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Symposium

Managing Native Invasive Juniper Species Using Fire[1]

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Abstract: Junipers (*Juniperus* spp.) are native woody shrubs that have expanded beyond their normal historical ranges in the western and southwestern United States since the late 1800s. Most ecologists and resource managers agree that juniper has become a deleterious native invasive plant that threatens other vegetation ecosystems, such as grasslands, through a steady encroachment and ultimate domination. The use of fire in managing junipers is based on a management goal to increase the disturbance return interval and thereby reduce the abundance and/or competitive impact of juniper in an ecosystem. In this paper, we discuss rates of juniper encroachment in relation to presettlement fire regimes, juniper encroachment and soil health, postfire vegetation responses, and long-term potential of different juniper treatment scenarios that involve prescribed fire.

INTRODUCTION

Junipers (*Juniperus* spp.) are native woody shrubs or small trees that have expanded beyond their normal historical ranges in the western and southwestern United States since the late 1800s (Ansley et al. 1995; Burkhardt and Tisdale 1976; Johnson 1962; Miller and Tausch 2001). The most likely reason for this is the change in the disturbance regimes associated with these communities and the lengthening of the time between disturbances that removed juniper. The factors that have contributed to the increased juniper include fire suppression, climate change, and overgrazing by livestock (Brooks and Pyke 2001; Miller and Tausch 2001; Smeins 1983). Overgrazing had the dual effect of weakening the competitive ability of grasses against emerging juniper seedlings and reducing herbaceous fine fuel that normally supported fires.

Fire will almost always reduce juniper canopy cover or density. The use of fire in managing junipers is therefore based on a management goal to reduce the physical presence and/or competitive impact of juniper in an ecosystem. There are positive aspects of juniper and, as such, there may be reasons for maintaining juniper stands in certain regions (Belsky 1996). For example, juniper forests increase cover and structural diversity for wildlife and thus may contribute to increased wildlife diversity (Maser and Gashwiler 1978). Increased wildlife diversity may lead to increased income from hunting or nonconsumptive recreational uses such as bird watching. Vast landscapes of juniper stands are also aesthetically appealing to those who prefer forests over grasslands. However, most ecologists and resource managers agree that there are many reasons why juniper has become a deleterious native invasive plant. Junipers threaten other vegetation ecosystems, such as grasslands, through a steady encroachment and ultimate domination (Bragg and Hulbert 1976; Tausch et al. 1981). Junipers can greatly reduce herbaceous production (Dye et al. 1995; Gehring and Bragg 1992; Miller et al. 2000; McPherson and Wright 1990), can increase bare ground and soil erosion (Davenport et al. 1998), and can mine soil nutrients from interstitial spaces (Tiedemann 1987). Juniper domination reduces habitat for wildlife species that depend on open spaces (Belsky 1996). Finally, closed canopy stands of juniper increase the risk of catastrophic crown fires that typically are more severe and damaging than are grassland fires (Wright and Bailey 1982).

The objective of this symposium paper entails a discussion of reducing juniper density or juniper cover using fire. Topics considered will be rates of juniper encroachment in relation to presettlement fire regimes, juniper encroachment and soil health, postfire vegetation responses, and the long-term potential of different juniper treatment scenarios that involve prescribed fire.

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JUNIPER ENCROACHMENT IN RELATION TO PRESETTLEMENT FIRE FREQUENCIES

Primary juniper species in the intermountain region are western juniper (*J. occidentalis*), Utah juniper (*J. osteosperma*), alligator juniper (*J. deppeana*), Rocky Mountain juniper (*J. scopulorum*), and one-seeded juniper (*J. monosperma*). The range of these species, when considered collectively, covers most of the western half of the United States, although densities and stand ages vary considerably (Short and McCulloch 1977). Expansion of many of these species is thought to have increased substantially in the past 120 yr (Miller and Tausch 2001).

Texas and the Southern Plains states are dominated by eastern redcedar (*Juniperus virginiana*), redberry juniper (*Juniperus pinchotii*), and Ashe juniper (*Juniperus asheii*). Density and distribution of these juniper species have increased remarkably in the past 50 to 60 yr. For example, from 1948 to 1982, redberry juniper distribution in northwest Texas increased from 2.5 to 4 million ha, or 60% (Ansley et al. 1995). Distribution of eastern redcedar and Ashe juniper in Oklahoma increased from 1.4 to 2.4 million ha, or 71%, during the short period from 1985 to 1994 (McNeill 2000).

Presettlement fire frequency west of the Mississippi varies from 1 to 6 yr in much of the Great Plains to >10 yr in the intermountain region (Frost 1998). Grassland communities in the Great Plains had more frequent fires than in the intermountain region due to a more even distribution of readily combustible fuel (grass) and a greater frequency of ignition potential from lightning strikes or Native American activities. Six years is a pivotal point with respect to juniper because some juniper species, such as *J. deppeana* and *J. pinchotii*, become resistant to fire at about 6 to 8 yr of age (Smith et al. 1975). Thus, if a region had a presettlement fire frequency of <6 yr, chances are that most seedling and juvenile juniper plants were killed by wildfires before they became fire resistant. The lengthening of the fire return intervals associated with settlement by Europeans in the late 1800s likely stimulated juniper encroachment.

Fire has the potential to be used where existing grassland and shrub ecosystems are threatened by juniper (Belsky 1996; Wright and Bailey 1982). Juniper gains in regions with historical fire frequencies <6 yr can almost always be considered a direct threat to ecosystems historically defined as grasslands. In contrast, juniper gains in intermountain areas with fire frequencies >10 yr may or may not represent a threat specifically to grasslands, but they directly affect many of the sagebrush (*Artemisia* spp.) steppe communities (Brooks and Pyke 2001). Another ecological and management concern with juniper encroachment is the potential of soil erosion.

JUNIPER ENCROACHMENT AND SOIL HEALTH

A detailed assessment of this factor is beyond the scope of this paper, but it merits mentioning that the ultimate base for long-term management of any rangeland ecosystem should be the health of the soil resource (Davenport et al. 1998). How soils respond to juniper encroachment is highly variable and is an area of much debate (Belsky 1996). Davenport et al. (1998) delineated a major trend among juniper sites with respect to soil erosion by stating that "... pinyon and juniper contribute to accelerated erosion only under a limited range of site conditions which, however, may exist over large areas," and later, "the majority of pinyon-juniper sites exist in either relatively stable or rapidly eroding conditions, with few examples of intermediate states." Grassland communities in the Great Plains are especially vulnerable to soil erosion resulting from juniper encroachment because they generally have deeper soils and more frequent precipitation events than most intermountain vegetative communities. As such, they may be some of the most sensitive ecosystems to juniper encroachment. Fire can play a role in limiting juniper-mediated soil erosion in these and other ecosystems.

VEGETATION RESPONSES TO JUNIPER TREATMENT WITH FIRE

While much research has demonstrated an increase in herbaceous production following juniper removal or reduction, posttreatment vegetation composition and succession trajectories can be highly variable (Tausch et al. 1993). Postfire succession models presented by Barney and Frischknecht (1974) and Everett and Ward (1984) portray a progression from annuals to perennial grasses to grass/shrub mixes to juniper dominance over time (Figure 1). In these models, juniper encroachment gradually gains over time. In the case of a resprouting species such as redberry juniper, a postfire increase to the point of dominance may occur much earlier (perhaps within 20 yr) than what might be found with other juniper species that depend on seedling recruitment. Annual forbs in this model would increase rapidly in the immediate postfire years (Koniak 1985) and might increase later as annual grasses and/or forbs when juniper is dominant. As juniper gains dominance, herbaceous species diversity and perennial grass production would likely decline.

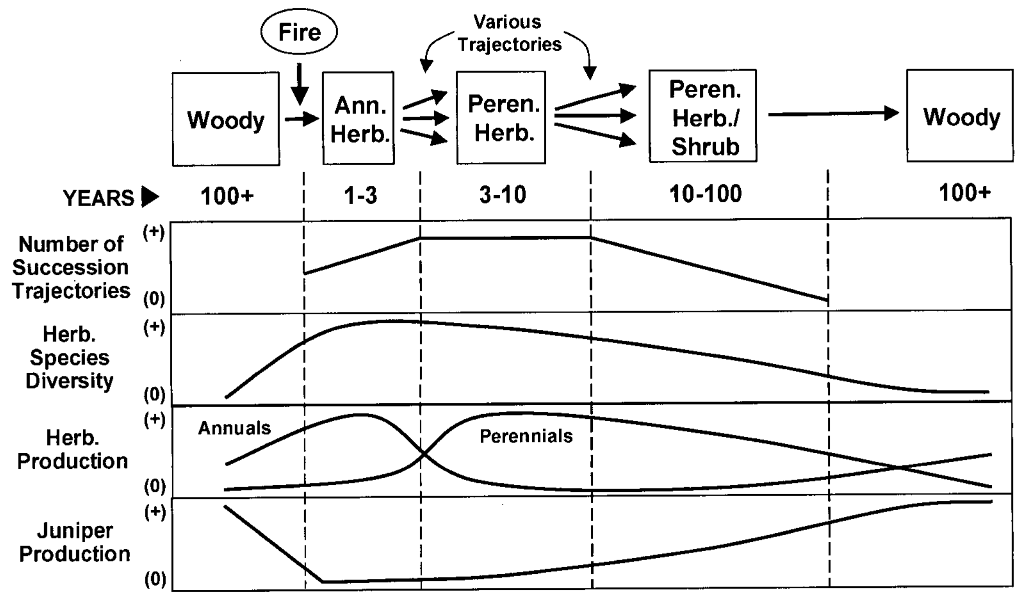

Figure 1. Hypothetical trends in number of possible succession trajectories and vegetation diversity and production following treatment of mature juniper stands with fire. Herb., herbaceous species (grasses, forbs).

We hypothesize that the number of postfire successional trajectories may be greatest during the transition from immediate postfire annual forbs to perennial grasses or when perennial grasses give way to shrubs. As juniper becomes dominant, the number of successional trajectories should decline.

The model portrayed in Figure 1 may still be applied toward much of the southern prairie of Oklahoma and Texas where perennial grasses remain dominant. However, in many areas of the intermountain region, the increase in annual grasses (*Bromus tectorum* and *Taeniatherum caput-medusae*) has largely altered this basic succession model by replacing the middle portions of the model (i.e., perennial grass, shrub/grass mix) with an annual grass-dominated phase that has potential for high fire frequency. If true, Miller and Tausch (2001) suggest these communities may not return to perennial grass or juniper woodland stages. In these regions, annual grasses may become a more important concern than reducing juniper stands with fire. From these observations, it may be stated that for fire to work as a management tool for juniper reduction, a reasonable potential must exist for perennial grasses to recover and establish following treatment.

THE USE OF COMBINED TREATMENTS

Most studies suggest that dense stands of mature juniper cannot be managed effectively with fire alone. These areas must be mechanically treated first to reduce juniper competition and increase herbaceous growth that fuels the fire (Rasmussen et al. 1986). A common mechanical treatment is chaining in which trees are felled by an anchor chain pulled between crawler tractors. Prescribed fire as a single treatment is most effective when juniper encroachment is in early stages, when juniper size and densities are low, and when the ecosystem is still primarily herbaceous.

Many studies have observed vegetative responses to juniper chaining (Rippel et al. 1983; Tausch and Tueller 1977), but few have quantified the effects of combined mechanical and fire treatments on dense juniper stands. A 7-yr study in north Texas (R. J. Ansley and H. T. Wiedemann, unpublished data) quantified the potential of standard and elevated chaining followed by fire on the restoration of a badly degraded site (40% bare ground) dominated with redberry juniper. The elevated chain, suspended 0.5 m aboveground through the use of a rotating ball attached to the chain midway between the two tractors (see Wiedemann and Cross 1996), was hypothesized to have less impact on the soil surface and accelerate the restoration process over that of the standard chain. Chaining was conducted in March 1997, and fires were applied 4 yr later in March 2001. The sites were not reseeded, and livestock grazing was excluded for the duration of the study.

Herbaceous production did not increase in treated plots until 3 yr after chaining (Figure 2). Production was reduced the first growing season following the burn, but it increased up to three times greater than the control in

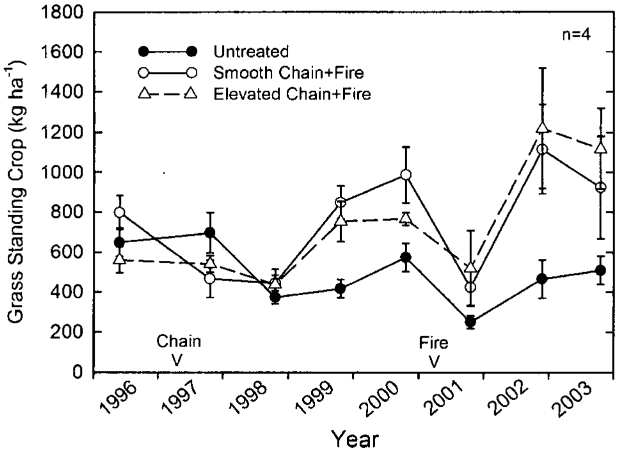

Figure 2. Season-ending grass standing crop responses to combined chaining and fire treatments of mature redberry juniper stands in north Texas.

the second and third years following the fire. However, while herbaceous production ultimately increased, percent bare ground did not change between treatments during the study (data not shown). Bare ground briefly increased after standard chaining, lending support for the elevated chain technique, but this difference between chain methods disappeared over time. Results suggest that gains in herbaceous production were a reflection of increases in growth of existing vegetation patches without further recruitment into bare soil areas. Thus, even after 7 yr of treatment and no grazing, restoration was still not complete. Droughts in 1998, 2000, and 2001 no doubt slowed the recovery process.

In Ashe juniper communities, a single mechanical treatment allowed juniper to significantly recover within 15 yr, while the same treatment followed by fire 5 yr later minimized juniper recovery. Prescribed fire altered the successional pattern to a more diverse shrub and herbaceous community (Rasmussen and Wright 1989). In the intermountain west, the lower precipitation patterns seem to have lengthened the time intervals, but similar patterns are apparent (Rasmussen et al. 1998).

LONG-TERM TREATMENT SCENARIOS

Hypothetical long-term treatment scenarios for mature juniper stands using mechanical, fire, or combined mechanical and fire treatments are displayed in Figure 3. These scenarios assume a normal and consistent weather pattern over 120 yr. We hypothesize that mechanical treatments alone, which are expensive and probably would not be applied more than every 40 yr, would not keep pace with the overall deleterious effects of juniper encroachment. Peak perennial grass and juniper production would gradually decline over time due to soil loss.

Fire, because of its lower cost, could be applied more frequently than mechanical treatments. If used alone and applied every 20 yr, fire, as currently used, would not be as effective initially as a mechanical treatment on reducing mature juniper cover and density. Over time and after several burns, fire may gradually reduce the peak potential of juniper recovery. Because of the frequency of treatment and maintenance of the herbaceous cover, there is less potential for loss of the soil base. Thus, peak perennial grass production would be expected to gradually increase, but it might take a century and

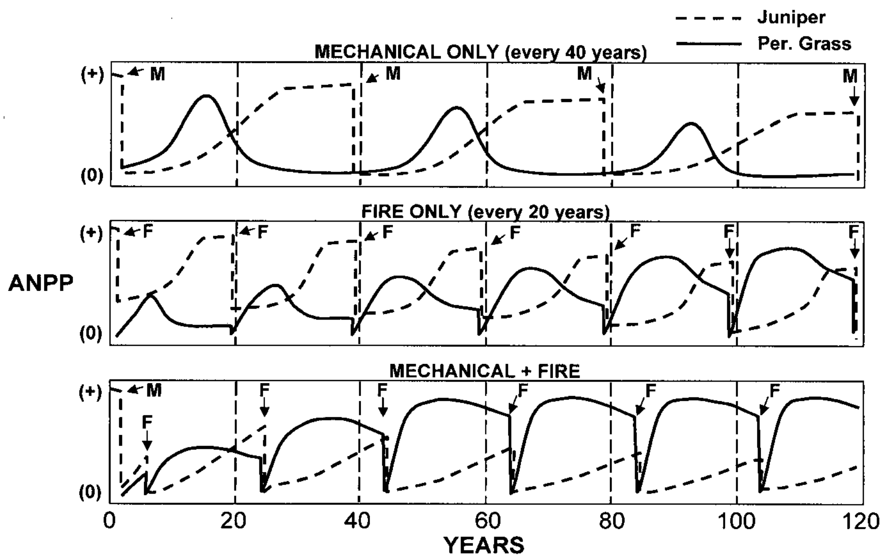

Figure 3. Hypothetical trends in juniper and perennial grass annual net primary production (ANPP) following mechanical, fire, or mechanical plus fire treatments of mature juniper stands. These trends assume no posttreatment reseeding.

six or seven fires to ultimately shift the balance to grass dominance.

Combined treatments of mechanical chaining followed by repeated fires will likely accelerate the restoration process. If an initial mechanical treatment were followed with fire in the first 5 to 10 yr, then at 20-yr intervals, we would expect to see juniper dominance kept in check indefinitely and perennial grass production to increase to a sustained peak in less time (here we estimate 50 yr) than what fire alone could achieve. Recovery time would be dictated on the basis of precipitation, with time decreasing with more precipitation and increasing as precipitation declined. A burn taking place less than 20 yr after the mechanical treatment would further accelerate restoration. However, as indicated by the data from the north Texas study, true restoration, even under a combined treatment scenario, may not occur rapidly. Conditions of the resource prior to treatment and weather conditions following treatment are key variables in determining rates of restoration (Everett and Ward 1984; Tausch and Tueller 1977). It should also be noted that the recovery rate and fire return intervals can vary, based on the scale of the disturbance. As the area burned increases, seed source dispersion can be altered to change the plant community succession trajectories.

The primary consideration in juniper management with fire is to shorten the fire return interval. Work has been focused on using an initial mechanical disturbance in mature juniper stands and on following this with fire to maintain juniper reduction. The challenge is to ensure a plant response that is desired by management. In the intermountain west, this often means reseeding, because of the displacement of perennial grasses with annuals, while in the Great Plains, grazing deferment can meet those needs.

Another challenge is to integrate utilization and conservation goals within the context of an ecological database that will continue to expand but will likely never be complete. Utilization goals (e.g., livestock grazing, hunting) are usually more short term and addressed at smaller spatial scales than are conservation-oriented goals. While considering both levels, management practices should remain site-specific whenever possible because of the high degree of variability between sites. However, regional and whole-ecosystem consequences of localized management applications must also be considered. Fire may play a role in managing juniper-dominated ecosystems, but care should be taken not to view it as a cure-all for every ecosystem ailment. Specific responses to fire must be quantified and cross-referenced across a variety of ecosystems to separate site-specific attributes from those that are more broadly applicable.

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