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Author(s): Louisa B. Evers, Richard F. Miller, Paul S. Doescher, Miles Hemstrom, and Ronald P. Neilson
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Simulating Current Successional Trajectories in Sagebrush Ecosystems With Multiple Disturbances Using a State-and-Transition Modeling Framework

Louisa B. Evers,[1] Richard F. Miller,[2] Paul S. Doescher,[3] Miles Hemstrom,[4] and Ronald P. Neilson[5]

Authors are [1]Fire Ecologist, Bureau of Land Management, Oregon State Office, Portland, OR 97204, USA; [2]Plant and Fire Ecologist Emeritus, Eastern Oregon Agricultural Research Station, Oregon State University, Corvallis, OR 97331, USA; [3]Restoration Ecologist, Department of Forest Ecosystems and Society, Oregon State University, Corvallis, OR 97331, USA; [4]Research Ecologist (retired), US Forest Service Pacific Northwest Research Station, Portland, OR 97204, USA; and [5]Bioclimatologist (retired), US Forest Service Pacific Northwest Research Station, Corvallis, OR 97331, USA.

Abstract

Disturbances and their interactions play major roles in sagebrush (*Artemisia* spp. L.) community dynamics. Although impacts of some disturbances, most notably fire, have been quantified at the landscape level, some have been ignored and rarely are interactions between disturbances evaluated. We developed conceptual state-and-transition models for each of two broad sagebrush groups—a warm-dry group characterized by Wyoming big sagebrush (*Artemisia tridentata* Nutt. subsp. *wyomingensis* Beetle & Young) communities and a cool-moist group characterized by mountain big sagebrush (*Artemisia tridentata* Nutt. subsp. *vaseyana* [Rydb.] Beetle) communities. We used the Vegetation Dynamics Development Tool to explore how the abundance of community phases and states in each conceptual model might be affected by fire, insect outbreak, drought, snow mold, voles, sudden drops in winter temperatures (freeze-kill), livestock grazing, juniper (*Juniperus occidentalis* var. *occidentalis* Hook.) expansion, nonnative annual grasses such as cheatgrass (*Bromus tectorum* L.), and vegetation treatments. Changes in fuel continuity and loading resulted in average fire rotations of 12 yr in the warm-dry sagebrush group and 81 yr in the cool-moist sagebrush group. Model results in the warm-dry sagebrush group indicated postfire seeding success alone was not sufficient to limit the area of cheatgrass domination. The frequency of episodes of very high utilization by domestic livestock during severe drought was a key influence on community phase abundance in our models. In the cool-moist sagebrush group, model results indicated at least 10% of the juniper expansion area should be treated annually to keep juniper in check. Regardless, juniper seedlings and saplings would remain abundant.

Key Words: annual grasses, juniper, livestock grazing, Vegetation Dynamics Development Tool, vegetation treatments

INTRODUCTION

Since the mid-19th century, domestic livestock grazing, introduction of nonnative invasive plants (e.g., cheatgrass [*Bromus tectorum* L.]), changes in wildfire occurrence, conversion of sagebrush-steppe to pinyon–juniper (*Pinus* spp.–*Juniperus* spp.) woodlands (Miller and Wigand 1994), and a history of treatments to eradicate or modify sagebrush (*Artemisia* spp. L.) communities (Pechanec et al. 1944; Frischknecht and Bleak 1957; Cooper and Hyder 1958; Johnson 1958, 1969; Harniss and Murray 1973; Bartolome and Heady 1978; Britton et al. 1981) have produced broad-scale alterations of sagebrush ecosystems throughout the western United States (Bunting et al. 2002; Hemstrom et al. 2002; Connelly et al. 2004; Miller et al. 2011). The loss and alteration of sagebrush community structure and abundance have been associated with declines of sagebrush-obligate species, most notably greater sage-grouse (*Centrocercus urophasianus*; Crawford and Gregg 2001; Connelly et al. 2004; Gregg and Crawford 2009); habitat for other wildlife; and livestock forage.

The ability to evaluate and predict short and long-term responses of sagebrush communities to natural disturbances, management actions, and their interactions in both time and space using models would allow managers to develop better management plans for the maintenance and restoration of these communities. The state-and-transition paradigm provides conceptual models of potential phases, states, and factors that may cause transitions between phases and states (Bestelmeyer et al. 2003, 2009). The use of state-and-transition models to describe changes in rangeland ecosystems is increasing, but most models are qualitative, simply identifying which disturbances may be responsible for movement between phases within a state and between states (Bestelmeyer et al. 2003; Peterson et al. 2009; Holmes and Miller 2010). A few studies have attempted to quantify the likelihood of movement between phases and states with a single disturbance type, such as the LANDFIRE project (Rollins and Frame 2006), but even fewer have examined multiple disturbances (e.g., Bunting et al. 2002; Hemstrom et al. 2002). Further, most quantitative studies published to date, such as those conducted by Bunting et al. (2002) and Hemstrom et al. (2002), typically relied primarily on expert opinion to estimate disturbance probabilities. Developing quantitative state-and-transition models based on objective data and using multiple disturbances would enhance the ability of land managers to use state-and-transition models to explore how changes in management may interact with natural disturbances and affect the potential long-term trajectory of rangeland ecosystems.

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Correspondence: Louisa Evers, Bureau of Land Management, Oregon State Office OR-933, 333 SW First Ave, Portland, OR 97204, USA. Email: levers@blm.gov

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