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A new approach to evaluate forest structure restoration needs across Oregon and Washington, USA

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A B S T R A C T

Widespread habitat degradation and uncharacteristic fire, insect, and disease outbreaks in forests across the western United States have led to highly publicized calls to increase the pace and scale of forest restoration. Despite these calls, we frequently lack a comprehensive understanding of forest restoration needs. In this study we demonstrate a new approach for evaluating where, how much, and what types of restoration are needed to move present day landscape scale forest structure towards a Natural Range of Variability (NRV) across eastern Washington, eastern Oregon, and southwestern Oregon. Our approach builds on the conceptual framework of the LANDFIRE and Fire Regime Condition Class programs. Washington–Oregon specific datasets are used to assess the need for changes to current forest structure resulting from disturbance and/or succession at watershed and regional scales.

Across our analysis region we found that changes in current structure would be needed on an estimated 4.7 million+ ha (40% of all coniferous forests) in order to restore forest structure approximating NRV at the landscape scale. Both the overall level and the type of restoration need varied greatly between forested biophysical settings. Regional restoration needs were dominated by the estimated 3.8+ million ha in need of thinning and/or low severity fire in forests that were historically maintained by frequent low or mixed severity fire (historical Fire Regime Group I and III biophysical settings). However, disturbance alone cannot restore NRV forest structure. We found that time to transition into later development structural classes through successional processes was required on approximately 3.2 million ha (over 25% of all coniferous forests). On an estimated 2.3 million ha we identified that disturbance followed by succession was required to restore NRV forest structure.

The results of this study are intended to facilitate the ability of local land managers to incorporate regional scale, multi-ownership context into local forest management and restoration. Meeting the region-wide restoration needs identified in this study will require a substantial increase in the pace and scale of restoration treatments and coordination amongst governments, agencies, and landowners.

1. Introduction

Ecological restoration has become a dominant paradigm for the management of many public forests across the United States (USDA Forest Service, 2012a,b). Ecological restoration is "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (SER, 2004). Within western states, this present focus on restoration is largely in response to the widespread degradation of terrestrial and aquatic habitats and uncharacteristic fire, insect, and disease outbreaks resulting from a century or more of wildfire suppression, intensive harvesting, grazing, and mining (Brown et al., 2004; Franklin et al., 2008; Hessburg and Agee, 2003; Hessburg et al., 2005; North et al., 2009; Peterson et al., 2005; Schoennagel et al., 2004). Since 2010 $20 to

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$40 million has been appropriated annually for the ecological restoration of federal forests through the Collaborative Landscape Restoration Program (CFLRP; H.R. 5263, fs.fed.us/restoration/CFLRP). In addition to CFLRP, the USDA Forest Service has undertaken a number of initiatives in recent years to increase the pace and scale of forest restoration including but not limited to implementing a new forest planning rule (USDA Forest Service, 2012a), the Watershed Condition Framework (USDA Forest Service, 2011a), and a bark beetle strategy (USDA Forest Service, 2011b). Similarly, state governments in Oregon, Washington and elsewhere are promoting both the ecological and economic benefits of forest restoration. For example, the Oregon Federal Forest Health Package (SB 5521 passed by the Oregon Legislature in 2013) is providing nearly $2.9 million for technical assistance and scientific support needed to increase the pace and scale of collaboratively developed management efforts and to pilot a new business model that contributes funding directly to help increase the pace and scale of implementing restoration work on national forests.

Despite highly publicized calls to increase the pace and scale of forest restoration (Rasmussen et al., 2012; USDA Forest Service, 2012b) we lack a comprehensive understanding of forest restoration needs. In many, but not all, of the interior Pacific Northwest forest ecosystems previous studies have documented patterns of departure from historical conditions (e.g., Everett et al., 2000; Hagmann et al., 2013; Haugo et al., 2010; Hessburg et al., 2005, 2000b; Heyerdahl et al., 2014; Perry et al., 2011; Wright and Agee, 2004). However these studies are not able to provide a systematic evaluation of where, how much, and what types of treatments are needed to restore forest structure at regional scales (100,000s–1,000,000s of ha). Until recently most restoration planning and implementation has occurred at scales of watersheds or smaller (⩽5000 ha). Although there has been a gradual increase in the size of proposed projects, small project areas are still often used. Because the overarching objectives of forest restoration are frequently to influence ecological processes such as disturbance regimes and habitat connectivity operating at very large spatial scales (10,000's–100,000's of ha), a broader spatial perspective is required to evaluate the overall magnitude of ecological and planning needs. Without an understanding of regional scale restoration needs it is difficult to accurately quantify the magnitude of restoration funding needs for state and national entities or to set the context for prioritization of limited land management resources. It is also difficult to determine the cumulative, regional scale impact of current restoration efforts and evaluate whether these efforts are "making a difference". Consequently, evaluation of restoration needs requires a perspective larger than individual watersheds or even individual national forests, and that considers forested lands across all ownerships within a region.

In this study we demonstrate a new approach for evaluating where, how much, and what types of treatments are currently needed to restore a Natural Range of Variability (NRV) in forest structure across eastern Washington, eastern Oregon, and southwestern Oregon. NRV is defined as a frequency distribution of ecosystem characteristics, including the appropriate spatial and temporal scales for those distributions and a reference period, typically prior to European settlement. These ecosystem characteristics may encompass a wide suite of terrestrial and aquatic considerations (Keane et al., 2009; Landres et al., 1999; Morgan et al., 1994; USDA Forest Service, 2012a); here we focus on forest structure.

We acknowledge the limitations of focusing on forest structure as an indicator of ecosystem health, and the NRV as the reference condition. Many biotic and abiotic components must be considered for comprehensive restoration of forest ecosystems, including forest structure. Nevertheless, forest structure presents a tractable coarse filter to which many other aspects of biodiversity (e.g., terrestrial wildlife habitat, riparian and aquatic habitat, herbaceous diversity and productivity, and fire, insect, and disease frequency and severity) respond (Agee, 1993; Hessburg et al., 1999; Johnson and O'Neil, 2001; Peterson et al., 2005). Ideally, we would also evaluate future range of variability (FRV) reference conditions that describe the expected response of forest ecosystems to climate change (Gartner et al., 2008; Keane et al., 2009). FRV is an emerging concept, but FRV reference models are not yet consistently available at a regional scale. While the specific impacts of climate change are uncertain, restoring to a NRV is assumed to increase forests' resilience and adaptive capacity (Agee, 2003; Hessburg et al., 1999; Keane et al., 2009; Millar et al., 2007; Stephens et al., 2013; Stine et al., in press). Finally, NRV does not necessarily represent desired conditions for federal forests, which reflect social and economic concerns as well as ecological ones. Nevertheless, NRV represents a strong foundation for developing desired conditions because it represents the ecological capability of the landscape (USDA Forest Service, 2012a).

2. Methods

2.1. Study area

We assessed forest vegetation restoration needs for the approximately 11,619,000 ha of forest across eastern Washington and eastern and southwestern Oregon, USA (Fig. 1). This geography generally includes the extent of historically frequent fire forests within the USDA Forest Service's Pacific Northwest Region. These forests cover very broad climatic, edaphic, and topographic gradients with widely varying natural disturbance regimes. They range from *Tsuga mertensiana forests* and parklands along the crest of the Cascade Range with a mean annual precipitation of 1600–2800 mm per year and historical fire return intervals of several centuries to dry *Pinus ponderosa* forests in southeast Oregon with mean annual precipitation of 355–760 mm per year and historical fire return intervals of less than 10 years (Agee, 1993; Franklin and Dyrness, 1973). Our challenge was to develop an approach that can be applied across this vast extent encompassing large environmental gradients with data that are consistent and meaningful.

2.2. Core concepts and data sources

We built upon the conceptual framework of the LANDFIRE and Fire Regime Condition Class (FRCC) programs (Barrett et al., 2010; Rollins, 2009) and incorporated Washington–Oregon specific datasets. Our assessment of forest vegetation restoration need is based on four primary data inputs: (1) a classification and map of forested biophysical settings, (2) NRV reference conditions for each biophysical setting, (3) a delineation of "landscape units" for each biophysical setting, and (4) a map of present day forest vegetation structure.

2.2.1. Mapping forested biophysical settings

Biophysical settings are potential vegetation units associated with characteristic land capabilities and disturbance regimes (Barrett et al., 2010). Many different forested biophysical settings are found across Washington and Oregon based on vegetation, soils, climate, topography, and historic disturbance regimes (Keane et al., 2007; Pratt et al., 2006; Rollins, 2009). They provide the framework for describing fire regimes. We mapped biophysical settings across Washington and Oregon using the 30 m pixel Integrated Landscape Assessment Projects' Potential Vegetation Type (PVT) dataset (Halofsky et al., in press), which compiled previous potential forest vegetation classification and mapping efforts including Simpson (2007) and Henderson et al. (2011). We also incorporated subsequent refinements to PVT mapping in