Forest Ecology and Management 291 (2013) 96–109

Contents lists available at SciVerse ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Stand development, fire and growth of old-growth and young forests in southwestern Oregon, USA

Thomas Sensenig [a], John D. Bailey [b,*], John C. Tappeiner [b]

[a] USDA Forest Service Region 6, Medford, OR 97504, United States

[b] Department of Forest Engineering, Resources and Management, Oregon State University, Corvallis, OR 97331, United States

ARTICLE INFO

Article history:
Received 28 August 2012
Received in revised form 28 October 2012
Accepted 2 November 2012
Available online 5 January 2013

Keywords:
Old-growth development
Douglas-fir
Age structure
Fire frequency
Fire and tree establishment

ABSTRACT

We studied stand development in three distinct forest types in southwestern Oregon using six stands each in uncut and clear-felled old-growth stands and nearby young stands (18 total). Old-growth stands showed a wide range of tree ages (>300 years) and low tree densities for several centuries; rapid early growth produced trees with large crowns and diameters, as well as low height-to-diameter ratios. In contrast, young stands established much quicker and at higher tree densities; beyond their initial 20 years, trees had smaller diameters at equivalent ages, slower growth rates, smaller crowns and higher H:D than trees in old-growth stands. Low-intensity disturbance, likely dominated by fire, was common in old-growth stands during their early development. Fire scars showed these stands burned frequently from 1700 to 1900, and low levels of tree recruitment occurred in a complex relationship with fire during this 200 years. There was no evidence of fire, however, in either old-growth or young stands after 1909, and their densities were well above that of 1900; in old-growth stands, 15–25% of the basal growth occurred from 1950 to 1990, and it appears that they are on a development pathway different from what they experienced from 1700 to 1900. Furthermore, tree recruitment has been limited in both old-growth and young stands since 1950 while biomass and fuels continue to accumulate rapidly. Past stand dynamics can be emulated by prescribed fire and light thinning to reduce risk of loss from severe fire or insects, as well as to partially restore stand conditions that existed prior to fire exclusion. Our results suggest that young stands can be grown to produce high levels of biomass/wood, or their development can be altered to more closely follow that of old-growth stands depending on management objectives.

1. Introduction

Sustainable forest management in drier forest types like those in southwestern Oregon requires an understanding of long-term forest development and disturbance regimes, primarily fire, which differs from that of more northern forests on more mesic sites. These drier forests have lost many older, dominant trees that are >1 m diameter at breast height (DBH; 1.37 m) to stand-replacing fire. Also, the mortality of large trees in unburned stands has been high, likely due to increasingly high stand densities (Latham and Tappeiner, 2002) and drought stress from 1987 to 1992 and 2000 (Sensenig et al., 1994). In addition to drought stress and high stand density, pathogens and insects contributed to mortality. Recent old-tree mortality rates exceed replacement by younger trees and, if this trend continues, presage a pronounced reduction in old-growth dry forest ecosystems (Lehmkuhl et al., 1991).

Beginning around 1900, land management and fire suppression policy led to major changes on forest lands throughout western North America. Suppression policy was initiated following severe fires, often reburns, which covered millions of hectares of forests, destroyed towns and burned entire watersheds. The relative absence of regular surface fire has facilitated establishment of an overabundance of small fire-sensitive trees (Agee, 1993, Taylor and Skinner, 2003). Generally overstocked conditions in forest stands, accumulations of surface and aerial fuels, and increased susceptibility to fire create a dilemma for forest managers. These dense old stands, while susceptible to drought-related mortality and to fire, are also the habitat for late-successional species (FEMAT, 1993). Maintaining this habitat in old-growth stands, and growing it in younger stands, are major objectives of federal forest management in western Oregon (FEMAT, 1993).

The Northwest Forest Plan specifically calls for managing over 7.5 million acres of federal forests for late successional/old-growth habitat and another 2 million acres of riparian reserves; however, currently about 80% of these forests are composed of dense stands of relatively small trees (20–24 cm dbh) that are <40–120 years of

* Corresponding author. Tel.: +1 541 737 1497.
E-mail addresses: tsensenig@fs.fed.us (T. Sensenig), john.bailey@oregonstate.edu (J.D. Bailey), john.tappeiner@oregonstate.edu (J.C. Tappeiner).

0378-1127/$ - see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.foreco.2012.11.006

age (FEMAT, 1993). These are classic even-aged stands that regenerated following timber harvest, wildfire, mining or other disturbance; they lack diversity in overstory tree size, age, and species as well as understory species and abundance (Spies and Franklin, 1991). Forest managers are concerned that such stands are particularly susceptible to drought-related mortality and stand-replacing wildfire. Thus, current policy calls for stand management to reduce mortality and fire hazard, and promote habitat characteristics associated with old-growth stands. Understanding tree growth, establishment of regeneration, and fire occurrence in both young and old stand types will help managers meet objectives for both stand types.

Studies on moist sites in northwestern Oregon have shown that large trees in old-growth stands grew much more rapidly at young ages than trees in young stands on similar sites (Tappeiner et al., 1997). Rapid early growth was an important characteristic of large old-growth trees (Poage and Tappeiner, 2002). Also, tree ages in old-growth stands were much more variable than those in young stands, suggesting a much different development in the two stand types. In a study throughout much of northwestern Oregon, Bailey and Tappeiner (1998) found that trees in old-growth stands had larger crowns, and stems were much larger in diameter relative to their height than trees in young trees (low height to diameter ratios-H:D). The crowns and stems of old trees are important components of stand structure and habitat in old-growth stands and the low H:D is indicative of resistance to damage from wind, ice, and snow (Wilson and Oliver, 2000). Knowledge of tree architecture (live crown length and H:D ratios) in old and young stands would provide goals for managing trees in young stand to achieve the characteristics of those in old stands. The objectives of this study were to provide forest ecologists and managers an understanding of old-growth and young forest development in three major forest types in southwestern Oregon, ranging from the mixed-conifer forests in the eastern Cascade through the Siskiyou mountains and into the mixed-evergreen forests of the coast ranges (Table 1). The old-growth stands we studied corresponded to Spies and Franklin's (1991) definition of old-growth forests for southwestern Oregon. We evaluated fire occurrence along with tree ages, growth rates and architecture with the methods used in more northerly forests (Tappeiner et al., 1997; Bailey and Tappeiner, 1998; Poage and Tappeiner, 2002), including:

(1) tree recruitment from 1700 to 1990;
(2) tree age distributions (1340–1990);
(3) stand density (trees and basal area/ha) from 1800 to 1990;
(4) stand-level fire occurrence from 1700 to 1990 by aging fire scars; and
(5) tree growth/architecture obtained by comparing radial growth rates of trees at the same ages in old-growth and young stands;
(6) tree architecture from measured tree height and crown length, and calculated live-crown ratios, and height-to-diameter ratio (Wilson and Oliver, 2000; Tappeiner et al., 2007).

1.1. Study area

This study was conducted in forests of three common and distinct ecological regions in southwestern Oregon: the Cascades (the eastern extent of the mixed conifer type in southern Oregon); the Siskiyous (the drier mixed conifer forests); and the mixed evergreen forests mid-Coast Range mountains. Douglas-fir is common in all these forests, and density of other conifers varies considerably among sites (Atzet et al., 1996; Franklin and Dyrness, 1973; Table 1).

Table 1
Locations and average stand characteristics (in 1990) of 18 old-growth and18 young stands studied in three forest types as defined by.

Forest type	Elevation (m)	Latitude	Longitude	Stand type	Trees (ha)	Basal area (m^2/ha)	Diameter (cm)	Tree ages (years)	Douglas-fir (%)	White fir (%)	Ponderosa Pine (%)
Cascades	1050–1739	N42-10–N42-20	W122-00–W122-30	Old-growth	98 (40–150)	47 (25–50)	66 (18–208)	(20–630)	(50–100)	(16–50)	(0–3)
				Young	780 (350–800)	43 (30–58)	25 (5–63)	(20–90	(14–93)	(0–82)	(0–6)
Siskiyous	1360–1800	N42-10–N42-25	W122-50–W123-10	Old-growth	101 (90–160)	49 (24–70)	70 (12–172)	(50–580)	(54–78)	(5–23)	(11–25)
				Young	895 (750–1100)	44 (30–53)	25 (5–66)	(20–90)	(50–89)	(12–56)	(0–2)
mid-Coast	530–1380	N42-30–N42-40	W123-30–W123-50	Old-growth	98 (70–160)	59 (50–90)	82 (11–170)	(120–500)	(50–81)	(2–20)	(4–25
				Young	740 (600–1060)	38 (28–72)	23 (6–78)	(20–90)	(66–100)	(0–38)	(0–2)

Franklin and Dyrness (1973). Values in parenthesis are ranges.