Ecosystem-Based Management in the Whitebark Pine Zone

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Abstract—Declining whitebark pine (*Pinus albicaulis*) forests have necessitated development of innovative methods to restore these ecologically valuable, high elevation ecosystems. We have began an extensive restoration study using prescribed fire and silvicultural cuttings to return native ecological processes to degenerating whitebark pine forests. Preliminary results indicate these restoration treatments are successfully restoring the fire processes at a small scale, but many challenges need to be met to achieve landscape scale whitebark pine ecosystem restoration. Prescribed fires are difficult to implement because highly variable mountain weather rarely allows favorable burning conditions and the remote settings of many whitebark pine stands may preclude economically feasible silvicultural harvesting. However, we believe any fire or silvicultural treatment that reduces competing tree species densities and allows whitebark pine regeneration can potentially aid in the conservation of whitebark pine ecosystems.

Whitebark pine (*Pinus albicaulis*) is a major seral tree species found in most upper subalpine areas of the northern Rocky Mountains and Cascades in the United States and Canada that is rapidly declining (Arno and Hoff 1990; McCaughey and Schmidt 1990; see Schmidt and McDonald 1990). This "keystone" species is critical for the maintenance of many unique ecosystem processes in high elevation landscapes. Whitebark pine produces large, nutritious seeds that are highly valued as food by many species of wildlife (Hutchins and Lanner 1982; Weaver and Forcella 1986). One bird, the Clark's Nutcracker (*Nucifraga columbiana*), has evolved a mutualistic relationship with the pine (Tomback 1998; Tomback and others 1990); it harvests the large seeds from cones on the tree and then stores them on the ground in caches that can contain as many as 15 seeds (McCaughey and Schmidt 1990; Tomback and others 1990). Cached seed unclaimed by the nutcracker (about 5 to 20 percent of those cached) can germinate and may grow into viable whitebark pine seedlings (Tomback 1989; Hutchins and Lanner 1982). The nutcracker especially likes to cache seeds in open areas, like those created by fire (Tomback and others 1990), and the pine is more likely to survive to maturity in these openings because there are few competing trees (Arno and Hoff 1990). Moreover, the nutcracker can disperse whitebark pine seeds much farther (up to 20 km) than wind typically disperses seeds of other associated tree species.

Whitebark pine benefits from wildland fire because it is more capable of surviving fire and regenerating after fire than its associated shade-tolerant species (Arno and Hoff 1990). Whitebark pine is able to survive low severity fires because it has thicker bark, a thinner and higher crown, and deeper roots. It readily recolonizes large, stand-replacement burns because Clark's Nutcrackers transport the seeds from distant unburned stands (McCaughey and others 1985; Tomback and others 1993). In fact, essentially all whitebark pine regeneration originates from unclaimed nutcracker caches (Tomback and others 1990). When fire is excluded from the high mountain landscape, whitebark pine is eventually replaced by shade-tolerant subalpine fir (*Abies lasiocarpa*), spruce (*Picea engelmannii*), or mountain hemlock (*Tsuga mertensiana*) (Alexander and others 1990; McCaughey and Schmidt 1990).

Sadly, these diverse and unique forests have been rapidly declining in about 50 percent of the species' range because of recent blister rust (*Cronartium ribicola*) and mountain pine beetle (*Dentroctonous ponderosae*) epidemics, and advancing succession resulting from fire exclusion (Arno 1986; Kendall and Arno 1990; Keane and Arno 1993; Keane and others 1994). The exotic disease, blister rust, was introduced to western North America circa 1910 and quickly spread across the entire range of whitebark pine by 1961 (Hoff and Hagle 1990). During the same period, the United States government initiated an aggressive fire suppression program that has accelerated in magnitude and technology into the present. An extensive mountain pine beetle epidemic occurred during the early 1930's in west-central Montana and central Idaho that killed many mature whitebark pine, and additional beetle epidemics in recent decades have killed many of the remaining trees. The net result of these three factors is the rapid die-off of whitebark pine that has accelerated the successional replacement of whitebark pine with fir and spruce (Hartwell 1997; Keane and Arno 1993; Kendall and Arno 1990). The beetles and blister rust killed the large, cone-producing whitebark pine, thereby reducing whitebark pine seeding potential, and then fire exclusion reduced the number of sites suitable for nutcracker caching, allowing the invasion of fir and spruce.

The long-term, detrimental effects of blister rust, beetle, and fire exclusion policies on whitebark pine ecosystems have necessitated development of innovative techniques for restoring the health and function of these high elevation, keystone ecosystems across the landscape. This paper

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summarizes the lessons learned from an ongoing, seven year study investigating methods for restoring whitebark pine to the high elevation landscape in and around the Bitterroot Mountains of west-central Montana and east-central Idaho (Keane and Arno 1996; Keane and others 1996a). This project, called *Restoring Whitebark Pine Ecosystems* (RWPE), involves five research sites (fig. 1) in whitebark pine forests that are different in biophysical environment, stages of decline, and stand structure. Prescribed burning and silvicultural harvest systems are being employed to reestablish and maintain whitebark pine in these areas.

Lessons Learned

Restoration Is Needed

Extensive field sampling and simulation modeling show that, without proactive restoration treatments, whitebark pine forests will continue to decline, forever changing the character of high mountain landscapes (Kendall and Arno 1990; Arno 1986; Keane and others 1990; Keane and others 1996b; Keane and others 1994). Today's continued fire exclusion policies, coupled with extensive and expanding rust epidemics, will continue to reduce whitebark pine to critically low levels.

There is concern by many ecologists that whitebark pine populations may become so low that the nutcracker will eat most seeds and cache very few, thereby becoming a seed predator rather than a seed disperser. Another concern is that nutcrackers may start frequenting other low elevation forests to the exclusion of whitebark pine forests with dwindling seed crops. And without fire creating openings and killing the fir and spruce, the limited number of nutcracker-cached seed in high elevation landscapes will rarely become cone-producing trees because of the excessive competition. Furthermore, natural blister rust resistance in the pine will never be passed along to progeny because there will be no openings to allow seedling growth.

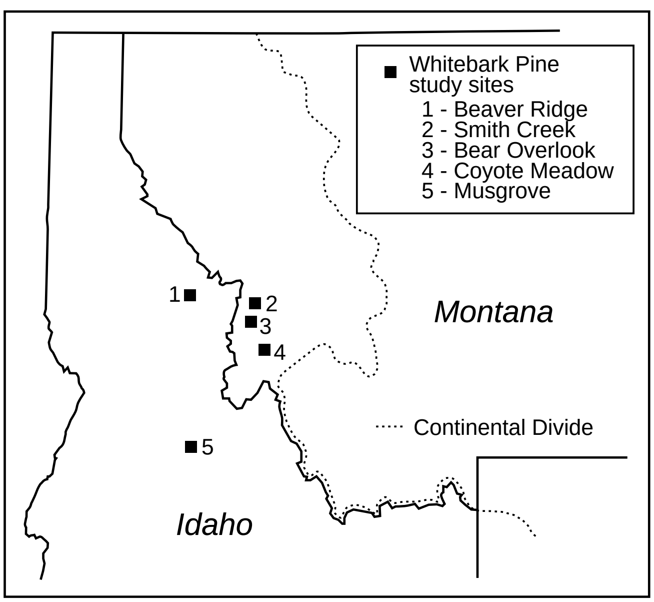

Figure 1—Whitebark pine research restoration sites in west-central Montana and Idaho.

The Most Effective Restoration Treatments

Prescribed burning and selection cuttings, either alone or together, are the most practical restoration treatments we have found so far. Prescribed burning is useful because it returns fire to the ecosystem. Selection cuttings (i.e., removing shade-tolerant fir and spruce) are effective in areas where burning is difficult (e.g., heavy fuel loads, adjacent to sensitive areas) and access is available (Debell and others 1997). These cuttings ensure selective removal of certain trees (e.g., firs) and generate cured slash that can aid implementation of prescribed fire in an environment that is otherwise difficult to burn except under severe fire weather. However, prescribed burning is usually necessary after a cutting because fire kills the numerous small fir and spruce seedlings that escaped the cutting. Fire also reduces slash to clear the ground for optimal nutcracker caching (Keane and Arno 1996; Lasko 1990; Tomback and others 1993).

Based on historical stand structures, we feel any crown, mixed severity, or surface fire could be justified in a mixed severity regime, so design characteristics of mixed severity fires can be very liberal, depending on the restoration objective and the current site conditions (Arno and others 1993; Morgan and others 1994; Norment 1991). Development of "one-size-fits-all" treatments and fire prescriptions are especially futile in whitebark pine forests because of the high degree of variability in pattern, process, composition, and structure.

Successful restoration treatments were implemented on the five RWPE study sites (fig. 1). Circular, 0.5 to 2 acre harvest units, called nutcracker openings, were created at the Smith Creek and Beaver Ridge sites by removing all trees but cone-bearing whitebark pine to encourage nutcracker caching. Prescribed burning inside nutcracker openings and within unharvested units at Smith Creek killed over 40 percent mature subalpine fir and reduced fuel loadings by 45 percent to create ideal caching habitat for the nutcracker. Cutting at the Bear Overlook, Coyote Meadows, and Musgrove sites was done to (1) eliminate fir and spruce competition, (2) create slash fuels to enhance fire spread, and (3) widen prescribed burning windows. One limitation of the RWPE study is all treatments were planned and implemented at the stand level, and successful, long-term restoration of whitebark pine needs to be accomplished at the landscape level.

It takes great patience to restore whitebark pine ecosystems with prescribed burning. High elevation whitebark pine forests are rarely sufficiently dry in the summer to conduct a prescribed burn because of late snowmelt and abundant summer precipitation. Then, in those occasional years where the high country is dry enough for a summer fire, the rest of the landscape is usually in extreme fire danger, and spotting from high elevation fires may start severe fires in low elevation forests (Brown and others 1994). Sometimes one or more years will pass before the right set of conditions allows the implementation of a prescribed burn.

We have been waiting six years to burn the high elevation Coyote Meadows study area.

Autumn seems to be the best season to initiate prescribed fire in whitebark pine forests providing fire danger is low in adjacent, low elevation areas. Since fine herbaceous and woody fuels are rarely cured by the beginning of fall because of high summer precipitation, it is essential that an early, hard frost kill most herbaceous plants and shrub foliage so they will dry quickly and provide dry fine fuels for fire propagation. Usually, the ensuing warm “Indian summer” conditions, common for many western autumns, dry frost-killed plant parts enough to carry a fire.

Probably the most practical tool for creating many, large openings over extensive, remote landscapes are prescribed natural fires, more recently termed wildland fire for resource benefit (WFRB) (Keane and Arno 1996). A WFRB is a lightning ignition that is allowed to burn within a given set of weather and fuel conditions (i.e., prescription), often without being confined by fire line or other man-made fuel breaks. Many whitebark pine forests are found in roadless or wilderness settings with little or no road access, so fire control structures used in conventional prescribed fire, such as hand-line and dozer lines, are costly and infeasible.

WFRB have many advantages. First, ignitions usually occur during the summer, the season when most whitebark pine forests burned historically. Second, a summer ignition can be allowed to burn over many weeks, creating a mosaic of low to high severity fire patterns across the burned area, which was historically common in whitebark pine forests. This makes WFRBs useful landscape restoration tools for both mixed severity and stand-replacement fire regimes. Third, more area can be treated more cheaply with WFRBs than with conventional prescribed fire because fire control structures are minimal and usually fewer people manage the fire. Fire managers risk a great deal with WFRBs because the fires can become uncontrollable wildfires due to the lack of control structures and long burning seasons, endangering human life and property.

Even an extensive burning program cannot rely solely on lightning ignitions. Brown and others (1994) found the highly successful WFRB program in the Selway-Bitterroot Wilderness Area did not burn sufficient area in the whitebark pine type (only 38 percent of historical fires). This is primarily because when whitebark pine forests finally become dry enough to burn, the lower elevation forests were usually very dry and in extreme fire danger. As a result, fire managers are unable or unwilling to allow any new ignitions to burn on the landscape, especially those ignitions in whitebark pine. Therefore, management-ignited prescribed fires, a fire started by fire managers and allowed to burn without fire control within a fire prescription, will probably be needed in the future to restore whitebark pine landscapes.

A Restoration Strategy

Whitebark pine ecosystem restoration does not exclusively imply that historical stand structures be recreated using silviculture or prescribed fire (Apfelbaum and Chapman 1997; Bonnicksen and Stone 1985). To succeed over the long term, ecosystem restoration must emphasize the return of ecosystem processes rather than historical stand and landscape structures and compositions (Crow and Gustafson 1997; Michener 1997; Parsons and others 1986). Historical disturbance regimes, stand structures, and landscape patterns should be used as guides rather than goals in restoration efforts. It is more important that restored processes be in agreement with current and future abiotic and biotic conditions so that restoration activities will have long-term success (Apfelbaum and Chapman 1997). Once important processes, such as the fire regime, are restored to an ecosystem, suitable stand and landscape structures and compositions will follow (Bell and others 1997; Parsons and others 1986). This becomes somewhat problematic when an exotic disease like blister rust devastates whitebark pine stands, but it is still the most viable alternative.

Maintenance of native fire regimes is the single most important management action to ensure conservation of whitebark pine into the future because it creates favorable habitat for seed caching by Clark’s nutcrackers that will effectively regenerate whitebark pine and enhance natural rust resistance (Keane and others 1990). It is important to design restoration treatments to match the characteristics of natural disturbance processes prevalent on the project landscape, and since fire shaped most historical whitebark pine landscapes, it would be desirable to craft restorative treatments to emulate fire’s effect.

Flexibility is crucial for restoration projects in whitebark pine because fire and climate regimes are notoriously variable in time and space. Scheduling treatments and designing future landscapes may be a futile task. The future pattern, severity, and frequency of wildland fires are especially difficult to quantify or describe for a particular spatial or temporal scale. Climate and weather have and will continue to change, and the rate of structural and compositional development across a landscape is also highly variable (Baker 1990; Bartlein and others 1997; Ferguson 1997). It is also highly probable that political, social, and biological climates will change during the century-long successional periods common in whitebark pine forests, and major advances in research and technology can quickly render planned restoration treatments ineffective or obsolete. So instead of conventional treatment schedules, managers may want to take an adaptive management approach to managing landscapes where all landscapes would be evaluated every 10 to 20 years to assess their need for restoration and plan accordingly. Each assessment can integrate the current state of scientific knowledge and technology and then adjust for any changes in the sociopolitical and biophysical environment.

Monitoring effects of restoration treatments is important because it provides feedback as to the success of the treatments for the specified objective to the entire land management community (Michener 1997). More importantly, monitoring is critical for building comprehensive knowledge bases for others to use in their restoration projects. This is especially important in these little studied, rust ravaged ecosystems because there are so few examples of successful treatments. Most monitoring can be accomplished by remeasurement of permanent plots, and taking repeat photographs from fixed points is a valuable, low-cost tool to compliment these measurements. Monitoring design can be intensive, where many variables are measured on numerous plots (Keane and Arno 1996), or less rigorous, where a limited set of measurements are taken on only a few representative plots (Michener 1997).

Restoration Is Feasible

Early results from RWPE restoration treatments, and again from simulation modeling, show prescribed burning and selective cutting treatments can be highly effective for restoring whitebark pine (Keane and Arno 1996; Keane and others 1996a; Keane and others 1990; Keane and others 1994). Moreover, our observations in this ecosystem lead us to believe that any ecologically sound treatment that opens the canopy and reduces subalpine fir competition will be successful. Granted, rust may kill some pine regeneration established after treatment, but chances are there will be a high level of rust resistance in the surviving seedlings. This resistance can then be passed to their progeny, ultimately conserving the species through natural breeding programs. The only way this can work at scales large enough to ensure the whitebark pine conservation is with an active fire program that utilizes conventional prescribed burning, WFRB, and manager-ignited fires to restore fire excluded ecosystems and maintain fire regimes.

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