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A Framework for Addressing Forest Health and Productivity in Eastern Oregon and Washington

Abstract

Healthy forests and rangelands are resilient to disturbances within a certain range of variation. In eastern Oregon and Washington, ecosystems have evolved in the presence of sporadic disturbances such as fire, floods, and insect and disease outbreaks. Ecological and human factors have combined to change disturbance regimes, structure, and patterns resulting in declining health and productivity in forest and rangeland ecosystems. We expect that with improved understanding of disturbance processes and careful management of the drivers of disturbance it is possible to enhance ecosystem resiliency. As an aid to managers in determining actions that may be successful in restoring resilience to ecosystems, we describe linkages among components that may enable managers to harness beneficial effects of disturbances while minimizing the adverse effects. A conceptual framework presented here identifies relations among factors that managers can influence, and that are important to ecological processes and outcomes. Integrating social and economic components helps managers to balance what the land will allow, what people want, and what society can afford. Influence diagrams help identify important linkages and the areas where research may help to weigh tradeoffs.

Introduction

Healthy forests and rangelands are a basic component in the economic, social, and physical health of human communities. In subsistence communities, the connection is clear; items people need for food, shelter, clothing, and health are obtained from the land local to the community. As communities depend more on trade for goods and services, the connection becomes less clear. However, many rural communities in eastern Oregon and Washington continue to depend on the productivity of the land for goods and services and the jobs they provide. Many people who are not directly employed in natural resource industries are drawn to the area as residents or visitors for recreation, clean air and water, and other amenities provided by healthy forests and rangelands. The issue that faces society now is whether the productivity and health of these ecosystems of eastern Oregon and Washington is at risk, and if so, what options managers have to restore their resilience and maintain their integrity.

The purpose of this paper is to provide a framework for thinking about forest health and productivity and the many factors that influence them.

The papers that follow will provide information to "flesh out" the framework.

Role of Disturbance

Healthy forests and rangelands require a mix of plant and animal species adapted to the site, suitable stocking levels and age distributions of those species, a variety of stand structures, and functioning ecological processes. Healthy ecosystems are dynamic, not static. They are resilient to disturbances within a range of variation and are, in many cases, dependent on them (White and Pickett 1985). Ecosystems in the Pacific Northwest have evolved in the presence of sporadic disturbances such as fire, floods, and insect and disease outbreaks (Agee 1990, Quigley et al. 1996). Such disturbances contribute to nutrient cycling and create canopy gaps and a mosaic of structures necessary for a rich diversity of plants and animals (Gast et al. 1991, Hessburg et al. 1994, Johnson 1994, Youngblood and Wickman, *In press*).

Unfortunately, factors have combined to change disturbance regimes and structural patterns and have resulted in declining health and productivity of forest and rangeland ecosystems in the interior

Northwest (Gast et al. 1991, Caraher et al. 1992, O'Laughlin et al. 1993, Everett et al. 1994, Langston 1994, Sampson and Adams 1994, Agee 1998). The system is at risk, and some species, structures, and functions are diminished or in danger of being lost.

The primary causes relate to changes that have occurred over the last 150 years (Covington et al. 1994, Everett et al. 1994, Quigley et al. 1996, Jaindl and Quigley 1996, National Research Council 2000). Early settlers used logging practices that removed high-value, large old trees from forests that were most accessible. Early grazing practices emphasized numbers of livestock resulting in substantial overgrazing. Fire was viewed as being detrimental, and efforts to suppress fire were largely successful after airplanes were enlisted in the efforts. When insect epidemics were widespread, various insecticides were applied to millions of acres. These factors all contributed to the current forest health situation in the inland West.

There are many examples of diminished function. Many sites more suited to drought- and fire-resistant ponderosa pine are now dominated by dense stands of fir—species susceptible to drought, fire, and insect and disease outbreaks (Wickman 1992). Suppression of fires that were part of the frequent, low-intensity fire regime has led to build-up of fuels and set the stage for huge crown fires that are difficult to contain (Mutch et al. 1993, Covington et al. 1994) and that have severe effects on vegetation, soil, and habitat. Habitat for many species is increasingly fragmented and isolated (Trombulak and Frissell 2000, Wisdom et al. 2000). Aquatic habitat has suffered increased sedimentation, less shading leading to higher water temperatures, loss of pools, and is isolated by barriers to passage (Trombulak and Frissell 2000, Howell 2001). Forest and rangelands have become depleted in native species and invaded by non-native plants (Quigley et al. 1996). Social and economic systems influence forest health and productivity and are also influenced by forest health conditions (Blatner et al. 1996, Tanaka and Bolon 1996).

Either current management approaches or taking a hands-off approach will likely result in ecosystem conditions at the landscape scale that continue to decline, or, at best, slowly improve over hundreds of years. Management actions that change species composition, density, and structure while considering ecosystem processes and capabilities,

may help to restore healthy, resilient, productive ecosystems (Quigley et al. 1996). Actions or "treatments" that have been undertaken with the expectation of improved forest health and productivity include "passive" approaches such as livestock exclusion or changes in grazing regime. "Active" approaches include treatments to modify stand composition, structure, and stocking level such as thinning, salvage logging, mechanical fuel treatment, and prescribed fire; or to control noxious weeds or insect pest outbreaks such as using herbicides, pesticides, *Bacillus thuringiensis*, or pheromones, or by introducing natural enemies of noxious weeds or insect pests.

Research Focus

To focus research on these issues, the Pacific Northwest Research Station formed a Research Initiative for Improving Forest Ecosystem Health and Productivity in Oregon and Washington by Managing Ecosystem Disturbance. Its specific goal is "to develop science-based information and technologies to assist landowners and managers in managing risks associated with fire, insects, and diseases...conserving the beneficial effects of these agents, while maintaining ecosystem integrity at multiple scales with the mix of products and conditions valued by society" (Hayes et al. 2000). To effectively deal with such complexity and geographic scope, we organized information in terms of ecological and socioeconomic structures and processes; agents that influence the processes, which we term "drivers"; and outcomes such as timber products, increase or decrease in endangered species, recreation, and water supply (Figure 1). We further examined these drivers, processes, and outcomes at various spatial scales. Temporal scale was also included but was difficult to address consistently. The expectation is that by careful management of the drivers and continual evaluation, we can enhance ecosystem resilience and improve outcomes (Figure 2). Examples of current outcomes that people would like to change include the loss of potential timber products and related jobs, degradation of ecological processes (hydrologic cycle, nutrient cycling, carbon sequestration), and risk to homes from catastrophic forest fires; loss of timber production and increased fire risk from insect outbreaks; threats to species survival; and loss of amenities and recreation opportunities. Many environmental drivers that affect ecological

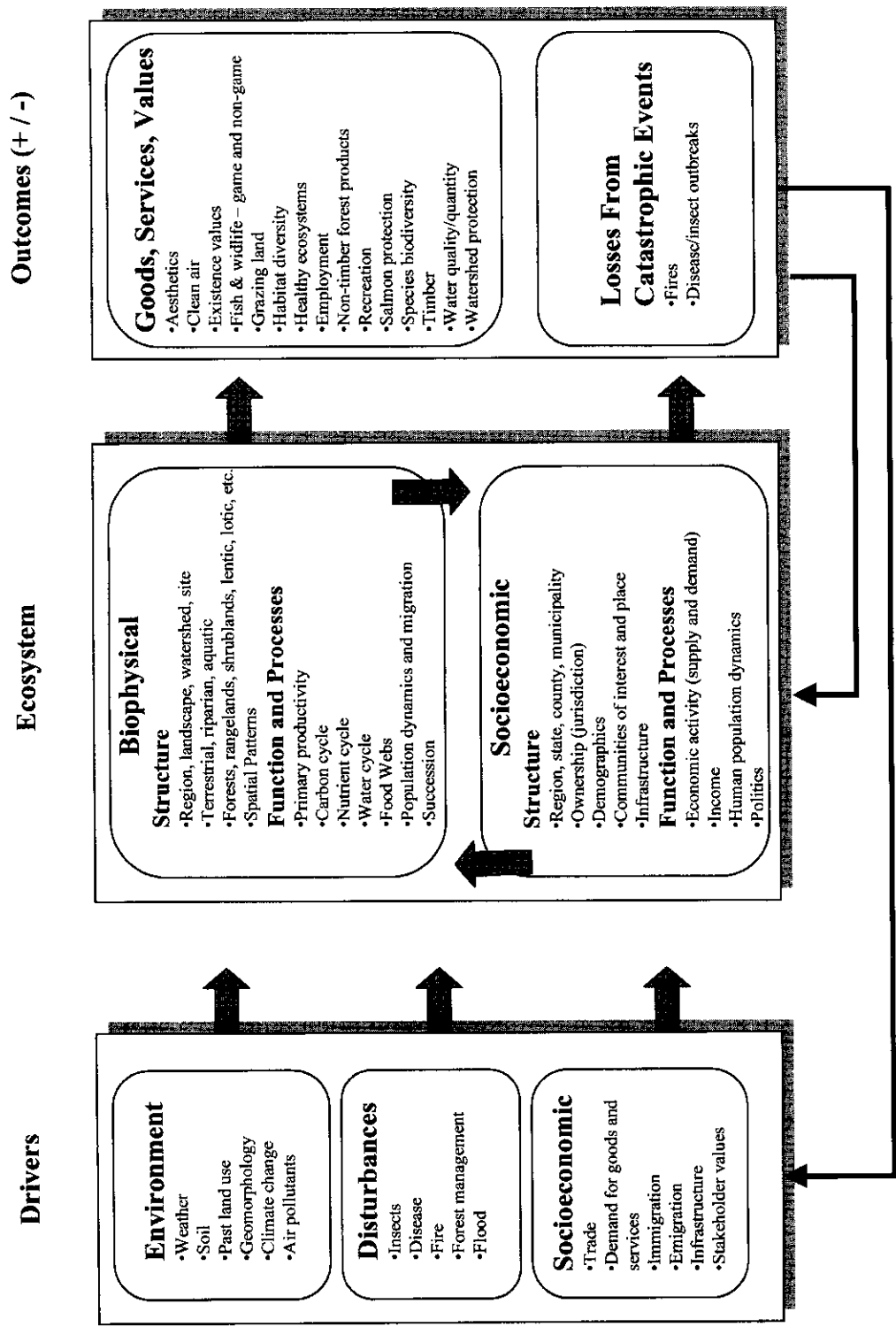


Figure 1. Conceptual model of the key elements, outcomes, and linkages for ecosystems of eastern Oregon and Washington.

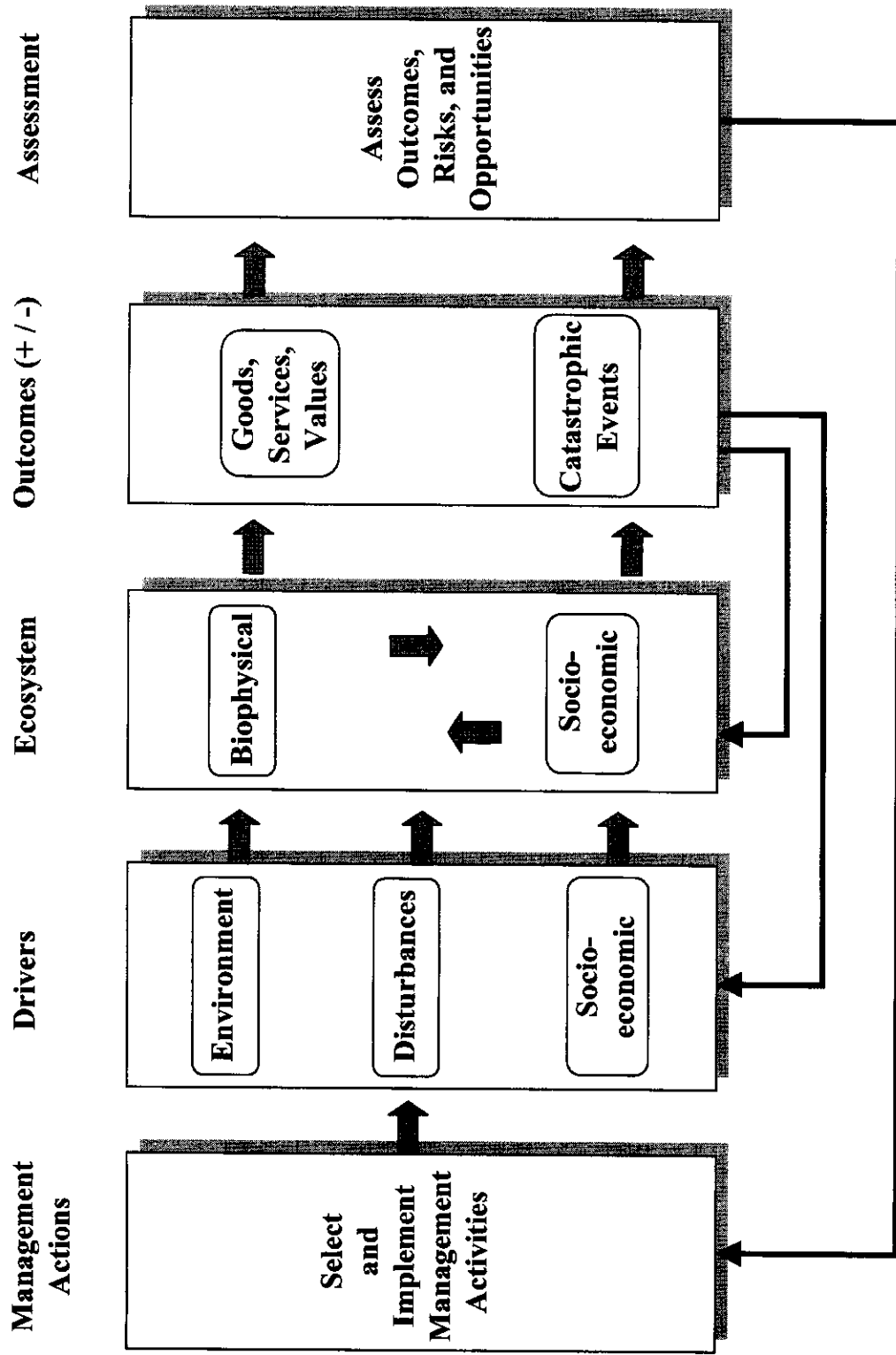


Figure 2. Model showing interaction of management actions and outcome assessments with key ecosystem elements.

processes—ocean cycles, volcanic activity, topography—are beyond the influence of management activities. Many of the disturbance and socio-economic drivers can be influenced, however, and the research initiative aims to offer information, models, and other decision-support tools to assist managers in that task. In the articles that follow we focus on fire, insects, disease, ungulate grazing, and, because we recognize that management can be a disturbance agent, we also examine the effects of treatment activities.

Influence Diagrams

As a start in determining what information is needed, PNW Research Station scientists engaged in the Forest Health and Productivity Initiative were asked to use their best judgment to identify the main components of ecosystem integrity, to identify the causative factors of those components, and to rate their degree of confidence in the knowledge base about the various relations and factors. Ecosystem integrity was defined to include wholeness, resiliency, and diversity of biophysical and socioeconomic factors across time and space (Haynes et al. 1996, Quigley et al. *In press*). Thus,

an ecological system with high integrity would include a mosaic of plant and animal communities consisting of well-connected, high-quality habitats that support a diverse assemblage of native and desired non-native species, all relevant life history stages, and the genetic diversity necessary for long-term persistence and adaptation in a variable environment (Quigley et al. *In press*).

The main components of broad-scale (sub-basin) ecosystem integrity identified by the team of scientists were: aquatic integrity, terrestrial integrity, social acceptability, socioeconomic resiliency, and air resource integrity. The team then identified the three most dominant factors influencing each component. The team recognized there were many other factors influencing each component, but they restricted the influence factors to the three most dominant. Each of these, in turn, was described by factors influencing it, and so on to no more than five levels. Creation of these influence diagrams at both the broad and mid scales (watershed or sub-watershed) were then used to identify knowledge gaps (components and linkages lacking information) and to gain insights into how the scientists collectively viewed interactions

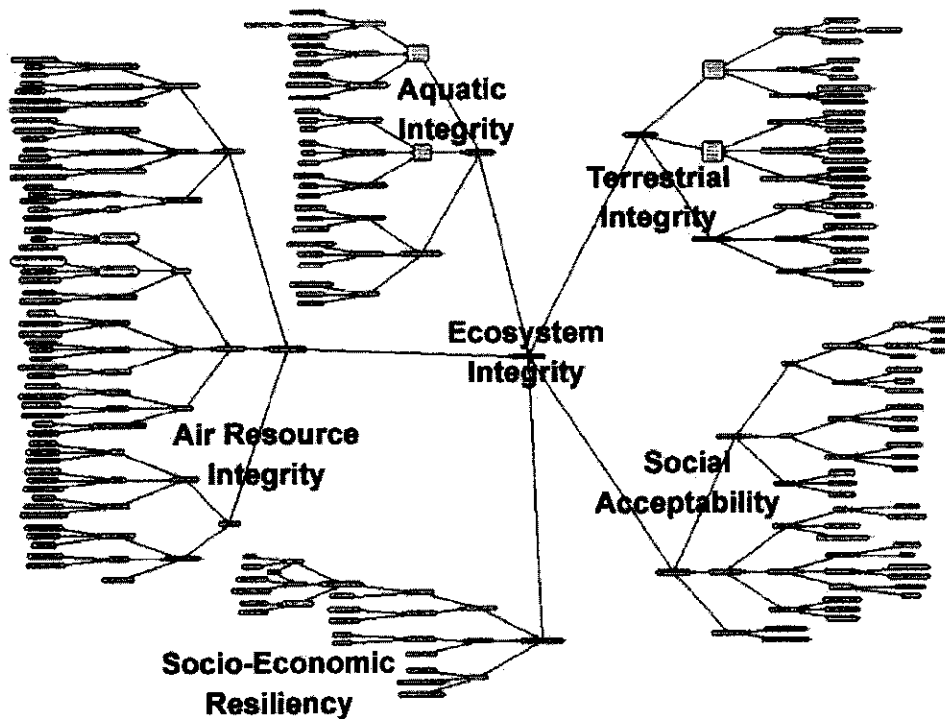


Figure 3. Broad-scale ecosystem integrity influence model.

and influences. (Diagrams were not completed at the fine scale (stand or site), because of the relative abundance of information at that scale.) There was no attempt to further rank influence factors for importance, but only for knowledge about the factors and linkages. The degree to which science explains each of these factors and connections between them was given a ranking of good, fair, or poor. The rankings were based on the ability to measure the factor directly or indirectly and availability of literature, i.e., empirical studies.

Figure 3 shows the overall diagram at the broad scale. Figure 4 shows a single branch of the mid-scale diagram as an example. Following this example, terrestrial integrity at the mid scale was considered by the experts to be influenced most by vegetation pattern, species diversity, and condition of source habitat. Vegetation pattern is

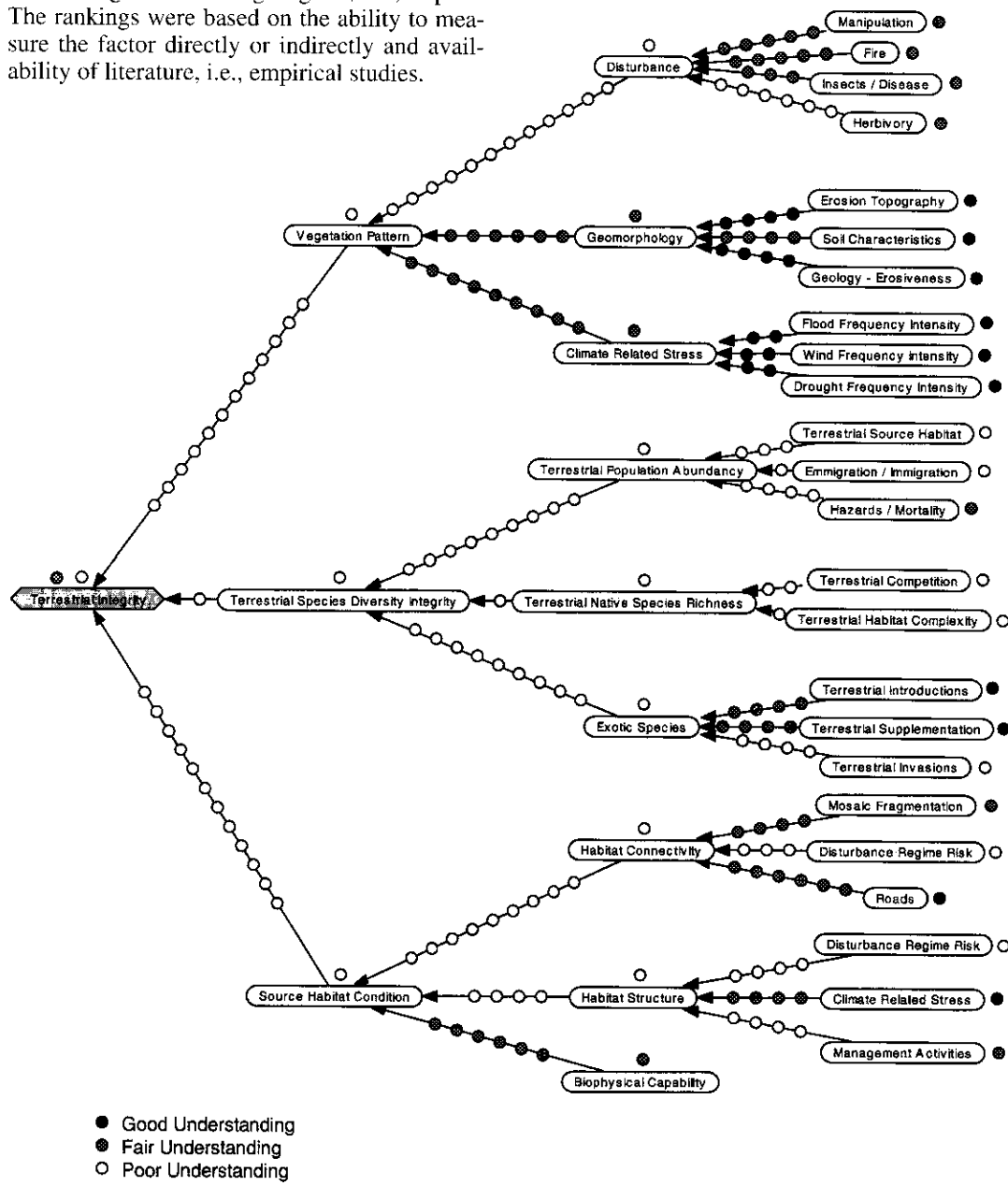


Figure 4. Mid-scale terrestrial integrity branch of the influence model.

in turn influenced by disturbance regimes, geomorphology, and climate-related stress, and so on.

Symbols on the diagram indicate good, fair, or poor for level of understanding. For disturbance regime, the influential factors are fairly well understood as are their influences on disturbance except for the influence of herbivory. The chronic nature of herbivory sets it apart from the more sporadic and often catastrophic disturbance factors such as fire and insect and disease outbreaks. There are numerous empirical studies at the fine scale and, to a lesser extent, at the mid scale that address cause-and-effect relations of fire, insects, and disease, and manipulation of these factors. As we move up the branch we find that the overall factor of disturbance and the interactive influence of disturbance regimes on vegetation patterns have not been as well studied, and therefore are considered poorly understood. Understanding of the other factors in this portion of the diagram is rated fair or good.

For terrestrial species diversity, the influences and linkages are poorly understood, with the exceptions of hazards/mortality. The introductions of non-native species and supplementation of native populations and their influence on the higher-order factor of terrestrial exotic species are reasonably well understood or at least readily measured.

For source habitat condition for terrestrial fauna and flora, the factors seen to be most influential were habitat connectivity (fragmentation), habitat structure, and biophysical capability. Habitat structure was seen to be most influenced by disturbance regime risk (the same factors that influence vegetation pattern), climate, and management activities. In this branch of the diagram, roads and climate-related stress are relatively well understood—in part because these are readily measurable factors. However, the influence of these factors on the next level is not as well understood.

Knowledge Gaps

This framework helps identify where research is most needed, such as causative factors that are important to ecosystem processes and outcomes, that managers can alter, and about which information is lacking. The detailed findings of information available or needed are summarized in Table 1 organized by category of use: understanding of disturbance regime, assessment of ecosystem

integrity, risk modeling, and management options. Items judged by the science team to be highest priority were identified as critical knowledge gaps. (Although Table 1 shows incomplete knowledge for disturbance drivers in modeling future risk, they were deemed lower priority than

TABLE 1. Knowledge availability and gaps identified in influence diagrams.

Element of Understanding or Inquiry	Degree to Which We Know or Understand (Critical Knowledge Gap)	
	Current	Future
DISTURBANCE REGIMES (Drivers)		
Fire	+	I **
Insects	+	I **
Diseases	- **	- **
Mgmt Actions	+	I **
CHARACTERIZE/ASSESSMENT (Biophysical & Socioeconomic Components of Ecosystem Integrity)		
Vegetation	I	- **
Terrestrial Habitat	+	- **
Water (Fish)	+	- **
Air	+	I **
Soil	+	- **
Sociocultural	- **	- **
Socioeconomic	+	I **
RISK MODELLING¹ (Drivers)		
Fire	+	I
Insects	+	-
Diseases	+	-
Mgmt Actions	+	I
Noxious Weeds	I **	I **
(Biophysical & Socioeconomic Components)		
Terrestrial Habitat	+ **	I **
Water (Fish)	+ **	I **
Air	I **	I **
Rural Interface	- **	- **
Sociocultural	- **	- **
Socioeconomic	+ **	I **
MANAGEMENT OPTIONS (Actions)		
Mitigation Treatments	I **	I **
Restoration Actions	I **	- **
Risk Reduction	I **	- **
Monitoring	- **	- **

- = poor understanding; + = better understanding;

I = incomplete understanding

** elements identified as critical knowledge gap

¹ Risk is probability that adverse outcomes happen.

the biophysical and socioeconomic components of risk modeling.) Factors and linkages were examined from the view of managing risks—not to eliminate disturbances, but to harness the beneficial effects while minimizing the adverse effects. The information was then further organized into areas of potential study and prioritized. These areas formed the focus of the Forest Health and Productivity Initiative of PNW Research Station (Hayes et al. 2000).

Examining the linkages at different scales illuminates the fact that information is limited when looking beyond fine-scale (stand or site level) interactions. More tools are needed to help evaluate cumulative effects, understand interactions of various agents, and assist in landscape planning. Prioritizing where to spend limited dollars is assisted if need and outcome are understood for a specific site relative to other sites, and for the watershed and the subbasin within which the site lies.

Identification of key indicators that can serve as measures of both beneficial and adverse effects of risk management and the means of monitoring them are also needed. The influence diagrams can help identify factors that may offer efficient means of quantifying change in important drivers, processes, or outcomes.

Examining the influence diagrams helps reveal areas where new knowledge may benefit management actions for a particular site while fulfilling ecological and socioeconomic requirements at the larger scale. Ways to partition landscapes into areas with similar characteristics (topography, riparian area, old-growth forest, fuel load, stocking level, plant community) would allow management appropriate to that category of sites, rather than prescribing a one-size-fits-all management standard. Managers would be assisted in choosing among management alternatives by tools that would allow them to (1) predict disturbance episodes, (2) predict activity outcomes on issues of interest (fire risk, timber harvest, jobs, water quality), and (3) weight the various factors that drive management activities (endangered species, diseases, recreation areas, noxious weeds, insect outbreaks, fuel loads, introduced species). Many assessment and predictive tools are available, but others are needed for larger scales or for managing multiple issues simultaneously.

Integrating social and economic components with ecological processes is also needed—

balancing what the land will allow, what people want, and what society can afford (Quigley and Bigler Cole 1997).

Information Availability

The influence diagrams help to identify factors important to understand, and the ratings help identify what is understood about the factors and linkages between factors. The next step, undertaken in this set of papers, was to organize and present that body of information in a way that is accessible to interested land managers. In order to initiate appropriate management activities, managers need several types of information. First, they need basic ecological information. Managers also need treatment options and understanding of the intended and unintended effects of those treatments on ecosystem components and processes. Further, managers need to be able to monitor a broad range of resources and processes in order to detect when risks to the system increase and to detect system responses to management actions. Finally, managers need tools to help determine what actions to take when faced with multiple disturbances and issues, and how to prioritize limited time, money, and personnel. These decision-support tools must be effective yet practical to help determine if treatments are ecologically effective, economically feasible, and socially acceptable. They need to help identify tradeoffs among ecological effects and community values and economics.

Research has provided a wealth of this needed information about forest health and productivity and disturbance agents in the inland Northwest. The following papers survey the information available on a selection of ecosystem drivers and issues of interest to managers. In preparing these papers, scientists were asked to focus on the reciprocal effects between a particular topic and forest health and productivity, as well as effects of treatments designed to improve some aspect of forest health and productivity. They were to attempt to identify to what scale the information applies, and any decision-support tools or monitoring thresholds that may have been determined. In the concluding paper, solutions based on the body of information presented in this collection of papers will be offered that may help improve forest and rangeland ecosystem resilience to disturbances.

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Note

This special issue of *Northwest Science* is a set of papers reviewing the state of knowledge about disturbance processes in eastern Oregon and Washington, related management practices, and effects on key management issues.