Chapter 13

APPLYING HISTORICAL FIRE-REGIME CONCEPTS TO FOREST MANAGEMENT IN THE WESTERN UNITED STATES: THREE CASE STUDIES

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13.1 INTRODUCTION

Studies of fire history have long been a core component of our understanding of fire regimes. Fire regimes – frequency, severity, size, and seasonality – provide a conceptual framework for restoring fire as an ecological process, and are the basis for management applications or strategies that utilize the natural or historical range of variation (HRV) concept (Hann et al. 1997; Barrett et al. 2006; Keane et al. 2009). Throughout this book, HRV has been defined as "the variation of ecological characteristics and processes over scales of time and space that are appropriate for a given management application" (Romme et al., Chapter 1, this book). Wong and Iverson (2004) were more specific, defining HRV (referring to it as the "range of natural variability") as "the temporal and spatial distribution of ecological processes and structures prior to European settlement of North America." The issues of how spatial and temporal scales, reference period, and data availability and accuracy affect HRV are discussed in other chapters of this book. Here we present several examples of real-world applications to illustrate the practical value of fire-history studies, as well as the challenges and concerns of doing so.

First, however, consider the gradient of fire regimes, ranging from frequent, low-severity fires (such as in ponderosa pine [*Pinus ponderosa*] ecosystems) to frequent, high-severity fires (in grasslands), to mixed-severity regimes (as in mixed-conifer forests across the American West), to the longer-interval regimes where fires are uncommon but are of high severity when they do occur (e.g. in some lodgepole pine [*Pinus contorta*] ecosystems and in moister western hemlock [*Tsuga heterophylla*] forests). These fire-regime gradients have profound ecological and management implications. One obvious implication arises from comparisons of current and past fire regimes in a given ecosystem. If we assume that past fire regimes were functioning in a resilient, sustainable manner, comparisons with the past can provide a measure of how well current ecosystems are functioning (i.e. are fire frequency and severity congruent with the HRV?). Lack of approximate congruence between past (or, potentially, future) patterns and current patterns could lead to fires with adverse outcomes on water, soil, wildlife, and biodiversity, attributes whose current expressions on the landscape are due in large part to their history.

Some fire regimes of forest ecosystems in the western United States are currently experiencing a departure from the HRV, for a variety of reasons. In some cases, a century or more of timber extraction, grazing, and fire suppression has led to greater tree density and more extensive mid-seral, closed-canopy forest relative to the historical range of conditions (Peterson et al. 2005). Changed forest structure has multiple ecological impacts, including changed disturbance regimes that can feed back into profound and sudden changes in fundamental ecosystem attributes such as species composition, forest structure, soils, nutrient cycling, and wildlife habitat. In other cases, where current rates of anthropogenic fire are much higher than under past conditions, similarly profound ecosystem changes can result. An example occurs in southern California, where high fire frequency has denuded mountain slopes of their shrub cover and led to high rates of soil erosion and the invasion of exotic plants (Stephenson & Calcarone 1999).

In this chapter, we present three case studies illustrating how historical ecology and HRV can be used to guide resource management and restoration in fire-prone forest ecosystems. The first two case studies – from Oregon and Arizona – involve application of fire-regime condition class (FRCC) methodology, providing a simple, easily understandable technique to measure current departure from historical conditions in forest structure and fire regime. The third case study – also from Oregon – describes a collaborative landscape-management process in which management plans and activities are derived directly from studies of HRV. In the three studies, common themes include the fundamental value of historical ecological data to contemporary and future resource management; the importance of using timely, easily understood assessment methods; and the need to implement findings in a collaborative framework.

13.2 CASE STUDY 1: FRCC AND THE NORTHWEST FIRE LEARNING NETWORK (NFLN): USING HRV AND STAKEHOLDER VALUES TO HELP PRIORITIZE AND FACILITATE FOREST RESTORATION

FRCC

FRCC (Hann et al. 2004; Barrett et al. 2006; Barrett et al. in press) is a quantitative system for identifying degree of ecological departure from the HRV in fire frequency, severity, and seral stages in a given area.

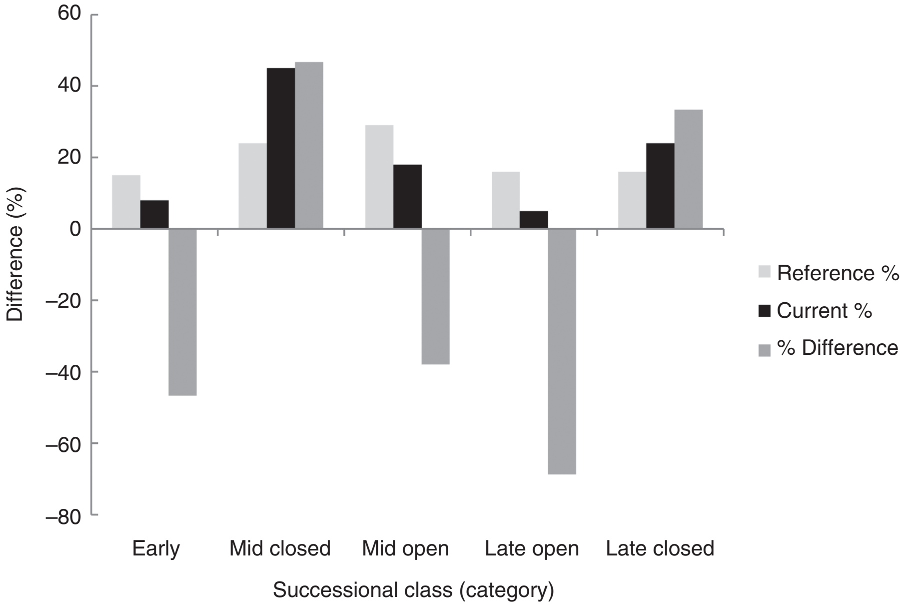

Fig. 13.1 Fire-regime condition class (FRCC) percent departure: successional class (defined by their canopy cover and size) reference and current percent in the upper Deschutes River basin (Oregon, USA) landscape, and the percent difference between the reference and current values. A Sörensen's Index-based similarity measure is used to determine the percent departure of the entire landscape. (See Hann et al. 2004.)

Hundreds of field practitioners have been trained in the method, and modeled FRCC is a key data layer in the national LANDFIRE spatial database (LANDFIRE 2010). The Healthy Forests Restoration Act (HFRA) of 2003 specifically directed Federal land-management agencies to use FRCC as a planning metric, and the method has been used in many national and regional restoration and fuel-management prioritization exercises (Hann & Bunnell 2001; Provencher et al. 2008, Rice et al., unpublished report).

This measure of a landscape's ecological departure from HRV consists of two parts: succession-class departure and fire-regime departure. The succession-class departure is a measure of the difference between the current mix of seral stages on a landscape and the historical mix. For each vegetation type, landscapes are organized into different seral stages defined by their successional status, canopy cover, and dominant species size (a mappable surrogate for age). Estimates of the proportions of the historical landscape occupied by each seral stage are modeled using nonequilibrium, aspatial, state-and-transition modeling, usually with the Vegetation Dynamics Development Tool (VDDT) (ESSA 2007). The average outcome of multicentury Monte Carlo simulations within VDDT is taken as the "reference" state, and this average outcome is compared with the contemporary mix of seral stages on the landscape, derived from field observation or (more commonly) from maps or satellite images. Sorenson's Index (a simple similarity index) is then used to quantify the level (percent) of "departure" from the reference state (see Hann et al. 2004 for specifics; Fig. 13.1). Similarly, the fire-regime departure compares historical and current measures of fire frequency and severity by means of a simple percent departure metric (Hann et al. 2004). In the end, the departure percentages for both succession-class and fire-regime departures are categorized into "Condition Classes," where Condition Class (CC) 1 represents current values that are 0–33% different from the reference values (CC1 is often defined as being "within HRV"), CC2 includes values that are >33–66% different ("moderately departed"), and CC3 represents values >67% different ("highly departed"). The key strength of FRCC is its relative simplicity and ease of communication. It has moved landscape-ecology assessments from a rather small group of expert practitioners in academia and research to a broad audience of users. The use of FRCC in LANDFIRE, in implementing HFRA, and in reporting accomplishments has helped institutionalize the method. Moving HRV concepts to this much broader array of practitioners and interests is no small achievement in technology transfer. Map displays of the three Condition Classes are an obvious and straightforward presentation of restoration need. Another strength is the consistency and availability of FRCC map data, which exist nationwide for all land ownerships.

Like all methods that try to simplify complex ideas into an easily digestible format, FRCC has shortcomings. Determining the historical reference conditions for FRCC applications relies heavily on VDDT. The average final outcome of the VDDT runs is used as the set of reference conditions for FRCC, rather than some measure of the variability in reference conditions. This reliance on the mean values from the state-and-transition models is probably the most criticized feature of FRCC (see Chapter 4, this book). In addition, expert judgment must often fill data gaps in the VDDT input parameters, especially in vegetation types for which there is not a rich history of HRV information. For example, in their tree-ring studies, Swetnam and Brown (2010) found that forest ecosystems with shorter fire-return intervals (which have been heavily studied) correlated fairly well with FRCC results, but those with longer intervals (which have been much less studied) did not. Another problem in the use of FRCC is its sensitivity to scale, but this is a problem common to all applications of historical data (see Chapter 5, this book). Even modest changes in the area analyzed can lead to significant changes in FRCC outcome. FRCC methodology was developed using relatively few structural stage classes (five), relatively uniform assumptions about the time period of the range of variation, and a focus on overstory structural conditions that tends to ignore species composition or the importance of understory fuels to fire behavior (Keane et al. 2009, H. Safford, pers. comm.).

Applying FRCC to restoration planning in oregon, USA

Changes in forest structure in central Oregon have occurred since Euro-American settlement due to fire exclusion, grazing, and timber management (Agee 1993). In forests historically adapted to frequent fire, changes in forest structure have led to changes in fire behavior, resulting in increased fire risk to human communities as well as a decline in or loss of plant and animal species adapted to fire regimes (Hessburg et al. 2005). Current forests may lack key elements of sustainable and resilient systems, posing a risk to their long-term persistence.

To help address these issues, federal agencies have treated thousands of hectares of forests and woodlands over the past 10 years through application of prescribed fire, thinning, and wildland fire to reduce fuel loads and/or modify fire behavior (National Fire Plan, http://199.134.225.81/index.htm), but the level of work has not matched the need (Reinhardt et al. 2008). Underinvestment in the use of fire and forest restoration, lack of or limitations in wood-product processing infrastructure, market conditions, fragmented ownership patterns, and long-standing disagreements over how forests should be managed continue to impede progress in addressing this problem.

The Nature Conservancy analyzed LANDFIRE National data for Oregon to examine the scope of Oregon forest departure from their modeled HRV (Macdonald et al. 2006) to better understand the scale of the problem. The analysis focused only on those forests and woodlands that are adapted to frequent fire (forests and woodlands with low- or mixed-severity fire regimes – Fire Regimes I and III) and today have moderately or highly altered species composition and structure (Condition Classes 2 and 3) as a result of fire exclusion and other factors. Out of the approximately 12.1 million hectares of forest and woodland in Oregon, over 6 million hectares are in Fire Regimes I and III and in Condition Classes 2 or 3; that is, moderately to highly departed from their HRV for forest structure, fire regime, or both. Public land, mostly Forest Service and Bureau of Land Management, accounted for almost 3.8 million hectares of this area.

To treat these 3.8 million hectares over the next 20 years, over 192 000 ha would need to be treated annually, not including treatments needed to maintain those areas that are in CC1 (i.e. considered to be within the historical range). Current treatment levels would need to more than double to close the gap between identified treatment needs and current efforts. With an increase in treatment rate comes a need to locate treatments strategically to maximize their effectiveness, minimize adverse impacts, protect important natural resources, and resume natural processes.

The NFLN and the Upper Deschutes River Basin

The NFLN was established in 2005 by The Nature Conservancy in cooperation with the Forest Service and Bureau of Land Management (see http://www.conservationgateway.org/topic/fire-learning-network). The Network's goal is to facilitate forest restoration by addressing barriers to restoring forests and fire resiliency on federal, state, and private landscapes. In Oregon and Washington, the NFLN has focused its efforts on several large, multi-jurisdictional landscapes. Here we consider the Upper Deschutes River Basin, an 800 000-ha landscape managed principally by the Forest Service, but with areas managed by private, state, and local government landowners as well.

In the Upper Deschutes Basin, the NFLN prioritized areas for restoration using a two-step process, first collecting and summarizing spatially explicit ecological information and then incorporating input from local stakeholders. In the first step, an NFLN technical team set out to develop an assessment of current forest conditions across the Basin with regard to their historical sustainability and to prioritize forests and stands in need of restoration. Using satellite imagery classified according to Forest Inventory and Analysis (FIA) ground plots, the team mapped vegetation structure across the Basin and assigned forest stands to FRCC succession classes. The FRCC Mapping Tool (Johnson & Tirmenstein 2007) characterized current percent departure (and CC) from the published FRCC reference conditions for central Oregon. The NFLN used these data to create a prioritized "Treatable Forest Stands" map, where high abundances of mid-successional stage, closed-canopy stands in ponderosa pine forests were found. The mid-seral closed class is often one of the most departed successional stages in currently fire-suppressed forests that once supported frequent surface fires (Fig. 13.1). Active management in these stands has the potential to shift forest structure to a mid-succession, open-canopy condition better aligned with HRV.

FRCC is a tool to help identify and prioritize stands for restoration, but it does not address legal challenges brought about by conflicting values and stakeholder distrust. To address this, NFLN held two stakeholder workshops in 2009 to develop a list of attributes valued by participants and spatial layers representing these values on the landscape. Participants in each workshop were asked what they valued most in the Upper Deschutes Basin and, in their opinion, what landscape attributes were most vulnerable to severe wildfires and other uncharacteristic changes (i.e. disturbance events outside the HRV that did not occur prior to Euro-American settlement; Hann et al. 2004). The resulting list of values was collaboratively refined, collapsing values that were redundant and translating values to attributes that could be spatially represented. The participants in each workshop agreed on the top values. Examples of these values included riparian areas and wetlands, threatened and endangered species, old-growth ponderosa pine and dry mixed-conifer forest, water quality, wildlife habitat, high-value recreation, and scenic quality/viewsheds. From the two workshops, spatial data were compiled to represent each value. Combined value scores (referring to the number of values that occupy the same pixel) were mapped. These results were then filtered by the Treatable Stands restoration priority map developed in step one. Areas where multiple stakeholder values and restoration needs overlapped were visually identified as high-value areas.

Step One identified 89 000 ha with restoration needs based on FRCC departure for fire regime, succession class departure, or both. Values overlaid on these restoration areas (Step Two) can help prioritize areas where stand-structure restoration might happen first. For example, although only 2 ha on the Upper Deschutes landscape registered all values identified at both workshops, 14 000 ha captured seven or more values. Based on the workshop results, the NFLN anticipates a large constituency of stakeholders will support restoration treatments on these areas with minimized legal challenges, facilitating more rapid and focused restoration activities within this important landscape.

13.3 CASE STUDY 2: COMPARISON OF HISTORICAL VERSUS CURRENT FIRE FREQUENCY AND SEVERITY IN ARIZONA

In 2005, the United States Forest Service entered into a cost-share agreement with The Nature Conservancy in Arizona to produce descriptions of HRV and vegetation-succession models for major vegetation types of the Southwest Region (Arizona and New

Mexico). This assessment summarized empirical studies for 11 major vegetation types, identifying departure from HRV and thus departure from the range of structure, composition, and disturbances. This information shapes regional priorities for ecological restoration and fuel-treatment activities and helps shape ecological goals for forest-plan revisions across the Region's 11 National Forests. HRV descriptions and successional models can be found at TNC (2011).

These descriptions include landscape vegetation and species composition, age- and size-class structure, and other attributes of patch or stand structure. The latter includes patch size and spatial distribution, vegetation density, and canopy closure and/or cover. HRV descriptions also include descriptions of the natural processes shaping potential vegetation through time, including succession or patch dynamics, climatic fluctuations, fire regimes, hydrological processes, nutrient cycling, predator–prey interactions, herbivory, insects and pathogens, windthrow, avalanche, and erosion.

The variability and rate of change of these characteristics are as important to understanding HRV as is the magnitude of their change. Thus, defining the time period for which the HRV is described is important, as is defining the influence of humans on changes in ecosystem characteristics. Longer time periods often reveal a greater range of variation. Several authors have noted that contemporary patterns of vegetation and their dynamic processes developed in the Southwest during the early Holocene, around 11 000–8000 years ago (Allen 2002). Due to limitations in the availability of recorded data from tree rings, pollen, and charcoal, we limited our description of the HRV (unless otherwise noted) to the period from 1000 AD to 1880, when significant European settlement in the region began. We refer to that portion of the HRV resulting from conditions after 1880 as the postsettlement or current period. To explore differences between presettlement (historical conditions) and postsettlement (current conditions), we used published values for ecosystem disturbances to build quantitative succession models for both.

Composition, structure, and function of ecosystems

Anthropogenic disturbance has led to major changes in ponderosa pine forest structure and function. With the introduction of grazing animals at various times during the nineteenth century, and active fire suppression throughout the twentieth century and into the twenty-first century, low-severity and frequent surface fires have been replaced with high-severity and infrequent crown fires (see Chapter 1, this book). Although the effects of these large, stand-replacing fires are variable, several fires have led to long-term changes from forested systems to grasslands, shrublands, and areas of dense pine regeneration (Savage & Mast 2005). Areas that have not yet burned have a higher density of young trees, changing the quality of habitat for wildlife and humans, and increasing the probability of stand-replacing fire (Covington & Moore 1994; Allen 2002).

Modeling outputs and trade-offs

As in the previous case study, the VDDT was used to develop both historical (pre-1880) and current (1880 to present) period models of vegetation change for several potential natural vegetation types of the Southwest. The VDDT software allows the user to model succession as a series of vegetation states differing in structure, composition, and cover, and to specify the amount of time it takes to move from one vegetation state to another in the absence of disturbance. Various disturbance agents (e.g. surface fires, stand-replacing fires, grazing, and insect outbreaks) affecting the transition of vegetation between states can then be incorporated as probabilistic functions. By varying the types and rates of disturbance across the landscape, the effects of different management treatments on future vegetation can be investigated. For the ponderosa pine model, we included the effects of fire, insects, and precipitation; we display the modeling outputs as proportions of ecological states or successional stages (Fig. 13.2).

In historical times, ponderosa pine occurred primarily as late-seral open forests dominated by large trees, with relatively small patches of younger trees (Covington & Moore 1994). The VDDT modeling process uses this type of information to generate reference conditions (ESSA Technologies Ltd. 2007). Fire suppression and the resulting uncharacteristic stand-replacing fires generated a novel state on the landscape, the so-called "anomalous grassland" (Savage & Mast 2005; Kuenzi et al. 2008). This novel state has experienced complete or nearly complete overstory tree removal and, in many cases, soil sterilization that favors exotic

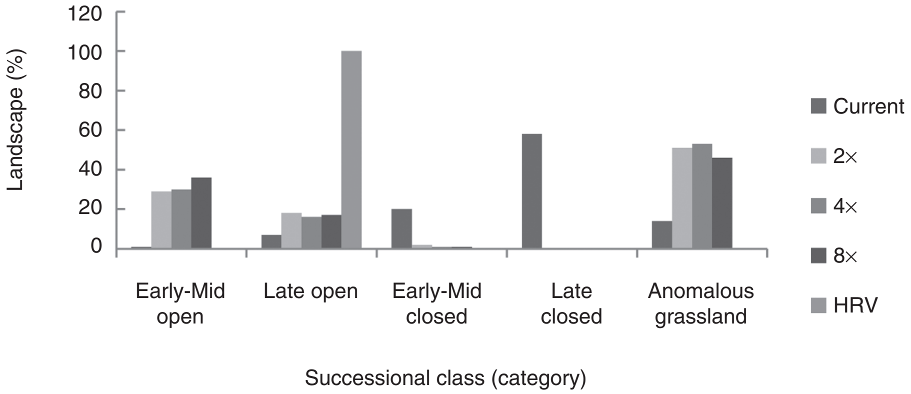

Fig. 13.2 Changes in ponderosa pine (*Pinus ponderosa*) forest condition under 100-year scenarios of varying stand-replacing fire (SRF) frequency. The current condition is compared with scenarios of increasing fire frequency (two, four, and eight times the current frequency; 2×, 4×, and 8×, respectively) and with the historical range of variation (HRV). With a warming climate, increases in fire frequency are anticipated. Data displays such as this allow planners to prepare for future scenarios, such as increases in a novel (anomalous) grassland state (last successional class displayed on *x*-axis). See text for further details.

species of grasses and forbs. At many sites, this novel state has been shown to persist for decades, suggesting an alternative stable state outside the HRV. Recently, succession models have explored scenarios of management over small to large areas (Provencher et al. 2008). We used our current-conditions model and changed the frequency of stand-replacing fires to give a simplistic indication of possible ecological trajectories for Southwest ponderosa pine under a warming climate. As a surrogate for increasing temperatures and drought, we can model increased frequency of stand-replacing fire across the landscape and compare modeling results to current and historical conditions (Fig. 13.2). Under current conditions, stand-replacing fire occurs about once every 100 years. When stand-replacing fire occurs as frequently as once every 50 years, about 50% of the landscape moves to the novel, anomalous grassland state. Other predicted changes include an expansion in early- and mid-open classes and losses in area within the closed-canopy condition (Fig. 13.2).

This methodology is a useful tool to describe potential landscape changes. By gaining some understanding of what these changes may be, management can be adjusted to help maintain landscape resiliency in the face of the more frequent fires expected in a warming climate.

13.4 CASE STUDY 3: INCORPORATING HISTORICAL ECOLOGY AND CLIMATE CHANGE INTO LAND MANAGEMENT: BLUE RIVER LANDSCAPE PLAN, WILLAMETTE NATIONAL FOREST, OREGON

The Blue River Landscape Plan and Administrative Study area, in the Willamette National Forest of western Oregon's Cascade Range, applies historical ecology information to the planning and conduct of active management on National Forest lands (Cissel et al. 1999). Management is planned in the context of general objectives of the Northwest Forest Plan (NWFP) (USDA and USDI 1994) to protect terrestrial and aquatic species, and in response to the Plan's specific charge to the Central Cascades Adaptive Management Area (AMA). This AMA, incorporating the Blue River Plan area, explores "approaches for integrating forest and stream management objectives and implications of natural disturbance regimes." The terrain is steep, ranging from 350 m to 1600 m elevation; the climate is wet (mean annual precipitation is ca. 2500 mm in lower elevation areas) and ranges from rain-dominated at low elevations to snow-dominated at upper elevations. The highly productive, dominantly conifer forest cover is in the western hemlock zone at low and middle elevations and the Pacific silver fir (*Abies amabilis*) zone at upper elevations (Franklin & Dyrness 1988). Timber harvest began in the 1950s and continues today, albeit at a much slower pace than during the 1950s through the 1980s. Most unharvested stands in the area date from wildfires in the 1500s and 1800s.

Fire history in the study area was interpreted from tree-establishment and fire-scar dates, using analysis of tree rings up to approximately 800 years old (Weisberg 1998). Archival and paleoecological records were also used. Site fire frequency ranged from 50 years to more than 500 years, and severity ranged from light ground fire to stand-replacement disturbance. About 25% of the native-forest area was clear-cut, and plantations were established in 1950–1990 in patches averaging ca. 15 ha in size. Additional areas of mature forest (80 to 200 years old) experienced light thinning during this period.

The management plan was guided by historical wildfire-regime information and considerations for watershed processes and species of special interest (Cissel et al. 1999). Historical fire regimes were used to develop three prescriptions for forest-stand management using cutting frequencies of 100, 180, and 260 years, with respective levels of live tree-canopy retention at 50, 30, and 15%. The geographic distribution of historical wildfire regimes was used to designate the spatial patterns of cuts, which were also designed in part to minimize further fragmentation of older forest created by earlier clear-cutting (Franklin & Forman 1987). Prescribed fire was selected to create snags and to maintain fire as a keystone process in the forest landscape. Some reserve areas for selected species and riparian reserves were designated, although much less extensively than in standard NWFP land allocations.

In keeping with the adaptive management purpose of this planning area, prescriptions were developed and implemented to examine effects of management practices. Monitoring, modeling, and other assessments of the practices and their effects on the environment have been conducted (Swanson et al. 2003; Gray & Miller 2006). The first two timber sales were executed as planned and environmental effects matched those expected. However, the overall rate of forest harvest has been much less than anticipated for both the NWFP and the Blue River areas because of public pressure against cutting of unharvested forests (Moeur et al. 2005; Rapp 2008).

The Blue River landscape-planning process considered climate variability. Historical variation in fire occurrence at the centennial scale (Weisberg & Swanson 2003) raises questions about ecological effects of a forest-harvest program in an area with century-long periods of extensive fire separated by two centuries of little fire. Because the nature of the future climate and its ecological impacts are uncertain, interdisciplinary deliberations on management implications of future climate change have not yet led to specific changes in the landscape plan. These deliberations instead led to several questions and considerations:

1. Do areas of persistent cold-air drainage provide thermal refuges from climate warming?
Recent research (Daly et al. 2009; Tepley 2010) documents substantial topographic effects on microclimate and fire regimes, suggesting that management to address climate change should be nuanced with respect to topography and air drainage.

2. Will the Cascades forest system exhibit abrupt and dramatic threshold responses to climate change? Some high-latitude ecosystems appear to be profoundly affected by climate change, both directly and indirectly (by fire, insects, etc.), but the Oregon Cascade forests do not, yet. Will they? Perhaps the limited influence of freezing temperatures in this maritime climate will limit some potential forms of threshold behavior in hydrologic systems and invertebrate communities observed in areas of colder climate (Williams & Liebhold 2002). It will be important to distinguish the effects of climate change from system change in response to other factors, including legacies of past land use and natural disturbance (see Chapter 5, this book).

3. What does the experience of developing and implementing early stages of the Blue River Landscape Plan say about alternative approaches to landscape management? First, it has been possible to design and implement some features of an HRV-based landscape-management approach that includes timber harvest. Second, there is value in blending approaches; in fact, the Blue River Landscape Plan is a blend of reserves derived from species-conservation approaches with a dynamic landscape-HRV approach. Third, climate change will likely bring new management imperatives, which will likely drive a new landscape-management approach aimed at fostering resilience of ecosystems in a changing environment. Finally, there will invariably be public opposition to new ideas in landscape management, so education and public involvement will be critical to success (Shindler & Mallon 2009).

4. Are current Federal land-management practices of fire suppression and harvest, limited mainly to thinning in plantations, creating landscapes vulnerable to climate-change impacts? The answer may depend on the historical fire regime. Fire suppression in forests historically characterized by frequent fire may lead to development of dense, stressed stands vulnerable to the added stress of climate change. On the other hand, thinning plantations in forests with historically low fire frequency, using approaches that maintain and enhance natural heterogeneity of stand and landscape composition and structure, may reduce stress imposed by climate change.

What does the future hold for continued implementation of the Blue River Landscape Plan and Study and for related learning opportunities? As for research, the H.J. Andrews Experimental Forest Long-Term Ecological Research program, located within the Blue River Plan area, can be expected to persist and provide insights to critical questions about landscape dynamics in a changing climate (Franklin et al. 1990). On the land-management and policy fronts, the Blue River Study has been hampered by near elimination of support for the AMA program at the NWFP scale and near cessation of logging of previously unharvested forest, which was expected to be a major source of wood products under at least the first few decades of the NWFP and Blue River Landscape Plan.

Nevertheless, collaboration of the Willamette National Forest and its long-standing partners in the science community carries the Blue River landscape work forward. These circumstances illustrate the need for long-term, institutional support for research and planning for managing landscapes that historical ecology tells us are inherently dynamic.

13.5 CONCLUSIONS

Although HRV does not provide an absolute target or goal for ecosystem restoration in itself, a knowledge of local to regional variability helps to understand current and potential future conditions in relation to the past. Use of HRV can provide a foundation for building quantitative models representing how ecosystems function. Input parameters of successional models can be changed to build a variety of plausible scenarios, allowing land managers and stakeholders to compare results of different treatment strategies and changes in disturbance frequency. Use of these tools can help us think strategically about goal setting and can inform a collaborative dialogue about the scale and scope of actions necessary to achieve those goals.

In this chapter we explored three practical applications of this process. The first two case studies (in Oregon and Arizona) compared current versus historical vegetation conditions using state-and-transition modeling and FRCC methodology, based on simple comparisons of forest structure between modeled reference conditions and current vegetation maps. Although FRCC methodology has some important limitations, it has found widespread use in many western landscapes in identifying restoration needs, due principally to its simplicity and its widespread availability.

Although significant effort and funding has been directed toward restoring Federally administered forest lands in the western United States with thinning and prescribed burning, it has become obvious that the areas treated are insufficient to improve conditions across many watersheds and regions. National, regional, and local FRCC assessments underline the extent of the fire-suppression problem and make clear the need for greater use of unplanned ignitions ("wildland fire use") in meeting restoration goals (Miller & Landres 2004; Doane et al. 2006). FRCC brings an understanding of landscape ecology to multiple levels of land-management agencies and to practitioners who would not otherwise be exposed to this perspective. The value of this in shaping future goals for managing fire regimes and biodiversity should not be underestimated.

The third case study (Blue River) employed more traditional fire-history methods to illustrate the application of the historical fire regimes in selecting the pattern of timber harvest rotations, and also to assess implications of climate change. This case study showed the value of blending assessment approaches and how stakeholder values and activism can complicate assessment and planning.

These case studies provide several important messages about applying HRV concepts to management. First, in a management context, relatively simple, extensive methods, such as FRCC assessment, are needed to communicate HRV concepts to a broad audience. They are also needed to make timely assessments in a continually changing planning horizon. This simplicity and timeliness comes at a cost of accuracy and a heavy reliance on state-and-transition modeling. The latter involves multiple assumptions, which may be difficult to verify.

Second, although the relevance of HRV has been questioned as changes in the climate move us into new domains of variation, Keane et al. (2009) point out that HRV parameters are good placeholders for initial conversations on goal-setting in the near term. When comparing several plausible climate-projection models, the outputs show more variability and uncertainty than exists from HRV estimates of the past (Stainforth et al. 2005; Keane et al. 2009). We know that past-forested landscapes exhibited a level of resilience that maintained forest structure and composition for hundreds of years, so using HRV conditions as a starting point for goal-setting – along with modifications for anticipated climate changes – should foster resilience as the changes are manifested.

Third, in predicting climate-change effects on forests, an assessment of the HRV is essential to understanding how these systems rebounded from disturbance and how they will continue to respond to future changes. The Blue River case study shows how HRV concepts can be used to answer questions about the effect of a warming climate on management options. Until credible and useful estimates of a future range of variation are available, HRV provides a powerful tool to help determine, illustrate, and communicate management options.

Finally, all three case studies indicate that information alone is never sufficient for land-use planning. Public involvement and values, as well as uncertain institutional support, can work at cross purposes to the actions suggested by an HRV assessment, regardless of its accuracy or the soundness of the science behind it. Fostering collaboration and good communication are therefore critical elements in successful implementation of an HRV approach.

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