Chapter 1: A Framework for the Development and Application of INLAS: the Interior Northwest Landscape Analysis System

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Abstract

The Interior Northwest Landscape Analysis System is a partnership among researchers and natural resource managers from both the public and private sectors. The project is an effort to increase our understanding of the role of vegetative succession, natural disturbance, and management actions at the watershed scale. The effort will advance the development and application of integrated landscape-level planning tools (models, methods, and information) that use consistent assumptions and common data. Focusing on the subbasin (landscape units of about 202 300 ha) and smaller scales, we will demonstrate the use of existing and new landscape simulation tools to project future succession, disturbance, and management under various policy scenarios. These scenarios will compare different approaches to achieving short- and long-term ecosystem goals and the effects of regulatory constraints, ownership patterns, and limited budgets. Of specific interest is the measurement of the long-term cumulative effects of fuels management and other treatments on key resources. The project is using a 178 000 ha watershed in northeast Oregon to prototype modeling tools and methods. The results of landscape simulations will help to inform the debate over sustainability of forest, range, and aquatic ecosystems in the intermountain West.

Keywords: Forest simulation analysis, midscale, vegetative succession, disturbance, management.

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Introduction

Despite a decade of scientific assessments throughout the interior Pacific Northwest (e.g., Caraher et al. 1992, Everett et al. 1994, Gast et al. 1991, Quigley et al. 1996) and elsewhere (e.g., FEMAT 1993, Johnson 1996), the debate continues over management of forested and range lands, and aquatic systems. It is clear from these and other analyses that decades of human activities to reduce the risk of unwanted disturbances like wildfires and to extract goods and services have led to substantial changes in forest conditions and productivity. It is also evident that there is no simple remedy given landownership patterns, ecosystem-level management objectives, existing landscape conditions, and the complex array of state and federal regulatory constraints (e.g., Clean Water Act 1977, Endangered Species Act [ESA] 1973, National Environmental Policy Act 1969, National Forest Management Act 1976). Large areas of forest land in the intermountain West remain in conditions lending themselves to uncharacteristically large and severe wildfires and insect or disease outbreaks (Ottmar and Sandberg 2001). The problems are compounded by finite budgets and changing economic conditions and social concerns that can contribute to constraints on land managers (Quigley et al. 2001).

With the continued dispersal of human populations into areas that were once considered "wild," the problem of how to manage for natural disturbance over large areas while not impinging on human populations or negatively affecting the conservation of rare or valuable resources becomes increasingly complex. Much of the debate over how to manage federal lands is focused on the tradeoffs among active management to produce goods and services, moderate wildfire and other natural disturbances, and the long-term preservation of federally protected plant and animal species. A relevant policy question is whether short-term goals intended to protect aquatic and terrestrial habitat for species listed under the 1973 ESA might impede forest management activities that are necessary to improve the long-term sustainability of these species. In the Blue Mountains of northeast Oregon, management direction for resource protection and other amenities may prevent treatment of the majority of fuel-laden stands (Wilson et al., n.d.). Market conditions and operational costs further reduce the extent to which management can be applied to reduce risk from natural disturbances (Barbour et al., in press).

One thing that is clear from these debates is that society as a whole does not share a common strategic vision of future forested landscapes. A blueprint for restoring and maintaining these landscapes is needed that considers the combined effects of forest succession, disturbance, and management (Quigley et al. 2001). Many questions remain concerning efficient and cost-effective scheduling and spatial distribution of management activities, such as prescribed fire, thinning, and selective harvesting, on large landscapes to achieve specified goals over the long run (Finney Chapter 9). Further, we do not understand the long-term compatibilities among commodity production, recreational use, fire risks, fuel treatments, cumulative effects of management activities on key resources, and fish and wildlife habitat goals. Some hypothesize that restricting active management will eventually lead to large natural disturbances that will negate the net effect of protective resource policies. Others feel that management itself poses the greatest threat to sensitive resources. Unfortunately, the debate has been fed, in part, from conflicting projections of potential outcomes. Decisionmakers need unbiased and consistent information about the likely outcomes of different policies or management practices as they evaluate options.

Landscape simulation tools can aid in the development of strategic visions for managing forested and range lands by providing a means to project long-term changes from succession, management, and disturbance (e.g., Bettinger et al. Chapter 4, Johnson et al. 1998, Keane et al. 1996, Mladenoff and Baker 1999, Spies et al. 2002). Understanding how landscapes respond over time to perturbations is key to the development of effective forest policy (Turner et al. 2002). Landscape simulation tools also can aid in the growing need to integrate social concerns with tradeoff analyses of natural resource values (Vogt et al. 2002) and provide a framework to build consistent modeling approaches across resource disciplines. Although a number of recent efforts have applied forest landscape simulation modules to analyze policy issues at broad scales (e.g., Johnson et al. 1998, Keane et al. 1996, Spies et al. 2002), there has been little operational use of these tools to examine management issues at the watershed or subbasin scale. In addition, previous work has largely been concerned with modeling of forest vegetation, with relatively little attention to the problem of modeling nonforest conditions and social values.

The overall goal of the Interior Northwest Landscape Analysis System (INLAS) project is to advance the development and application of integrated landscape models and apply these tools to examine the effects of forest management on long-term trajectories of forest, range, and aquatic conditions at the subbasin and smaller scales. A primary focus of this work will be to apply simulation methods to measure the relative effects of forest succession, disturbance, and management on multiple-resource goals (fig. 1).

Decisionmakers can apply the techniques developed in this project to measure the response of large landscapes to different management scenarios ranging from active to passive, while accounting for expected levels of natural disturbance (Quigley et al. 2001). They also can help landowners, managers, and regulatory agencies integrate new scientific information into biological assessments, watershed analyses, subbasin reviews, and forest management plans. The landscape simulation methods that are advanced by this project will also have utility in a wide range of ecological research, especially that pertaining to disturbance processes and their effects on landscape pattern.

The combined development and application of landscape simulation methods will focus on a set of research objectives that will be addressed on a prototype analysis area. These are:

1. Evaluate the combined effects of management, natural disturbance, and succession on current and future resource conditions. The current set of regulations and management directions for individual species and habitats may not allow achievement of long-term, landscape-level ecosystem goals to both manage fuels and protect resources. We will examine possible conflicts created by existing policy and management directions between short-term management for site-specific conditions and the long-term potential for episodic and chronic disturbances to degrade those conditions. We will create a baseline scenario against which we can compare alternative policy and management options. This baseline scenario will follow current guidelines and forest plans. We will then contrast potential outcomes from this scenario with two opposing scenarios: (1) **passive**, i.e., custodial management and (2) **active**, i.e., management actions aimed at accelerated achievement of goals. Each scenario will examine a range of approaches that might be followed by different owners.

2. Develop new knowledge about how to reduce resource impacts by arranging spatial schedules of treatments to manage disturbance. We will use an adaptive approach to apply information developed during early analyses to design spatially explicit schedules of treatments that reduce both immediate adverse effects on desirable site-specific conditions and long-term risks from stochastic disturbances. This work will illustrate ways to make the most of spatial and temporal variation in terrestrial and aquatic conditions to reduce adverse long-term cumulative effects on sensitive resources by taking selective management actions, such as reducing fuel loads.

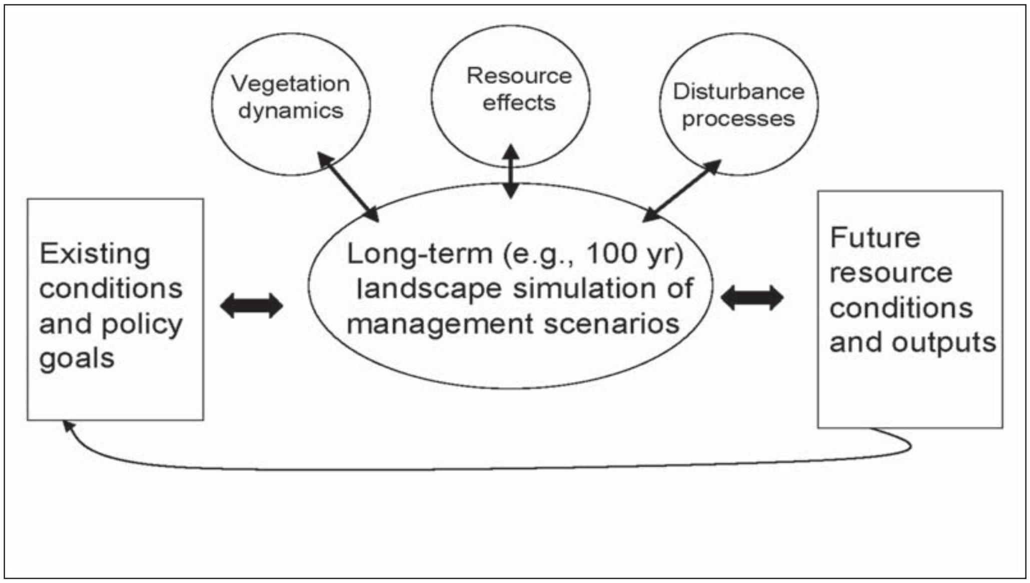

Figure 1—Interior Northwest Landscape Analysis System conceptual framework.

3. Identify the policy, sociocultural, economic, and ecological constraints associated with the application of active or idealized spatially explicit schedules of fuel treatments. Spatial arrangement of fuel treatments on large landscapes can have an important effect on wildfire spread rates (Finney 1998, 2001). Idealized spatial and temporal distributions of fuels management treatments that attempt to minimize wildfire risk may, however, violate constraints imposed by other objectives or policies. Our analysis will identify policy, sociocultural, economic, and resource constraints that might prevent implementation of otherwise theoretically optimal treatment patterns (e.g., Finney 1998).

4. Develop methods to help managers identify problematic watersheds. The difficulty of achieving management objectives in individual watersheds differs considerably owing to particular combinations of physiography, vegetation, social values, economics, and management strategies. Our methods integrate finer resolution variables (e.g., stand density, fire hazard, wildlife habitat, economics, and management restrictions) to help to identify subwatersheds where actions might enhance specific goals or where current policies intended to mitigate risks and effects of unpredicted disturbances might be ineffective over the long term.

5. Examine the long-term consequences and socioeconomic feasibility of density management objectives at the watershed scale. Current assessments by the USDA Forest Service reveal large areas of dense stands that exceed desired stocking levels (Wilson et al., n.d.). What are the most economically efficient ways of altering these conditions, and maintaining stands at desired stocking levels? What are the implications and conflicts associated with achieving these objectives in terms of other resource values? Can we effectively integrate socioeconomic considerations into analyses of subwatershed-scale risk factors that measure deviations from desired stocking? Will the net effects of some management activities result in more long-term stocking problems than they solve? Long-term simulation of forest management will be used to address these and related questions.

Research Approach

The INLAS is building on two alternative methods to create a framework for modeling landscape change. First, a state and transition approach (see Hemstrom et al. Chapter 2) is being used to build a relatively coarse simulation system that integrates conifer succession and disturbance, forest management, fluvial processes, invasive plants, and herbivory. State and transition modeling uses a relatively coarse stratification of landscape conditions into **states** and simulates changes in landscape condition over time by using **transition probabilities** (Hemstrom et al. Chapter 2). These state and transition models evolved from successional studies in ecology and have recently found their way into forest planning and landscape assessment (Hann et al. 1997). Some of the advantages of this system are that software is well developed (Kurz et al. 2000), and data needed to run the model are available. The disadvantage of these methods is that they do not consider tree list type data or other detailed information about vegetative conditions (Hemstrom et al. Chapter 2).

The second approach uses the extension of tree-level growth models (e.g., Forest Vegetation Simulator [FVS], Stage 1973; ORGANON, Hann et al. 1995) to simulate landscapes as an assemblage of individual stands, polygons, or pixels (Ager Chapter 3, Bettinger et al. Chapter 4). This stand-level simulation approach has been the focus of considerable work over the past 10 to 15 years, and many improvements have been made to consider stand contagion, optimization, wildlife, spatial spread of insect epidemics, and consideration of nontimber values, as well as interfaces to the stand simulators to simplify the process of organizing stands for simulation (reviewed in Ager Chapter 3). We are exploring several stand-level simulation approaches, ranging from simple systems that use FVS and FVS postprocessors to model each stand in a landscape (Ager Chapter 3) to systems based on the Simulation and Analysis of Forests with Episodic Disturbance (SafeD) model (Graetz 2000) that can perform spatial optimization and incorporate natural disturbances (Bettinger et al. Chapter 4). Like the state and transition approach, there is a growing interest in this type of modeling for both research and operational applications. Stand-level landscape simulation models are well suited to problems where a relatively high degree of biological and spatial resolution is required. This includes studies where tree-level parameters like size and species are needed, and where management choices are tailored to stand metrics.

By applying both models, we will demonstrate tradeoffs between the two modeling approaches and their relative merits at different biological and spatial scales (fig. 2). For instance, state and transition models are relatively easy to build for large areas because they represent landscapes as a discrete and finite number of states and transitions. They also can be applied to a wide range of problems where process models or data are not available. A state and transition approach may be the most viable approach to building an integrated landscape simulation system. By comparison, stand-level process models require fine-scale quantitative data on stand conditions and can provide detailed data on stand characteristics through time, which are needed for many assessment and planning projects.

By using the two modeling frameworks described above, we will explore how to integrate other important ecosystem components (fig. 1). Each of the ecosystem components represents a model (or models) that is integrated into the framework and takes information from and feeds information to the vegetation simulator. Output from these resource effects models alters vegetative conditions or constrains management or succession and changes the resource outputs available from the landscape.

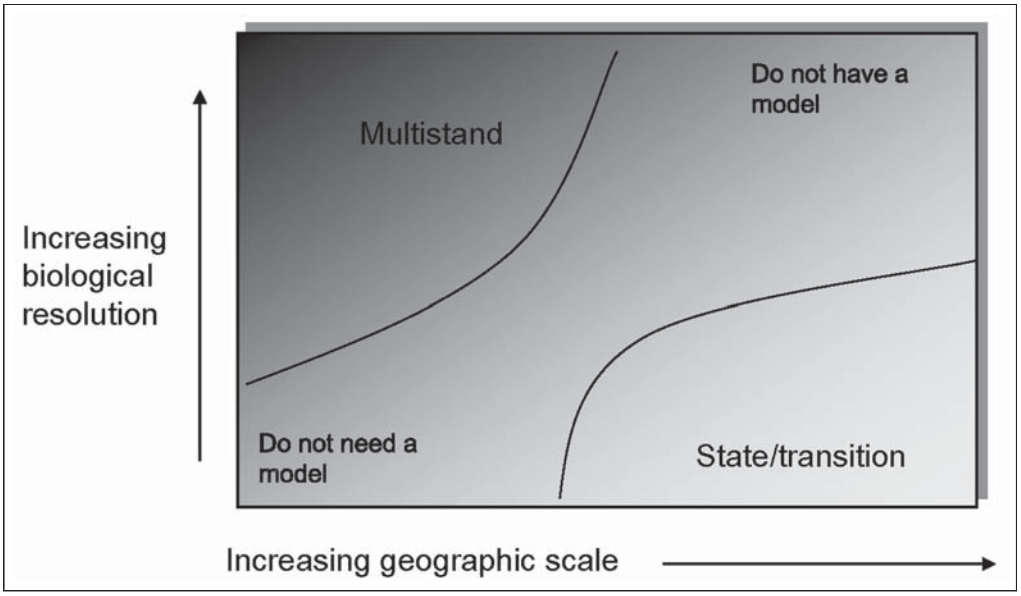

Figure 2—Comparison of a multistand versus state/transition modeling approach for forest landscape simulation in terms of biological and geographic scale.

Descriptions of the status or state of the art of modeling efforts in each of the areas, along with research needs, are provided in the subsequent chapters of this volume. Wales and Suring (Chapter 5) identify methods to describe and evaluate habitat abundance, quality, and distribution across space and time to help managers and policymakers understand how successional processes, natural disturbance, and management actions influence terrestrial habitats. Wondzell and Howell (Chapter 6) review alternative modeling approaches for assessing conditions and prioritizing the restoration of aquatic habitat in the context of biophysical characteristics of streams and watersheds and landscape processes. Chronic disturbance by domestic and wild ungulates is known to significantly affect ecosystem patterns, but as Vavra et al. (Chapter 7) describe, there is a need to develop models that can project the effects of ungulate herbivory at multiple scales. By contrast, episodic disturbances such as insect and disease outbreaks or wildfire have been the subjects of intensive modeling efforts. Ager et al. (Chapter 8) review the quantitative methods for modeling mortality caused by insects and disease and describe the major gaps in this area. Finney (Chapter 9) describes the state of the art and research needs in integrating wildfire into landscape planning models. Lettman and Kline (Chapter 10) examine approaches to evaluate economic impacts of current and alternative management scenarios, and public values and attitudes toward forests. The impacts of human population growth, diversification, movement, and accompanying land use change are important factors in forest management as the wildland/urban interface expands. Clark (Chapter 11) describes approaches for identifying and evaluating the values and places that are important to people. Kline (Chapter 12) describes modeling and analyses of residential and other development scenarios that can contribute to anticipating where land use change is likely to occur. Barbour et al. (Chapter 13) describe techniques for displaying the ecological and economic costs and benefits of timber removal or gathering nontimber forest products.

The specifics of how these individual components might be refined and integrated are part of the major developmental challenges of the INLAS project. Some aspects of integration are covered in the chapters that follow in this volume, whereas others will be developed as the project evolves.

Project Area

Lying within the Upper Grande Ronde watershed, a 4th-hydrologic unit code (HUC4) subbasin, the INLAS project area comprises four HUC5 units occupying about 178 000 ha of mixed forest and rangelands on the eastern flank of the Blue Mountains southwest of La Grande, Oregon (fig. 3). The La Grande Ranger District of the Wallowa-Whitman National Forest administers about 123 000 of these ha (fig. 4). Most of the remaining land is nonindustrial private (about 55 000 ha). Smaller areas are owned by the Confederated Tribes of the Umatilla (about 13 800 ha), Boise Cascade (about 5000 ha), and the state of Oregon (about 810 ha). Numerous residences exist on nonindustrial private lands around the town of Starkey. The topography is highly varied and complex, with deeply dissected drainages feeding into the Grande Ronde River as it runs north through the center of the subbasin (fig. 5). Elevations range from 820 to over 2130 m. Vegetation ranges from xeric, bunchgrass communities at the lower, north end of the project area, to mixed conifer and subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) on the eastern flanks of the Elkhorn Mountains. Fuel loadings are highly heterogeneous across the project area, and a number of large wildfires have occurred over the last 10 years, burning about 8100 ha. Two additional large wildfires burned as much as 24 300 ha on lands immediately adjacent to the Upper Grande Ronde subbasin and project area. An outbreak of spruce budworm (*Choristoneura occidentalis*) occurred throughout the 1980s causing extensive Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and grand fir (*Abies grandis* (Dougl. ex D. Don) Lindl.) mortality throughout the Blue Mountains including the Upper Grande Ronde subbasin. Outbreaks of bark beetles (*Dendroctonus* spp.) have also occurred in and adjacent to the project area.

Forest Service lands are managed with emphases ranging from scenic areas to commodity production. The Starkey Experimental Forest and Range (about 8900 ha) is located in the project area on the southwestern portion of the subbasin and includes research facilities of the Starkey Project (Rowland et al. 1997, Vavra et al. 2002). The Upper Grande Ronde subbasin contains habitat for three federally threatened species, the Canada lynx (*Lynx canadensis*), the gray wolf (*Canis lupus*), and the bald eagle (*Haliaeetus leucocephalus*). About 40 additional terrestrial vertebrates of conservation concern identified by Wisdom et al. (2000) are likely to occur in the Upper Grande Ronde subbasin. This area may provide habitat for several of the 15 insect species currently listed as threatened, endangered, or sensitive in east-side forests (LaBonte et al. 2001). The project area includes potential habitat for three federally listed threatened and one candidate plant species (USF&WS 2002). An additional eight plant species, currently designated as sensitive by the USDA, Forest Service, Pacific Northwest Region, have been documented in the INLAS project area. The Grande Ronde River and its tributaries also contain habitat for federally threatened chinook salmon (*Oncorhynchus tshwaytscha* (Walbaum)), bull trout (*Salvelinus fontinalis*), and steelhead (*Salvelinus confluentus)*. For more detailed information about this area, an extensive bibliography of reports and published literature is provided in the final chapter of this volume (Aitken and Ager Chapter 14).

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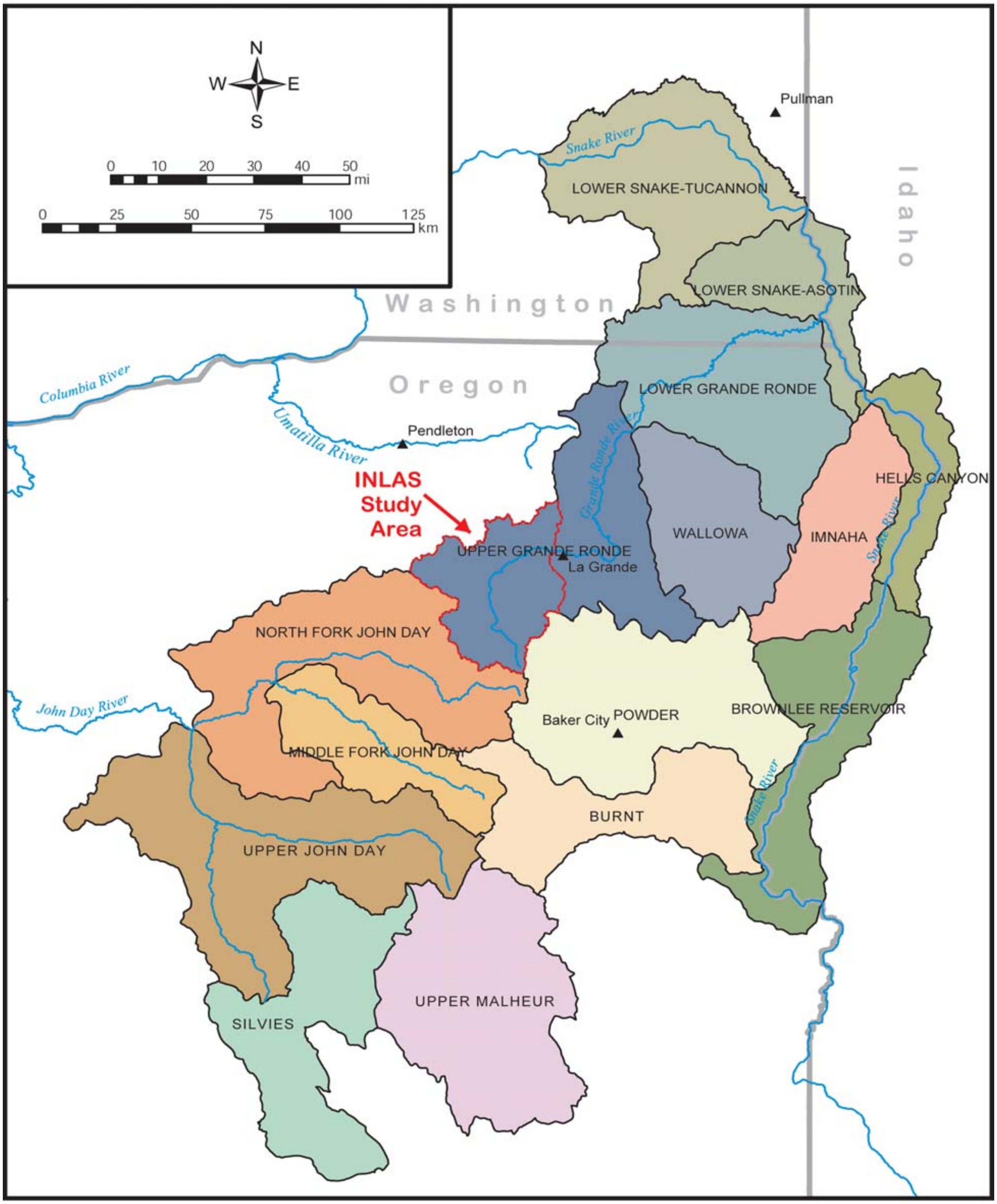

Figure 3—Location of Interior Northwest Landscape Analysis System project area within the Blue Mountains ecoregion (in 4th-hydrologic unit codes).

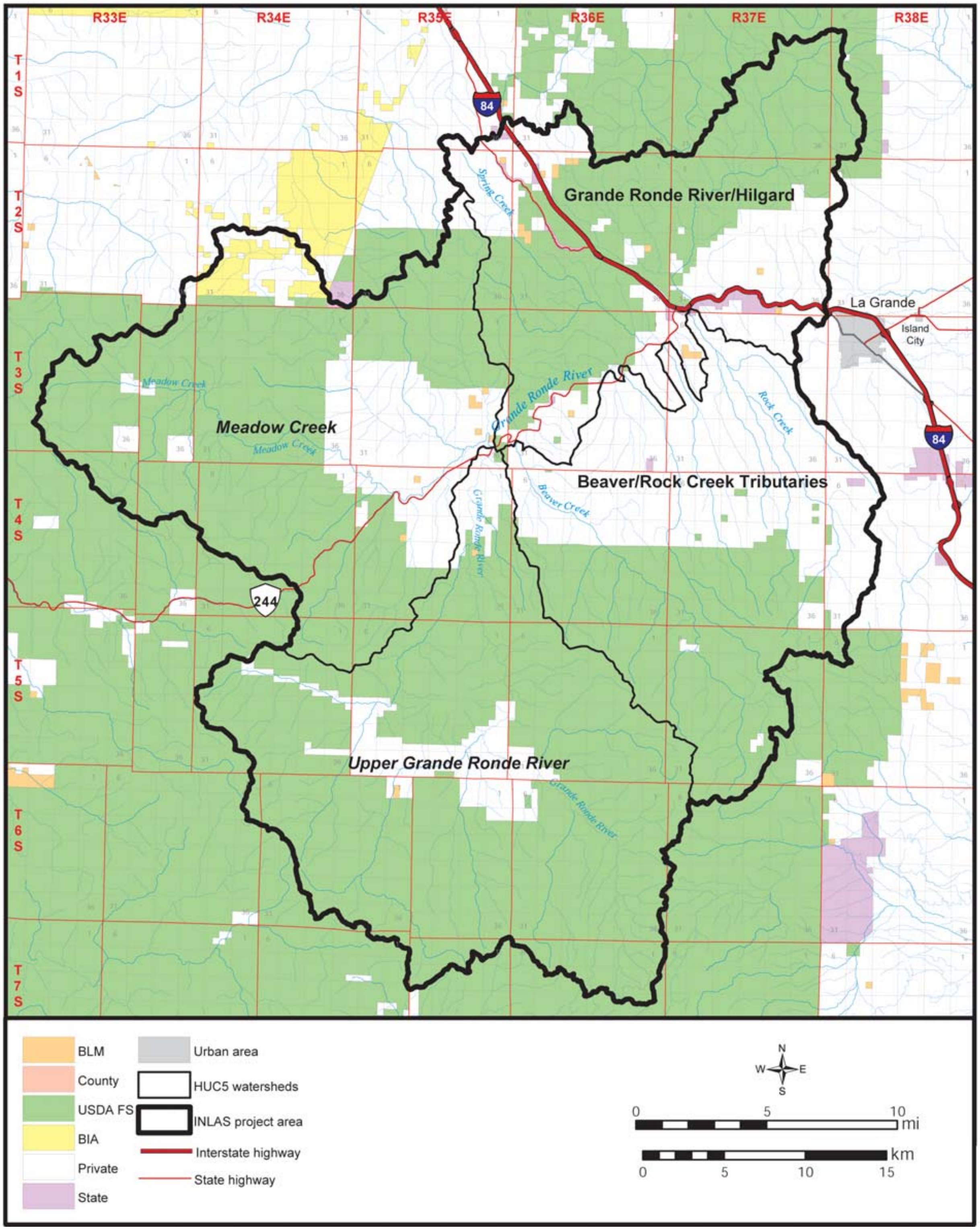

Figure 4—Ownership in Interior Northwest Landscape Analysis System project area.

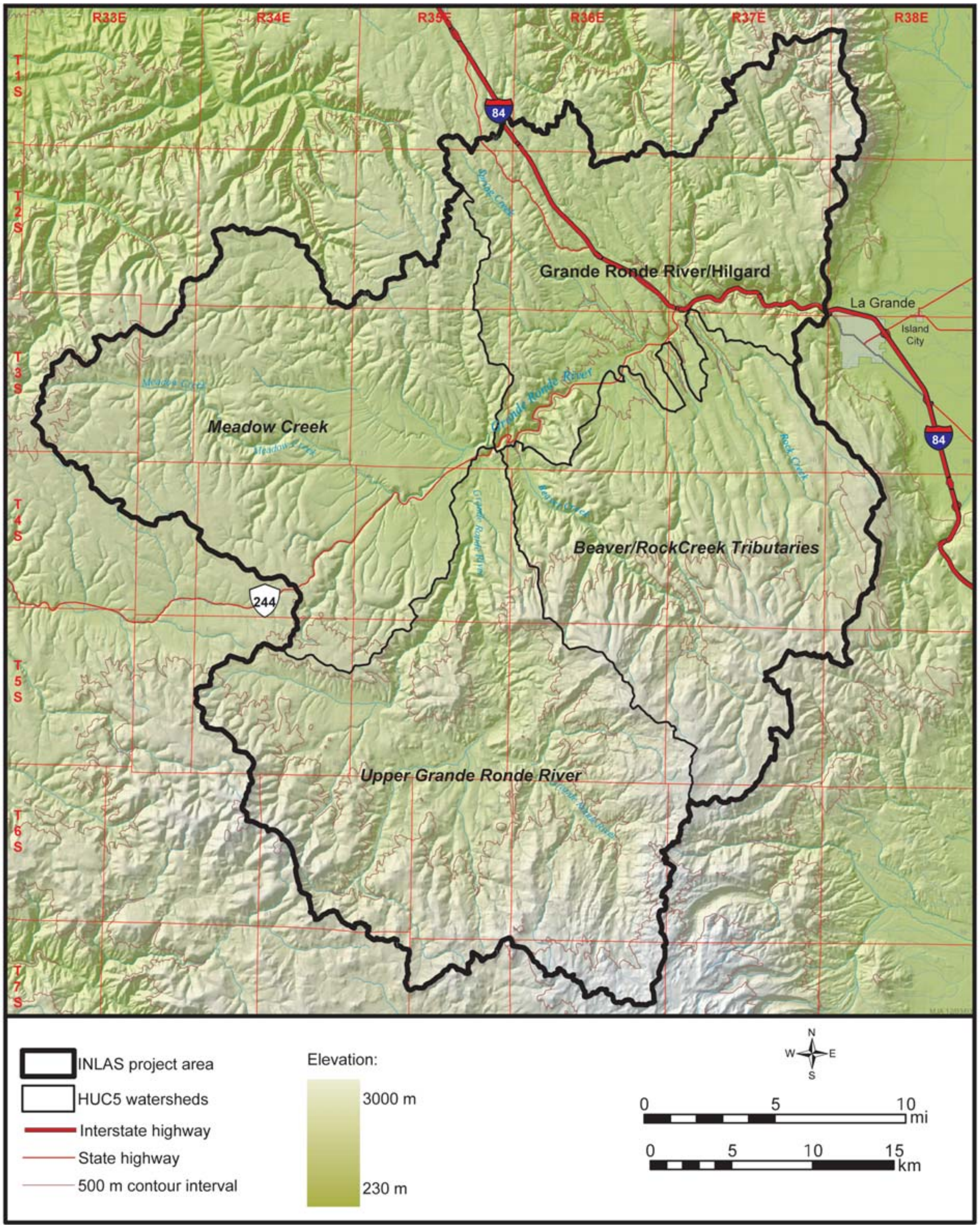

Figure 5—Topography of Interior Northwest Landscape Analysis System project area.

Audience and Products

Although the direct application of analyses from the prototype area is limited in geographic scope, the lessons learned while conducting these analyses will find use in the much broader policy arena. The product mix from the INLAS project will include methodologies, new scientific knowledge, and much information germane to current policy debates over sustainability and conservation of natural resources. Analyses will clarify many socioeconomic and ecological interactions for which we have a poor understanding. This will help scientists identify the most productive areas for future research.

We anticipate that methods we develop for the Upper Grande Ronde prototype area will have applicability to other areas. Some of the methods we develop at the subbasin scale can be “scaled up” to larger areas, e.g., analysis of lynx habitat, or applied on a large number of other subbasins across the Blue Mountains to answer midscale questions. In addition, by developing methods at the midscale, we hope to better understand the larger scale issues and develop ways to use our methods and results at both larger (e.g., forest or regional planning) and smaller scales, (e.g., watershed assessments and project plans). We are working closely with the regional planning staff members to ensure the products produced by INLAS are useful and fit into the planning process. We are also working with the La Grande Ranger District on a relatively small (about 2400 ha) wildland/urban interface fuels-reduction project to prototype some of the analysis tools.

The users of the products developed during this project include those involved in, or interested in the outcome of, watershed assessments, forest planning, and policy analysis. A major drawback of previous landscape modeling efforts is that the data requirements and intricacies of the modeling process rendered existing systems unworkable to most prospective users. Many of our methods and processes are built on existing data, tools, and software to make them more readily adaptable by managers who may already be familiar with the underlying programs. Where new design and development are needed, we plan to work with developers to facilitate the incorporation of our prototype software into preferred systems.

Some of the anticipated outcomes from the INLAS project include:

- Developing methods to perform analyses at the interface of policy, management, and science that rely on a consistent set of assumptions and common data.
- Providing information from landscape analyses to local and state political leaders, government and private resource managers, scientists, and policymakers.
- Demonstrating the breadth of management options to policymakers, resource managers, researchers, and the public.
- Facilitating discussions about realistic balances among goals among managers, policymakers who represent different landowners, and the public.
- Illustrating how actions by nonfederal owners might influence the capability of meeting different policy objectives on federally managed land and vice versa.
- Gaining insights into the influence of scale in determining the importance of management actions within different ownership patterns.
- Identifying specific knowledge gaps in ecological research, management science, and resource planning analysis.

The development and application of different aspects of the work are described in the chapters that follow. Each of these component efforts will produce methods and tools that not only contribute to accomplishing the specific goals of the INLAS project but also can operate outside of the INLAS simulation framework. The integrative products resulting from interactions among sets of two or more components of the framework will help to highlight how different resource values complement or conflict with one another.

English Equivalent

When you know:	Multiply by:	To get:
Hectares (ha)	2.47	Acres (ac)
Meters (m)	3.28	Feet (ft)

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