatially and temporally (Crone and Haynes, 2001; Hann et al., 2001; Hemstrom et al., 2001; Haynes et al., 2001; Raphael et al., 2001; Rieman et al., 2001; companion articles). Surveying ICBEMP results offers us an opportunity to draw inferences about both the use of broad-scale indicators in science policy discussions and the successful use of bioregional assessments in environmental policy analysis. In this paper we focus on the ICBEMP experience to explore the inferences around policy-relevant science that can be drawn from broadscale ecosystem management.

2. Testing for tradeoffs or compatibility

Some of the most contentious broad-scale, policy-relevant science concerns involve the potential for understanding the extent and nature of tradeoffs that are assumed to occur among biophysical and socioeconomic components of ecosystems. Much of the framework for this debate has been provided by scientists who often view themselves as advocates for a sustainable biosphere (Risser et al., 1991) and perceive limited opportunities for mutual gains in both biophysical and socioeconomic systems. The natural resource policy debate is often portrayed as involving direct tradeoffs among environmental changes and socioeconomic well-being. The policy issue has often been reduced to the jobs versus the environment issue that has characterized much of the forestry debate of the past decade. The rhetoric often ignores the possibility that, instead of direct tradeoffs, opportunities for compatible changes do exist among alternative management strategies.

Much of the job versus environment debate has been based on assertions or piecemeal collections of data. The depth of data generated through the ICBEMP experience now presents a way to examine this question. We can use the composite measures developed in the ICBEMP to examine the direction and extent of tradeoffs between ecological and socioeconomic conditions as we consider different management strategies. We can see, for example, if improving environmental conditions are necessarily coupled with degrading socioeconomic conditions, or vice versa. An alternative proposition is that compatibility exists among environmental and socioeconomic changes, at least across a range of options. The theoretical underpinnings for this discussion rely on the concepts of joint production and Pareto optimality (see Henderson and Quandt (1980) for a general discussion of both concepts). Conceptually, such a discussion can be illustrated rather simply, when reduced to two dimensions. That is, opportunities exist for either mutual gains or increase in one dimension while the other dimension remains stable. The challenge is to develop composite measures that act as proxies for discussing these two dimensions and changes that may be projected to occur in ecological and socioeconomic conditions under different management alternatives.

Fig. 1 illustrates, conceptually, the challenge facing land management agencies such as the FS and BLM in the ICBEMP assessment area, that are trying to manage for both ecological and socioeconomic well-being (the general problem has been described in forestry by

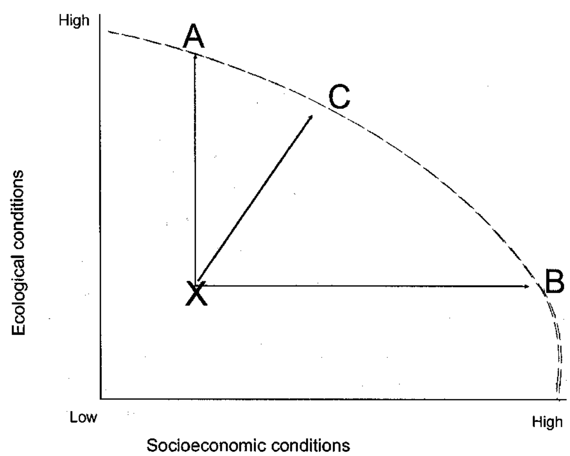

Fig. 1. Hypothetical joint production function between ecological and socioeconomic conditions showing opportunities for compatible changes of both.

[1]The Basin is defined as those portions of the Columbia river basin inside the United States and east of the crest of the Cascade Range, and those portions of the Klamath river basin and the Great basin in Oregon

Gregory (1972)). The curve represents the production possibility frontier (the set of all combinations of ecological and socioeconomic conditions with no waste and no inputs left over from which more of one output could be achieved without giving up some of the other). If our current position is point X, society could be better off if we moved closer to the production possibility frontier in any positive direction. However, people who place high value on socioeconomic conditions are concerned that improvements in ecological conditions will likely mean a move to the left of point A, at which point socioeconomic conditions will be reduced. Similarly, people who place high value on ecological conditions are concerned that improvements in socioeconomic conditions will likely mean a move below point B, at which point ecological conditions will suffer. Resistance to change means we forgo opportunities to move toward C, at which both ecological and socioeconomic conditions improve and everybody is better off. This last condition - nobody is worse off and at least someone is better off - is a move closer to Pareto optimality, a useful concept that does not require the marketplace to determine value. In this simple two-dimensional example, all points bounded by X-A-B are desirable, for the amount of each of the two resources is at least as good as a point X, the status quo. The challenge is to identify points like C - and the path to reach them - in a complex world with multiple inputs and multiple desired outputs. Many scientists see Fig. 1 as too simple to provide a "good" representation of the system under consideration. They would argue that, for example, ecological integrity should have two or three axes given the complexity and sometimes competing or contradicting dimensions to the problem. Though this would add more dimension to Fig. 1, the essential policy and science issues illustrated would be much the same.

Fig. 1 presents a challenge to find opportunities for compatible ecosystem management such as point C that allow us to provide greater social and ecological benefits from land management. To do this, we used two multi-faceted, broad-scale, summary variables that measure ecosystem performance - ecological integrity (see Quigley et al., 2001) and socioeconomic resiliency (Crone and Haynes, 2001; Home and Haynes, 1999) to address the concept of compatibility as applied to three management alternatives (S1, S2, S3) outlined in the ICBEMP supplemental draft environmental impact statement (SDEIS) (USDA and USDI, 2000). These three alternatives cover some 25.4 million hectares of FS and BLM administered lands across the entire Basin.

All three of the alternatives considered were designed to fit within the broad purpose and need of improving or maintaining ecological conditions over the long term, supporting economic and social needs, and providing predictable and sustainable levels of products and services (including fish, wildlife and native plant communities), from lands administered by the FS or the BLM in the project area. Alternative S1 continues practices described in approximately 60 separate land management plans in the study area, including amendments and modifications to existing direction. Many of these existing plans are based on the assumption that ecological impacts can be mitigated (USDA and USDI, 2000). Alternative S2 attempts to minimize short-term risk from management activities by requiring a step-down planning process to provide broad- and mid-scale[2] context for proposed actions before conducting actions on-the-ground. Though initial actions are delayed because of this planning and analysis process, the intent of the alternative is to focus activities and resources in those areas where they would have the greatest chance of successfully restoring, maintaining or improving ecological systems. Alternative S3 places considerably less emphasis on completing broad- or mid-scale step-down or context-setting planning processes prior to taking initial restoration and maintenance actions in many areas (i.e., it accepts a higher level of short-term risk), while aggressively taking actions to reduce long-term risk to natural resources from human and natural disturbances. Alternative S3 also promotes economic participation by the local workforce by prioritizing activities near communities that are economically specialized in outputs from FS and BLM administered lands, and near tribal communities (USDA and USDI, 2000).

[2]In the ICBEMP assessment process, broad-scale landscapes and analyses covered large drainage basins (millions of hectare or more) and used 1 km2 pixel resolution. Intermediate- (or mid-) scales covered subbasins to subwatersheds (tens of thousands to millions of hectare). Fine-scale analyses and maps covered subwatersheds to individual vegetation stands (tens of hectare to tens of thousands of hectare) (Hemstrom et al., 2001).

We adopt the proposition that compatibility exists and the SDEIS alternatives achieve both greater levels of ecological integrity and socioeconomic resiliency. The null proposition is, of course, that the jobs versus environment arguments, so prevalent in the debates over public land management, have substance. As some will recognize, this is similar to contemporary discussions of the integration of ecological and socio-economic issues as part of the stewardship debate (see Sexton et al., 1999). Often in that debate, however, integration is seen as an end itself, whereas here we are attempting to address a policy issue of an integrated nature.

2.1. Synthesizing the science data

In the ICBEMP, ecological integrity and socioeconomic resiliency were developed as broad-scale measures of ecosystem condition and performance resulting from changes in management of FS and BLM administered land. They were developed as simple linear sums of fine scale data or developed from a combination of both time series (or trend) and cross-sectional data. These types of additive measures are called multi-metric indicators and are less common than other types of ecological indicators that focus on specific extent, status, ecological capital, or functioning of ecosystems (see NRC, 2000). On the other hand, these types are relatively common as indicators of socioeconomic conditions and trends (such as a stock market index). They are unitless composite types of measures either for broad sets of conditions or for the extent that processes or functions are operational. Developing these measures was a significant challenge in itself and included both fundamental questions about their basis and empirical concerns about how disparate measures could be aggregated into meaningful composite measures.

We defined ecological integrity as a joint measure of forest integrity (developed from disturbance histories and inventory conditions), rangeland integrity, and aquatic integrity (see Quigley et al., 1996, 2001). Socioeconomic resiliency was defined as the ability of human institutions to adapt to change where institutions included both communities and economies (Home and Haynes, 1999). It was developed jointly from economic resiliency based on a measure of local economic diversity and social resiliency using proxies for community capacity and social systems (Crone and Haynes, 2001; Home and Haynes, 1999).

Ecological integrity, maintaining long-term sustainability of resources and environments, gets at the heart of many legal mandates as well as social interests. A strategy might prevail in the short-term while sustainability declines, but success will be marked by the ability of the system to reorganize in a resilient fashion and support the conditions and flows that exist through time. Broad swings across a spectrum of conditions and flows will likely lead to dissatisfaction with the strategy. Similarly, any strategy that causes the people who are linked with the resource to experience broad swings and reduction of options will likely not prevail in the long term. A successful strategy will need to link human values, wants, and needs with options that can persist through time. Some short-term adjustment may be needed from time to time, but a successful strategy gives full consideration to the human side of managing ecosystems. Humans are considered an important part of the ecosystem, not separate or isolated from it. This point is, of itself, contentious. However, it gets at the heart of policy questions and the ability to implement such policies.

2.2. Applying the broad-scale indicators

The data for testing our proposition are summarized in Table land represent trends in integrity and resiliency. Data for trends in ecological integrity were developed for each of the 164 subbasins in the Basin (Quigley et al., 2001) and the data for socioeconomic resiliency were developed for 104 counties present in the Basin (Crone and Haynes, 2001). Trends (decreasing, no change, increasing) were assigned numeric values. For ecological trends, the data covered only the area of FS and BLM administered land within each subbasin. The socioeconomic data were aggregated using three different weighting schemes: the area of FS and BLM administered land within each county; the total county area (as a proportion of the total Basin area); and, the population of each county (as a proportion of the total population of the Basin). The differences between the basis for the socioeconomic and ecological data are not trivial. That is, areas of importance ‘to humans and areas of importance to other components of the ecosystem seldom have the same spatial or temporal boundaries. Meaningful categories

Table 1 Summary trends in ecological integrity and socioeconomic resiliency for each of three alternative approaches to managing BS and BLM lands in the ICBEMP assessment area (note: numbers may not sum to 100 due to rounding)

	Alternative S1	Alternative S2	Alternative S3
Ecological integrity[a]			
Decreasing trends	20.4	12.4	15.2
Stable trends	46.6	37.3	44.0
Increasing trends	33.0	50.3	40.7
Socioeconomic resiliency[b]			
Weighted by FS and BLM area per county			
Decreasing trends	36.6	0	20.7
Stable trends	47.9	58.4	63.6
Increasing trends	15.5	41.6	15.7
Weighted by total county area			
Decreasing trends	30.4	3.4	21.0
Stable trends	61.3	74.3	70.4
Increasing trends	8.4	22.3	8.6
Socioeconomic resiliency[c]			
Weighted by population			
Decreasing trends	5.3	0.3	2.6
Stable trends	93.2	94.3	95.8
Increasing trends	1.5	5.4	1.6

[a] Percent of FS/BLM lands in the assessment area.
[b] Percent of area in the assessment area.
[c] Percent of population in the assessment area.

for measurement or discussion for ecological components are not directly comparable to categories meaningful for human systems. This reflects one of the intractable questions in the integration of natural and social sciences.

Table 1 shows the trends in ecological integrity and socioeconomic resiliency for the three SDEIS alternatives. Alternatives S2 and S3 generally improve trends in conditions relative to S l. Alternative S2 generally shows more subbasins with increasing trends than the other alternatives. In alternative S2, multi-scale analysis generally precedes activities, resulting in restoration or maintenance treatments that are more effective at reversing downward trends or prioritizing actions so as to achieve improvements in conditions based on multiple objectives. The relatively small differences among the alternatives for socioeconomic resiliency, when based on population, reflect that often it was the sparsely populated counties of the Basin that experienced the most change in socioeconomic resiliency. The extent of the Basin in stable socioeconomic condition shows that human populations of the entire Basin are relatively unaffected by management actions on public lands, even though a large amount of land area is affected.

Developing indexes for the comparable ecological and socioeconomic measures is the last step in developing the data to examine the potential effects of the three SDEIS management alternatives in the conceptual model shown in Fig. 1. Table 2 shows the five weighting scenarios and resulting index values for ecological integrity and three different bases for considering socioeconomic resiliency. The range in weights illustrates how robust the relationships were among the indexes for the alternatives if varying levels of importance were assigned to increasing, stable, or decreasing trends. Essentially, weights were assigned to each trend direction (increasing, stable, decreasing), multiplied by the percent represented by the trend, and then summed across all trends. The resulting total for alternative S2 and for alternative S3 was divided by its respective total for alternative Sl and multiplied by

Table 2 Summary indexes for trends in ecological integrity and socioeconomic resiliency under varying weighting scenarios assigned to decreasing, increasing, and stable trends for each of the alternative approaches to managing FS and BLM lands in the ICBEMP assessment area

Weighting scenario	Weighting factors by trend			Socioeconomic resiliency						Ecological integrity	
	Increasing	Stable	Decreasing	Weighted by FS and BLM land area		Weighted by total area of county		Weighted by population			
				S2	S3	S2	S3	S2	S3	S2	S3
Equal weight	2	3	4	123	106	115	103	103	101	108	104
Decreasing emphasized	1	3	4	141	113	127	108	105	102	ill	105
Increasing emphasized	2	3	5	130	105	119	103	104	101	111	105
Stable is good	2	4	5	129	109	120	105	104	101	108	104
Decreasing emphasized, stable is good, and increasing is emphasized	1	4	5	146	116	132	109	105	102	110	105

100, in essence treating alternative S1 as the base and using it to index the other two alternatives. The results can be plotted in two-dimensional space as shown in Figs. 2-4. An important caveat is that while we have dealt with spatial specificity, we are mixing to some extent the temporal duration over which these concepts of compatibility are observed.

We are able to assess the proposition described earlier at the Basin level where the spatial dimensions of data sets coincide. From both the development of these measures and as Figs. 2-4 show, various interactions are abundant and potential tradeoffs exist. This analysis shows that the design of alternatives S2 and S3 facilitate complementary changes in both

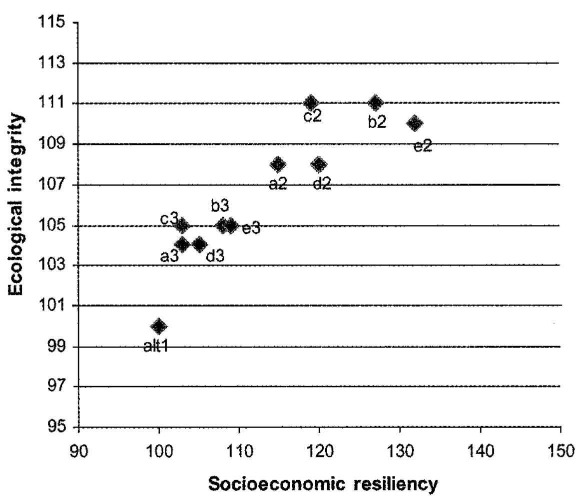

Fig. 2. Tradeoff between ecological integrity and socioeconomic resiliency for management alternatives by county as a proportion of total land area in the interior Columbia river basin assessment area for each management alternative (S1-S3) and weighting scenario. Weighting scenarios a-a are defined in Table 2. Alternative S1 was used a baseline comparison to index alternatives S2 and S3.

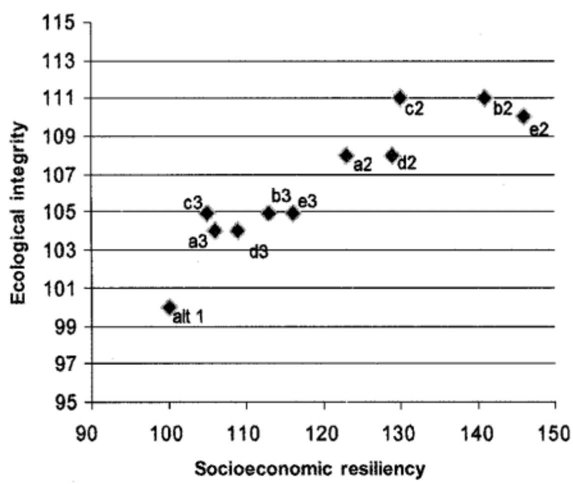

Fig. 3. Tradeoff between ecological integrity and socioeconomic resiliency for management alternatives by FS and BLM land area as a proportion of total land area in the interior Columbia river basin assessment area for each management alternative (S1-S3) and weighting scenario. Weighting scenarios a-e are defined in Table 2. Alternative S1 was used a baseline comparison to index alternatives S2 and S3.

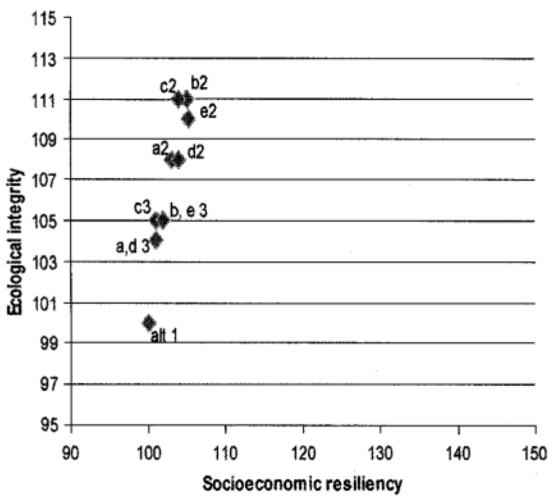

Fig. 4. Tradeoff between ecological integrity and socioeconomic resiliency for management alternatives by county population as a proportion of total population in the interior Columbia river basin assessment area for each management alternative (S1-S3) and weighting scenario. Weighting scenarios a-e are defined in Table 2. Alternative S1 was used a baseline comparison to index alternatives S2 and S3.

ecological integrity and socioeconomic resiliency as compared to alternative S1. That is, both alternatives lead to increases in both ecological integrity and socioeconomic resiliency under all the weighting scenarios. Relative to socioeconomic integrity, ecological integrity varies little across the alternatives and weighting scenarios (range of index values from 104 to 111 for ecological integrity versus a range of socioeconomic index values from 101 to 146). This reflects the methods used to summarize the changes. The greatest differences in socioeconomic resiliency are shown for values based on the amount of FS and BLM administered land in the Basin. When socioeconomic resiliency is based on the population in the Basin, socioeconomic resiliency (101-105) is less responsive to the management alternatives than is the ecological integrity trends (104-111). These index values help explain why leaders in rural counties with substantial FS and BLM administered lands argue that impacts from potential changes in FS and BLM management will be substantial, while leaders of more urban counties argue that impacts will be few. Given that the indexes for alternatives S2 and S3 move upward and to the right when compared to alternative Sl in the two-dimensional space also demonstrates that it is possible to expand multiple benefits.

3. Science inferences

These results do not reject the proposition, and suggest that the character of the policy debate should be more about compatibility of outputs and less of a jobs versus environment nature discussion. Fig. 2 raises a number of questions about the concept of compatibility - of what, where, when, and for whom? By failing to reject the proposition, we adopt the position that compatibility exists. It is important to bear in mind, however, that compatibility is a social rather than scientific construct. It is also scale-dependent. Many argue that compatibility increases with scale as the opportunities to move activities among landscapes increase with the consideration of larger areas. Others would argue that human judgments of compatibility of social acceptability of land management activities are often made locally and that local decisions may pose threats to the flexibility inherent in broad-scale land management.

What inferences, then, can be drawn about different land management strategies? First, these results illustrate the utility of broad-scale measures in providing a framework to consider differences between alternative approaches to land management. Second, while not explicit, the temporal specificity of something like Fig. 2 reminds us of the dynamic nature of the variables that determine broad-scale measures. Changes in the underlying variables would shift the relationship revealed in Fig. 2. Third, framing the notions of comparability or tradeoffs gives us a platform for judging the sensitivity of outcomes to different sources and magnitudes of risks. Fourth, another general inference is that the science/policy debate during the past decade has been narrowed considerably by asserting ecological limitations but not acknowledging the full scope and complexity of deliberate societal choices. Evidence of this includes the relatively tight grouping of index values for ecological integrity trends and for population weighted socioeconomic resiliency trends for the three alternatives considered. While it is true that other alternatives might have been developed to reflect a broader spectrum of potential outcomes, there appears to be no real incentive for managers to consider a wider array of outcomes.

4. Management inferences

Just as there are important inferences for science, there are inferences to consider in the development of management strategies. We recognize the role of science is to provide information for decisions that improve resource conditions and stewardship. A need for clarity in the discussions over differences in perceptions of the goals for public land management still exists, however. Where the goal of community stability had broad support in the 1960s, the majority of support appears to have shifted to something like managing for biodiversity or ecological integrity. The challenge is to develop the science that provides references for understanding such shifts in goals while successfully managing risks to human and ecological systems.

To members of the scientific community these inferences for management may seem like a restatement of the obvious. But the difference is that the underlying scientific information for these inferences is now available. That is, while in the past many of these have been assertions, we now can restate them with underlying data, analyses, and projections of conditions.

4.1. Managing risk

The ecosystems of the Basin are dynamic. In ecosystems such as these, where disturbance processes play a major role in shaping and modifying vegetative structure and pattern, management strategies need to account for these dynamics. Mandating that old growth remain old growth by permanently allocating a particular stand for that purpose will result in eventual disappointment given the dynamics of these ecosystems. The uncertain nature of how these systems change needs to be considered as a key component of any management strategy.

Recognizing the temporal and spatial variability of a defined range of ecological and socioeconomic conditions will help managers manage so that each component has a place on the landscape. Adequately accounting for this variation will render the one-size-fits-all approach to management direction, direction aimed at preserving static conditions, as inappropriate and likely, ineffective. Although the simple management direction that suggests a single buffer width across wide landscapes or the mandate to never cut a tree above a certain diameter is easy to administer and regulate, it fails to recognize that the average stream rarely exists or that old forest might consist of smaller diameter trees in some settings.

No single component of the ecosystem is, or can be, completely isolated. It follows that any treatment, no matter how well planned to effect only one species or function, will have integrated effects. The significance of this is in recognizing that modifying one component will result in a cascade of effects, some both surprising and unintended, across many other components. Though our knowledge about these interactions is far from complete, accepting the concept should cause managers to ask questions that go beyond a single discipline.

As discussed above, actions directed toward individual components of a system will engender a variety of effects among other components. So too with risk. If management is restricted to the avoidance of a single type of risk, the interaction with other types or sources of risk may render the management ineffective. Successfully addressing this issue, for instance, would require consideration of terrestrial habitats within riparian areas in conjunction with aquatic habitats. A focus on in-stream conditions will not result in reducing risk induced through overland flow or shade removal by fire. Often, managers can maximize opportunity and minimize risk by partitioning them among spatial and temporal scales (see Quigley et al., 1996).

Managing large ecosystems often means recognizing that a high degree of variability exists in ecological and socioeconomic conditions, that these conditions are related and dynamic, and that, therefore, risks and opportunities are also interactive across space and through time. In that context, managers practicing ecosystem management choose among various risks and opportunities that will attain stated goals in ways that are consistent with the inherent capabilities of the system (Haynes et al., 1996).

4.2. Attributes of a successful land management strategy

Though true societal consensus is problematic, a strategy which gives focus and context to individual activities, and allows for adaptation and modification in light of new information, can increase compatibility between shifting, and often conflicting, social goals. If the goals for ecosystem management are to attempt to maximize both ecological integrity and socioeconomic resiliency (Haynes et al., 1996) and to minimize risk, assessments at multiple scales will be essential to understanding whether regional and local goals are being met. The linkage between management activities and outcomes needs occasional validation and existing conditions require periodic checks against desired conditions.

However, an expanded knowledge base contributes little if it does not influence decisions in new and different ways. As we learn more about ecosystems we should seek to develop more options for managers to choose among; that is, spread the space between alternatives more than shown in the context of Fig. 2. Equally as important to the magnitude of change is the direction of change. If we can recognize when actions are tending to reduce integrity or resiliency, we would expect managers to make adjustments to offset the negative changes in one dimension while making changes in the other dimension.

5. Conclusions

The ICBEMP in the northwestern United States provided an useful example where composite measures revealed current conditions and trends under varying management strategies. These measures enabled a more complete and integrated policy discussion but the development of these measures themselves was a challenge since they were based on a synthetic compilation of various indicators.

We could not reject the proposition that compatibility exists between changes in environmental and socioeconomic conditions for the set of land management strategies being considered by the FS and BLM in the Basin.

These results also challenge some of the conventional thinking of scientists about their roles in environmental policy in the sense of expanding the range of possibilities in the relationship among ecological and socioeconomic conditions. At the same time, participation in science intensive policy assessments (like habitat conservation strategies for endangered species such as the Northern spotted owl *(Strix occidentalis caurina)* and the Columbia-snake sockeye salmon *(Oncorhynchus nerka))* have raised questions about the role of scientists as advocates. Inevitably these management and sciences inferences drawn from the ICBEMP science efforts will be questioned. But they have already played an influential role in the revision of the FS planning regulations where ecological integrity as defined by Quigley et al. (2001) was proposed as a necessary condition for ecological sustainability by the Committee of Scientists (1999).

Many will see the reduction of broad-scale consequences to two dimensions and the use of broad-scale indicators as being overly simplistic given the complex social-environmental nature of the problem. But from the perspective of modeling it is an elegant solution to a vastly complex problem that uses empirical data to represent theoretic abstractions at the interface of science and policy. We acknowledge both the simplicity and the limits to this approach, but suggest it is instructive about the fundamental interactions of prospective land management strategies and their ecological and socioeconomic outcomes. It has the power to change our perceptions and to stimulate further research on the development of empirical measures of highly abstract concepts such as integrity.

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