Fire Regimes and Modern Expansion of Western Juniper in Northeastern California

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Introduction

Western juniper has occupied its historical range for the past 5,000 years, based on macrofossils. During this time period, the range of western juniper has expanded and contracted in response to variation in climate and fire. However, since the late 1800s it is expanding its range and increasing in abundance at rates exceeding those of any expansion during the previous 5,000 years. Specifically, over 90 percent of modern western juniper woodlands have developed in the past 100 years. Today, western juniper occupies 3.5 million acres in northeastern California and 5 million acres in eastern Oregon. The Lava Beds National Monument in northeastern California has instituted a prescribed fire program in response to its concerns over the recent expansion of western juniper, the loss of presettlement plant communities, and an increase in fuel loads. However, the lack of information on historical fire regimes and plant succession dynamics following fire has limited the National Park Service's (NPS) ability to design and implement a prescribed fire program that simulates historical conditions and restores grassland and shrub-steppe communities.

Objectives and Methods

Our objectives were to answer the following questions for plant associations currently occupied by western juniper in the Lava Beds National Monument:

1. How frequent and severe were presettlement fires (before ca. 1870), and did fire regimes vary among the plant associations?
2. What plant communities were likely maintained under different fire-return intervals?
3. To what degree have juniper woodlands expanded since the late 1800s?

To achieve our objectives, we first identified six plant associations. To characterize the vegetation that currently exists in these plant associations (i.e., post-settlement vegetation), we measured plant characteristics at 18 sites[1], which were stratified by plant association and time-since-last-fire. We inferred presettlement vegetation in these plant associations from post-settlement vegetation, historical fire regimes, and a model of the rate of post-fire succession that we developed from chronosequences of existing vegetation (Fig. 1). We reconstructed historical fire regimes from fire scars, the establishment dates of post-fire cohorts of trees, and the death dates of trees killed by fire.

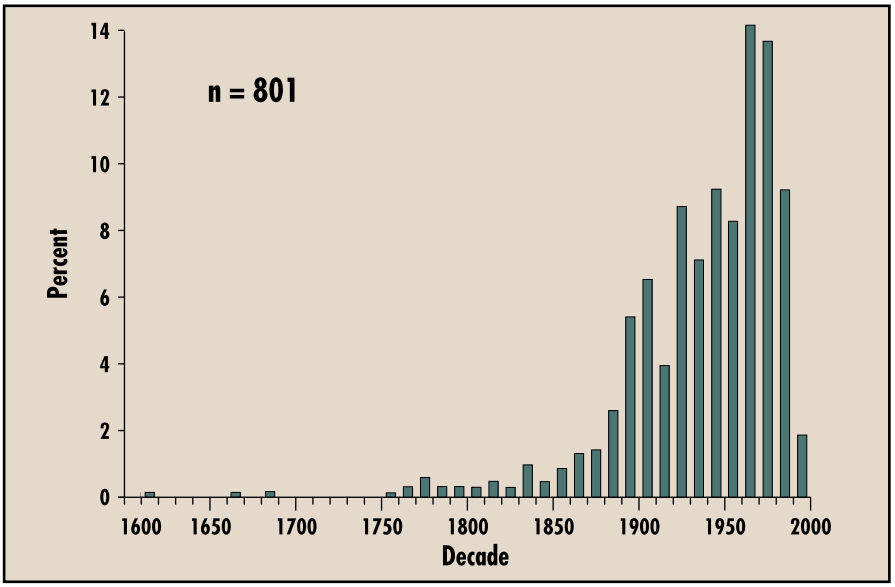

Figure 1. Establishment of western juniper by decade in the Lava Beds National Monument, California.

Results and Discussion

Western juniper has significantly increased in abundance and encroached on grassland and shrub-steppe communities across the Lava Beds National Monument (Fig. 1). Our data suggest that fire regimes have dramatically changed in the more productive plant associations characterized by Idaho fescue and that western juniper is a newcomer, encroaching into these communities since the late 1800s. The expansion of western juniper coincides with the reduced role of fire in the late 1800s.

[1] Site is an area representing a plant association by time-since-fire combination, which is floristically and structurally similar.

Ponderosa pine/Idaho fescue plant association. Mean presettlement fire-return intervals were 8–10 years, which maintained a scattered stand of ponderosa pine with an understory of Idaho fescue. Following a fire-free period of near 100 years, plant communities have succeeded from mountain big sagebrush/bitterbrush to a dense canopy of mountain mahogany, and currently are in transition to western juniper woodland (Fig. 2).

Mountain big sagebrush-Bitterbrush/Idaho fescue and Mountain big sagebrush-Bitterbrush/Bluebunch wheatgrass-Idaho fescue plant associations. We inferred from the data that mean fire-return intervals in the remaining two mountain big sagebrush plant associations containing Idaho fescue were less than 20 years. The absence of fire has resulted in shrub canopies exceeding 40 percent and the gradual transition to western juniper woodland. Fire-return intervals of less than 20 years would have maintained a dynamic state of grass-dominated to open shrub grasslands (Fig. 3). Western juniper was not a part of the presettlement vegetation.

Mountain big sagebrush/Bluebunch wheatgrass-Thurber's needlegrass plant association. The existing vegetation suggests that the presettlement fire regime was sufficient to limit the establishment of large mature western juniper trees.

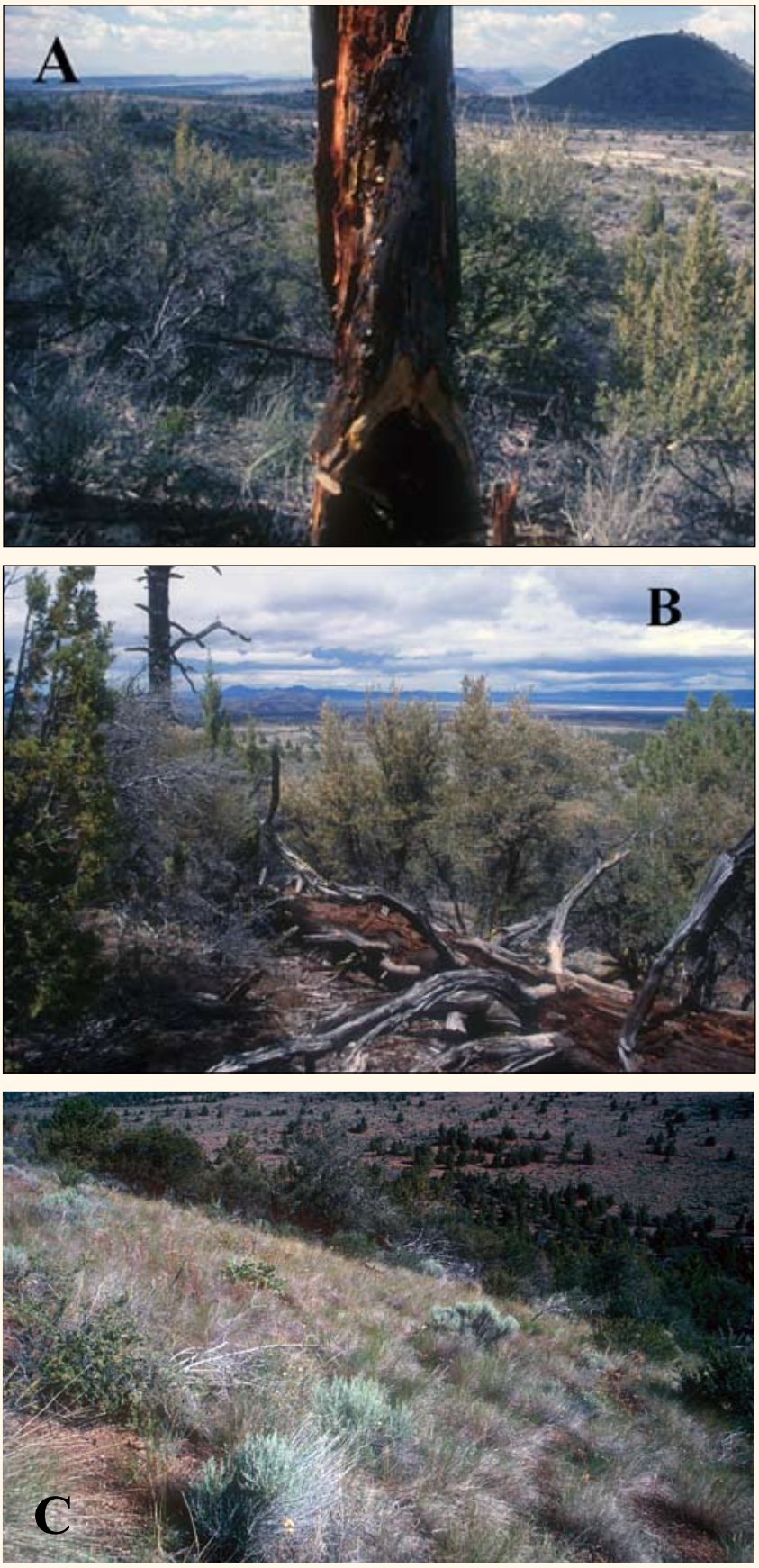

Figure 2. Presettlement fire-return interval in the ponderosa pine/Idaho fescue plant association (a and b) was 8–9 years. Last fire event was 1893 (a), 1904 (b), and early 1990s (c). Stands a and b currently are dominated by mountain mahogany and young juniper. Stand c is dominated by Idaho fescue and bluebunch wheatgrass that would have persisted under the presettlement fire regime.

The maximum fire-free interval that limits western juniper encroachment is estimated to be 50 years. Mature western juniper trees were not part of the presettlement vegetation in this plant association, based on the current lack of live or dead mature western juniper trees. However, this plant association is currently occupied by early to mid-successional western juniper woodland. The oldest trees on the site we sampled were established in the late 1800s with a second pulse following a fire in 1941. Plant community structure maintained under the past fire regime would have been a dominance to codominance of shrubs with a codominant to subdominant layer of perennial grasses.

Curl-leaf mountain mahogany-Bitterbrush-Mountain big sagebrush/Bluebunch wheatgrass-Western needlegrass plant association. In contrast, infrequent (150 years), high-intensity fires burned through this plant association, which could result in stand replacement. Plant communities were in a continual state of change between shrub-steppe and western juniper woodland, and western juniper trees were part of the presettlement vegetation. Periodic fires probably were supported by several years of wetter-than-average conditions preceding the fire event, which allowed the build-up of fine fuels and severe weather conditions during the fire event.

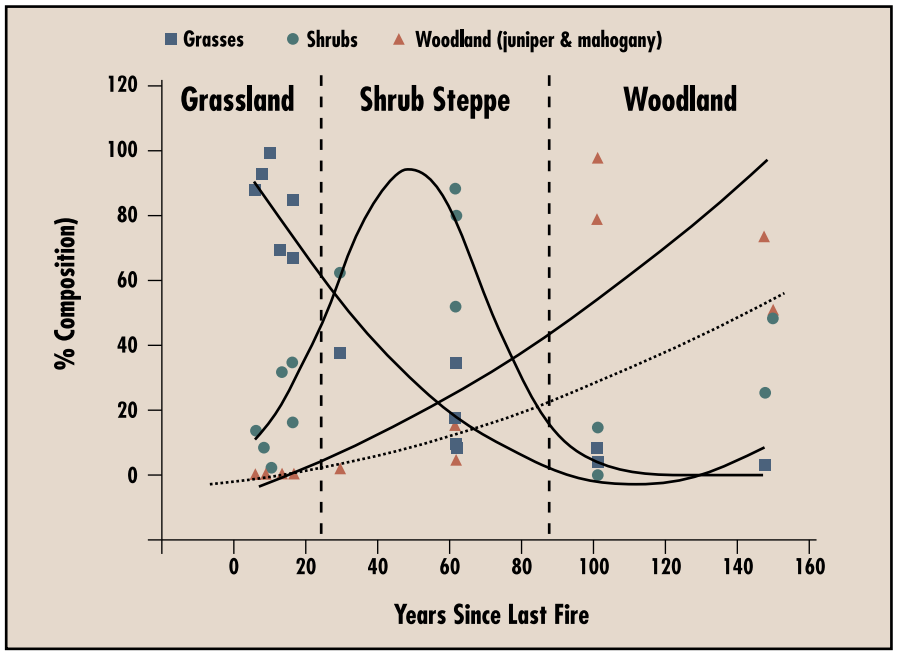

Figure 3. Model of the rate of post-fire succession from grassland to shrub-steppe to western juniper woodland. Percent composition is derived from measured cover of existing herb (i.e., grass), shrub (excluding curl-leaf mountain mahogany), and overstory layer (i.e., trees, western juniper, plus curl-leaf mountain mahogany) at Lava Beds National Monument. Moist sites are those plant associations that contain Idaho fescue; arid sites are those that contain western needlegrass.

Conclusions

Our vegetation composition, tree age distribution, and fire history data suggest that, across the southern half of the Lava Beds National Monument:

- Historically, fire regimes were heterogeneous, varying across plant associations and ranging from frequent, low-severity to infrequent, high-severity regimes.
- These fires historically prevented the development of western juniper woodlands across most, but not all, of the six plant associations that we studied.
- As a consequence of recent fire exclusion, western juniper has greatly expanded since the late 1800s.
- In the continued absence of fire, most plant associations eventually will be dominated by western juniper and hence will be outside their range of historical variation in vegetation composition and structure.

These data currently are being used by the NPS in the development of their long-term fire management plan. The fire plan takes into account in which plant communities western juniper has encroached because of the reduced role of fire and in which plant communities western juniper already was part of the plant association. This work also suggests that fire-return intervals of less than 20 years are required to maintain grasslands and less than 50 years to maintain shrub-steppe communities (Fig. 3).