

ICBEMP Reference List (Including Abstract)

11/01

1. Barrett, S.W.; Arno, S.F.; Menakis, J.P. 1997. Fire episodes in the Inland Northwest (1540-1940) based on fire history data. Gen. Tech. Rep. INT-GTR-370. Ogden, UT: U.S Department of Agriculture, Forest Service, Rocky Mountain Research Station. 17 p.
Keywords: fire/climate.
Abstract: Presents maps of major fire episodes in the inland northwestern United States between 1540 and 1940 based on a compilation of fire history studies. Estimates annual acreage historically burned in this region and compares that with recent fire years.
2. Bull, E.L.; Parks, C.G.; Torgersen, T.R. 1997. Trees and logs important to wildlife in the interior Columbia River basin. Gen. Tech. Rep. PNW-GTR-391. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 55 p.
Keywords: wildlife/non-vascular plants/disturbance.
Abstract: This publication provides qualitative and quantitative information on five distinct structures: living trees with decayed parts, trees with hollow chambers, trees with brooms, dead trees, and logs. Information is provided on the value of these structures to wildlife, the decay or infection processes involved in the formation of these structures, and the principles to consider for selecting the best structures to retain.
3. Bunting, S.C.; Kingery, J.L.; Hemstrom, M.A.; Schroeder, M.A.; Gravenmier, R.A.; Hann, W.J. *In press*. Altered rangeland ecosystems in the interior Columbia basin. Gen. Tech. Rep. PNW-GTR-XXX. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. (Quigley, T.M., tech ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
Keywords: restoration/landscape dynamics/wildlife/exotic plants.
Abstract: A workshop was held to address specific questions related to altered rangeland ecosystems within the Interior Columbia Basin. Focus was primarily on public lands administered by the Forest Service and Bureau of Land Management. Altered ecosystems were considered to be those where human-induced and/or natural disturbances are of sufficient magnitude to affect ecosystem processes, causing long-term loss or displacement of native community types and loss of productivity, making it difficult or impossible to restore these ecosystems to historical conditions. Seventeen rangeland Potential Vegetation Types (PVT) were identified by ICBEMP and briefly described. Reasons that rangeland ecosystems are altered include: presence of invasive species, uncharacteristic grazing effects, climatic change, change in fire regime, and other factors related to human presence. However, primary causes of alteration and restoration potential differs between PVTs. Some altered rangeland ecosystems may be restored by; stabilizing ecosystem processes, restoring native plant communities, reducing the spread of invasive species, or conserving existing biota. In some altered conditions, these options have a relatively high probability of success over the short-term with low to moderate cost at the site scale. However, in other altered areas, restoration options are expensive, have a low probability of success, and require long time frames. Restoration of rangeland PVTs is also necessary for the survival of some animal species whose populations are in decline such as the Columbian sharp-tailed grouse and greater sage-grouse.
4. Burchfield, J.A.; Allen, S.D.; McCool, S.F. 1997. An estimate of the social consequences of alternatives in the Eastside and Upper Columbia River Basin Preliminary Draft Environmental Impact Statements. In: Quigley, T.M.; Lee, K.M.; Arbelbide, S.J., tech. eds. Evaluation of the Environmental Impact Statement Alternatives by the Science Integration Team. Gen. Tech. Rep. PNW-GTR-406. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 759-834. Chapter 6. Volume 2.
Keywords: EIS/social/American Indian/recreation/resiliency.
Abstract: (Part of Introduction) The Interior Columbia Basin Ecosystem Management Project (ICBEMP) is a combined science and management effort of the Forest Service (FS) and Bureau of Land Management (BLM). The project developed two large-scale Environmental Impact Statements (EISs) in two planning areas called the Eastside (EEIS) and Upper Columbia River Basin (UCRB). The Eastside area covers lands

administered by the Forest Service or BLM in eastern Oregon and Washington, while the UCRB area covers lands in nearly all of Idaho, western Montana, and small portions of adjacent states. The EISs were written in response to a variety of complex and controversial situations on these federally administered lands, including declines in forest health, increasing scarcity of anadromous and inland coldwater fisheries, rangeland reform, increasing risk of catastrophic fire, and the social and economic consequences of these conditions. The EISs describe seven alternatives, five of which are approaches to implementing ecosystem management.

The project's Science Integration Team (SIT) evaluated the consequences of these alternatives as defined in the *Preliminary Draft Environmental Impact Statements* (EISs) (USDA, USDI 1996a, 1996b). The ICBEMP contracted with The Bolle Center for People and Forests, University of Montana, to conduct an evaluation of the social consequences of the alternatives. The contract report, available to the public as part of the project record, begins by discussing the framework used to assess social consequences, followed by the criteria used to evaluate the alternatives and a description of the panel process conducted for the evaluation. An overview of the panels' conclusions provides context for interpreting their comments. The main section of the report is the evaluation of consequences, organized by the evaluation criteria. A short conclusions section provides direction for future efforts. In addition, the report contains detailed descriptions of the panel process, notes taken during the panels, workbooks completed by panelists, and written information provided panelists to help guide their judgments. Most of the information in this chapter is extracted from that report.

5. Burkhardt, J.W. 1996. Herbivory in the intermountain West: an overview of evolutionary history, historic cultural impacts and lessons from the past. Station Bulletin 58. Moscow, Idaho: University of Idaho, College of Forestry, Idaho Forest, Wildlife and Range Experiment Station. 35 p.
Keywords: wildlife/land management practices.
Abstract: (Introduction) There has been increasing interest in environmental issues related to land use in the western U.S. over the past decade. Traditional consumptive uses of renewable natural resources are coming under increasing scrutiny, especially on public lands. Certainly a major part of these land use concerns focuses on livestock grazing on public lands. While livestock grazing may be one of humankind's oldest endeavors, second to hunting or food gathering, (Towne and Wentworth 1951) its environmental sustainability is being questioned.
Our experience with historic livestock grazing in western North America provides a mixed track record. While most rangelands remain productive and stable after more than a century of livestock grazing, problems with altered plant communities and eroding streams abound. As a response to those problems there is a questioning of the ecological sustainability of livestock grazing. This paper is a review of the scientific literature relating to prehistoric and historic herbivory on the Intermountain West of North America. This characterization of the nature and role of prehistoric herbivory in comparison to our historic domestic grazing experience can provide useful insight to future management of livestock grazing.
6. Crone, L.K.; Haynes, R.W. 1999. Revised estimates for direct-effect recreational jobs in the interior Columbia River basin. Gen. Tech. Rep. PNW-GTR-483. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 29 p. (Quigley, T.M., tech ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
Keywords: recreation/employment.
Abstract: This paper reviews the methodology used to derive the original estimates for direct employment associated with recreation on Federal lands in the interior Columbia River basin (the basin), and details the changes in methodology and data used to derive new estimates. The new analysis resulted in an estimate of 77,655 direct-effect jobs associated with recreational activities on Federal lands in the basin. This estimate is a little over one-third of the previous estimate. The new estimated direct-effect recreational jobs amount to 4.48 percent of the total estimated jobs in the basin in 1994. This is still slightly larger than the estimated percentage of jobs in ranching, mining, and lumber and wood products combined (3.52 percent) in the basin. The intent of the original analysis is clarified, limitations of the data are brought forward, a cross-sectional analysis is conducted, and suggestions for future research are provided.
7. Crone, L.K.; Haynes, R.W. 2001. Socioeconomic evaluation of broad-scale management strategies. Forest

Ecology and Management. 153: 147-160.

Keywords: economics/social/restoration/resiliency/EIS.

Abstract: This paper examines the socioeconomic effects of alternative management strategies for Forest Service and BLM lands in the Interior Columbia basin. From a broad scale perspective, there is little impact or variation between alternatives in terms of changes in total economic activity or social conditions in the region. However, adopting a finer scale and examining effects on the counties that are likely to be most impacted by federal lands management reveals that many of these counties may be better off under one alternative in the short-term, but better off under another alternative in the longer term. The agencies can reduce their short-term impacts on federal resource reliant counties with low socioeconomic resiliency, by concentrating initial restoration efforts in specific areas, but the environmental justice issues associated with such a policy should also be considered.

8. Crone, L.K.; Haynes, R.W.; Reyna, N.E. 1999. Different perspectives on economic base. Res. Note PNW-RN-538. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 21 p.

Keywords: economics/employment.

Abstract: Two general approaches for measuring an economic base are discussed. Each method was used to define the economic base for each of the counties included in the Interior Columbia Basin Ecosystem Management Project area. A more detailed look at four selected counties results in similar findings from both approaches. Limitations of economic base analyses are noted.

9. Ferguson, S.A. 1997. A climate-change scenario for the Columbia River basin. Res. Pap. PNW-RP-499. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 9 p. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).

Keywords: climate.

Abstract: This work describes the method used to generate a climate-change scenario for the Columbia River basin. The scenario considers climate patterns that may change if the atmospheric concentration of carbon dioxide (CO₂), or its greenhouse gas equivalent, were to double over pre-Industrial Revolution values. Given the current rate of increase in atmospheric CO₂ concentration, doubling could occur within the next 50 to 100 years.

The Columbia River basin is in a transition climate zone between predominating maritime to the west, arctic to the north, and continental to the east. Consequently, it is difficult to characterize through means and averages. Therefore, many of the current stochastic methods for developing climate-change scenarios cannot directly apply to the basin. To circumvent this problem, a composite approach was taken to generate a climate scenario that considers knowledge of current regional climate controls, available output from general circulation and regional climate models, and observed changes in climate.

The resulting climate-change scenario suggests that precipitation could increase substantially during winter (+20 to +50 percent) and moderately during spring and autumn (+5 to +35 percent). A slight decrease (0 to -5 percent) in summer precipitation is possible, except for the southeastern portions of the basin that may experience an increase in convective precipitation (+5 percent).

Low-elevation (<1 kilometer) temperatures throughout the year may increase 1 to 3 °C, with greatest increases during winter. This amount of temperature change is possible because of an expected loss of low-elevation snow cover. At high elevations, increased cloud cover could cause average temperatures to decrease during winter but be synchronized with possible warming at low elevations during summer. The diurnal range of temperature could decrease, especially in summer and autumn.

10. Ferguson, S.A. 1998. Air quality climate in the Columbia River basin. Gen. Tech. Rep. PNW-GTR-434. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 23 p. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).

Keywords: air quality/climate.

Abstract: Aspects of climate that influence air quality in the Columbia River basin of the Northwestern

United States are described. A few, relatively simple, analytical tools were developed to show the spatial and temporal patterns of mean-monthly mixing heights, precipitation scavenging, upper level and surface trajectory winds, and drought that inhibit pollution uptake. Also, potential changes in air quality from the effects of increasing greenhouse gases are discussed.

11. Ferguson, S.A. 1999. Climatology of the interior Columbia River basin. Gen. Tech. Rep. PNW-GTR-445. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 31 p. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).

Keywords: climate.

Abstract: This work describes climate means and trends in each of three major ecological zones and 13 ecological reporting units in the interior Columbia River basin. Widely differing climates help define each major zone and reporting unit, the pattern of which is controlled by three competing air masses: marine, continental, and arctic. Paleoclimatic evidence and historical weather records show that the region has undergone significant fluctuations in temperature and precipitation as air masses alternate dominance over the basin. The major change in climate occurred near the time of western settlement with the end of the "Little Ice Age." Since then there have been numerous annual cycles in climate that may be related to the Pacific Decadal Oscillation. During the last 50 years, winter precipitation has decreased slightly and summer precipitation has increased throughout most of the basin. At the same time, winter temperatures have increased and summer temperatures have slightly decreased. Some impacts of changes in climatic means and trends on ecological conditions in the basin are discussed.

12. Ferguson, S.A. 2000. The spatial and temporal variability of rain-on-snow. In: International Snow Science Workshop: Proceedings of a conference. Bozeman, MT: Montana State University: 178-183.

Keywords: climate.

Abstract: Snow melt during rainfall causes large-scale flooding and avalanching. These rain-on-snow events are most well-documented in the coastal mountain ranges of western North America. To determine what role they play in interior mountains, we analyzed flood frequencies in the Columbia River basin and modeled rain-on-snow potential from daily temperature and precipitation data. Applying the model with geographically distributed weather data allowed maps of rain-on-snow potential at 2km spatial resolution to be generated from characteristic climate years of 1982 (cold and wet), 1988 (warm and dry), and 1989 (average). It was found that rain-on-snow events are more likely during cool, wet years (such as 1982). A greater number of events and more widespread distribution of events occur during this type of climate. The cool temperatures allow low-elevation snow to accumulate and frequent storms bring the possibility of mid-winter rain. Warm, dry years (1988) are less likely to experience rain-on-snow events. There is little low-elevation snow at these times and only occasional precipitation. During all years, areas most susceptible to rain-on-snow are those where topography allows incursion of relatively warm, moist marine air flows from the Pacific Ocean into the Columbia Plateau and up the Washington, and northwestern Montana where valleys open into the Columbia plateau; the Blue Mountains of northeastern Oregon; and western Wyoming and central Idaho adjacent to the Snake River.

13. Fluharty, D.L. 2000. Characterization and assessment of economic systems in the interior Columbia basin: fisheries. Gen. Tech. Rep. PNW-GTR-451. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 114 p. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).

Keywords: fish/economics/recreation/American Indian/climate .

Abstract: Economic value of commercial, recreational, and tribal fishing is one measure of the importance of fisheries in the interior Columbia River basin (the basin) but only part of the values associated with fish of that region. The basin historically has provided substantial intraregional anadromous stock fisheries and contributes to interregional fisheries along the entire west coast of the United States and Canada. Harvest management, construction of dams and irrigation facilities, changes in habitat, and other factors have led to significant declines in some stocks of fish, thereby diminishing their economic importance to the region. Resident fish like trout, sturgeon, sucker, lamprey, whitefish, and other species are harvested in tribal and recreational fisheries. With the exception of sturgeon, these species do not support significant commercial fisheries. Introduced species of many warm water recreational fish, like the walleye, have brought additional changes to the ecosystem of the basin and affect economic values of fishing.

Future economic and societal values of fisheries can be expected to increase because of major ongoing efforts to recover stocks of anadromous salmon; however, the magnitude and timing of recovery are uncertain. Increasing human populations in the basin along with steady or increased demand for recreational fishing will continue to raise the value of both native and introduced species. This will make food and recreational fisheries enhancement through artificial propagation more likely, but at the same time, raise the demand for protection of wild stocks and conservation-oriented management to produce low environmental impact and high-quality fisheries. Shifts in social preferences may bring demands for commercial and recreational allocation adjustments, which can greatly impact economic valuation of fisheries. Global climate change, intermittent drought, and interdecadal shifts in ocean conditions provide additional complexity and uncertainty that affect fish values.

14. Galliano, S.J.; Loeffler, G.M. 1999. Place assessment: how people define ecosystems. Gen. Tech. Rep. PNW-GTR-462. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 31 p. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
Keywords: social.
Abstract: Understanding the concepts of place in ecosystem management may allow land managers to more actively inventory and understand the meaning that people attach to the lands and resources under the care of the land manager. Because place assessment has not been used operationally in past large-scale evaluations and analyses, it was necessary in the assessment of the interior Columbia basin (hereafter referred to as the basin) to apply theories based on available literature. These theories were used within two large test areas inside the assessment area boundaries. From the test area experiences, it was apparent that the most appropriate scale for place assessment was at the community level. Ecological subsections, however, can serve as acceptable surrogates for place identification when time constraints do not permit adequate place inventories at the community level. Subsections provide a method for establishing the identity and themes of relatively large places. The identities and themes of these large places are useful in public land and resource planning for encouraging public participation early in the planning process, for measuring the importance of a place relative to its neighboring places, and for predicting possible environmental changes resulting from management alternatives. Place assessment in the basin demonstrated the importance of place to humanity, illustrated how inventory concepts of place can be operationalized for ecosystem assessments, and suggested how place assessments may be used in subsequent levels of analysis, planning, and decisionmaking.
15. Galliano, S.J.; Loeffler, G.M. 2000. Scenery assessment: scenic beauty at the ecoregion scale. Gen. Tech. Rep. PNW-GTR-472. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 30 p. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
Keywords: scenery/social/air quality/recreation.
Abstract: Scenic quality is an important amenity on public lands in the interior Columbia basin (hereafter referred to as the basin). People's interests in and expectations about ecosystems can help establish desired aesthetic conditions for the varied landscapes found in the basin. This paper, a portion of the social science assessment for the Interior Columbia Basin Ecosystem Management Project, explains the procedures used to inventory scenic quality throughout the basin by using two primary indicators: landscape character and scenic condition. Landscape character is expressed as landscape themes, which portray the overall images of a large geographic area. Scenic condition is measured in degrees of scenic integrity which express various levels of alteration to the landscape by humans to natural-appearing landscapes. Most landscapes in the basin are forests and shrub-grasslands having a predominantly natural appearance. Urban and rural developments visually dominate relatively few of the basin's landscapes although they are highly visible where they do occur. The overall scenic integrity of landscapes in the basin remains at a relatively high level with over 80 percent dominated by natural-appearing views.
16. Graham, R.T.; Harvey, A.E.; Jain, T.B.; Tonn, J.R. 1999. The effects of thinning and similar stand treatments on fire behavior in Western forests. Gen. Tech. Rep. PNW-GTR-463. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 27 p.
Keywords: fire/restoration/land management practices.

Abstract: In the West, thinning and partial cuttings are being considered for treating millions of forested acres that are overstocked and prone to wildfire. The objectives of these treatments include tree growth redistribution, tree species regulation, timber harvest, wildlife habitat improvement, and wildfire-hazard reduction. Depending on the forest type and its structure, thinning has both positive and negative impacts on crown fire potential. Crown bulk density, surface fuel, and crown base height are primary stand characteristics that determine crown fire potential. Thinning from below, free thinning, and reserve tree shelterwoods have the greatest opportunity for reducing the risk of crown fire behavior. Selection thinning and crown thinning that maintain multiple crown layers, along with individual tree selection systems, will not reduce the risk of crown fires except in the driest ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) forests. Moreover, unless the surface fuels created by using these treatments are themselves treated, intense surface wildfire may result, likely negating positive effects of reducing crown fire potential. No single thinning approach can be applied to reduce the risk of wildfires in the multiple forest types of the West. The best general approach for managing wildfire damage seems to be managing tree density and species composition with well-designed silvicultural systems at a landscape scale that includes a mix of thinning, surface fuel treatments, and prescribed fire with proactive treatment in areas with high risk to wildfire.

17. Graham, R.T.; Quigley, T.M.; Gravenmier, R. 2000. An integrated ecosystem assessment of the interior Columbia basin. *Environmental Monitoring and Assessment*. 64: 31-40.
 Keywords: ecological integrity/social.
 Abstract: Driven by the need to replace interim direction, address recent species listings as threatened or endangered under the Endangered Species Act, and break the gridlock of implementing actions, the U.S. Department of Agriculture, Forest Service (FS) and the U.S. Department of the Interior, Bureau of Land Management (BLM), initiated an effort to develop a scientifically-sound, ecosystem-based strategy for lands they administer in the Interior Columbia Basin. The effort included an integrated assessment of 58.3 million ha in seven states describing the Basin's current conditions and risks associated with different management strategies. The assessment provides the foundation for environmental impact statements outlining management direction for 31 million hectares of FS and BLM administered lands. The process produced a framework for ecosystem management, ecosystem component (social, economic, landscape, terrestrial, and aquatic) assessments, and estimates of ecological integrity and socioeconomic resiliency.

18. Gravenmier, R.A.; Wilson, A.E.; Steffenson, J.R. 1997. Information system development and documentation. In: Quigley, T.M.; Arbelbide, S.J., tech. eds. *An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins*. Gen. Tech. Rep. PNW-GTR-405. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 2012-2066. Chapter 8. Volume 4.
 Keywords: GIS/database documentation/technology transfer.
 Abstract: (Part of Introduction) This chapter is intended to provide a broad overview of the data, databases, and models employed by the ICBEMP and includes general recommendations for information management. Brief discussions of team organization, technology, GIS data and documentation, methods for integrating data, analysis methods, data release procedures, and data limitations are incorporated. A full discussion of the individual data layers and resulting analyses is not included. Much of this information can be found in either the documentation for each GIS data layer or the various staff area chapters within this document. It is hoped that the documentation of the information resource methods employed by the ICBEMP and the recommendations resulting from them will aid future efforts and highlight the need for a long-term information resource management strategy as part of ecosystem management.

19. Hann, W.J.; Hemstrom, M.A.; Haynes, R.W.; Clifford, J.L.; Gravenmier, R.A. 2001. Costs and effectiveness of multi-scale integrated management. *Forest Ecology and Management*. 153: 127-146.
 Keywords: fire/vegetation modeling/economics/restoration/EIS/natural resource policy.
 Abstract: To understand benefits of integrating management at landscape scales, we estimated cost and projected integrated outcomes for three alternatives for public land management in the interior Columbia River basin over 100 years. Effectiveness was measured in terms of costs and trends of long term (100 year) land and fire management, landscape health, and reduction of risks across several broad aquatic, terrestrial, landscape and socioeconomic indicators. Lowest costs with most positive cumulative trends for these variables occurred where alternatives "step down" assessment and planning from broader scales, focusing restoration efforts sufficiently to overcome opposite effects of traditional reserve protection or

commodity management strategies. Integrated management implemented at interconnected scales appears to have multiple positive outcomes. Landscape health, conditions for native fish and wildlife species and jobs from restoration activities can improve while risks to firefighters and property decline.

20. Hann, W.J.; Jones, J.L.; Karl, M.G.S.; Hessburg, P.F.; Keane, R.E.; Long, D.G.; Menakis, J.P.; McNicoll, C.H.; Leonard, S.G.; Gravenmier, R.A.; Smith, B.G. 1997. Landscape dynamics of the basin. In: Quigley, T.M.; Arbelbide, S.J., tech. eds. An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins. Gen. Tech. Rep. PNW-GTR-405. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 337-1055. Chapter 3. Volume 2.

Keywords: landscape dynamics/ecological integrity/vegetation modeling/fire/climate/air quality/land management practices/exotic plants/disturbance.

Abstract: (Part of Introduction) Landscape ecology was defined by Forman and Godron (1986) as the study of the structure, function, and change in a heterogeneous land area comprising interacting ecosystems. In North America, the science of landscape ecology has developed rapidly since the 1970s. The recent proliferation of landscape ecology literature and its associated application in resource management and land-use planning has been fueled in part by the complexity of multi-scale issues related to achieving public objectives for sustaining resource production and the biological diversity (or biodiversity) of native systems. These issues have required the rapid implementation of relatively new and non-traditional ecosystem management principles, assessment techniques, and management prescriptions at landscape levels, in both public and private natural resource management (Bourgeron and others 1994, Box 1995, Everett and others 1994a, Haynes and others 1996, Jaindl and others 1996, Jensen and Everett 1994, Kennedy and Quigley 1994, National Research Council 1994, Quigley and others 1996)...

The objective of the landscape assessment is to display an understanding of the spatial and temporal dynamics of landscape patterns, and their relation to social, economic, terrestrial, and aquatic systems. In order to assess biodiversity, ecological integrity was evaluated. That is, we assessed the ability of landscapes to renew themselves while taking into account their paleoecological, historical, current, and future biophysical potentials. This assessment of the Basin was based on the principles and methods outlined by Allen and Hoekstra (1992), Forman (1995), Forman and Godron (1986), King (1990), and Turner and Gardner (1990). Many of the methods published by Hessburg (1993), Jensen and Bourgeron (1994), Keane (1987), and Keane and others (1989, 1990a, 1990b, 1990c) were also incorporated. In addition, many methods were created through an iterative process as the assessment was conducted (see Keane and others 1996a).

21. Hann, W.J.; Jones, J.L.; Keane, R.E.; Hessburg, P.F.; Gravenmier, R.A. 1998. Landscape dynamics. *Journal of Forestry*. 96(10): 10-15.

Keywords: landscape dynamics/land management practices/vegetation modeling/fire/landscape patterns/disturbance.

Abstract: Assessment of the landscape dynamics of the ecosystems within the interior Columbia River basin included both natural and human changes. We describe the relationships between land use, ecosystem health, species diversity, and interactions with inherent disturbance processes and biophysical capabilities. We found that both traditional commodity and reserve system management strategies cause short-term fragmentation leading to long-term simplification of biophysical and socioeconomic landscape systems; active ecological management, on the other hand, can sustain the capabilities of these systems.

22. Hann, W.J.; Karl, M.G.S.; Jones, J.L.; Gravenmier, R.A.; Long, D.G.; Menakis, J.P.; Keane, R.E. 1997. Landscape ecology evaluation of the preliminary draft EIS alternatives. In: Quigley, T.M.; Lee, K.M.; Arbelbide, S.J., tech. eds. Evaluation of the Environmental Impact Statement Alternatives by the Science Integration Team. Gen. Tech. Rep. PNW-GTR-406. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 29-434. Chapter 2. Volume 1.

Keywords: EIS/landscape dynamics/vegetation modeling/land management practices/ecological integrity/exotic plants/fire.

Abstract: (Part of Introduction) The landscape evaluation of alternatives for the Eastside and Upper Columbia Preliminary Draft Environmental Impact Statements (PDEISs) presents a comparison of outcomes for key landscape variables across the seven alternatives for the Basin. The evaluation process

involved simulation and analyses of predicted effects, and also qualitative evaluation, of the alternatives as described in direction to the Science Integration Team (SIT) in a letter dated February 26, 1996...

The purpose of the landscape dynamics evaluation is to predict the effects of the alternatives on landscape components (table 2.1). These components vary depending on the management emphasis of the alternatives (table 2.2; appendix 2-C). The seven different alternative themes in the preliminary draft EIS have a broad range of outcomes considering the variation in landscape components and the difference in spatial location and effects through time.

23. Hardy, C.C.; Burgan, R.E.; Ottmar, R.D. 2000. A database for spatial assessments of fire characteristics, fuel profiles, and PM10 emissions. Sampson, R.N.; Atkinson, R.D.; Lewis, J.W., eds. Mapping wildfire hazards and risks. Chapter 9. New York: Food Products Press: 229-244.
Keywords: fire/air quality/database documentation.
Abstract: This paper describes the procedures and data used to develop a database of 28 fire, fuels, and smoke attributes for the broad-scale scientific assessment of the Interior Columbia River Basin. These attributes relate to three general areas: (1) fire weather, fuel moisture, and fire characteristics; (2) fuel loading and fuel consumption; and (3) PM10 smoke emissions. The process flow and development protocols for creation of the database are fully described and illustrated, with examples provided where appropriate. This database was developed for application to a certain geographic area with parameters specific to both the biophysical environment and the management issues of that area. However, the methods and protocols used to develop this comprehensive suite of fire-related data are applicable to any ecosystem for which predictions are needed for wildfire hazard, fire potential, biomass consumption, and smoke emissions.
24. Harris, C.; McLaughlin, W.; Brown, G.; Becker, D.R. 2000. Rural communities in the inland Northwest: an assessment of small rural communities in the interior and upper Columbia River basins. Gen. Tech. Rep. PNW-GTR-477. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
Keywords: social/resiliency.
Abstract: An assessment of small rural communities in the interior and upper Columbia River basin was conducted for the Interior Columbia Basin Ecosystem Management Project (ICBEMP). The characteristics and conditions of the rural communities in this region, which are complex and constantly changing, were examined. The research also assessed the resilience of the region's communities, which was defined as a community's ability to respond and adapt to change in the most positive, constructive ways possible for mitigating the impacts of change on the community. The study found that a town's population size, autonomy, economic diversity, quality of life, and experience with change were all factors related to the town's resiliency and the extent to which it was changing and preparing for change.
25. Harrison, R.D.; Chatterton, N.J.; Page, R.J.; Curto, M.; Asay, K.H.; Jensen, K.B.; Horton, W.H. 1996. Competition, biodiversity, invasion, and wildlife usage of selected introduced grasses in the Columbia and Great Basins. Research Report 155. Logan, UT: Utah Agricultural Experiment Station, Utah State University. 86 p. Available from: USDA-Agricultural Research Service, Forage and Range, Utah State University, Logan, UT 84322-6300
Keywords: native plants/exotic plants/biodiversity/wildlife/restoration.
Abstract: (Purpose) This report examines the competitive ability, invasiveness, wildlife use, and known effects on overall biodiversity within the Columbia and Great Basins of nine seeded grass species or species complexes: crested, intermediate and tall wheatgrass; bulbous and Kentucky bluegrass; hard and sheep fescues; orchardgrass, and reed canary grass.
26. Haynes, R.W.; Graham, R.T.; Quigley, T.M. tech. eds. 1996. A framework for ecosystem management in the Interior Columbia Basin including portions of the Klamath and Great Basins. Gen. Tech. Rep. PNW-GTR-374. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 66 p. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
Keywords: natural resource policy/technology transfer/American Indian.

Abstract: A framework for ecosystem management is proposed. This framework assumes the purpose of ecosystem management is to maintain the integrity of ecosystems over time and space. It is based on four ecosystem principles: ecosystems are dynamic, can be viewed as hierarchies with temporal and spatial dimensions, have limits, and are relatively unpredictable. This approach recognized that people are part of ecosystems and that stewardship must be able to resolve tough challenges including how to meet multiple demands with finite resources. The framework describes a general planning model for ecosystem management that has four iterative steps: monitoring, assessment, decision-making, and implementation. Since ecosystems cross jurisdictional lines, the implementation of the framework depends on partnerships among land managers, the scientific community, and stakeholders. It proposes that decision-making be based on information provided by the best available science and the most appropriate technologies for land management.

27. Haynes, R.W.; Graham, R.T.; Quigley, T.M. 1998. A framework for ecosystem management in the interior Columbia basin. *Journal of Forestry*. 96(10): 4-9.
Keywords: natural resource policy/technology transfer.
Abstract: A framework was developed to set forth the relationship of science to management for the Interior Columbia Basin Ecosystem Management Project. It incorporates a general planning model that has four iterative steps: monitoring, assessment, decisionmaking, and implementation. In this effort we recognized that people are part of ecosystems and that stewardship must resolve the challenge of how to meet multiple demands with finite resources. Science helps decisionmakers choose among options for dynamic systems, but the real challenge is determining whose values will influence land management.
28. Haynes, R.W.; Horne, A.L. 1997. Economic assessment of the basin. In: Quigley, T.M.; Arbelbide, S.J., tech. eds. An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins. Gen. Tech. Rep. PNW-GTR-405. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 1715-1869. Chapter 6. Volume 4.
Keywords: economics/human population/employment/fish/land management practices/special forest products.
Abstract: (Part of Introduction) The Charter of the Interior Columbia Basin Ecosystem Management Project (ICBEMP) charged the Science Integration Team to identify, among other issues, the economic outcomes associated with current Forest Service (FS) and Bureau of Land Management (BLM) activities in the assessment area. We identified three dominant economic themes having to do with (1) regional economies, (2) economic efficiency, and (3) equity. The importance of management of FS and BLM lands to regional economic activity is examined under the first theme. The theme of economic efficiency examines whether the resources associated with the Federal lands are being administered to provide society with good value. The theme of equity assesses how the benefits and cost provided by these Federal lands are being distributed throughout the population. Society is the judge of the fairness of the distribution, and it expresses its preferences through elected officials, legislation, and the judiciary.
29. Haynes, R.W.; Horne, A.L.; Reyna, N.E. 1997. Economic evaluation of the preliminary draft EIS alternatives. In: Quigley, T.M.; Lee, K.M.; Arbelbide, S.J., tech. eds. Evaluation of the Environmental Impact Statement Alternatives by the Science Integration Team. Gen. Tech. Rep. PNW-GTR-406. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 731-758. Chapter 5. Volume 2.
Keywords: EIS/economics/recreation/employment/land management practices.
Abstract: (Part of Introduction) This economic evaluation of the preliminary draft Environmental Impact Statement (EIS) alternatives is based on data, methods, and analysis reported in the Economic Assessment chapter (Haynes and Horne, in press) of the *Assessment of Ecosystem Components in the Interior Columbia Basin and Portions of the Klamath and Great Basins* (Quigley and Arbelbide, in press). It begins with a summary of our findings about the current economic condition of the Basin. We then examine the primary and secondary effects of each alternative using measures of outputs provided by the EIS teams [animal unit months (AUMs), Recreation Opportunity Spectrum (ROS) acres, timber harvest, and unroaded areas]. We identify effects on specific economic sectors for the Basin as a whole and for particular counties. Using the concept of economic resiliency, we discuss the impact of the alternatives against the backdrop of the changing Basin economy. We then evaluate the effect of the alternatives on efficient use of Federal land resources in which efficiency is defined as the benefits provided, not cash flows. In the final section, we

discuss the effects of the alternatives on the distribution of costs and benefits among the American people.

30. Haynes, R.W.; Quigley, T.M. 2001. Broadscale consequences of land management: Columbia basin example. *Forest Ecology and Management*. 153: 179-188.
Keywords: ecological integrity/resiliency/restoration.
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.
31. Haynes, R.W.; Quigley, T.M.; Clifford, J.L.; Gravenmier, R.A. 2001. Science and ecosystem management in the interior Columbia River basin. *Forest Ecology and Management*. 153: 3-14.
Keywords: ecological integrity/EIS.
Abstract: Significant changes over the past 150 years in aquatic, terrestrial, landscape, and socioeconomic systems have altered biophysical systems in the interior Columbia basin. Changes and conflict in public policy concerns, such as resource use vs. restoration vs. conservation are especially evident in the more than 34 percent of total forest and rangeland in the United States that are federally administered. In the last decade, design and implementation of complex land management strategies has become an issue for public land managers. In turn, the scientific community is often challenged to develop approaches for management of complete ecosystems. This paper discusses the use of science in the assessment and evaluation phases of one large scale (multi-region) ecosystem management effort on federal lands in the Columbia River basin, the Interior Columbia Basin Ecosystem Management Project (ICBEMP), and briefly describes the evaluations of three alternative management strategies which are detailed by other papers in this issue. This paper contends that understanding the context of land management decisions is essential to defining the veracity or applicability of alternative land management strategies. Evaluating the alternatives is a complicated science process, which requires understanding the effects of each set of direction over both the short and long term, projecting the effects of those directions, making assumptions about pieces not yet developed, and modeling resource change.
32. Haynes, R.W.; Reyna, N.E.; Allen, S.D. 1998. Social and economic systems. *Journal of Forestry*. 96(10): 28-32.
Keywords: economics/employment/resiliency/social/American Indian/human population.
Abstract: The social and economic assessments conducted for the Interior Columbia Basin Ecosystem Management Project characterized social and economic conditions and trends. The basin has a robust economy that is growing, diversifying, and reducing the importance of traditional resource industries. Even so, there remain many places that are not sharing in this prosperity or easily adapting to the changes to traditional rural lifestyles that growth brings.
33. Hemstrom, M.A.; Korol, J.J.; Hann, W.J. 2001. Trends in terrestrial plant communities and landscape health indicate the effects of alternative management strategies in the interior Columbia River basin. *Forest Ecology and Management*. 153: 105-126.
Keywords: landscape dynamics/vegetation modeling/disturbance/EIS/landscape patterns/restoration.
Abstract: Current and potential future conditions of terrestrial plant communities and landscape health were modeled for three alternative public land management strategies in the Interior Columbia River Basin. Landscape health was defined as an integration of the degree to which vegetation and disturbance conditions resemble native patterns and support levels of human activity. The range of vegetation and disturbance variability for a period before the middle nineteenth century was used as a basis for comparison of current and future regimes to the "historical" system. Departure from the "historical" regime in wildland environments was found to be related to altered disturbance patterns, especially changed fire regimes,

forest insect and disease levels and excessive livestock grazing effects. Overall, mid-seral forests are currently more prevalent than they were in the past and old forests, especially single-layer structural types, are less abundant. Nonnative plant species and altered plant community composition conditions exist across broad areas of rangelands. Landscape health has declined substantially in many areas. Proposed management strategies that emphasize maintenance and restoration activities in a hierarchical landscape approach should generate improved landscape health conditions over the next 100 years. However, the massive scale of changes to disturbance and vegetation patterns from historical to current times and the cost of implementing restoration activities make dramatic improvement unlikely.

34. Hemstrom, M.A.; Wisdom Michael J.; Hann, W.J.; Rowland, M.M.; Wales, B.C.; Gravenmier, R. *In press*. Sagebrush-steppe vegetation dynamics and restoration potential in the interior Columbia Basin, USA. *Conservation Biology*.
Keywords: vegetation modeling/landscape dynamics/restoration/wildlife/land management practices.
Abstract: We modeled the dynamics and restoration of sagebrush (*Artemisia* spp.) habitats for Greater Sage-Grouse (*Centrocercus urophasianus*) in the interior Columbia Basin and adjacent portions of the Great Basin (referred to as basin). Greater Sage-Grouse have undergone widespread decline and are of conservation focus on over 13 million ha of sagebrush steppe in the basin, much of which is managed by the U.S. Forest Service (FS) and U.S. Bureau of Land Management (BLM). Consequently, we evaluated changes in the amount and quality of sage-grouse habitat on 8.1 million ha of FS-BLM lands in the basin. Changes were estimated from historical to current conditions and from current conditions to those projected 100 years in the future under proposed management and under two restoration scenarios. The two restoration scenarios were designed to improve long-term (100-year) projections of sage-grouse habitat on FS-BLM lands in relation to current conditions and proposed management. Scenario 1 assumed a 50% reduction in detrimental grazing effects by livestock (through changes in stocking rates and grazing systems) and a six-fold increase in areas treated with active restoration relative to proposed management. Scenario 2 assumed a 100% reduction in detrimental grazing effects and the same level of active restoration as scenario 1. Under the two scenarios, amount of FS-BLM habitat for sage grouse within treated areas declined by 17-19% 100 years in the future compared with the current period, but was 10-14% higher than the 100-year projection under proposed management. Habitat quality under both scenarios was substantially improved compared with the current period and proposed management. Our results suggest that aggressive restoration could slow the rate of sagebrush loss and improve the quality of remaining habitat.
35. Hessburg, P.F.; Salter, R.B.; Richmond, M.B.; Richmond, M.B.; Smith, B.G. 2000. Ecological subregions of the interior Columbia basin, USA. *Applied Vegetation Science*. 3(2): 163-180.
Keywords: landscape patterns/climate/landscape dynamics/geology.
Abstract: Land evaluations are not always conducted with adequate understanding of the relevant geologic and climatic contexts and their appropriate scales. This understanding is essential for developing representative sampling, monitoring, and conservation designs, and for pooling results of landscape analysis. To provide context for several regions of the interior northwestern United States, we conducted an ecoregion classification of the interior Columbia River Basin and vicinity ('the Basin'). We grouped land units that are influenced by the same higher order geology and landform features, and share similar areal composition of potential vegetation and climate attributes. We used the TWINSpan procedure to group 7496 watersheds of the Basin into 53 ecological subregions. We evaluated the contribution of attributes to group separation by discriminant analysis, and evaluated subregion robustness to prediction by cross-validation. Classification accuracy ranged from 80 - 97% across the subregions. All watersheds were classified to a subregion, and there were strong resemblances between members of adjacent subregions. Subregions with strong resemblances shared a similar composition of attributes, but differed in relative abundance and attribute combinations. We evaluated the geologic and climatic context of each subregion considering four levels in a nested land unit hierarchy. Most subregions nested at one of at least four scales, but some overlapped. Our results suggest that observation levels for a given ecological phenomenon need not be nested within their appropriate context levels, and across broad geographic areas context of the same phenomenon occurs at different scales.
36. Hessburg, P.F.; Smith, B.G. 1999. Management implications of recent changes in spatial patterns of interior Northwest forests. In: *Transactions of the 64th North American Wildlife and Natural Resources*

Conference: Proceedings of a conference. [Place of publication unknown]: [Publisher unknown]: 55-78.
Keywords: landscape dynamics/vegetation modeling/fire/land management practices/landscape patterns.
Abstract: (Part of Introduction) This paper summarizes results of a study conducted under the aegis of the Interior Columbia Basin Ecosystem Management Project. We report on a midscale scientific assessment of vegetation change in terrestrial landscapes of the interior West, associated change in landscape vulnerability to fire, insect and pathogen disturbances, and management implications of those changes. Our assessment area included the interior Columbia River basin east of the crest of the Cascade Range and portions of the Klamath and Great Basins in Oregon (collectively, the basin). States included in the assessment area were eastern Oregon and Washington, Idaho, western Montana and Wyoming, and northern California, Utah and Nevada (Figure 1).

37. Hessburg, P.F.; Smith, B.G.; Kreiter, S.D.; Miller, C.A.; McNicoll, C.H.; Wasienko-Holland, M. 2000. Classifying plant series-level forest potential vegetation types: methods for subbasins sampled in the midscale assessment of the interior Columbia basin. Research Paper PNW-RP-524. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 59. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
Keywords: landscape patterns/fire/disturbance/vegetation modeling/landscape dynamics.
Abstract: In the interior Columbia River basin midscale ecological assessment, we mapped and characterized historical and current vegetation composition and structure of 337 randomly sampled subwatersheds (9500 ha average size) in 43 subbasins (404 000 ha average size). We compared landscape patterns, vegetation structure and composition, and landscape vulnerability to wildfires and 21 major forest insect and pathogen disturbances of historical and current forest vegetation coverages. We report on methods used to classify and map potential vegetation of individual patches of sampled subwatersheds at the plant level.
38. Hessburg, P.F.; Smith, B.G.; Kreiter, S.D.; Miller, C.A.; Salter, R.B.; McNicoll, C.H.; Hann, W.J. 1999. Historical and current forest and range landscapes in the interior Columbia River basin and portions of the Klamath and Great Basins: Part 1--Linking vegetation patterns and landscape vulnerability to potential insect and pathogen disturbances. Gen. Tech. Rep. PNW-GTR-458. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 357 p. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
Keywords: landscape patterns/fire/disturbance/landscape dynamics/vegetation modeling.
Abstract: Management activities of the 20th century, especially fire exclusion, timber harvest, and domestic livestock grazing, have significantly modified vegetation spatial patterns of forests and ranges in the interior Columbia basin. Compositional patterns as well as patterns of living and dead structure have changed. Dramatic change in vital ecosystem processes such as fire, insect, and pathogen disturbances, succession, and plant and animal migration is linked to recent change in vegetation patterns. Recent change in vegetation patterns is also a primary reason for current low viability and threatened, endangered, or sensitive status of numerous native plant and animal species. Although well intentioned, 20th century management practices have not accounted for the larger patterns of living and dead vegetation that enable forest ecosystems to function in perpetuity and maintain their structure and organization through time, or for the disturbances that create and maintain them. Knowledge of change in vegetation patterns enhances resource manager and public awareness of patterns that better correspond with current climate, site conditions, and native disturbance regimes, and improves understanding of conditions to which native terrestrial species have already adapted.

In this study, we characterized recent historical and current vegetation composition and structure of 337 randomly sampled subwatersheds (9500 ha average size), in 43 of 164 total subbasins (404 000 ha average size), selected by stratified random draw on all ownerships within the interior Columbia River basin and portions of the Klamath and Great Basins (collectively referred to as the basin). We compared landscape patterns, vegetation structure and composition, and landscape vulnerability to 21 major insect and pathogen disturbances of historical and current vegetation coverages. For each selected subwatershed, we constructed historical and current vegetation maps from interpretations of 1932-66 and 1981-93 aerial photos, respectively. Areas with homogeneous vegetation composition and structure were delineated as patches to a minimum size of 4 ha. We then attributed cover types (composition), structural classes (structure), and series-level potential vegetation types (site potential) to individual patches within

subwatersheds by modeling procedures. We characterized change in vegetation spatial patterns by using an array of class and landscape pattern metrics and a spatial pattern analysis program. Finally, we translated change in vegetation patterns to change in landscape vulnerability to major forest pathogen and insect disturbances. Change analyses results were reported for province-scale ecological reporting units.

Forest and range ecosystems are significantly altered after their first century of active management, but there is reason for guarded optimism. Large areas remain relatively unchanged and intact, such as can be found on the east side of the Cascade Range in Washington and in the central Idaho mountains, and these areas may provide an essential "nucleus" for conservation strategies and ecosystem restoration. Strategies for improving the health of basin ecosystems can build on existing strengths. Improved understanding of change in vegetation patterns, causative factors, and links with disturbance processes will assist managers and policymakers in making informed decisions about how to address important ecosystem health issues.

39. Hessburg, P.F.; Smith, B.G.; Miller, C.A.; Kreiter, S.D.; Salter, R.B. 1999. Modeling change in potential landscape vulnerability to forest insect and pathogen disturbances: methods for forested subwatersheds sampled in the midscale interior Columbia River basin assessment. Gen. Tech. Rep. PNW-GTR-454. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 56 p. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).

Keywords: vegetation modeling/landscape dynamics/disturbance/land management practices/landscape patterns.

Abstract: In the interior Columbia River basin midscale ecological assessment, including portions of the Klamath and Great Basins, we mapped and characterized historical and current vegetation composition and structure of 337 randomly sampled subwatersheds (9500 ha average size) in 43 subbasins (404 000 ha average size). We compared landscape patterns, vegetation structure and composition, and landscape vulnerability to 21 major forest insect and pathogen disturbances of historical and current forest vegetation coverages. Forest vegetation composition, structure, and patterns were derived from attributes interpreted and mapped from aerial photographs taken from 1932 to 1966 (historical), and from 1981 to 1993 (current). Areas with homogeneous vegetation composition and structure were delineated as patches to a minimum size of 4 ha. Results of change analyses were reported for province-scale ecological reporting units (ERU's). In this paper, we report on methods used to characterize historical and current patch and subwatershed vulnerability to each of 21 insect and pathogen disturbance agents.

We assessed landscape vulnerability to defoliator, bark beetle, dwarf mistletoe, root disease, blister rust, and stem decay disturbances. We used patch composition, structure, logging disturbance, and physical environment attributes to compare vegetation vulnerability of historical subwatersheds with that of their current condition. Patch vulnerability factors included items such as site quality, host abundance, canopy layers, host age or host size, patch vigor, patch (stand) density, connectivity of host patches, topographic setting, and presence of visible logging disturbance. Methods reported here can be used to landscape or watershed analysis to evaluate or monitor change in the magnitude and spatial pattern of vegetation vulnerability to insect and pathogen disturbances, and in planning to compare potential disturbance futures associated with alternative vegetation management scenarios.

40. Hessburg, P.F.; Smith, B.G.; Salter, R.B. 1999. Using estimates of natural variation to detect ecologically important change in forest spatial patterns: a case study, Cascade Range, eastern Washington. Res. Pap. PNW-RP-514. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 65 p.

Keywords: landscape dynamics/vegetation modeling/landscape patterns/restoration.

Abstract: Using hierarchical clustering techniques, we grouped subwatersheds on the eastern slope of the Cascade Range in Washington State into ecological subregions by similarity of area in potential vegetation and climate attributes. We then built spatially continuous historical and current vegetation maps for 48 randomly selected subwatersheds from interpretations of 1938-49 and 1985-93 aerial photos, respectively, and attributed cover types, structural classes, and potential vegetation types to individual patches by modeling procedures. We estimated a natural range of variation (NRV) in spatial patterns of patch types by subwatersheds and five forested ecological subregions. We illustrate how NRV information can be used to characterize the direction and magnitude of vegetation change occurring as a consequence of management.

41. Hessburg, P.F.; Smith, B.G.; Salter, R.B. 1999. Detecting change in forest spatial patterns from reference conditions. *Ecological Applications*. 9(4): 1232-1252.

Keywords: landscape patterns/vegetation modeling/landscape dynamics/restoration/land management practices.

Abstract: Timber harvest, fire suppression, road construction, and domestic livestock grazing have transformed spatial patterns of Interior Northwest forests. As a consequence, parameters of current disturbance regimes differ radically from historic regimes; present-day wildlife habitat distributions differ from historical distributions; and long-term survival of some native terrestrial species is uncertain. Public land managers are under increasing scientific and social pressure to mold existing forest spatial patterns to reflect those resulting from natural disturbance regimes and patterns of biophysical environments. However, knowledge of the characteristics of natural spatial patterns is unavailable.

Using a dichotomized ordination procedure, we grouped the 343 forested subwatersheds (mean area, 8000 ha) on the eastern slope of the Cascade Mountains in Washington State into ecological subregions by similarity of area in potential vegetation and climate attributes. We built spatially continuous "historical" (1938-1956) and "current" (1985-1993) vegetation maps for 48 randomly selected subwatersheds from aerial photo interpretations. From remotely sensed attributes, we classified cover types, structural classes, and potential vegetation types and attributed them to individual patches. We then estimated a reference variation (RV) in spatial patterns of patch types (cover type and structural class), by subwatersheds and five forested ecological subregions, using the 48 historical vegetation maps stratified by subregion and a spatial pattern analysis program. Finally, we compared the current pattern of an example subwatershed (MET_11) with the RV estimates of its corresponding subregion to illustrate how reference conditions can be used to evaluate the importance of spatial pattern change. By evaluating pattern changes in light of RV estimates (nominally, the sample median 80% range of a metric) and the full range of class and landscape metrics, we could identify both current and historic conditions of MET_11 that fell outside the RV. This approach gives land managers a tool to compare characteristics of present-day managed landscapes with reference conditions to reveal significant pattern departures, as well as to identify specific pattern characteristics that might be modified through management. It also provides a means to identify "outlier" conditions, relative to subregion RV estimates, that may occasionally be the object of pattern restoration activities.

42. Hessburg, P.F.; Smith, B.G.; Salter, R.B.; Ottmar, R.D.; Alvarado, E. 2000. Recent changes (1930s-1990s) in spatial patterns of interior northwest forests, USA. *Forest Ecology and Management*. 136: 53-83.

Keywords: landscape patterns/fire/vegetation modeling/landscape dynamics/disturbance/land management practices.

Abstract: We characterized recent historical and current vegetation composition and structure of a representative sample of subwatersheds on all ownerships within the interior Columbia River basin and portions of the Klamath and Great Basins. For each selected subwatershed, we constructed historical and current vegetation maps from 1932 to 1966 and 1981 to 1993 aerial photos, respectively. Using the raw vegetation attributes, we classified and attributed cover types, structural classes, and potential vegetation types to individual patches within subwatersheds. We characterized change in vegetation spatial patterns using a suite of class and landscape metrics, and a spatial pattern analysis program. We then translated change in vegetation patterns to change in patterns of vulnerability to wildfires, smoke production, and 21 major forest pathogen and insect disturbances. Results of change analyses were reported for province-scale ecological reporting units (ERUs). Here, we highlight significant findings and discuss management implications.

Twentieth century management activities significantly altered spatial patterns of physiognomies, cover types and structural conditions, and vulnerabilities to fire, insect, and pathogen disturbances. Forest land cover expanded in several ERUs, and woodland area expanded in most. Of all physiognomic conditions, shrubland area declined most due to cropland expansion, conversion to semi- and non-native herblands, and expansion of forests and woodlands. Shifts from early to late seral conifer species were evident in forests of most ERUs; patch sizes of forest cover types are now smaller, and current land cover is more fragmented. Landscape area in old multistory, old single story, and stand initiation forest structures declined with compensating increases in area and connectivity of dense, multilayered, intermediate forest structures. Patches with medium and large trees, regardless of their structural affiliation are currently less abundant on the landscape. Finally, basin forests are now dominated by shade-tolerant conifers, and

exhibit elevated fuel loads and severe fire behavior attributes indicating expanded future roles of certain defoliators, bark beetles, root disease, and stand replacement fires. Although well intentioned, 20th century management practices did not account for landscape-scale patterns of living and dead vegetation that enable forest ecosystems to maintain their structure and organization through time, or for the disturbances that create and maintain them. Improved understanding of change in vegetation spatial patterns, causative factors, and links with disturbance processes will assist managers and policymakers in making informed decisions about how to address important ecosystem health issues.

43. Hill, L. 1998. A summary of SAF's comments on ICBEMP. *Journal of Forestry*. 96(10): 40-41.
Keywords: EIS/social/economics/public comment/natural resource policy.
Abstract: Five local units of the Society of American Foresters reviewed the ICBEMP documents. A reading of their comments reveals common issues: that ICBEMP prescribes standards that will limit local managers' flexibility, that implementation of those standards will be expensive in both time and money, and that the potential consequences to local communities are not adequately or accurately described.
44. Horne, A.L.; Haynes, R.W. 1997. Spatial and temporal scales of economic analysis for ecosystem management. In: Cordell, H.K.; Caldwell, L.; Mou, S., eds., comps. Integrating social science and ecosystem management: a national challenge: Proceedings of a conference. Gen. Tech. Rep. GTR-SRS-17. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 112-117.
Keywords: economics/natural resource policy.
Abstract: Economic processes do not fall neatly into spatial and temporal hierarchies as do ecologic processes; economic analyses are most useful when conducted at broader scales and should not be limited to spatial and temporal dimensions. The "public good" nature of some ecosystem outputs creates problems causing simultaneous assessments of supply and demand in a hierarchical manner to be incorrect. A valuable contribution of a spatial hierarchy is to identify what ecosystem outputs an ecoregion or subregion is best suited to produce.
45. Horne, A.L.; Haynes, R.W. 1999. Developing measures of socioeconomic resiliency in the interior Columbia basin. Gen. Tech. Rep. PNW-GTR-453. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 41 p. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
Keywords: social/resiliency/economics.
Abstract: Measures of socioeconomic resiliency were developed for the 100 counties studied in the Interior Columbia Basin Ecosystem Management Project. These measures can be used for understanding the extent to which changes in policies for management of Federal lands may affect socioeconomic systems coincident with those lands. We found that most of the basin's residents (67 percent) live in counties with a high degree of socioeconomic resiliency; however, these counties represent only 20 percent of the land base. Whereas 68 percent of the basin is categorized as having low socioeconomic resiliency, only 18 percent of the people live in these areas. These findings allow land managers to better gauge the impacts of land management actions and to focus social and economic mitigation strategies on places of greatest need.
46. Hower, J.; Zieroth, E. 1994. Eastside Ecosystem Management Project . *Women in Natural Resources*. 16(1): 17-19.
Keywords: EIS/natural resource policy.
Abstract: (Article Heading) Ecosystems do not recognize state or federal land boundaries. Six states, 19 tribes, and numerous federal agencies are trying to find a way to collaborate on managing the vast Columbia River drainage and environs.
47. Humphrey, C.; Perez, J.; Sutton, J. 1998. Public comment on the ICBEMP process. *Journal of Forestry*. 96(10): 39 p.
Keywords: EIS/public comment/natural resource policy.
Abstract: More than 83,000 citizens and interested parties heeded the Interior Columbia Basin Ecosystem Management Project's call for public comment; the content of their letters has been compiled by analysts not involved in the project itself. For every issue raised there were both proponents and critics. Nevertheless, the ICBEMP scientists will seek to incorporate the information and opinions in the final environmental impact statements due next year.

48. James, S. 2000. Earthworms (Annelida: Oligochaeta) of the Columbia River basin assessment area. Gen. Tech. Rep. PNW-GTR-491. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 13 p. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
Keywords: invertebrates/land management practices/ecological function.
Abstract: Earthworms are key components of many terrestrial ecosystems ; however, little is known of their ecology, distribution, and taxonomy in the eastern interior Columbia River basin assessment area (hereafter referred to as the basin assessment area). This report summarizes the main issues about the ecology of earthworms and their impact on the physical and chemical status of the soil. The three main ecological types of earthworms found in the basin assessment area are epigeic, endogeic, and anecic. Each type has a different life history pattern, resource requirement, and ecological function. Effects of environmental and habitat variables in the basin assessment area on these three types are summarized. Key ecological functions of earthworms are presented in relation to the ecological types and habitats of earthworms in the basin assessment area. These key ecological functions include the effects of earthworms on soils, their role in nutrient cycling, and their relation to other fauna.
- Distributions of earthworm species in the basin assessment area also are summarized. Although most of the known species from the area are exotics from Europe, at least three species are native to the region. Unpublished records indicate that there may be many more species that have either not yet been collected or for which descriptions have not yet been published. Both the possibility of discovering additional macrofaunal biodiversity and the precarious status of at least one known species argue for additional research on earthworms in the basin assessment area.
- Effects of land use and management practices on earthworms are explored by examining research on similar human influences in other ecosystems as no research on these issues has been done in the Western United States. Suggestions for land use and future research priorities are provided.
49. Jensen, M.; Goodman, I.; Brewer, K.; Frost, T.; Ford, G.; Nesser, J. 1997. Biophysical environments of the basin. In: Quigley, T.M.; Arbelbide, S.J., tech. eds. An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins. Gen. Tech. Rep. PNW-GTR-405. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 99-320. Chapter 2. Volume 1.
Keywords: geology/hydrology/climate.
Abstract: (Part of Introduction) This chapter describes important biophysical environments of the Interior Columbia Basin and those portions of the Klamath River Basin and Great Basin in Oregon (Basin). Specifically included is information about methods used in describing the environments, and descriptions of the environments' ecological processes, associated management interpretations, and general characteristics. Information is presented at multiple spatial scales for various types of biophysical environments, including geologic, geoclimatic, potential vegetation, soils, and hydrologic systems.
50. Keane, R.E.; Garner, J.L.; Schmidt, K.M.; Long, D.G.; Menakis, J.P.; Finney, M.A. 1998. Development of input data layers for the FARSITE fire growth model for the Selway-Bitterroot Wilderness Complex, USA. Gen. Tech. Rep. RMRS-GTR-3. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 66 p.
Keywords: fire/fire modeling/GIS/technology transfer.
Abstract: Fuel and vegetation spatial data layers required by the spatially explicit fire growth model FARSITE were developed for all lands in and around the Selway-Bitterroot Wilderness Area in Idaho and Montana. Satellite imagery and terrain modeling were used to create the three base vegetation spatial data layers of potential vegetation, cover type, and structural stage. Fire behavior fuel models and crown characteristics were assigned to combinations of base layer categories on these maps by local fire managers, ecologists, and existing data. FARSITE fuels maps are used to simulate growth of prescribed natural fires in the wilderness area, aiding managers in the planning and allocation of resources. An extensive accuracy assessment of all maps indicated fuels layers are about 60 percent accurate. This methodology was designed to be replicated for other areas.
51. Keane, R.E.; Long, D.G. 1998. A comparison of coarse scale fire effects simulation strategies. Northwest

Science. 72(2): 76-90.

Keywords: fire/fire modeling/landscape dynamics/vegetation modeling.

Abstract: Development of management-oriented computer models for coarse scale fire simulation is often problematic because of the tradeoff between prediction realism and model utility. This study compares three spatial modeling strategies of increasing complexity for simulating coarse scale succession and fire dynamics across the 80 million ha Interior Columbia River Basin (ICRB). In all three approaches successional dynamics are modeled using a multiple pathway approach where seral community types, called succession classes, are linked along pathways that converge to a stable community type called a potential vegetation type which represents a unique biophysical setting that is static throughout a simulation. Fire dynamics are simulated using three stochastic approaches implemented in three separate computer models. The Columbia River Basin succession Model (CRBSUM) simulates fire using probabilities from a uniform probability distribution that reflects a representative fire return interval. CRBSUM was modified to create CRBSUM2 that simulated fire occurrence at the potential vegetation type level and subsequent fire effects at the successional class level. The FIREPAT (FIRE PATtern) model stochastically simulates fire starts from a three parameter Weibull function. Fire is then spread across the landscape using a cookie-cutter approach where an exponential probability function determines the size of an ellipse wherein all pixels will be burned. Simulated landscape patterns and disturbance results are compared across the three approaches. Results indicate models of increasing complexity require additional parameterization and computer time, but provide more realistic results.

52. Keane, R.E.; Long, D.G.; Menakis, J.P.; Hann, W.J.; Bevins, C.D. 1996. Simulating coarse-scale vegetation dynamics using the Columbia River basin succession model---CRBSUM. Gen. Tech. Rep. INT-GTR-340. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 50 p.

Keywords: vegetation modeling/GIS/landscape dynamics.

Abstract: The Columbia River Basin Succession Model (CRBSUM) simulates broad-scale landscape changes as a consequence of various land management policies. CRBSUM is a spatially explicit, deterministic model with stochastic properties that simulates changes in vegetation cover types and structural stages on landscapes over long periods. CRBSUM was used to simulate coarse-scale landscape changes in the Interior Columbia River Basin as a result of four management scenarios called management futures. CRBSUM results have an inherent 1 to 5 percent variability because of the stochastic structure of the model. Sensitivity analysis results suggest moderate changes in disturbance probabilities (25 percent increase) will only slightly affect simulated results.

53. Lee, D.C.; Sedell, J.R.; Rieman, B.E.; Thurow, R.F.; Williams, J.E. 1998. Aquatic species and habitats. Journal of Forestry. 96(10): 16-21.

Keywords: aquatic integrity/fish/hydrology/biodiversity/habitat modeling/population modeling.

Abstract: Continuing human activities threaten the highly prized aquatic resources of the interior Columbia basin. Precipitous declines in native species, particularly Pacific salmon, and a large influx of introduced species have radically altered the composition and distribution of native fishes. Fortunately, areas of relatively high aquatic integrity remain, much of it on federally administered lands. These areas can provide a starting point for protecting and restoring aquatic resources throughout the basin if decisive action is taken.

54. Lee, D.C.; Sedell, J.R.; Rieman, B.E.; Thurow, R.F.; Williams, J.E.; Burns, D.; Clayton, J.; Decker, L.; Gresswell, R.; House, R.; Howell, P.; Lee, K.M.; MacDonald, K.; McIntyre, J.; McKinney, S.; Noel, T.; O'Connor, J.E.; Overton, C.K.; Perkinson, D.; Tu, K.; Van Eimeren, P. 1997. Broad-scale assessment of aquatic species and habitats. In: Quigley, T.M.; Arbelbide, S.J., tech. eds. An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins. Gen. Tech. Rep. PNW-GTR-405. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 1057-1496. Chapter 4. Volume 3.

Keywords: aquatic integrity/fish/biodiversity/habitat trend/land management practices/hydrology/invertebrates.

Abstract: (Part of Introduction) In this chapter, we report on a broad-scale scientific assessment of aquatic resources conducted as part of the Interior Columbia Basin Ecosystem Management Project. Our assessment area, collectively referred to as the Basin, included the Columbia River Basin east of the crest

of the Cascade Mountains (Washington, Oregon, Idaho, western Montana, and small portions of Nevada, Utah, and Wyoming), and those portions of the Klamath Basin and the Great Basin in Oregon...

In creating this assessment we addressed four primary objectives. First, we broadly characterized the geophysical and biological settings that define the natural potential of the Basin to support aquatic resources. Second, we identified anthropogenic factors that affect aquatic habitats and the species they support, either directly or through indirect disruption of natural processes. Special emphasis was given to effects of Federal land management. Third, we conducted a broad-scale assessment of the current condition of aquatic habitats and species. Though we focused primarily on fishes, ancillary information was also gathered on mollusks, other invertebrates, and aquatic plants. Finally, we worked to synthesize our information such that it might provide a regional context for Federal management agencies to devise proper management strategies for aquatic and riparian habitats.

55. Lehmkuhl, J.F.; Kie, J.G.; Nyberg, H.; Bender, L.C.; Servheen, G. 2001. Evaluating the effects of ecosystem management alternatives on elk, mule deer, and white-tailed deer in the interior Columbia River basin. *Forest Ecology and Management*. 153: 89-104.
Keywords: Bayesian/wildlife/habitat modeling/population modeling/viability/EIS/land management practices.
Abstract: Elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), and white-tailed deer (*Odocoileus virginianus*) are highly valued for their game, aesthetic, and spiritual qualities by sportsman, wildlife enthusiasts, and Native Americans in North America. As part of the Interior Columbia Basin Ecosystem Management Project (ICBEMP) of the U.S. forest Service and Bureau of Land Management, we: (1) defined key habitat associations of those species that could be used for a broad-scale (58 million ha analysis of management practices; and, (2) determined how three ecosystem management alternatives of a Supplemental Draft Environmental Impact Statement might affect the regional distribution of habitat for those species across the Basin over the next 100 years. For the three species, we developed a Bayesian Belief Network model that used available SDEIS datasets to estimate historical, current, and future habitat capability under the management alternatives in each of the 7,467 subwatersheds (mean 8 000 ha) in the study area. The model quantified "Inherent Habitat Capability" as a function primarily of forage habitat capability, with cover as a minor influence. Forage habitat capability was a function of the percentage area of rangeland and early seral forest community types, and the qualitative influences of livestock overgrazing, wildfire, and prescribed fire. For the current and future periods, an "Adjusted Habitat Capability" was estimated by adjusting Inherent Habitat Capability for the negative effects of poor security from human disturbance. Open road density, cover area, and a terrain relief index were used to estimate the security effect. Habitat capability was reported by 15 ecological regions within the study area as mean subwatershed capability. Under all management alternatives, habitat capability increased about 5% for all three ungulate species over the next 100 years. Limitations of the coarse analysis scale restrict application of the model to large-scale assessments. Lacking regional population data, verification of model output was not feasible at the scale of analysis. However, the model was considered useful for tracking regional changes given the available habitat data and regional-scale objectives of the effort.
56. Lehmkuhl, J.F.; Raphael, M.G.; Holthausen, R.S.; Hickenbottom, J.R.; Naney, R.H.; Shelly, J.S. 1997. Historical and current status of terrestrial species and the effects of proposed alternatives. In: Quigley, T.M.; Lee, K.M.; Arbelbide, S.J., tech. eds. *Evaluation of the Environmental Impact Statement Alternatives by the Science Integration Team*. Gen. Tech. Rep. PNW-GTR-406. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 537-730. Chapter 4. Volume 2.
Keywords: EIS/wildlife/native plants/viability.
Abstract: (Part of Introduction) The purpose of this analysis is to provide an assessment of the degree to which habitat conditions on lands administered by the Forest Service (FS) and Bureau of Land Management (BLM) within the Basin contribute to long-term persistence (at least 100 years) of plants and animals. Secondly, we examine the extent to which other lands and other influences might affect populations of species over and above the influences of habitat conditions on federally administered lands. This assessment is not a quantitative population viability analysis as it does not employ an explicit model of genetic or demographic risk to species persistence. Rather, we view our assessment as a structured and reasoned series of judgments about projected amounts and distributions of habitat and the likelihood that such habitat would allow populations of selected species to persist over the long run. The assessment meets

the essential criterion of a population viability analysis, to provide an estimate of the likelihood that a population will persist to some arbitrarily chosen future time (Boyce 1992). However, it does so through the use of structured professional judgment rather than through the use of population projection models. The methodology and its limitations are discussed below.

57. Machlis, G.E.; Force, J.E.; McKendry, J.E. 1995. An atlas of social indicators for the Upper Columbia River Basin. Contribution Number 759. Moscow, Idaho: Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow, Idaho. 55p.
Keywords: social/economics/human population.
Abstract: (Part of Introduction) To manage federal lands following ecosystem management principles requires careful planning, for ecosystems are complex and there are many competing needs. Careful planning requires an accurate and objective assessment of current conditions. Hence, understanding the social, cultural, and economic conditions within a region is crucial for successful ecosystem management.
In this atlas, social indicators are defined as an integrated set of social, economic and ecological measures which are 1) collected over time, 2) taken from available data sources, and 3) useful to ecosystem management and decision-making. The indicators in this atlas are not simply a collection of various statistics displayed in maps, but an integrated set of indicators organized around a key concept - the *human ecosystem*.
58. Marcot, B.G. 1996. An ecosystem context for bat management: a case study of the interior Columbia River Basin. In: Barclay, R.M.R.; Brigham, R.M., eds. Bats and Forests Symposium: Proceedings of a conference. Victoria, BC: British Columbia Ministry of Forests: 19-36.
Keywords: wildlife/ecological function/habitat trend.
Abstract: The ecological role and environmental requirements of 15 species of bats were analyzed in an ecosystem assessment of the interior Columbia River Basin, USA. Ecological roles of bats potentially contribute to nutrient cycling, insect population control, transmission of disease, hosting obligate ectoparasites, and accumulation of pesticides. Such roles can influence ecological processes in forest canopies, soils, and water bodies, and population levels of arthropods and their predators, and of other species of bats. Specific studies are needed on rates of effects. The macroecology and collective environmental requirements of all 15 bat species also provide for a wide range of other species in forest, wetland, riparian, and other settings. Such a systems - and biodiversity-wide approach helps put bat management into an ecosystem context and helps focus needs for further inventory, monitoring, and research.
59. Marcot, B.G. 1997. Research information needs on terrestrial vertebrate species of the interior Columbia River basin and northern portions of the Klamath and Great Basins: a research, development, and application database. Res. Note PNW-RN-522. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 29 p.
Keywords: wildlife/invertebrates/technology transfer.
Abstract: Research information needs on selected invertebrates and all vertebrates of the interior Columbia River basin and adjacent areas in the United States were collected into a research, development, and application database as part of the Interior Columbia Basin Ecosystem Management Project. The database included 482 potential research study topics on 232 individual species and 18 species groups of animals, representing significant gaps in scientific knowledge. Research study topics in the database can be retrieved by use of keyword searches. Keyword subjects include basic ecology, distribution, inventory and monitoring, environmental disturbance, effects of land use management activities, and other topics. Research study topics can be prioritized once a land management plan is in place for the basin and an assessment is conducted of risk management on species and their environments. The database is included on computer files available on the World Wide Web at URL <http://www.fs.fed.us/pnw/marcot.html>.
60. Marcot, B.G.; Castellano, M.A.; Christy, J.A.; Croft, L.K.; Lehmkuhl, J.F.; Naney, R.H.; Nelson, K.; Niwa, C.G.; Rosentreter, R.E.; Sandquist, R.E.; Wales, B.C.; Zieroth, E. 1997. Terrestrial ecology assessment. In: Quigley, T.M.; Arbelbide, S.J., tech. eds. An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins. Gen. Tech. Rep. PNW-GTR-405. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 1497-1713. Chapter 5. Volume 3.

Keywords: wildlife/invertebrates/native plants/non-vascular plants/biodiversity/ecological function/habitat trend/American Indian.

Abstract: (Part of Introduction) The purpose of this chapter is to present an assessment of terrestrial (land-based) ecology of the Interior Columbia Basin Ecosystem Management Project (ICBEMP) assessment area, also called the Basin. We describe prehistoric, historic, and current conditions and trends in terrestrial habitats, environments, selected individual species, species groups, ecological communities, and terrestrial ecosystems. The purpose is to meet the objectives described by the ICBEMP Charter.

This chapter does not explicitly analyze viability of species, but much of the base ecological information provided herein is essential for subsequent analyses. Although inferring population viability from habitat conditions has been advanced by others (for example, Boyce and others 1994), additional factors of demography, population genetics, interspecies relations, and disturbance dynamics need to be considered.

In this chapter we address the following nine elements: (1) information that will be necessary to assess species viability under future scenarios or planning alternatives; (2) species rarity, endemism, and biodiversity; (3) biogeography; (4) the role of natural areas; (5) ecological functions of species; (6) species of interest to American Indian tribes; (7) federally listed threatened, endangered, and candidate species; (8) selected conservation issues including rangelands and old forests; and, (9) further information needs.

61. Marcot, B.G.; Croft, L.K.; Lehmkuhl, J.F.; Naney, R.H.; Niwa, C.G.; Owen, W.R.; Sandquist, R.E. 1998. Macroecology, paleoecology, and ecological integrity of terrestrial species and communities of the interior Columbia River basin and northern portions of the Klamath and Great Basins. Gen. Tech. Rep. PNW-GTR-410. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 131 p. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).

Keywords: wildlife/non-vascular plants/native plants/invertebrates/biodiversity.

Abstract: This report presents information on biogeography and broad-scale ecology (macroecology) of selected fungi, lichens, bryophytes, vascular plants, invertebrates, and vertebrates of the interior Columbia River basin and adjacent areas. Rare plants include many endemics associated with local conditions. Potential plant and invertebrate bioindicators are identified. Species ecological functions differ among communities and variously affect ecosystem diversity and productivity. Species of alpine and subalpine communities are identified that may be at risk from climate change. Maps of terrestrial ecological integrity are presented.

62. Marcot, B.G.; Holthausen, R.S.; Raphael, M.G.; Rowland, M.M.; Wisdom, M.J. 2001. Using Bayesian belief networks to evaluate fish and wildlife population viability under land management alternatives from an environmental impact statement. *Forest Ecology and Management*. 153: 29-42.

Keywords: Bayesian/habitat modeling/population modeling/viability/wildlife/fish.

Abstract: We developed procedures for using Bayesian belief networks (BBN) to model habitat and population viability of selected at-risk fish and wildlife species. The BBN models represent the ecological causal web of key environmental correlates (KECs) that most influence habitat capability, potential population response for each species, and influence of habitat planning alternatives. BBN models represent site-specific KECs, habitat capability at the subwatershed level, and pattern of habitat capability across all subwatersheds. BBNs use Dirichlet prior probability distributions and standard Bayesian updating of posterior probabilities. We derived estimates of prior and conditional probabilities from a mix of empirical data and expert judgment, mostly the latter. Sensitivity analyses identified planning decisions and KECs that most influence species outcomes, and can help prioritize monitoring activities. BBN models, however, substitute for neither field studies nor empirical, quantitative population viability analyses of population demography and genetics.

63. McCool, S.F.; Burchfield, J.A.; Allen, S.D. 1997. Social assessment. In: Quigley, T.M.; Arbelbide, S.J., tech. eds. An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins. Gen. Tech. Rep. PNW-GTR-405. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 1871-2009. Chapter 7. Volume 4.

Keywords: social/American Indian/resiliency/human population/recreation/scenery/employment.

Abstract: (Part of Introduction) Human use of natural resources in the Basin is a major determinant of

ecosystem conditions. Over time, human uses have changed dramatically, resulting in equally dramatic effects on the land, water, air, and other species. Human values regarding ecosystems have changed as well, as have the economic needs of an increasingly complex society.

To understand how people relate to and interact with the environments in which they live or have an interest, it is essential to recognize that people are part of the ecosystem, both in the sense of being another species dependent on ecosystem components and because humans determine how ecosystems are socially defined, studied, and managed. The public and federal agencies agree that ecosystem management should consider this "human dimension" of ecosystems. Past management has not adequately accounted for the linkages between people and their environment, the ways people affect the environment, the cultural and spiritual values people place on environments, and the meanings that people attach to specific areas and localities.

The Human Dimensions Task Group (1993) describes six types of information important to understanding the human component of ecosystems: historical context, perceptions of resource character, existing social conditions, existing managerial situation, societal needs and demands, and the effects of humans on ecosystems. Corresponding regional efforts have also been developed that list principles and related strategies for incorporating the human dimension into ecosystem management (Human Dimension Study Group 1994). Our understanding of nature and human relationships with the environment are cultural expressions used to define who we were, who we are, and who we hope to be at this place and in this space (Greiger and Garkovich 1992).

64. McCool, S.F.; Haynes, R.W. 1996. Projecting population change in the interior Columbia River basin. Res. Note PNW-RN-519. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 14 p.
Keywords: human population/social.
Abstract: Management of ecosystems requires projecting the human population for a biologically significant timeframe, because the impacts of potential alternative ecosystem management strategies will differ depending on the size, location, and expectations of the human population. Increases since 1990 in the net migration rates are changing the expectations for projections of population in the interior Columbia River basin. We present two population projections: low and high. The low projections are from the U.S. Bureau of the Census sources and essentially assume little net migration, which is generally a repeat of the 1980s when the basin was characterized by slight net out-migration. The high projections maintain higher net migration and higher rates of natural increase than the low projection. By 2040, the high projections are twice the low projections. Where the low projection has an annual increase of 0.3 percent, the rate of growth in the high projection is 1.6 percent per year.
65. McGinnis, W.J. 1996. Selected economic and demographic data for counties of the interior Columbia River basin. Res. Note PNW-RN-520. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 84 p.
Keywords: human population/economics/employment.
Abstract: A variety of county data have been assembled in support of the Interior Columbia River Basin Ecosystem Management Project. This research note is an effort to make some of the basic demographic and economic data available to the public for the counties involved in the assessment.
66. McGinnis, W.J.; Christensen, H.H. 1996. The interior Columbia River basin: patterns of population, employment, and income change. Gen. Tech. Rep. PNW-GTR-358. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 43 p. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
Keywords: economics/human population/employment.
Abstract: Public expectations for management of public resources are changing, and public agencies are moving toward sustainable ecosystem management that incorporates information on ecological, economic, and social systems. A broad assessment of these systems is being undertaken for the interior Columbia River basin. This paper describes some basic population characteristics of the area and focuses on the economic conditions there during the last several decades by using population, personal income, nonfarm labor income, and employment as primary indicators.

67. McIver, J.; Starr, L. 2001. Restoration of degraded lands in the interior Columbia River basin: passive vs. active approaches. *Forest Ecology and Management*. 153: 15-28.
 Keywords: restoration/land management practices/exotic plants.
 Abstract: Evidence for success of passive and active restoration is presented for interior conifer forest, sagebrush steppe, and riparian ecosystems, with a focus on the Columbia River basin. Passive restoration, defined as removal of the stresses that cause degradation, may be most appropriate for higher-elevation forests, low-order riparian ecosystems, and for sagebrush steppe communities that are only slightly impaired. More active approaches, in which management techniques such as planting, weeding, burning, and thinning are applied, have been successful in forests with excessive fuels and in some riparian systems, and may be necessary in highly degraded sagebrush steppe communities. There is general agreement that true restoration requires not only reestablishment of more desirable structure or composition, but of the processes needed to sustain these for the long term. The challenge for the restorationist is to find a way to restore more desirable conditions within the context of social constraints that limit how processes are allowed to operate, and economic constraints that determine how much effort will be invested in restoration.
68. Mills, T.J.; Clark, R.N. 2001. Roles of research scientists in natural resource decision-making. *Forest Ecology and Management*. 153: 189-198.
 Keywords: natural resource policy/technology transfer.
 Abstract: The issues surrounding natural resource decision-making in the present day are complex, varied and debated frequently and contentiously by the public. The complexity of the issues poses new challenges for scientists who are being asked to actively engage in this debate. This raises questions about what is credible scientific information and how such information is used in often emotionally or politically laden natural resource management decisions. One result has been an uncomfortable partnership among scientists and natural resource managers. Scientists are being asked to frame their research in ways that maintain scientific independence yet are responsive to management questions, at scales that often challenge existing scientific knowledge and under severe time constraints. Resource decision-makers are challenged to clarify their management goals, to fully understand and use the science, and to explicitly identify the level of acceptable risk. Using the Interior Columbia Basin Ecosystem Management Project as an example, lessons learned from the interaction among scientists and natural resource decision-makers is discussed and propositions for appropriate roles are presented. When properly generated, presented, and accountably used. Science facilitates discussion among competing interests by helping define the range of available choice and focusing discussions on consequences of social choice. By expanding and revealing the range of possible outcomes, scientists increase the likelihood that management decisions are understood and that those decisions can endure.
69. Niwa, C.G.; Sandquist, R.E.; Crawford, R.; Frest, T.J.; Griswold, T.; Hammond, P.; Ingham, E.; James, S.; Johannes, E.J.; Johnson, J.; Kemp, W.P.; LaBonte, J.; Lattin, J.D.; McIver James; McMillin, J.; Moldenke, A.; Moser, J.; Ross, D.; Schowalter, T.; Tepedino, V.; Wagner, M.R. 2001. Invertebrates of the Columbia river basin assessment area. Gen. Tech. Rep. PNW-GTR-512. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 74 p. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
 Keywords: invertebrates/biodiversity/ecological function/land management practices.
 Abstract: A general background on functional groups of invertebrates in the Columbia River basin and how they affect sustainability and productivity of their ecological communities is presented. The functional groups include detritivores, predators, pollinators, and grassland and forest herbivores. Invertebrate biodiversity and species of conservation interest are discussed. Effects of management practices on wildlands and suggestions to mitigate them are presented. Recommendations for further research and monitoring are given.
70. O'Hara, K.L.; Latham, P.A.; Hessburg, P.F.; Smith, B.G. 1996. A structural classification for Inland Northwest forest vegetation. *Western Journal of Applied Forestry*. 11(3): 97-102.
 Keywords: vegetation modeling/landscape dynamics.
 Abstract: (Part of Introduction) In this paper, we examine some alternative vegetation classification systems following the framework presented by Kimmins (1987) for vegetation classification except that we only discuss categories that include systems commonly used in the Inland Northwest. We advocate the use

of a structural or physiognomic vegetation classification based on the biological process of stand development which can be used across variable spatial scales.

71. O'Laughlin, J.; Maynard, B.; Fitzgerald, S.; Arneson, A.; Pittman, D. 1998. Seven suggestions for revising ICBEMP. *Journal of Forestry*. 96(10): 42-46.
Keywords: EIS/social/economics/public comment/natural resource policy.
Abstract: Ecosystem management is a still-developing concept. The version developed for federal lands in the interior Columbia River basin region includes unreasonable assumptions and outcomes, according to SAF foresters in the region. One of ICBEMP's goals, maintaining ecosystem health and integrity, defies clear definition and quantification, and yet this overrides the goal of achieving sustainable and predictable outputs. The management alternative recommended by ICBEMP portends negative socioeconomic impacts for many communities. A less diverse approach is closer to federal cooperation with states in using existing processes and standards to protect aquatic habitats.

72. Ottmar, R.D.; Alvarado, E.; Hessburg, P.F. 1998. Linking recent historical and current forest vegetation patterns to smoke and crown fire in the interior Columbia River basin. In: *Proceedings, 13th conference on fire and forest meteorology: Proceedings of a conference*. Moran, WY: International Association of Wildland Fire: 523-534.
Keywords: fire/landscape dynamics/restoration/fire modeling/landscape patterns/air quality.
Abstract: Little information is available on how shifts in forest composition and structure over time resulting from natural succession, disturbance, and human intervention have changed landscapes with respect to fuel build-up, wildfire and prescribed fire smoke production, and crown fire of recent historical and current time periods based on vegetative attributes in 337 subwatersheds on all ownerships within the Interior Columbia River basin. Vegetation cover and structure, and management disturbance features were continuously delineated from recent historical (1930s to 1960s) and current period (1985-1993) aerial photographs of the sampled subwatersheds. Results of change analyses were reported for 13 province-scale Ecological Reporting Units (ERU) and for selected subwatersheds.

Fuel loading increased over the sample period in 8 of the 13 ERUs; 6 of the changes were significant ($P \leq 0.2$). The largest mean difference was a fuel loading increase of 10.8 megagrams/hectare on the Lower Clark Fork ERU. In general, fuel loading increase was positively correlated with forest vegetation composition shifts from open patches of seral species such as ponderosa pine and western larch to dense patches of mixed coniferous forests. Decreases in fuel loading were positively correlated with recent wildfires or human activities such as logging followed by fuels treatment. Fuel loading increase was responsible for noted increases in modeled smoke production by wildfires and vulnerability to crown fires. Under current conditions, modeled PM10 smoke production from wildfire was two to four times the amount from a prescribed fire.

Individual subwatersheds displayed much larger changes over time than at the ERU scale. Change at the subwatershed scale was typically related to wildfires, human management activity, or natural succession. For example, the Upper Coeur d'Alene subwatershed 0501, one of 5 subwatersheds that receive special GIS analysis in this study, displayed a large increase in fuel loading over time, with a corresponding large increase in modeled smoke production and crown fire vulnerability. The subwatershed was partially burned by major wildfires in the early 1900s, with a stand of grand fir, Douglas-fir, and ponderosa pine regenerating during the 1920s and 1930s. Under a fire-exclusion policy, forests matured to predominately understory reinitiation and young multi-story structure resulting in the noted fuel loading increase.

73. Parks, C.G.; Bull, E.L.; Torgersen, T.R. 1997. Field guide for the identification of snags and logs in the interior Columbia River basin. Gen. Tech. Rep PNW-GTR-390. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 40 p.
Keywords: wildlife/non-vascular plants/disturbance.
Abstract: This field guide contains descriptions and color photographs of snags and logs of 10 coniferous and 3 deciduous tree species found in the interior Columbia River basin. Methods are described to distinguish among the different species when various amounts of branches, cones, and bark are missing. Wildlife use of the different species of snags and logs are listed. Snags and logs are each classified into three categories based on structural features. Six indicators of fungal decay are illustrated.

74. Quigley, T.M. 1997. February 1996 and February 1997 EIS versions: changes in effects. In : Quigley, T.M.; Lee, K.M.; Arbelbide, S.J., tech. eds. Evaluation of the Environmental Impact Statements by the Science Integration Team. Gen. Tech. Rep. PNW-GTR-406. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 897-934. Chapter 8. Volume 2.
Keywords: EIS.

Abstract: (Introduction) The EIS Teams provided the Science Integration Team (SIT) with preliminary Draft Environmental Impact Statements (DEISs) in October 1995 containing chapters on the purpose and need, affected environment, and objectives and standards of alternatives for initial evaluation of effects and consequences. This version of the DEISs did not contain enough detail to make a complete evaluation of effects and consequences. The SIT provided a preliminary analysis of effects to the EIS Teams. In February 1996 the EIS Teams provided an updated version of the preliminary DEISs for evaluation of alternatives by the SIT. Interactions with public groups, other agencies, county and state officials and internal Forest Service and Bureau of Land Management staff continued during the period of alternative development. This resulted in continued evolution of the EIS standards and objectives. The February 1996 preliminary DEISs were the versions on which the SIT focused its analysis of consequences and effects. This publication documents the analysis of the February 1996 version. Nearing completion of the DEISs in February 1997, the EIS Team provided updated versions of the DEISs for final review by the SIT before publication in May 1997. Because of the fluid nature of the alternatives, it is essential to refer directly to the DEISs to obtain an understanding of the alternatives as they are being proposed.

The changes in the DEISs from February 1996 to February 1997 primarily clarify or define processes to be implemented, define completion schedules for standards, tie standards more clearly to objectives, or define desired ecological outcomes. For instance, ecological performance measures or quantifiable ecological goals were added to all alternatives. All alternatives continue to describe the analysis required to modify non-process EIS standards, while providing equal or greater assurance of meeting objectives. The purpose of this chapter is to provide a brief description of the evolution in the EIS and some insight into the changes in effects and consequences that have resulted. The organization of the chapter is by SIT staff area. Within each section, changes to the DEIS are discussed in terms of how they affect outcomes and consequences related to the effects the SIT staff areas reported for the February 1996 preliminary draft EISs. The type of effect is described, but no attempt is made here to describe in complete detail all the associated effects or consequences likely from implementing the revised DEIS alternatives. The SIT worked closely with the EIS team as they documented effects and consequences within the DEIS itself. For an enumeration and discussion of effects refer directly to the revised DEISs.

75. Quigley, T.M. tech. ed. 2000. Index to selected science publications of the Interior Columbia Basin Ecosystem Management Project. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 61 p. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
Keywords: technology transfer.

Abstract: (Purpose) This publication provides an easy-to-use, single index to the following major publications of the Science Integration Team:

—*A Framework for Ecosystem Management in the Interior Columbia Basin and Portions of the Klamath and Great Basins*

—*An Assessment of Ecosystem Components in the Interior Columbia Basin and Portions of the Klamath and Great Basins*

—*Highlighted Scientific Findings of the Interior Columbia Basin Ecosystem Management Project*

—*Integrated Scientific Assessment for Ecosystem Management in the Interior Columbia Basin and Portions of the Klamath and Great Basins*

—*Status of the Interior Columbia Basin: Summary of Scientific Findings*

These publications together exceed 2,000 pages in length. Our continuing goal for the scientific assessment

is to make the information understandable, accessible, and useful. With this index, we link detailed technical writing with more easily understood highlights and summaries. The abstracts from these documents are included below for easy reference. A CD-ROM of these documents is available from the Pacific Northwest Research Station. Additional supporting material also is being published.

76. Quigley, T.M.; Arbelbide, S.J. tech. eds. 1997. An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins. Gen. Tech. Rep. PNW-GTR-405. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 4 vol. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
Keywords: technology transfer.
Abstract: The Assessment of Ecosystem Components in the Interior Columbia Basin and Portions of the Klamath and Great Basins provides detailed information about current conditions and trends for the biophysical and social systems within the Basin. This information can be used by land managers to develop broad land management goals and priorities and provides the context for decisions specific to smaller geographic areas. The Assessment area covers about 8 percent of the U.S. land area, 24 percent of the Nation's National Forest System lands, 10 percent of the Nation's BLM-administered lands, and contains about 1.2 percent of the Nation's population. This results in a population density that is less than one-sixth of the U.S. average. The area has experienced recent, rapid population growth and generally has a robust, diverse economy. As compared to historic conditions, the terrestrial, aquatic, forest, and rangeland systems have undergone dramatic changes. Forested landscapes are more susceptible to fire, insect, and disease than under historic conditions. Rangelands are highly susceptible to noxious weed invasion. The disturbance regimes that operate on forest and rangeland have changed substantially, with lethal fires dominating many areas where non-lethal fires were the norm historically. Terrestrial habitats that have experienced the greatest decline include the native grassland, native shrubland, and old forest structures. There are areas within the Assessment area that have higher diversity than others. Aquatic systems are now more fragmented and isolated than historically and the introduction of non-native fish species has complicated current status of native fishes. Core habitat and population centers do remain as building blocks for restoration. Social and economic conditions within the Assessment area vary considerably, depending to a great extent on population, diversity of employment opportunities, and changing demographics. Those counties with the higher population densities and greater diversity of employment opportunities are generally more resilient to economic downturns. This Assessment provides a rich information base, including over 170 mapped themes with associated models and databases, from which future decisions can benefit.
77. Quigley, T.M.; Arbelbide, S.J.; Graham, R.T. 1997. Assessment of ecosystem components in the Interior Columbia Basin and portions of the Klamath and Great Basins: an introduction. In: Quigley, T.M.; Arbelbide, S.J., tech. eds. An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins. Gen. Tech. Rep. PNW-GTR-405. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 1-32. Chapter 1. Volume 1.
Keywords: natural resource policy.
Abstract: (Part of Introduction) The Pacific Northwest has been involved in controversy over the ownership, management, and disposal of natural resources since the descendants of Europeans began inhabiting the area 150 years ago. In recent decades, the debate over public land management has focused primarily on resource allocation, as commodity production took precedence over the custodial protection of national forest lands that characterized the early 20th century. In recent years concerns have grown about issues related to species associated with old forest structures, anadromous fish, forest health (including widespread insect and disease mortality and fire), and rangeland health. Appendix 1-A contains a chronology of recent, related events that reflect these concerns.

This assessment was precipitated by the current debate over the management of USDA Forest Service (FS) and USDI Bureau of Land Management (BLM) administered lands in those portions of the Columbia River basin within the United States and east of the Cascade crest and those portions of the Klamath and Great basins in Oregon. (This entire area is referred to as "the Basin" in this document.) To fully understand this debate and the implications associated with it, one needs to understand the biophysical, social, and economic components of ecosystems within the Basin. This assessment area includes Federal, State,

county, and private resources. Such a broad examination provides information on conditions, trends, and potential outcomes associated with management of the Basin's natural resources.

78. Quigley, T.M.; Bigler Cole, H. 1997. Highlighted scientific findings of the Interior Columbia Basin Ecosystem Management Project. Gen. Tech. Rep. PNW-GTR-404. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 34 p.
Keywords: ecological integrity/social/economics/restoration.
Abstract: Decisions regarding 72 million acres of Forest Service- and Bureau of Land Management-administered lands will be based on scientific findings brought forth in the Interior Columbia Basin Ecosystem Management Project. So me highlights of the scientific findings are presented here. Project scientists drew three general conclusions: (1) Conditions and trends differ widely across the landscape; as a result, one-size-fits-all strategies will neither effectively restore nor ma intain ecosystems. (2) Ecosystem elements are linked to one another; effective ecosystem management requires an understanding of these linkages. (3) The scientific assessment highlighted a wide variety of risks important to ecological and socioeconomic systems. It also brought forth numerous opportunities to restore ecological systems and provide goods and services. To realize the opportunities, managers must recognize and manage the risks. Three management options were analyzed: current direction, active restoration, and reserve system establishment. Analysis revealed that active restoration was effective in addressing basinwide risks and opportunities.
79. Quigley, T.M.; Gravenmier, R.A.; Arbelbide, S.J. [and others]. tech. eds. 1999. The Interior Columbia Basin Ecosystem Management Project: scientific assessment [CD-ROM]. Station Misc. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. (Quigley, Thomas M., ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
Keywords: technology transfer
Abstract: This CD-ROM contains digital versions (Adobe Acrobat portable document files [PDF]) of the major scientific documents prepared for the Interior Columbia Basin Ecosystem Management Project (ICBEMP). "A Framework for Ecosystem Management in the Interior Columbia Basin and Portions of the Klamath and Great Basins" describes a general planning model for ecosystem management. The "Highlighted Scientific Findings of the Interior Columbia Basin Ecosystem Management Project" provides an overview of the science information. The "Status of the Columbia Basin: Summary of Scientific Findings" summarizes the scientific findings from the ICBEMP. "An Integrated Scientific Assessment for Ecosystem Management in the Interior Columbia Basin and Portions of the Klamath and Great Basins" links landscape, aquatic, terrestrial, social, and economic characterizations to describe biophysical and social systems. The "Assessment of Ecosystem Components in the Interior Columbia Basin and Portions of the Klamath and Great Basins" provides detailed information about current conditions and trends for the biophysical and social systems within the basin.
80. Quigley, T.M.; Haynes, R.W.; Graham, R.T. tech. eds. 1996. Integrated scientific assessment for ecosystem management in the interior Columbia basin and portions of the Klamath and Great Basins. Gen. Tech. Rep. PNW-GTR-382. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 303 p. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment.).
Keywords: ecological integrity/aquatic integrity/resiliency.
Abstract: The Integrated Scientific Assessment for Ecosystem Management for the Interior Columbia Basin links landscape, aquatic, terrestrial, social, and economic characterizations to describe biophysical and social systems. Integration was achieved through a framework built around six goals for ecosystem management and three different views of the future. These goals are: maintain evolutionary and ecological processes; manage for multiple ecological domains and evolutionary timeframes; maintain viable populations of native and desired non-native species; encourage social and economic resiliency; manage for places with definable values; and, manage to maintain a variety of ecosystem goods, services, and conditions that society wants. Ratings of relative ecological integrity and resiliency are found on 16 and 20 percent of the area, respectively. Low integrity and resiliency are found on 60 and 68 percent of the area. Different approaches to management can alter the risks to the assets of people living in the Basin and to the ecosystem itself. Continuation of current management leads to increasing risks while management approaches focusing on reserves or restoration result in trends that mostly stabilize or reduce risks. Even

where ecological integrity is projected to improve with the application of active management, population increases and the pressures of expanding demands on resources may cause increasing trends in risk.

81. Quigley, T.M.; Haynes, R.W.; Hann, W.J. 2001. Estimating ecological integrity in the interior Columbia River basin. *Forest Ecology and Management*. 153: 161-178.
Keywords: ecological integrity/restoration.
Abstract: The adoption of ecosystem-based management strategies focuses attention on the need for broad scale estimates of ecological conditions; this poses two challenges for the science community: estimating broad scale ecosystem conditions from highly disparate data, often observed at different spatial scales; and interpreting these conditions relative to goals such as sustainability. The Interior Columbia Basin Ecosystem Management Project (ICBEMP), estimated relative composite ecological integrity by clustering conditions among proxy variables representing three component integrity ratings (forestland, rangeland, and aquatic integrity). Composite ecological integrity provides an estimate of relative system condition within the interior Columbia River basin assessment area that is responsive to changes in broad scale land management practices. Broad-scale measures can be used to assess progress toward land management goals or as an aide for managers in selecting or prioritizing areas (watersheds) for treatment. Currently, federal land managers are using estimates of current composite ecological integrity and trends in ecological integrity to prioritize management activities and understand effects of management actions.
82. Quigley, T.M.; Haynes, R.W.; Hann, W.J.; Lee, D.C.; Holthausen, R.S.; Gravenmier, R.A. 1998. Using an ecoregion assessment for integrated policy analysis. *Journal of Forestry*. 96(10): 33-38.
Keywords: ecological integrity/aquatic integrity/resiliency.
Abstract: In broad terms, managing an ecosystem means maintaining both the integrity of ecological systems and the resilience of social and economic systems. Ratings of ecological integrity and socioeconomic resilience are combined to make general statements about ecosystem conditions in the interior Columbia basin. Risks to integrity and resilience arise from many sources, both natural and human-caused, and reducing risks in one component may increase risks to another. Three management alternatives—maintaining current practices, restoring with active management, and setting up reserves—present different opportunities to manage the risks inherent in biophysical and social systems and meet ecosystem management goals.
83. Quigley, T.M.; Lee, D.C.; Haynes, R.W.; Sedell, J.R.; Holthausen, R.S.; Hann, W.J.; Rieman, B.E.; Marcot, B.G.; Horne, A.L. 1997. Ecological integrity, socioeconomic resiliency, and trends in risk. In: Quigley, T.M.; Lee, K.M.; Arbelbide, S.J., tech. eds. *Evaluation of the Environmental Impact Statement Alternatives by the Science Integration Team*. Gen. Tech. Rep. PNW-GTR-406. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 835-896. Chapter 7. Volume 2.
Keywords: EIS/ecological integrity/resiliency.
Abstract: (Introduction) The Draft Environmental Impact Statements describe two primary needs underlying the proposed action: (1) restore and maintain long-term ecosystem health and integrity; and (2) support the economic and/or social needs of people, cultures, and communities, and provide sustainable and predictable levels of products and services. The needs are linked with specific goals selected by the EIS teams. The goals they identified include: 1) maintain, and where necessary restore, the long-term health and integrity of forest, rangeland, aquatic, and riparian ecosystems; 2) provide sustainable and predictable levels of products and services within the capability of the ecosystem; 3) provide opportunities for diverse cultural, recreational, and aesthetic experiences within the capability of the ecosystem; 4) contribute to the recovery and delisting of threatened and endangered species; and, 5) manage natural resources consistent with treaty and trust responsibilities to American Indian tribes (Preliminary Draft EISs 1996). These needs and goals were examined by addressing ecological integrity, socioeconomic resiliency, and the risks associated with human ecological interactions.

A composite estimate of current ecological integrity was developed across the entire Basin for all FS- and BLM-administered land and the trend in ecological integrity was estimated for each alternative over the next 100 years. This required identification of the current condition of specific ecological integrity components (aquatic/riparian, forest, rangeland, and hydrologic) (Quigley and others 1996). Current socioeconomic resiliency was estimated for social and economic systems, and its variation across the Basin

was described (Quigley and others 1996). The trends in risk associated with human ecological interaction represents the change expected to result from people interacting with the wildland system, and the change expected as disturbances within the wildland system come in conflict with human assets. These trends are projected for each alternative. They provide useful estimates to show how FS and BLM management as proposed in the alternatives might influence ecological integrity and socioeconomic resiliency. These estimates are not intended to be measures of final outcomes, but are an indication of the direction of movement brought on by the implementation of each EIS alternative. Each alternative was evaluated to project how the actions of the FS and BLM would contribute to integrity, socioeconomic resiliency, and human ecological interactions.

84. Quigley, T.M.; Lee, K.M.; Arbelbide, S.J. tech. eds. 1997. Evaluation of the Environmental Impact Statement Alternatives by the Science Integration Team. Gen. Tech. Rep. PNW-GTR-406. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 4 vol. 1094 p. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: Scientific Assessment.)

Keywords: EIS/restoration/land management practices.

Abstract: The Evaluation of EIS Alternatives by the Science Integration Team describes the outcomes, interactions, effects, and consequences likely to result from implementing seven different management strategies on Forest Service (FS) and Bureau of Land Management (BLM) administered lands within the Interior Columbia Basin and portions of the Klamath and Great Basins. Two environmental impact statement teams developed seven alternative approaches to the management of forest, rangeland, aquatic, and watershed systems of FS- and BLM-administered lands. The alternatives varied from continuation of current management, to managing biodiversity within a network of large reserves, to actively managing to restore ecosystem health and integrity. Continuing with current management direction, in the absence of interim protection measures, results in continued declining trends in ecological integrity and increasing risk to species. No single alternative was found to result in improved outcomes for all species, reduced risk to ecological integrity, and improved resiliency for social and economic systems. Alternatives that prioritize activities to restore and/or maintain ecological integrity and simultaneously provide desired goods and services within the capability of the ecosystem appear to have favorable trends in most species outcomes, landscape functions, and resiliency in social and economic systems. The Draft and Final Environmental Impact Statements are expected to differ to some extent from the preliminary Draft Environmental Impact Statement analyzed for this evaluation.

85. Quigley, T.M.; Lee, K.M.; Arbelbide, S.J. 1997. Introduction. In: Quigley, T.M.; Lee, K.M.; Arbelbide, S.J., tech. eds. Evaluation of the Environmental Impact Statement Alternatives by the Science Integration Team. Gen. Tech. Rep. PNW-GTR-406. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 1-28. Chapter 1. Volume 1.

Keywords: EIS.

Abstract: (Part of Introduction) In July 1993, as part of his plan for ecosystem management in the Pacific Northwest, President Clinton directed the Forest Service (FS) to "develop a scientifically sound and ecosystem-based strategy for management of Eastside forests." To accomplish this, in January 1994, the Chief of the Forest Service and the Director of the Bureau of Land Management jointly established this Interior Columbia Basin Ecosystem Management Project (ICBEMP). The area covered by the ICBEMP includes lands within the interior Columbia Basin east of the Cascade crest and those portions of the Klamath and Great Basins within Oregon (the Basin) (map 1.1). This area includes over 58.4 million hectares (144.6 million ac), 30.9 million hectares (76.3 million ac) of which are lands administered by the U.S. Department of Agriculture, Forest Service and the U.S. Department of Interior, Bureau of Land Management (BLM).

Three teams were established to accomplish the project's objectives, a Science Integration Team (SIT) and two Environmental Impact Statement (EIS) Teams. The EIS teams were established to prepare Environmental Impact Statements, one covering the Upper Columbia River basin (UCRB), those portions of the interior Columbia River basin in Idaho, Montana, Wyoming, Nevada, and Utah, and one covering Oregon and Washington east of the crest of the Cascade Range (Eastside). These areas are displayed in maps 1.2 and 1.3. Tables 1.1 and 1.2 show the amount of agency-administered land in each area. Drawing on information developed for the assessment, the EISs were to examine management options for FS- and

BLM-administered lands in the Basin.

Both EISs were developed with a common set of alternatives. Decisions resulting from the EISs will not completely replace existing land and resource management plans but place the focus on those broad-scale issues that have been challenging to address on a unit-by-unit basis. Many conditions and decisions, most appropriately addressed at the local level, are not addressed in the EISs.

86. Raphael, M.G.; Marcot, B.G.; Holthausen, R.S.; Wisdom, M.J. 1998. Terrestrial species and habitats. *Journal of Forestry*. 96(10): 22-27.
Keywords: biodiversity/ecological function/wildlife/habitat modeling/population modeling/viability.
Abstract: The assessment of interior Columbia basin terrestrial species compared prehistoric, historical, and current terrestrial environments and plant and animal communities and looked closely at habitat changes that would affect sensitive vertebrates. We then projected three management scenarios and estimated future distributions of forest cover and other habitat elements on the viability of plant and animal populations. Among the implications for biodiversity conservation strategies: identifying and managing groups of species with similar ecological functions may be more effective than managing individual keystone species. The assessment also revealed gaps in our scientific knowledge of biodiversity in the region.
87. Raphael, M.G.; Wisdom, M.J.; Rowland, M.M.; Holthausen, R.S.; Wales, B.C.; Marcot, B.G.; Rich, T.D. 2001. Status and trends of terrestrial vertebrates in relation to land management in the interior Columbia River basin. *Forest Ecology and Management*. 153: 63-88.
Keywords: Bayesian /habitat modeling/population modeling/viability/EIS/wildlife.
Abstract: We analyzed effects of three land management alternatives on 31 terrestrial vertebrates of conservation concern within the interior Columbia River basin study area. The three alternatives were proposed in a Supplemental Draft Environmental Impact Statement (SDEIS) that was developed for lands in the study area administered by the U.S. Department of Agriculture Forest Service (FS) and U.S. Department of Interior Bureau of Land Management (BLM). To evaluate effects of these alternatives, we developed Bayesian Belief Network (BBN) models, which allowed empirical and hypothesized relations to be combined in probability-based projections of conditions. We used the BBN models to project abundance and distribution of habitat to support potential populations (population outcomes) for each species across the entire study area. Population outcomes were defined in 5 classes, referred to as outcomes A through E. Under Outcome A, populations are abundant and well-distributed, with little or no likelihood of extirpation. By contrast, populations under Outcome E are scarce and patchy, with a high likelihood of local or regional extirpation. Outcomes B, C, and D represent gradients of conditions between the extremes of classes A and E. Most species (65%, or 20 of 31) were associated with outcome A historically and with outcomes D or E currently (55%, or 17 of 31). Population outcomes projected 100 years into the future were similar for all three alternatives but substantially different from historical and current outcomes. For species dependent on old-forest conditions, population outcomes typically improved one outcome class - usually from E or D to D or C - from current to the future under the alternatives. By contrast, population outcomes for rangeland species generally did not improve under the alternatives, with most species remaining in outcomes C, D, or E. Our results suggest that all three management alternatives will substantially improve conditions for most forest-associated species but provide few improvements for rangeland-associated vertebrates. Continued displacement of native vegetation by exotic plants, as facilitated by a variety of human-associated disturbances, will be an on-going challenge to the improvement of future conditions for rangeland species.
88. Raphael, M.G.; Wisdom, M.J.; Wales, B.C. *In press*. Status and trend in diversity of alpine vertebrates in the northwestern United States. in: Korner, C.; Spehn, E., editors. *Mountain biodiversity: a global assessment*. London, UK: Parthenon Publishing.
Keywords: wildlife/biodiversity/habitat trend.
Abstract: We examined the distribution of vertebrate species along an elevational gradient from the Columbia River to the surrounding Cascade and northern Rocky Mountains in a 58-million ha area of the northwestern United States. The area supports diverse terrestrial communities and associated plant and animal species. Marcot et al. (1997) identified 487 species of resident or migratory terrestrial vertebrates that occur in this area. Alpine habitats, which cover <1% of the area, support nearly 10% of the total

vertebrate species. At least four of these species are endemic to alpine habitats; alpine areas support a distinctive set of species and thus make a strong contribution to overall vertebrate diversity in the study area. Although habitats for many terrestrial vertebrates in the area have declined since settlement by Europeans (Lehmkuhl et al., 1997; Marcot et al., 1997; Raphael et al., 1998; Wisdom et al., 2000; Raphael et al. in press), the extent of alpine habitat has not declined. However, potential effects of global warming could substantially reduce the future extent of alpine habitat. Other threats to the amount and quality of alpine habitat and hence vertebrate diversity include recreational activity, ozone depletion, mining, and invasions of exotic species.

89. Rieman, B.E.; Lee, D.C.; Thurow, R.F. 1997. Distribution, status, and likely future trends of bull trout within the Columbia River and Klamath River basins. *North American Journal of Fisheries Management*. 17: 1111-1125.
Keywords: fish/habitat trend/landscape patterns/geology/population modeling/restoration/hydrology.
Abstract: We summarized existing knowledge regarding the distribution and status of bull trout *Salvelinus confluentus* across 4,462 subwatersheds of the interior Columbia River basin in Oregon, Washington, Idaho, Montana, and Nevada and of the Klamath River basin in Oregon, a region that represents about 20% of the species' global range. We used classification trees and the patterns of association between known distributions and landscape characteristics to predict the likely distribution of bull trout in unsampled subwatersheds. Bull trout are more likely to occur and the populations are more likely to be strong in colder, higher-elevation, low- to mid-order watersheds with lower road densities. Our results show that bull trout remain widely distributed and occur in most of the subbasins representing the potential range. Some strong and relatively secure populations exist. In general, bull trout are better represented in the region as a whole than many other native species. Important declines in distribution and status are evident, although the extent of change is clouded by uncertainties in the historical distribution. Despite the broad distribution, much of the current range is poorly represented by strong or protected populations. The southern margins of the range are a particular concern and could be an important priority for conservation management. Continued habitat loss associated with disruptive land use practices threatens remaining bull trout populations. Even with no further habitat loss, existing fragmentation could contribute to continuing local extinctions aggravated by the expansion of introduced species and the effects of climate change.
90. Rieman, B.E.; Lee, D.C.; Thurow, R.F.; Hessburg, P.F.; Sedell, J.R. 2000. Toward an integrated classification of ecosystems: defining opportunities for managing fish and forest health. *Environmental Management*. 25(4): 425-444.
Keywords: ecological integrity/aquatic integrity/restoration/fish/disturbance/habitat modeling.
Abstract: Many of the aquatic and terrestrial ecosystems of the Pacific Northwest United States have been simplified and degraded in part through past land-management activities. Recent listings of fishes under the Endangered Species Act and major new initiatives for the restoration of forest health have precipitated contentious debate among managers and conservation interests in the region. Because aggressive management activities proposed for forest restoration may directly affect watershed processes and functions, the goals of aquatic and terrestrial conservation and restoration are generally viewed as in conflict. The inextricable links in ecological processes and functions, however, suggest the two perspectives should really represent elements of the same problem; that of conserving and restoring more functional landscapes. We used recent information on the status and distribution of forest and fish communities to classify river subbasins across the region and explore the potential conflict and opportunity for a more integrated view of management. Our classification indicated that there are often common trends in terrestrial and aquatic communities that highlight areas of potential convergence in management goals. Regions where patterns diverge may emphasize the need for particular care and investment in detailed risk analyses. Our spatially explicit classification of subbasin conditions provides a mechanism for progress in three areas that we think is necessary for a more integrated approach to management: (1) communication among disciplines; (2) effective prioritization of limited conservation and restoration resources; and (3) a framework for experimentation and demonstration of commitment and untested restoration techniques.
91. Rieman, B.E.; Peterson, J.T.; Clayton, J.; Howell, P.; Thurow, R.F.; Thompson, W.; Lee, D.C. 2001. Evaluation of potential effects of Federal land management alternatives on trends of salmonids and their habitats in the interior Columbia River basin. *Forest Ecology and Management*. 153: 43-62.
Keywords: Bayesian/fish/habitat modeling/population modeling/viability/EIS.

Abstract: Aquatic species throughout the interior Columbia River basin are at risk. Evaluation of the potential effects of federal land management on aquatic ecosystems across this region is an important but challenging task. Issues include the size and complexity of the systems, uncertainty in important processes and existing states, flexibility and consistency in the analytical framework, and an ability to quantify results. We focused on salmonid fishes and their habitats as indicators of conditions in aquatic ecosystems and used Bayesian Belief Networks as a formal, quantitative framework to address the issues in our evaluation of land management alternatives proposed for the interior Columbia River basin. Because empirical information is limited at the scales relevant to our analysis, an ability to combine both empirical and more subjective information was key to the analysis. The representation of linkages through conditional probabilities made uncertainty explicit. We constructed two general networks. One represented the influence of landscape characteristics and existing and predicted management activities on aquatic habitats. A second represented the influence of habitat, existing biotic conditions, and for two anadromous species, ocean and migratory conditions, on the status of six widely distributed salmonid fishes. In the long term (100 years) all three land management alternatives were expected to produce positive changes in the status and distribution of the salmonids and their habitats. Trends were stronger for habitat than for the status of salmonids because of greater uncertainty in linking the fish and habitat networks and constraints outside spawning and rearing habitat on federal lands in the study area. Trends were stronger for resident salmonids than anadromous forms because of additional effects of the migratory corridor assumed for the latter. Alternative S2, which approached ecosystem restoration more conservatively, generally produced the strongest positive changes, and alternative S3, designed to promote more aggressive restoration, the weakest. Averaged across the basin, differences among the alternatives were small. Differences were greater at finer temporal and spatial scales. In the short term (10 years) alternative S3 was expected to lead to further degradation in some areas. By formalizing our understanding and assumptions in these networks, we provided a framework for exploring differences in the management alternatives that is more quantifiable, spatially explicit, and flexible than previous approaches.

92. Rorig, M.L.; Ferguson, S.A. 1999. Characteristics of lightning and wildland fire ignition in the Pacific Northwest. *Journal of Applied Meteorology*. 38: 1565-1575.
Keywords: climate/fire.
Abstract: Lightning is the primary cause of fire in the forested regions of the Pacific Northwest, especially when it occurs without significant precipitation at the surface. Using thunderstorm occurrences and precipitation observations for the period 1948-77, along with automated lightning strike data for the period 1986-96, it was possible to classify convective days as either "dry" or "wet" for several stations in the Pacific Northwest. Based on the classification, a discriminant analysis was performed on coincident upper-air sounding data from Spokane, Washington. It was found that a discriminant rule using the dewpoint depression at 85 kPa and the temperature difference between 85 and 50 kPa was able to classify correctly between 56% and 80% of the convective days as dry or wet. Also, composite maps of upper-air data showed distinctly different synoptic patterns among dry days, wet days, and all days. These findings potentially can be used by resource managers to gain a greater understanding of the atmospheric conditions that are conducive to lightning-induced fires in the Pacific Northwest.
93. Rosentreter, R.E. 1999. Restoration of community structure and composition in cheatgrass dominated rangelands. In: Rose, R.; Haase, D.L., eds. *Native plants: propagating and planting: Proceedings of a conference*. Corvallis, Oregon: Oregon State University College of Forestry: 92-99.
Keywords: restoration/exotic plants/native plants/non-vascular plants/land management practices.
Abstract: Restoration in cheatgrass (*Bromus tectorum*) dominated rangelands is a tremendous challenge. It requires the control of both the existing cheatgrass litter and its seedbank, as well as the establishment of plants that can compete with future cheatgrass flushes. Perennial plants that are seeded must be capable of utilizing the entire soil profile, provide competitive growth over a long phenological period, and provide tight nutrient cycling, especially of nitrogen and phosphorus. Restoration efforts must include management actions that limit the reintroduction of exotic annual plants and prevent soil surface trampling or disturbance by livestock and off-highway vehicles. Maintenance of a patchy vegetative structure of the plant community appears necessary to retain native species. The perennial bunchgrasses form clumps with an open, low-growing vegetation in the interspaces that typically includes biological soil crusts. The crust component contributes to the maintenance of the community and helps exclude exotic annuals from the site.

94. Rowland, M.M.; Wisdom, M.J.; Wales, B.C. 2001. Broad-scale assessment of environmental conditions for selected ground squirrels in the interior Columbia Basin [Abstract]. In: Idaho Academy of Science.
95. Saab, V.A.; Dudley, J.G. 1998. Responses of cavity-nesting birds to stand-replacement fire and salvage logging in ponderosa pine/Douglas-fir forests of southwestern Idaho. Res. Pap. RMRS-RP-11. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 23 p.
 Keywords: wildlife/fire/land management practices.
Abstract: In Spring 1994, the Intermountain Research Station (now Rocky Mountain Research Station), Boise National Forest, and Region 4 of the Forest Service initiated long-term studies on bird responses to different fire conditions in ponderosa pine/Douglas-fir forests of southwestern Idaho. The first phase of the project is to evaluate effects of high-intensity wildfire on cavity-nesting birds and their associated habitats. During spring/summer 1994-1996 we monitored 695 nests of nine cavity-nesting bird species (including three Forest Service Sensitive Species: Black-backed, White-headed, and Lewis' woodpeckers) and measured vegetation at nest sites and at 90 randomly located sites. The burned forests used for study areas were created in 1992 and 1994 by primarily high-intensity wildfire, thus most standing trees were snags. Nests and vegetation were monitored in three treatments: standard-cut salvage logged, wildlife-prescription salvage logged, and unlogged controls. Tree densities for small diameter trees (>23 cm to <=53 cm [$>9''$ to $\leq 20''$] diameter breast height [dbh]) in the unlogged units averaged 81 snags per ha (33 per acre) and for larger trees (>53 cm dbh [$>20''$]) averaged 17 snags per ha (7 per acre). In salvage-logged units about 50% of the trees were harvested, tree densities for small trees averaged 43 snags per ha (17 per acre) and for large trees averaged 5 snags per ha (2 per acre). Lewis' Woodpecker was the most abundant (208 nests) and successful cavity nester on the 2-4 year-old burns, while Black-backed and White-headed woodpeckers were rare (23 nests). Lewis' Woodpecker and American Kestrel experienced the highest nesting success in the salvage-logged units, whereas Northern Flicker and Hairy Woodpecker were most successful in the unlogged units. All bird species selected nest sites with higher tree densities than that measured at random sites, and cavity nesters as a group selected clumps of snags rather than snags that were retained in uniform, evenly-spaced distributions. Among bird species, Black-backed Woodpeckers used nest sites with the highest tree densities, while Lewis' Woodpeckers selected relatively open nest sites. Cavity nesters as a group selected larger diameter and more heavily decayed snags than that expected based on availability of such snags. Snags with the highest probability (>85%) of being classified as nest trees were characterized by heavy decay and broken tops that pre-dated the wildfire. We discuss management implications of stand-replacement fire and post-fire salvage logging for cavity-nesting birds. Future plans are outlined, including bird and plant responses to different fire conditions (stand-replacement fire, fire suppression, and prescribed fire). The intent of this work is to provide information on the action and no action alternatives to the Forest Health Initiative.
96. Saab, V.A.; Rich, T.D. 1997. Large-scale conservation assessment for Neotropical migratory land birds in the interior Columbia River basin. Gen. Tech. Rep. PNW-GTR-399. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 56 p. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
 Keywords: wildlife/land management practices/habitat trend/population modeling.
Abstract: The status and habitats of 132 species of neotropical migratory landbirds (NTMB) are evaluated within the Interior Columbia River Basin (CRB). Objectives are to examine population trends, estimate NTMB responses to alternative management activities and provide recommendations by habitat and species that will lead to long-term persistence of NTMB populations. Five habitats (riparian, old growth forests, shrubsteppe, grasslands, and juniper) are identified for management priorities based on species declines, vulnerability to human activities and habitat loss. Among the four management themes considered, more species (63) were of high management concern under Consumptive Management than any other theme. Active and Passive Management themes are predicted to have negative effects on the fewest species, 23 and 16, respectively.
97. Samson, F.B.; Eames, M.R.; Holthausen, R.S.; Lee, D.C.; Murphy, W.; Newhouse, D.A.; Rich, T.D.; Sands, A.R.; Wales, B.C.; Wisdom, M.J. 1997. Wildlife conservation and ecosystem health in the Interior Columbia River Basin. In: Transactions, 62nd annual North American Wildlife and Natural Resources Conference: Proceedings of a conference. [Place of publication unknown]: [Publisher unknown]: [pages unknown].

Keywords: wildlife/habitat modeling/restoration.

Abstract: The working group in this effort takes advantage of extensive broad-scale information gathered within the Basin (Hann et al. in press, Marcot et al. in preparation). This paper, authored by the working group, compares the three major paradigms in natural resource conservation and their respective relation to wildlife conservation and ecosystem health. Further, it provides an overview of changed ecological conditions within the Basin and addresses two questions. What are specific wildlife conservation actions and opportunities at the regional scale? And, what lessons can be learned from integrating wildlife conservation with overall strategies for ecosystem health at the regional scale?

98. Schlager, D.B.; Freimund, W.A. 1997. Legal and institutional obstacles to implementing ecosystem management. In: Cordell, H.K.; Caldwell, L.; Mou, S., eds., comps. Integrating social science and ecosystem management: a national challenge: Proceedings of a conference. Gen. Tech. Rep. GTR-SRS-17. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 57-72.
Keywords: natural resource policy/social/technology transfer.
Abstract: To successfully implement ecosystem management, natural resource managers must balance both public and private interests and environmental preservation with human development in overcoming legal and institutional barriers. Institutional barriers to ecosystem management include uncertainty regarding ecosystem management and interorganizational coordination; perceived threats to private interests and public trust; and institutional structure, culture, and attitudes. Legal obstacles include the Federal Advisory Committee Act, the Endangered Species Act, the National Environmental Policy Act, and the National Forest Management Act.
99. Schlosser, W.E.; Blatner, K.A. 1997. Special forest products: an east-side perspective. Gen. Tech. Rep. PNW-GTR-380. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 27 p. (Quigley, T.M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
Keywords: special forest products/economics/non-vascular plants.
Abstract: The special forest products industry has gained increasing attention, as timber harvest levels in the Pacific Northwest have declined, and has been heralded, at least by some, as a partial solution to the employment problems common throughout the rural areas of Washington, Oregon, Idaho, and Montana. To date, relatively little work has been published on those portions of the industry located east of the Cascade Range. Yet the east side produced about 48 percent of the total wild edible mushroom harvest (about 1.9 million pounds worth \$11.8 million) during 1992. The region also accounts for all of the baby's breath harvested in the Pacific Northwest and has the potential to produce large quantities of other floral products. It also seems to have the potential to become an important producer of other edibles and medicinal products; however, relatively little is known about this segment of the industry. The following report provides overview of the special forest products industry east of the Cascade Range and evaluates its potential for expansion.
100. Schoettle, A.W.; Tonnessen, K.; Turk, J.; Vimont, J.; Amundson, R. authors. Acheson, Ann; Peterson, Janice, tech. eds. 1999. An assessment of the effects of human-caused air pollution on resources within the interior Columbia River basin. Gen. Tech. Rep. PNW-GTR-447. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 66 p. (Quigley, T.M., tech. ed. The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
Keywords: air quality/non-vascular plants.
Abstract: As assessment of existing and potential impacts to vegetation, aquatics, and visibility within the Columbia River basin due to air pollution was conducted as part of the Interior Columbia Basin Ecosystem Management Project. This assessment examined the current situation and potential trends due to pollutants such as ammonium, nitrogen oxides, sulfur oxides, particulates, carbon, and ozone. Ecosystems and resources at risk are identified, including certain forests, lichens, cryptogamic crusts, high-elevation lakes and streams, arid lands, and class I areas. Current monitoring data are summarized and air pollution sources identified. The assessment also includes a summary of data gaps and suggestions for future research and monitoring related to air pollution and its effects on resources in the interior Columbia River basin.
101. Sedell, J.R.; Lee, D.C.; Rieman, B.E.; Thurow, R.F.; Williams, J.E. 1997. Effects of proposed alternatives

on aquatic habitats and native fishes. In : Quigley, T.M.; Lee, K.M.; Arbelbide, S.J., tech. eds. Evaluation of the Environmental Impact Statement Alternatives by the Science Integration Team. Gen. Tech. Rep. PNW-GTR-406. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 435-535. Chapter 3. Volume 1.

Keywords: EIS/fish/viability/invertebrates.

Abstract: (Part of Introduction) The Aquatics and Riparian Science Teams analyzed the seven alternatives by evaluating their effectiveness in sustaining aquatic ecosystem structure and function, and their expected effect on 25 taxa of native fishes. Our analysis focused on alternatives as defined in Chapter 3 of the Preliminary Draft Environmental Impact Statements (EISs) (USDA and USDI 1996a, 1996b). The analysis consisted of three steps. In step one, we identified the level of protection, maintenance, or restoration of aquatic and riparian habitats offered by each alternative. In step two, we identified expected changes in distribution and status of seven widely-distributed salmonid species that would likely result from implementation of each alternative. Step three involved a similar, though less intensive, effort to identify expected changes in the populations of 18 more narrowly-distributed fish species of special concern. Each step built on the preceding one, as the sections below demonstrate.

Our assessment is based on professional interpretation of both quantitative and qualitative information collected for the purpose of this evaluation or generated as part of the broader scientific assessment (Lee and others, in press). Participants in the evaluation (evaluation team) included Forest Service (FS) and Bureau of Land Management (BLM) scientists from the Science Integration Team (SIT) Aquatics Team that participated in the Broadscale Assessment of Aquatics Species and Habitats (Lee and others, in press), and additional invited scientists from the FS, Environmental Protection Agency (EPA), National Marine Fisheries Service (NMFS), and U.S. Fish and Wildlife Service (USFWS) (appendix 3-A). Information relative to the alternatives and individual fish species were prepared by the SIT, Eastside EIS (EEIS) and Upper Columbia River Basin EIS (UCRB) staffs and presented to the evaluation team in a series of discussions held at the Forestry Sciences Laboratory in Boise, Idaho, on March 7 and 8, and 11 to 13, 1996. The intent of the discussions was to explore issues and probable outcomes associated with each alternative. A series of questions was developed by the evaluation team and used to guide discussion (described below). Notes taken during the discussion were used by the SIT aquatics team to frame the issues and formulate the evaluation in this report. The conclusions presented herein reflect the consensus view of the SIT Aquatics Team that participated in the evaluation.

102. Thompson, W.L.; Lee, D.C. 2000. Modeling relationships between landscape-level attributes and snorkel counts of chinook salmon and steelhead parr in Idaho. *Canadian Journal of Fisheries and Aquatic Sciences*. 57: 1834-1842.
Keywords: fish/climate/restoration/habitat modeling/population modeling/hydrology/geology.
Abstract: Knowledge of environmental factors impacting anadromous salmonids in their freshwater habitats, particularly at large spatial scales, may be important for restoring them to previously recorded levels in the northwestern United States. Consequently, we used existing data sets and an information-theoretic approach to model landscape-level attributes and snorkel count categories of spring-summer chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) parr within index areas in Idaho. Count categories of chinook salmon parr were negatively related to geometric mean road density and positively related to mean annual precipitation, whereas those for steelhead parr were negatively related to percent unconsolidated lithology. Our models predicted that chinook salmon parr would be in low count categories within subwatersheds with $>1 \text{ km} \cdot \text{km}^{-2}$ geometric mean road densities and (or) $<700 \text{ mm}$ mean annual precipitation. Similarly, steelhead parr were predicted to be in low count categories in subwatersheds with $>30\%$ unconsolidated lithology. These results provide a starting point for fish biologists and managers attempting to map approximate status and quality of rearing habitats for chinook salmon and steelhead at large spatial scales.
103. Thurow, R.F.; Lee, D.C.; Rieman, B.E. 1997. Distribution and status of seven native salmonids in the interior Columbia River basin and portions of the Klamath River and Great basins. *North American Journal of Fisheries Management*. 17: 1094-1110.
Keywords: fish/landscape patterns/hydrology/restoration/habitat modeling/population modeling.
Abstract: We summarized presence, absence, current status, and potential historical distribution of seven native salmonid taxa —bull trout *Salvelinus confluentus*, Yellowstone cutthroat trout *Oncorhynchus clarki*

bouvieri, westslope cutthroat trout *O. c. lewisi*, redband trout and steelhead *O. mykiss gairdneri*, stream type (age-1 migrant) chinook salmon *O. tshawytscha*, and ocean type (age-0 migrant) chinook salmon—in the Interior Columbia River basin and portions of the Klamath River and Great basins. Potential historical range was defined as the likely distribution in the study area prior to European settlement. Data were compiled from existing sources and surveys completed by more than 150 biologists. Within the potential range of potamodromous salmonids, status was unknown in 38-69% of the area, and the distribution of anadromous salmonids was unknown in 12-15%. We developed models to quantitatively explore relationships among fish status and distribution, the biophysical environment, and land management, and used the models to predict the presence of taxa in unsampled areas. The composition, distribution, and status of fishes within the study area is very different than it was historically. Although several of the salmonid taxa are distributed throughout most of their potential range, declines in abundance and distribution and fragmentation into smaller patches are apparent for all forms. None of the salmonid taxa have known or predicted strong populations in more than 22% of their potential ranges, with the exception of Yellowstone cutthroat trout. Both forms of chinook salmon are absent from more than 70% and steelhead from more than 50% of their potential ranges, and all are approaching extirpation in portions of their remaining ranges. If current distributions of the taxa are useful indicators, many aquatic systems are remnants of what were larger and more complex, diverse, and connected systems. Because much of the ecosystem has been altered, areas supporting strong populations or multiple species will be critical for conservation management. Moreover, restoration of a broader matrix of productive habitats also will be necessary to allow fuller expression of phenotypic and genotypic diversity in native salmonids.

104. Thurow, R.F.; Lee, D.C.; Rieman, B.E. 1999. Status and distribution of chinook salmon and steelhead in the interior Columbia River basin and portions of the Klamath River basin. In: Knudsen, E.E.; Steward, C.R.; MacDonald, D.D.; Williams, J.E.; Reiser, D.W., eds. Sustainable fisheries management. New York: Lewis Publishers: 133-160.

Keywords: fish/restoration/habitat modeling/population modeling/hydrology.

Abstract: This chapter summarizes information on presence, absence, current status, and probable historical distribution of steelhead *Oncorhynchus mykiss* and stream-type (age-1 migrant) and ocean type (age-0 migrant) chinook salmon *O. tshawytscha* in the interior Columbia River basin and portions of the Klamath River basin. Data were compiled from existing sources and via surveys completed by more than 150 biologists working in the region. We developed models to quantitatively explore relationships among fish status and distribution, the biophysical environment, and land management. Biophysical setting was an important determinant of species distributions and habitat suitability. We applied model results to predict fish presence in unsampled areas and mapped expected distributions in more than 3,700 subwatersheds. Chinook salmon and steelhead are extirpated from more than 50% of their potential historical ranges. Most remaining populations are severely depressed; less than 2% of the watersheds in the current range were classified as supporting strong populations of steelhead or stream-type chinook salmon. Wild, indigenous fish are rare; 22% of remaining steelhead stocks and less than 17% of chinook salmon stocks were judged to be genetically unaltered by hatchery-reared fish. Much of the historical production has been eliminated. However, a core for maintaining and rebuilding functional areas remains. Protection of core areas is critical to stock persistence and restoration of a broader matrix of productive habitats will be necessary for productive and sustainable fisheries. This effort will require conservation and restoration of sufficient habitats to ensure the full expression of phenotypic and genotypic diversity in chinook salmon and steelhead.

105. U.S. Department of Agriculture; Forest Service 1996. Status of the interior Columbia basin: summary of scientific findings. Gen. Tech. Rep. PNW-GTR-385. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station; U.S. Department of Interior, Bureau of Land Management. 144 p.

Keywords: ecological integrity/landscape dynamics.

Abstract: The Status of the Interior Columbia Basin is a summary of the scientific findings from the Interior Columbia Basin Ecosystem Management Project. The Interior Columbia Basin includes some 145 million acres within the northwestern United States. Over 75 million acres of this area are managed by the USDA Forest Service or the USDI Bureau of Land Management. A framework for ecosystem management is described that assumes the broad purpose is to maintain the integrity of ecosystems over time and space. An integrated scientific assessment links landscape, aquatic, terrestrial, social, and

economic characterizations to describe the biophysical and social systems. Ecosystem conditions within the Basin have changed substantially within the last 100 years. The status of ecosystems is described in terms of current conditions and trends under three broadly defined management options. The scientific information brought forward will be used in decision-making, and may potentially amend Forest Service and Bureau of Land Management plans within the Basin. The information highlighted here represents an integrated view of biophysical and socioeconomic elements at a scale never before attempted. The risks and opportunities are characterized in the broad context of the Basin for managers and the public to use as a foundation for discussion about future management.

106. Waters, E.C.; Holland, D.W.; Haynes, R.W. 1997. The economic impact of public resource supply constraints in northeast Oregon. Gen. Tech. Rep. PNW-GTR-398. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 23 p. (Quigley, T.M., tech.ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
Keywords: economics/employment/recreation.
Abstract: Traditional, fixed-price (input-output) economic models provide a useful framework for conceptualizing links in a regional economy. Apparent shortcomings in these models, however, can severely restrict our ability to deduce valid prescriptions for public policy and economic development. A more efficient approach using regional computable general equilibrium (CGE) models as well as a brief survey of relevant literature is presented. Evidence suggests that a regional economic transformation, characterized by stable or declining employment in resource-based industries and growth in tourism and retirement-based services, is already underway.
107. Weber, N.S. 1997. Morels and allied cup-fungi of the Interior Columbia River Basin. In: Kaye, T.N.; Liston, A.; Love, R.M.; Luoma, D.L.; Meinke, R.J.; Wilson, M.V., eds. Conservation and management of native plants and fungi. Corvallis, OR: Native Plant Society of Oregon: 227-233.
Keywords: non-vascular plants/native plants.
Abstract: Label data on Pezizales collected in the interior Columbia River Basin in the United States and deposited at BPI, ID, MICH, NY, OSC, WSP, and WTU were analyzed. About 400 names were encountered; about 200 were included on a final list. The number of collections per name was determined, and each taxon was assigned to one or two likely functional groups (e.g., mycorrhizal, coprophilous). Number of collections per name proved to be of relatively little value as an estimate of abundance. Certain functional groups (e.g., coprophilous and phoenicoid taxa) were poorly represented in these herbaria. The number of collections per decade, per state, and per major collector were calculated. The data on number of collections per decade indicate more about the abundance of collectors than about the fungi themselves.
108. Williams, D.R.; Patterson, M.E. 1996. Environmental meaning and ecosystem management: perspectives from environmental psychology and human geography. *Society and Natural Resources*. 9(5): 507-521.
Keywords: social/natural resource policy.
Abstract: The contribution of human dimensions research to the ecological paradigm emerging in natural resource management involves the development of contextually rich, and spatially and historically specific, understandings of places. As an eclectic and integrative field of inquiry, environmental psychology offers a growing body of research that promotes a view of the person as a social agent who seeks out and creates meaning in the environment. As developed in environmental psychology, research from the adaptive, goal-directed, and sociocultural paradigms is reviewed to illustrate alternative approaches to studying environmental meaning. These paradigms, taken together, provide complementary conceptual approaches for assessment and mapping of the diverse and often competing environmental meanings that various constituencies attach to natural resources. From human geography, the concept of *place* offers a framework for integrating environmental meanings into ecosystem management. Place constitutes a concrete focal point where natural forces, social relations, and human meanings overlap and can be integrated in theory and practice.
109. Williams, D.R.; Patterson, M.E. 1999. Environmental psychology: mapping landscape meanings for ecosystem management. In: Cordell, H.K.; Bergstrom, J.C., eds. Integrating social sciences with ecosystem management: human dimensions in assessment, policy, and management. Champaign, IL: Sagamore Publishing: 141-160.
Keywords: social/natural resource policy.

Abstract: (Part of Introduction) If we take seriously the view that people are part of the ecosystem, then good ecosystem management requires a thorough map of landscape meanings. An important theme in this chapter is that such a map necessitates adjustments in how we currently view human-environment relationships. This chapter will discuss the concept of environmental meaning, present a framework that characterizes different approaches resource managers may adopt to study and understand landscape meanings, review current applications and knowledge gaps associated with each approach, and conclude by suggesting six principles to guide the integration of social science into ecosystem management.

110. Williams, D.R.; Stewart, S.I. 1998. Sense of place: An elusive concept that is finding a home in ecosystem management. *Journal of Forestry*. 1998(May): 18-23.
 Keywords: social/scenery.
 Abstract: "Sense of place" offers resource managers a way to identify and respond to the emotional and spiritual bonds people form with certain spaces. We examine reasons for the increasing interest in the concept and offer four broad recommendations for applying sense of place to ecosystem management. By initiating a discussion about sense of place, managers can build a working relationship with the public that reflects the complex web of lifestyles, meanings, and social relations endemic to a place.
111. Wisdom, M.J.; Holthausen, R.S.; Wales, B.C.; Hargis, C.D.; Saab, V.A.; Lee, D.C.; Hann, W.J.; Rich, T.D.; Rowland, M.M.; Murphy, W.J.; Eames, M.R. 2000. Source habitats for terrestrial vertebrates of focus in the interior Columbia basin: broad-scale trends and management implications. Gen. Tech. Rep. PNW-GTR-485. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 529 p. 3 vol. (Quigley, T.M., tech.ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
 Keywords: wildlife/habitat modeling/viability/land management practices/restoration.
 Abstract: We defined habitat requirements (source habitats) and assessed trends in these habitats for 91 species of terrestrial vertebrates on 58 million ha (145 million acres) of public and private lands within the interior Columbia basin (hereafter referred to as the basin). We also summarized knowledge about species-road relations for each species and mapped source habitats in relation to road densities for four species of terrestrial carnivores. Our assessment was conducted as part of the Interior Columbia Basin Ecosystem Management Project (ICBEMP), a multiresource, multidisciplinary effort by the USDA Forest Service (FS) and the USDI Bureau of Land Management (BLM) to develop an ecosystem-based strategy for managing FS and BLM lands within the basin. Our assessment was designed to provide technical support for the ICBEMP and was done in five steps. First, we identified species of terrestrial vertebrates for which there was ongoing concern about population or habitat status (species of focus), and for which habitats could be estimated reliably by using a large mapping unit (pixel size) of 100 ha (247 acres) and broad-scale methods of spatial analysis. Second, we evaluated change in source habitats from early European settlement (historical, circa 1850 to 1890) to current (circa 1985 to 1995) conditions for each species and for hierarchically nested groups of species and families of groups at the spatial scales of the watershed (5th hydrologic unit code [HUC]), subbasin (4th HUC), ecological reporting unit, and basin. Third, we summarized the effects of roads and road-associated factors on populations and habitats for each of the 91 species and described the results in relation to broad-scale patterns of road density. Fourth, we mapped classes of the current abundance of source habitats for four species of terrestrial carnivores in relation to classes of road density across the 164 subbasins and used the maps to identify areas having high potential to support persistent populations. And fifth, we used our results, along with the results from other studies, to describe broad-scale implications for managing habitats deemed to have undergone long-term decline and for managing species negatively affected by roads or road-associated factors.

Our results indicated that habitats for species, groups, and families associated with old-forest structural stages, with native grasslands, or with native shrublands have undergone strong, widespread decline. Implications of these results for managing old-forest structural stages include consideration of (1) conservation of habitats in subbasins and watersheds where decline in old forests has been strongest; (2) silvicultural manipulations of mid-seral forests to accelerate development of late-seral stages; and (3) long-term silvicultural manipulations and long-term accommodation of fire and other disturbance regimes in all forested structural stages to hasten development and improvement in the amount, quality, and distribution of old-forest stages. Implications of our results for managing rangelands include the potential to (1) conserve native grasslands and shrublands that have not undergone large-scale reduction in composition of

native plants; (2) control or eradicate exotic plants on native grasslands and shrublands where invasion potential or spread of exotics is highest; and (3) restore native plant communities by using intensive range practices where potential for restoration is highest.

Our analysis also indicated that >70 percent of the 91 species are affected negatively by one or more factors associated with roads. Moreover, maps of the abundance of source habitats in relation to classes of road density suggested that road-associated factors hypothetically may reduce the potential to support persistent populations of terrestrial carnivores in many subbasins. Management implications of our summarized road effects include the potential to mitigate a diverse set of negative factors associated with roads. Comprehensive mitigation of road-associated factors would require a substantial reduction in the density of existing roads as well as effective control of road access in relation to management of livestock, timber, recreation, hunting, trapping, mineral development, and other human activities.

A major assumption of our work was that validation research will be conducted by agency scientists and other researchers to corroborate our findings. As a preliminary step in the process of validation, we found high agreement between trends in source habitats and prior trends in habitat outcomes that were estimated as part of the habitat outcome analysis for terrestrial species within the basin. Results of our assessment also were assumed to lead to finer scale evaluations of habitats for some species, groups, or families as part of implementation procedures. Implementation procedures are necessary to relate our findings to local conditions; this would enable managers to effectively apply local conservation and restoration practices to support broad-scale conservation and restoration strategies that may evolve from our findings.

112. Wisdom, M.J.; Rowland, M.M.; Wales, B.C.; Hemstrom Miles A.; Hann, W.J.; Raphael Martin G.; Holthausen, R.S.; Gravenmier, R.A.; Rich, T.D. *In press*. Modeled effects of sagebrush-steppe restoration on Greater sage-grouse in the interior Columbia basin, USA. *Conservation Biology*.
Keywords: wildlife/habitat modeling/population modeling/viability/restoration.
Abstract: Habitats of Greater Sage-Grouse (*Centrocercus urophasianus*) have declined across western North America, and most remaining habitats occur on lands administered by U.S. Forest Service (FS) and U.S. Bureau of Land Management (BLM). Consequently, managers of FS-BLM lands need effective strategies to recover sagebrush (*Artemisia* spp.) habitats on which this species depends. In response to this need, we evaluated the potential benefits of two restoration scenarios on Greater Sage-Grouse in the interior Columbia Basin and adjacent portions of the Great Basin of the western United States. Scenario 1 assumed a 50% reduction in detrimental grazing effects (through changes in stocking rates and grazing systems) and a 6-fold increase in areas treated with active restoration (e.g., prescribed burning, native seedings, wildfire suppression) compared to future management proposed by the FS-BLM. Scenario 2 assumed a 100% reduction in detrimental grazing effects and the same increase in active restoration as scenario 1. To evaluate benefits, we estimated the risk of population extirpation for sage grouse 100 years in the future under the two scenarios, and compared this risk with that estimated for proposed (100-year) FS-BLM management. We used estimates of extirpation risk for historical (circa 1850 to 1890) and current time periods as context for our comparison. Under historical conditions, risk of extirpation was very low on FS-BLM lands, but increased to a moderate probability under current conditions. Under proposed FS-BLM management, risk of extirpation on FS-BLM lands increased to a high probability 100 years in the future. Benefits of the two restoration scenarios, however, constrained the future risk of extirpation to a moderate probability. Our results suggest that expansive and sustained habitat restoration can maintain desired conditions and reduce future extirpation risk for sage grouse on FS-BLM lands in western North America. Continued spread of exotic plants, however, presents a formidable challenge to successful restoration, and warrants substantial research and management attention.
113. Wisdom, M.J.; Wales, B.C.; Holthausen, R.S.; Hann, W.J.; Hemstrom, M.A.; Rowland, M.M. *In press*. A habitat network for terrestrial wildlife in the interior Columbia Basin. *Northwest Science*.
Keywords: wildlife/habitat modeling/restoration.
Abstract: Habitat managers need information about landscape conditions in relation to the composite requirements of species that deserve attention in conservation planning. Consequently, we characterized and mapped a broad-scale network of habitats for five suites of terrestrial vertebrates in the 58 million-ha Interior Columbia Basin (Basin). These five suites, referred to as Families, are composed of 44 species whose habitats have declined strongly from historical (circa 1850-1890) to current periods in the Basin, and

thus are of conservation focus. Two of the five Families consist of species that depend on old forests. Species in another Family depend on early-seral forests. Species in the remaining two Families depend on sagebrush-steppe or open-canopy sagebrush (*Artemisia* spp.) and grasslands. For each Family, we characterized current habitat conditions at the scale of the watershed (mean size of 22,500 ha). Each watershed was classified as one of three conditions. Watersheds in Condition 1 contained habitats that have undergone little change in quality or abundance since the historical period. By contrast, watersheds in Condition 2 or 3 contained habitats that have changed from historical conditions, but in different ways. Watersheds in Condition 2 had habitats of high abundance but moderate resiliency and quality. Watersheds in Condition 3 contained habitats of low abundance or low resiliency and quality. The majority of watersheds (59% -80%) were in Condition 3 for all five Families, whereas the lowest percentage (5% -25%) of watersheds was in Condition 2 for four of five Families. Connectivity among watersheds for all Families appeared low in many parts of the Basin due to spatial gaps associated with expansive areas of habitat extirpation. Our condition maps constitute a broad-scale network of habitats that could be useful for developing multi-species research hypotheses and management strategies in the Basin.

114. Wisdom, M.J.; Wales, B.C.; Holthausen, R.S.; Hargis, C.D.; Saab, V.A.; Hann, W.J.; Rich, T.D.; Lee, D.C.; Rowland, M.M. authors. 1999. Wildlife habitats in forests of the interior Northwest: history, status, trends, and critical issues confronting land managers. In: Transactions of the 64th North American Wildlife and Natural Resources Conference: Proceedings of a conference. [Place of publication unknown]: [Publisher unknown]: 79-93.
 Keywords: wildlife/habitat modeling/viability/land management practices/restoration.
 Abstract: In this paper, we summarize results of large-scale landscape and wildlife habitat assessments that were conducted as part of the Interior Columbia Basin Ecosystem Management Project (ICBEMP). The ICBEMP was established in January 1994 through a charter signed by the Chief of the USDA Forest Service (FS) and the Director of the USDI Bureau of Land Management (BLM) (USDA Forest Service 1996). The charter directed that work be undertaken to develop and adopt an ecosystem-based strategy for all FS- and BLM-administered lands within the Interior Columbia Basin (Basin). This area extends over 145 million acres (58 million hectares) in Washington, Oregon, Idaho, Montana, and small portions of Nevada, California, Utah, and Wyoming (Figure 1). Fifty-three percent of the Basin is public land administered by the FS or BLM.
115. Wisdom, M.J.; Wales, B.C.; Rowland, M.M.; Raphael, M.G.; Holthausen, R.S.; Rich, T.D.; Saab, V.A. *In press*. Performance of greater sage-grouse models for Conservation assessment in the interior Columbia basin, USA. *Conservation Biology*.
 Keywords: wildlife/habitat modeling/population modeling/viability.
 Abstract: Valid modeling of habitats and populations of Greater Sage-Grouse (*Centrocercus urophasianus*) is a critical management need because of increasing concern about population viability. Consequently, we evaluated performance of two models designed to assess landscape conditions for Greater Sage-Grouse across 13.6 million ha of sagebrush steppe in the interior Columbia Basin and adjacent portions of the Great Basin of the western United States (referred to as basin). The first model (environmental index model) predicted conditions at the scale of the subwatershed (mean size of 7800 ha), using inputs of habitat density, habitat quality, and effects of human disturbance. Predictions ranged on a continuous scale from 0 (lowest environmental index) to 2 (optimal environmental index). The second model (population outcome model) predicted the composite, range-wide conditions for sage grouse based on the contribution of environmental index values from all subwatersheds and measures of range extent and connectivity. Population outcomes were expressed as five classes (A through E) that represented a gradient from continuous, well-distributed populations (outcome A) to sparse, highly isolated populations with a high likelihood of extirpation (outcome E). To evaluate performance, we predicted environmental index values and population outcome classes in areas currently occupied by sage grouse versus areas where extirpation has occurred. Our a priori expectations were that models should predict substantially worse environmental conditions (lower environmental index) and a substantially higher probability of extirpation (lower population outcome class) in extirpated areas. Results for both models met these expectations. For example, a population outcome of class E was predicted for extirpated areas, as opposed to class C for occupied areas. These results suggest that our models provided reliable landscape predictions for the conditions tested. This finding is important for conservation planning in the basin, where the models were

used to evaluate management of federal lands on sage grouse.

116. Wisdom, M.J.; Warren, N.M.; Wales, B.C. *In press*. Vertebrates of conservation concern in the interior Northwest: Priorities for research. Northwest Science.
Keywords: wildlife/technology transfer.
Abstract: Research on terrestrial vertebrates typically has focused on species with commodity value (commodity species such as game and furbearers) or threatened or endangered status (TE species). While these species deserve research attention, other species of conservation concern (species with rare or declining habitats or populations) are neither commodity nor TE species, and thus may not be studied extensively. To better understand this issue and its implications for research, we identified 218 terrestrial species of conservation concern in the Interior Northwest, and placed 187 of these species in three categories: (1) commodity, (2) TE, or (3) neither commodity nor TE. We conducted a literature search on the 187 species and calculated the mean number of citations/species, as an index of the degree to which research has been conducted on species in each category. A large majority (75%) of species of conservation concern was neither commodity nor TE, with a substantially smaller percentage in commodity (21%) and TE (4%) categories. By contrast, number of citations/species was highest for TE species (mean= 58.9, SE = 21.7), intermediate for commodity species (mean= 20.34, SE = 1.7), and lowest for species that were neither commodity nor TE (mean=20.34, SE = 1.7). Our results confirm that the majority of vertebrates of conservation concern have received little attention from research compared to those with commodity or TE designations. Our results could be used to guide priorities for future research on vertebrates of conservation concern in the Interior Northwest.

117. Witmer, G.W.; Martin, S.K.; Sayler, R.D. 1998. Forest carnivore conservation and management in the interior Columbia basin: issues and environmental correlates. Gen Tech. Rep. PNW-GTR-420. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 51 p. (Quigley, T.M., tech.ed.; The Interior Columbia Basin Ecosystem Management Project: scientific assessment).
Keywords: wildlife/landscape patterns/land management practices.
Abstract: Forest carnivores in the Pacific Northwest include 11 medium to large-sized mammalian species of canids, felids, mustelids, and ursids. These carnivores have widely differing status in the region, with some harvested in regulated furbearer seasons, some taken for depredations, and some protected because of rarity. Most large carnivores have declined in numbers or range from human encroachment, loss or modification of forest habitat, accidental deaths (e.g. mortality from vehicles), illegal kills, and our inability to adequately monitor and protect populations. Efforts to reverse these trends include new approaches to reduce conflicts with humans, research to better define habitat needs, formation of expert carnivore working groups, and use of Geographic Information System models to predict specific impacts of habitat modifications. Long-term preservation of large carnivores in the region is problematic unless we reduce forest fragmentation and conflicts with humans and improve our ability to quantitatively integrate population dynamics with landscape level habitat requirements.