Forest Ecology and Management 378 (2016) 233–243

Contents lists available at ScienceDirect

Forest Ecology and Management

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

Multi-scale reference conditions in an interior pine-dominated landscape in northeastern California

Martin W. Ritchie

US Forest Service Pacific Southwest Research Station, 3644 Avtech Parkway, Redding, CA 96002, United States

ARTICLE INFO

Article history:
Received 12 April 2016
Received in revised form 11 July 2016
Accepted 12 July 2016
Available online 3 August 2016

Keywords:
Stand density
Biomass
Crown area
Ponderosa pine

ABSTRACT

A plot-based census was conducted of trees >8.9 cm in breast height diameter in a 4000 ha forest in northeastern California in 1933 and 1934, prior to any harvest activity. The trees were tallied by size class and species on contiguous plots specified to be 1.01 ha in size, although some plots had a forested area less than this specification due to natural openings in the forest. In general, variability in all metrics declined as scale increased across a range from 1 ha to 244 ha, although much of this variability was in the tails; the inner quartile range appeared to be more stable, particularly so for crown area. Although metrics were derived at a smaller scale (<1 ha) from partial plots, these may be unreliable due to the study design and possible confounding factors. The landscape distribution of tree sizes was bimodal and skew positive with a maximum tree size of 189.2 cm. However locally the distribution of tree sizes was more ragged and variable in shape. Species distribution appears to have shifted in a direction away from pine dominance in the years since the census was conducted. Historically, these stands were approximately 86 percent pine by basal area, with some variation depending on slope position. The stem density was dominated by young, thrifty-mature trees of good or moderate vigor but basal area and crown area was dominated by mature or over-mature trees with moderate or poor vigor. Crown area tended to be low with 90 percent of observations between 13 and 35 percent at the 1 ha scale.

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1. Introduction

Land managers often consider historic condition metrics, including range of variability, in guiding decision making. Forest restoration efforts may benefit from reference condition metrics describing the range of variability of stands from a time when stands exhibited greater resiliency to disturbance (Swetnam et al., 1999). Reference conditions also provide insight into processes that have shaped forest dynamics and may help managers gain an understanding of influence of past activities on the landscape (Safford et al., 2012).

Although reference conditions are important in understanding how forests functioned in the past, and can be used in guiding management today (Higgs et al., 2014; Fulé, 2008) they are not without limitations. Our understanding of reference conditions are often shaped by data which are limited in geographic scope and in total area dedicated to sample plots (e.g. Fulé et al., 1997 roughly 2.5 ha in sample plots over 700 ha). Furthermore, climate change effects may require consideration of a more process-based approach to restoration, rather than one heavily dependent on historic metrics (Safford et al., 2012).

In ponderosa pine forests of the southern Cascades, general trends have been toward more closed forests with smaller trees (Taylor, 2000) and species shifts to late seral dominance (Hessburg et al., 2000; Agee, 2003). These same types of trends may be inferred from other regions as well (Moore et al., 2004; Fulé et al., 1997). The primary reason cited for these general trends is the change in fire regime over the last century, although livestock grazing and past harvest practices have also contributed.

Any discussion of reference condition variability should be framed in the context of scale. Scale can have a major impact on the interpretation of reference data (White and Walker, 1997). Much of the work that has been done was derived from observations at a very limited scale (e.g. Harrod et al., 1999; Lydersen et al., 2013). While there has been a good deal of focus on local patch dynamics (e.g. Lydersen et al., 2013), less research conducted on larger scale inferences, primarily because of the difficulty in obtaining historic data over a large landscape (Baker, 2014; Stephens et al., 2015).

The objective of this analysis is to present historic metrics covering a 4000 ha forest reflecting pre-harvest conditions, with particular emphasis on variability across the landscape and the relationship between variability and scale of observation. These observations were also compared to a limited area for which we

E-mail address: mritchie@fs.fed.us

http://dx.doi.org/10.1016/j.foreco.2016.07.017
0378-1127/Published by Elsevier B.V.

have more current data to indicate changes over time in areas with no influence of harvesting. The historic data come from a census of trees conducted at Blacks Mountain Experimental Forest (BMEF) by Austin Hasel in 1933 and 1934 (Hasel, 1938).

Austin Hasel was a researcher at the California Forest and Range Experiment Station in Berkeley, California in the late 20s and 30s. Hasel initiated an effort to collect data on BMEF that would serve two primary purposes. The first was to provide detailed volume and vigor estimates for trees across the entire forest by administrative compartments. The second objective was to develop an understanding of sampling concepts as applied in western forests (Hasel, 1938). Hasel was specifically interested in the practical effects of random vs. systematic sampling on the estimation of error (Hasel, 1938, 1942b), and the effects of plot configuration (strips vs. plots) or plot size (Hasel, 1942a). With this in mind, Hasel established a complete census for all trees on the Experimental Forest above 8.9 cm (3.5 in.) breast height diameter (dbh) by contiguous 1.01 ha (2.5 acre) plots. This census was done in such a way as to facilitate grouping into various size plots and a variety of sample intensities and strategies.

2. Methods

2.1. Location

Blacks Mountain Experimental Forest (BMEF) was formally designated in 1934, although some preliminary research work began prior to this designation. It is located on the Lassen National Forest (40.72° N, 121.18° W) in northeastern California with elevations ranging from 1700 to 2100 m. The southwest portion is a flat basin (Halls Flat) while most of the rest of the forest has gentle slopes, <15 percent (Fig. 1). The climate is characterized by warm, dry summers and median annual precipitation is approximately 500 mm, about 75 percent of which falls, primarily as snow, from November to April. BMEF is currently 4300 ha but the original configuration was slightly smaller because of several patented in-holdings (∼400 ha) which have since been added. The forested acreage is reduced further by several hundred ha of small non-timbered openings, these are primarily grasslands with no recent evidence of trees (Fig. 1).

Today, ponderosa pine (*Pinus ponderosa* Lawson & C. Lawson) can be found throughout the forest while Jeffrey pine (*Pinus Jeffreyi* Balf.) occurs primarily at the lower elevation. In some areas the pines reside in a mix with white fir (*Abies concolor* (Gord. and Glendl.) Lindl. ex Hildebr.), and incense-cedar (*Calocedrus decurrens* (Torr.) Florin). Western juniper (*Juniperus occidentalis* Hook.) is sparsely distributed in the lower elevations of the forest and are found only rarely. Junipers were not recorded in the Hasel study.

Fire was once a frequent occurrence at Blacks Mountain. Historically the fire return interval on sites <40 ha ranged from 5 to 17 years (Norman, 2002). Fire has been effectively excluded from the Experimental Forest during the 20th century (Skinner, 2005). The first disruption in the historic fire regime was due to widespread sheep grazing in the late 1800s; later in the early 1900s the Forest Service began instituting aggressive fire suppression policies.

2.2. The Hasel data

Hasel's observations at Blacks Mountain predate management and provide a remarkable compilation of stand structure on contiguous plots across a large forested area. The trees recorded (those >8.9 cm in diameter) largely reflect conditions that exclude ingrowth from fire exclusion. The primary pulse of regeneration in this region dates to the turn of the century (Taylor, 2000; Youngblood et al., 2004). This pulse in regeneration is linked to the introduction of sheep grazing in the late 1800s (Norman and Taylor, 2005; Skinner and Taylor, 2006).

Prior to the commencement of observations of the forest conditions by Hasel, a compartment mapping exercise was completed

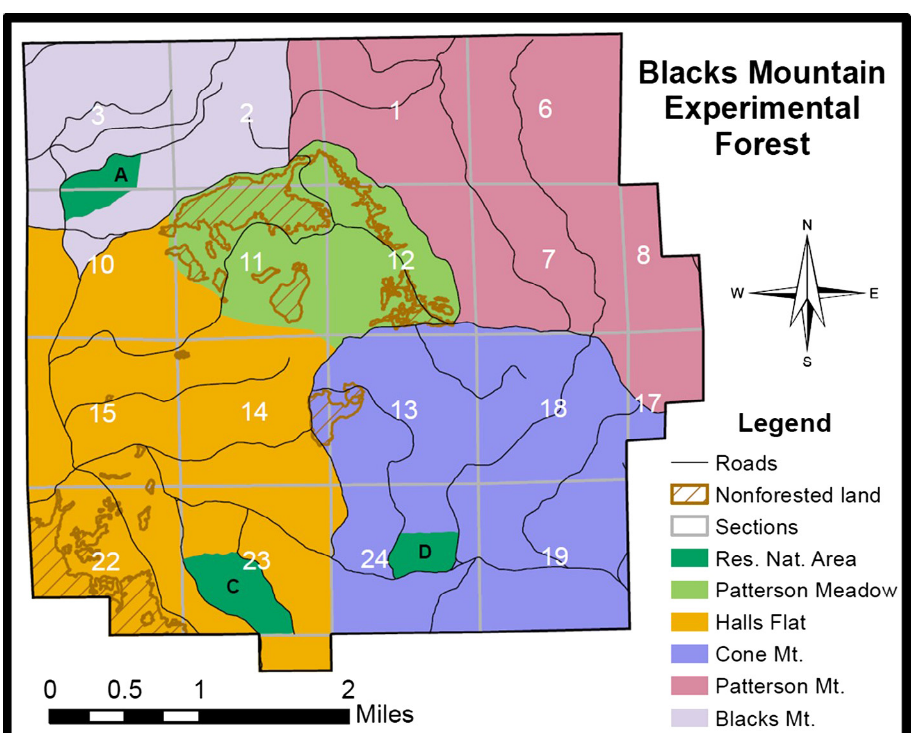

Fig. 1. Map of Blacks Mountain Experimental Forest with two basin regions and three up-slope regions; numbered square sections displayed are 1609 m on each side. Most roads displayed were not present at the time of 1933–1934 tree census.