Fire history of a western Montana ponderosa pine grassland: A pilot study

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Introduction

A primary goal in the management of forests and grasslands is to maintain community structure and disturbance processes within their historical range of variation. If, within a managed ecosystem, either is found to lie outside that range, restoration may be necessary. Both maintenance and restoration are currently guided by the principles of ecosystem management, which relies on knowledge of both historical processes and current ecosystem conditions (Forest Ecosystem Management Team 1993). In ecosystems historically sustained by fire, site-specific fire regime data can be combined with information on present composition and structure to design ecologically appropriate restoration and management prescriptions. While this approach to restoring fire-adapted ecosystems is appropriate for many publicly managed forests, it is actually mandated for U.S. Forest Service-designated Research Natural Areas (RNA). Research Natural Areas are established as examples, of forests or grasslands, that most closely represent historical vegetation and wildlife habitat, and that are largely products of natural disturbance processes and ecosystem succession (U.S. Department of Agriculture, 1994).

The 110 ha Sawmill Creek Research Natural Area is 16 km southeast of Stevensville, Montana, in the Bitterroot National Forest. This area was designated a RNA in 1992 to preserve, through natural disturbance processes or their surrogates, its native bunchgrass communities and the old growth ponderosa pine (*Pinus ponderosa*) /Douglas-fir (*Pseudotsuga menziesii*) stands that grow in several narrow, north-south ravines (Figure 1). However, the vegetation composition and structure of the RNA has changed in recent decades, and now may be in a condition outside its historical range of variation. Specifically, numerous Douglas-fir trees have established in the understory of the ravine forests, and Rocky Mountain juniper has encroached on the grasslands. We speculate fire exclusion was a likely cause of the recent changes in structure and composition, as it has been elsewhere in the interior west (*e.g.,* Weaver 1959, 1961, Cooper 1960, Covington and Moore 1994). Surface fires were historically frequent in ponderosa pine forests near the RNA (Barrett 1981), and some of the large ponderosa pine trees in the ravines at Sawmill have multiple fire scars, suggesting that the RNA historically sustained frequent surface fires as well. Forest Service Fire Reports initiated in the early 1900's contain no record of significant wildfire activity in the RNA, although a 1923 fire burned 300 acres near the northeast boundary (Johnson and Stewart 1998), and could have burned through the RNA's upper grasslands.

Our objective for this pilot study was to reconstruct a preliminary, multi-century history of surface fires at the Sawmill Creek RNA from fire scars on ponderosa pine trees. This fire history will provide evidence of the frequency of past fires that sustained the forest and grassland communities in the RNA, which may be used to help guide future management of the RNA.

Figure 1. Upper Sawmill Creek RNA, showing forested ravines and recent invasion of grasslands.

Study area

Elevation at the Sawmill Creek RNA ranges from 1400 to 1650 m. The slopes are primarily southerly, but are bisected by moderately steep, north-south ravines. The climate is generally continental, with hot, dry summers and cold winters (Figure 2). Monthly precipitation peaks in May-June, followed by temperature peaks in July and August.

The RNA has five distinct plant communities (Sikkink 1997):

- Grassland (bluebunch wheatgrass, Idaho fescue, rough fescue, arrowleaf balsamroot),
- Shrub Savanna (big sagebrush, arrowleaf balsamroot, rough fescue),
- Mixed Tree-Shrub Savanna (ponderosa pine, Douglas-fir, bluebunch wheatgrass, snowberry, arrowleaf balsamroot),
- Canyon Forest (ponderosa pine, Douglas-fir, Rocky Mountain juniper, pinegrass, Idaho fescue,
- Riparian forest (ponderosa pine, Douglas-fir, Rocky Mountain maple, mockorange, gray alder).

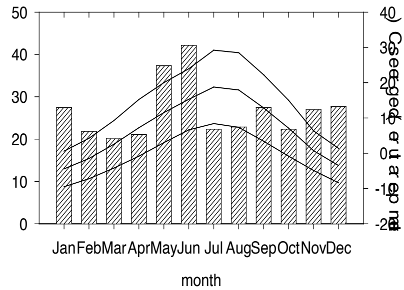

Figure 2. Climate at Stevensville, Montana, 16 km northwest of Sawmill Creek RNA (1911-2002, Western Regional Climate Center 2003). Bars indicate total monthly precipitation; lines indicate maximum, mean, and minimum monthly temperatures.

The Grassland community occurs on the upper slopes and drier aspects of the RNA; Shrub Savanna and Mixed Tree-Shrub Savanna are found on the midslopes, and Canyon Forest on the lower slopes and mesic aspects of the ravines. Riparian Forest communities form narrow ribbons along the bottoms of the ravines. We sampled in the Tree-Shrub Savanna and Canyon Forest types.

The RNA was influenced by twentieth-century human activities before its designation in 1992. Prior to 1945, the RNA was subject to unregulated livestock grazing, followed by permitted grazing until 1961 (Johnson and Stewart 1998). In the 1950's, standing snags were cut to reduce the occurrence of lightning fires. In the 1960's, roads were built through the RNA to retrieve forest products from an adjacent ravine, and some limited sanitation harvesting of large trees adjacent to roads also occurred. In addition to human use, elk and mule deer currently make heavy use of the RNA as winter range for both grazing and cover.

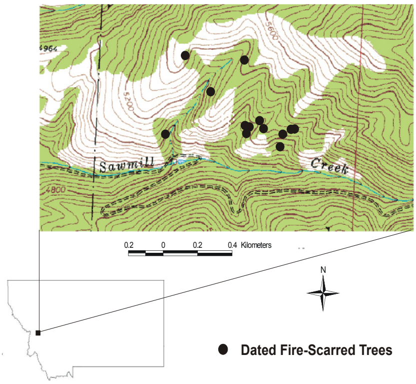

Figure 3. Location of sampled and dated fire-scarred trees (clear areas are not forested).

Methods

We searched the RNA to identify those ponderosa pine trees with the maximum number of well-preserved fire scars. We used a chain saw to remove fire-scarred sections from thirty trees (Figure 3), and analyzed seven live and six dead trees for this pilot study. The sections were sanded until the cell structure was visible with a binocular microscope. We assigned calendar years to tree rings using a combination of visual crossdating of ring widths and cross-correlation of existing, measured ring-width series (Holmes 1983, Cook *et al.* 1999). To determine the calendar year of fire occurrence, we noted the year in which each scar formed. We also noted the position of the scar within the ring (earlywood, latewood, ring boundary or unknown), as an indication of the season during which the fire burned. The dates of all fire scars from the samples were combined into a single record of fire occurrence for the RNA (Dieterich 1980). General features of fire occurrence were assessed using fire charts in which horizontal time lines represent individual tree lifespans and vertical crossbars, on the time lines, identify years with evidence of fire (Dieterich 1980, Grissino-Mayer 1995).

Results

Historically, surface fires were frequent at the Sawmill RNA (Figure 4). However, these fires ceased abruptly around 1900. Consequently, we concentrated on the period from 1700 to 1900 as the period during which fire regimes could be

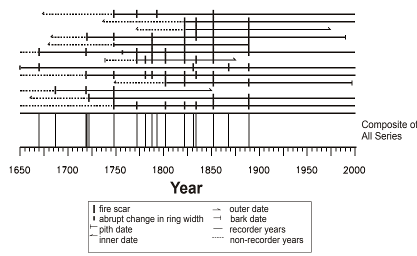

Figure 4. Chronology of surface-fire occurrence at Sawmill Creek RNA. Each horizontal line shows the record of surface fire occurrence for a single tree, with the date of each fire indicated by a vertical line.

reliably reconstructed at this site from our data. Within this period, 65 fire scars corresponded to 13 separate calendar years. During the period of reliability (1700 – 1900), surface fires burned in the RNA every 13 years on average and the time between fires varied from 2 to 32 years (Figure 5). Because ring widths were often very narrow, we were able to assign an intra-annual position to a minority of the scars (33%). These scars were nearly evenly split between growing season scars (earlywood plus latewood) and ring-boundary (dormant season) scars (12 and 9 scars, respectively).

Discussion

The frequency of past surface fires at the RNA is similar to that reconstructed in similar forest types elsewhere in this region (e.g., Barrett and Arno 1982, Arno *et al.* 1997). For ≈200 years prior to 1900, surface fires burned at Sawmill Creek RNA every 13 years, on average, with the longest interval being 32 years. However, similar to other sites in the region, surface fires in our study area ceased abruptly prior to 1900. The last fire reconstructed at the RNA occurred 114 years ago, more than triple the longest previous interval. Significant changes in plant community composition and structure would be expected as a result of this extended fire-free period.

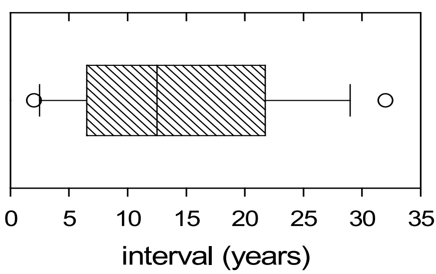

Figure 5. Composite fire-return intervals at Sawmill Creek RNA. The box encloses the 25th to 75th percentiles, while the whiskers enclose the 10th to 90th percentiles of the distribution of fire return intervals. The vertical line indicates the median, and values falling outside the 10th to 90th percentiles are shown as circles.

Sikkink's (1997) comprehensive analysis of the Sawmill RNA vegetation indicates that currently over twice as many Douglas-fir occupy the site than the more fire-adapted ponderosa pine. Ponderosa pine's fire tolerance advantage over Douglas-fir, especially in the smaller size classes (Fischer and Bradley 1987; Kalabokidis and Wakimoto 1992) was likely a primary factor in the development of a ponderosa pine-dominated stand during the period of regular fire occurrence. Old ponderosa pine still dominates the overstory (i.e., trees >50 cm), but Douglas-fir, overwhelmingly, dominates all younger, smaller size classes (Figure 6). In addition, Douglas-fir, with a high percentage of dwarf-mistletoe infection, appears to be more disease-prone than ponderosa pine at this site (data on file, M.G. Harrington, Fire Sciences Lab, Missoula MT).

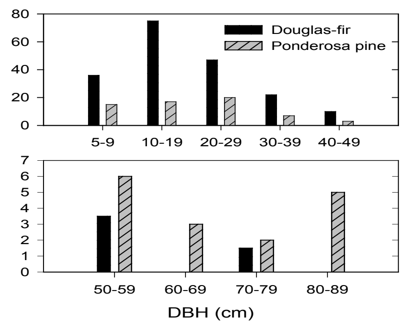

Figure 6. Density by size class of Douglas-fir and ponderosa pine in the upland forest communities at Sawmill Creek RNA (adapted from Sikkink, 1997). Note difference in Y axis scales.

The recent increase in forest density, and the shift toward less fire-tolerant species is consistent with our interpretation of a previously fire-suppressed, open forest ecosystem now experiencing forest ingrowth. Without a return to the short fire intervals that controlled stand density and reduced fuels, existing old-growth trees will likely be lost in a future, stand-replacing wildfire or suffer stress due to competition for limited site resources. Additionally, the current condition will likely continue to diminish the regeneration potential of ponderosa pine and the vigor of associated shade-intolerant understory species.

The re-introduction of fire and/or fire surrogates to the Sawmill Creek RNA appears to be an appropriate strategy for restoring this area to its historical condition. However, simply because a forest or grassland was maintained historically by fire does not dictate the immediate use of fire as a restoration tool. For ecosystems adapted to low-severity, surface fires, where an accepted departure from the historical or desired ecological conditions are relatively small, prescribed fires can be a viable replacement for natural fires. Prescribed fires can be effective in reducing the density of juvenile, fire-sensitive trees and in consuming excess organic matter. Conversely, if the current departure is large, as at the Sawmill RNA, returning fire alone may result in undesired consequences (e.g., Tiedeman *et al* 2000). Attempting to reduce excess juvenile and pole-sized trees and substantial amounts of organic debris with prescribed fire can lead to mortality of the favored old growth cohort. Preliminary experiments with mechanical tree and fuel reduction have proven successful in reducing this risk, even though some regard it as less ecologically acceptable than the use of fire treatments alone (Fiedler *et al* 1996). Equipped with information about the historical fire regime, the manager can develop an appropriate plan that replicates the historical disturbance process that once sustained these forest and grassland ecosystems. The manager might also choose to more closely approximate the range of historical variation by varying both the fire return interval as well as the season of burning.

Since the completion of the pilot study, we have obtained fire-scarred sections from an additional eighteen ponderosa pine trees at the RNA. We will cross-date these sections to yield a more complete reconstruction of fire history that will be used in the current effort to restore this RNA to its historical ecosystem structure and composition.

Acknowledgments
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