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Comparing alternative management strategies of fire, grazing, and weed control using spatial modeling

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ABSTRACT

Modeling can be used to resolve controversies generated by differing opinions about the effects of livestock grazing, fire management, and herbicide application on western public lands. We used spatial simulations of 10 potential vegetation types to compare 6 management scenarios over 20 years in a 141,853 ha landscape in eastern Nevada. Scenarios were compared by incrementally varying one factor at a time and were based on the Bureau of Land Management's (BLM's) potential restoration plans. The following factors were varied: managed fire, livestock grazing, mechanical and chemical treatment of vegetation, and restoration budgets. After 20 years the differences in vegetative composition between scenarios were small. BLM's level of funding was too low to improve ecological condition because the landscape was too degraded, however, current funding could maintain communities that retained native perennial understories. In general, the effects of livestock grazing were minor and undesirable compared to benefits gained from the use of mechanical and chemical methods followed by seeding. Mechanical methods and herbicide application in addition to current fire management had more desirable effects than without fire management.

1. Introduction

Livestock grazing, fuels management, and herbicide application on western public lands are controversial topics often strongly opposed or supported by environmental advocacy groups, local communities, the livestock industry, conservation organizations, Native American tribes, and other groups (Fleischner, 1994; Brown and McDonald, 1995; Brussard et al., 1994; Wuerthner and Matteson, 2002; Freilich et al., 2003). Stakeholders support or challenge the actions of public land managers because they share different values about land uses and/or because there is historic distrust of public land management. Disagreements about public land management often increase with the size of a landscape and its ecological complexity (Walters and Holling, 1990), and the paucity of ecological knowledge on key features of the ecosystem (e.g., Baker and Shinneman, 2004).

Controversies related to range management are common because over the last 150 years western rangelands have undergone unprecedented change (Blackburn and Tueller, 1970; National Research Council, 1994; McPherson and Weltzin, 2000; Young and Sparks, 2002). Prior to settlement, the grasslands and shrublands of the arid West were structured primarily by fire, precipitation cycles, and insects with grazing

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ungulates playing a role whose importance varied regionally. However, these roles have changed; domestic livestock now graze the large majority of both private and public lands in western North America, and wildfire occurs at times, frequencies, and intensities that are outside of pre-settlement ranges (Blackburn and Tueller, 1970; Brown and McDonald, 1995; Schmidt et al., 2002). Longer fire-free intervals, the long-term historic consumption of fine fuels by livestock, and aggressive policies of fire-suppression starting in the 1920s (Pyne, 2004) have favored the expansion of woody species throughout grasslands and steppes that historically supported few trees, even in areas that have had livestock use removed for decades (Miller and Rose, 1999; Tausch and Nowak, 1999; Curtin and Brown, 2001; Pyne, 2004).

While longer fire-free intervals have favored woody species, the regional-scale invasion of cheatgrass (*Bromus tectorum* L.) has shortened fire-free intervals. Cheatgrass, a non-native annual, increased dramatically after historic livestock use reduced native bunchgrasses and forbs (Young et al., 1987; Young and Sparks, 2002). Because native plant species do not survive the frequent fires facilitated by cheatgrass (Young et al., 1987), or do not compete successfully against cheatgrass for soil moisture (Melgoza et al., 1990), and some do not disperse as effectively, the system moves toward a cheatgrass monoculture nearly devoid of biodiversity, habitat, and economic values. Cheatgrass control, even for the purpose of restoring native species, is resisted by the public because it is best achieved by the application of herbicides.

Adaptive management theory proposes that stakeholders may reduce the uncertainty of management dilemmas by comparing the effects of alternative, sometime novel management actions on whole ecosystems using simple, yet robust experimental design procedures (Walters and Holling, 1990; Wilhere, 2002). Because the space, investment, and time frame required to carry out an experiment can be large, modeling of alternative management actions is often recommended prior to experimentation, if only to discard ineffective actions and document beliefs about system function (Hilborn et al., 1995; Hardesty et al., 2000; Forbis et al., 2006). Managers also may not have the time or funding to wait several years for experimental results, therefore, modeling provides more immediate recommendations while field data are being collected and interpreted.

State-and-transition models (Horn, 1975; Westoby et al., 1989; McIver and Starr, 2001; Bestelmeyer et al., 2004) are increasingly popular in natural resource management because their discrete representations of vegetation dynamics simplify ecological complexity and can be developed in cooperation with specialists and lay-people. It is also useful that public domain software exists to easily develop state-and-transition models from scratch and rapidly view simulated results (e.g., Beukema et al., 2003b; Forbis et al., 2006).

State-and-transition modeling is largely a-spatial (e.g., Westoby et al., 1989; Miller and Tausch, 2001; Stringham et al., 2003; Bestelmeyer et al., 2004). A-spatial models are far easier to understand and quantify than spatial ones. There are, however, compelling circumstances in which the spatial component cannot be ignored because the spatial interactions among vegetation types and states change ecological processes and management outcomes (Schroeder et al., 1999; Hemstrom et al., 2001; Keane et al., 2002). Spatial modeling might also appeal to managers if the model is applied to the digital version of a real landscape where they can test alternative scenarios and view simulation results on maps of relevant landscapes (e.g., Hemstrom et al., 2001; Hardesty et al., 2000; Keane et al., 2002).

We spatially simulated the effects of six different scenarios of livestock, fire, and non-native species management on the composition of vegetation for a 141,853 ha public lands landscape. A central goal of our spatial modeling effort was to integrate expert knowledge to best estimate the effects of controversial management strategies for public lands. We chose

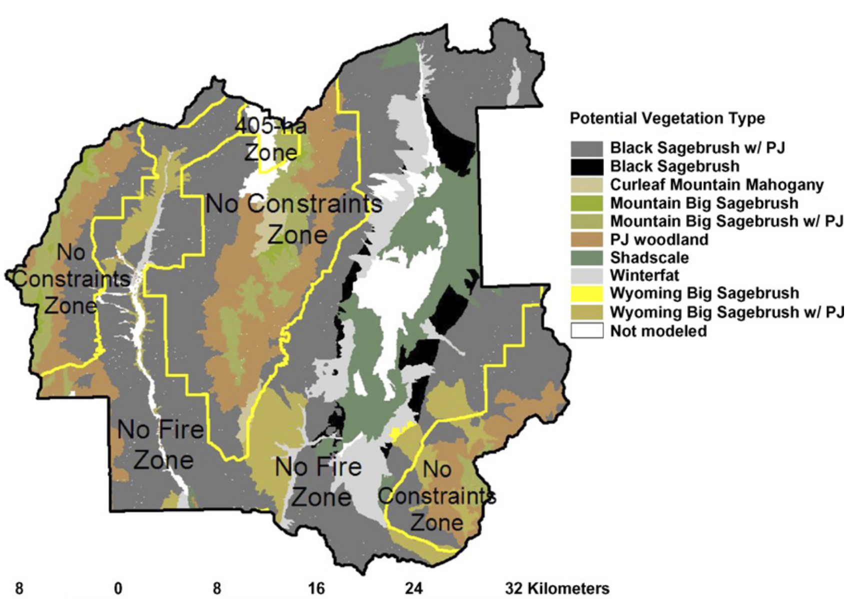

Fig. 1 – Potential vegetation types and fire suppression zones for the Antelope and North Spring valleys, Eastern Nevada. The black lines delineate the fire suppression zones; no constraints, 405-ha (1000-acres) fire, and no fire.