Fire and Pacific Coast Whitebark Pine

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Abstract

Although whitebark pine ecosystems are widely distributed along the Pacific Coast mountain ranges, their fire ecology is not well known. In the Cascade Range, evidence of historic fires is common and fire return intervals are wide-ranging. Overall, findings from the Pacific Coast ranges indicate that whitebark pine readily recolonize stand-replacing fires. Fire severity is variable, reflecting a mixed severity regime. Perhaps as a result of fire exclusion, late-seral competing species have taken over about 12.5% of former whitebark pine dominated stands in the Cascades. Managers are encouraged to carefully reintroduce fire. Priority should be given to sites characterized by historically frequent non-stand replacing fire. Fire professionals should promote lightning-caused fire whenever possible, plan prescribed fires based on site-specific stand histories, and work with Natural Resource Specialists to protect disease-resistant trees from lethal burning.

Introduction

Since the early 1980's we've become aware of fire's multi-faceted influence on whitebark pine (*Pinus albicaulis*) ecosystems, but nearly exclusively in the U.S. Rocky Mountains. As a keystone process, fire is often responsible for promoting whitebark pine in two fundamental ways. First, fire can limit less fire-hardy competitors (Arno and Hoff 1990). Second, blazes promote regeneration as evinced by Clark's nutcrackers caching seeds in recently burned sites (Tomback and others 1993). Insight regarding fire dynamics and whitebark pine have been revealed primarily through research into fire history, post-fire effects, and succession.

In comparison to the Rocky Mountains, the Pacific Coastal whitebark pine forests support more tree species, endure a different climate, and tend to be more isolated into smaller stands – all important implications for applying fire. Yet little is known about the relationship between fire and these forests.

This paper reviews emerging findings along the Pacific Coast and provides some preliminary recommendations for managing whitebark pine with fire. The conclusions from several studies are offered, including a recent fire history project conducted by Siderius and Murray (2005) which has not yet been published in the scientific literature.

Emerging Results and Discussion

Fire: Commonplace or Rare?

A commonly held view of natural fire, is that it tends to be rare in the high elevations of the Pacific Coast mountains where sparse fuels and lingering snowpacks limit burning. Virtual absence of fire evidence, such as tree scars, is commonly believed – and supports this notion

(Mastrogiuseppe 2003). However, until recently no systematic investigation of fire's history in the whitebark pine zone had been conducted in this region.

In 2003, we initiated a field study to examine Cascadian fire history and found evidence that fire was a common element of whitebark pine forests in the past (Siderius and Murray 2005). Although fire scars may not be as widespread, compared to the Rocky Mountains, we found a substantial number. The presence of charcoal, either on the ground or on tree relics, was observed at 88% of sites signifying fire's prevalent influence (fig. 1).

Figure 1— Fire scars and charred wood are common in the whitebark pine zone of the Cascades. (Left: Sawtooth Ridge, Chelan Ranger District (photo by Joel Siderius.) Right: Mission Ridge above Wenatchee, WA (photo by Michael Murray.))

Post-fire Succession

Studies indicate that whitebark pine readily establish the post-burn environment in this region. Perhaps the first formal observation is an account by Hofmann (1917) on the flanks of Mount Adams, WA. On a large burn (approximately 28,000 hectares) from 1892, whitebark pine were observed reproducing along with noble fir (*Abies procera*) and Pacific silver fir (*A. amabilis*). Firs dominated the new tree cover (66%) followed by whitebark pine (9%), hemlock (*Tsuga* sp.) (9%), and lesser amounts of other species. They formed a fairly uniform distribution.

A fire on Cathedral Peak, Yosemite National Park, CA was examined for post-fire recruitment of whitebark pine (Tomback 1986). This high-severity burn supported significantly more seedlings than the adjacent unburned site. Tomback (1986) surmised that Clark's nutcrackers were the primary source of regeneration. McDowell (2006) found a negative relationship between fire-induced mortality volume and seedling densities. She also reported higher seedling recruitment at greater distances from the burn edges.

A chronosequence of stand conditions resulting from nine fires was examined in whitebark pine – subalpine fir (*Abies lasiocarpa*) forests of the southern BC Coastal Mountains by Campbell and Antos (2003). They found that both whitebark pine and subalpine fir established well in the post-fire environment. However, by about 269 years post-burn, whitebark was reduced in favor of subalpine fir.

Severity

In examining tree age structure, Campbell and Antos (2003) found both stand-replacing and mixed-severity burns among past fires. The stand-replacing fires were most common. Hofmann (1917) characterized the large Mount Adams Burn as killing "almost all of the timber" except for "occasional patches in such places as near a marsh or spring." Tomback (1986) observed that the Cathedral Peak fire severely burned a stand of krummholz

whitebark pine. Some live trees were nearly consumed by the flames, leaving only charred fragments.
We examined the most recent fire event at each site we sampled (Siderius and Murray 2005). Based on forty-three fires, we found a mix of high-severity (56%) and non-stand replacing (44%) fires.

Two very small lightning-caused fires at Crater Lake National Park were monitored for mortality after they were suppressed. The Mulligan Fire occurred in a closed-canopy stand of mountain hemlock (*Tsuga mertensiana*) – Shasta fir (*Abies x shastensis*) – whitebark pine in 2002. All five mature whitebark pine in the perimeter were heated by flames. Two were directly killed by torching. One of the three remaining scorched trees was colonized by mountain pine beetle (*Dendroctonus ponderosa*) within days of the fire. By the next year, it was dead.

The Dutton Fire ignited in August 2004 in a timberline mosaic of meadows among small 'islands' of whitebark pine supporting a minor component of mountain hemlock and Shasta fir (fig. 2). This fire torched or scorched most trees within the small (.01 ha) island where fire was unable to spread in the sparse fuels of the surrounding meadow. Within a month, most of the torched trees were heavily infested with mountain pine beetle, thus a stand-replacing event was the outcome.

Figure 2—The 2004 Dutton Fire, Crater Lake National Park, was a small stand-replacing burn. (Photo by Michael Murray.)

Frequency

To date, only one study has examined the historical frequency of natural fires in whitebark pine ecosystems. Siderius and Murray (2005) studied three Cascadian National Parks (Crater Lake NP, Mount Rainier NP, and North Cascades NP) along with adjacent National Forest lands.

Cascadian forests support an impressive range of fire frequency. We detected fire return intervals for every 10-year class up to 160-169 years (fig. 3). Most fires (67%) occurred at intervals less than 100 years. However, 18% of plots supported evidence of only a single fire and 14% had only charcoal evidence – suggesting longer (multi-century) fires. Individual burns often fail to leave detectable evidence, so it's possible that we missed some events, thus overestimating fire interval lengths. This potential shortcoming is inherent to fire history research (Agee 1993).

Overall, we found a negative correlation between latitude and frequency of non-stand replacing fires. This modest correlation is significant (r_s=.453 at P=0.10) and indicates that fire intervals shorten with higher latitudes (fig. 4). This may be explained by lightning pattern and the tendency of northern forests to support more complete understory vegetation cover providing surface fuel.

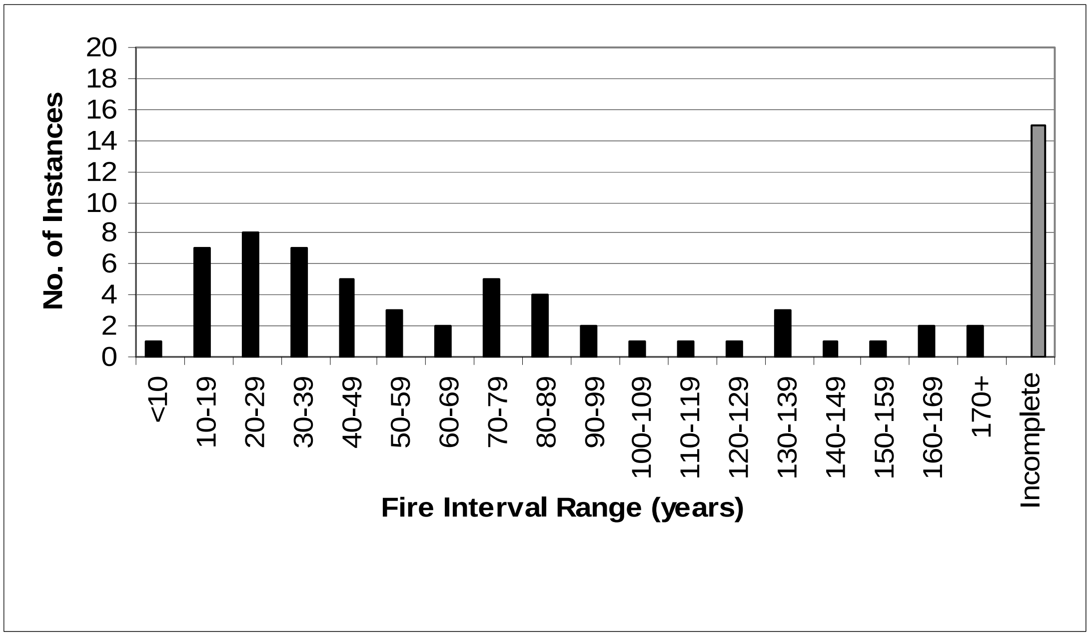

Figure 3—Distributional frequency of fire intervals. Last bar denotes instances where only a single fire was detected – incomplete interval (Siderius and Murray 2005).

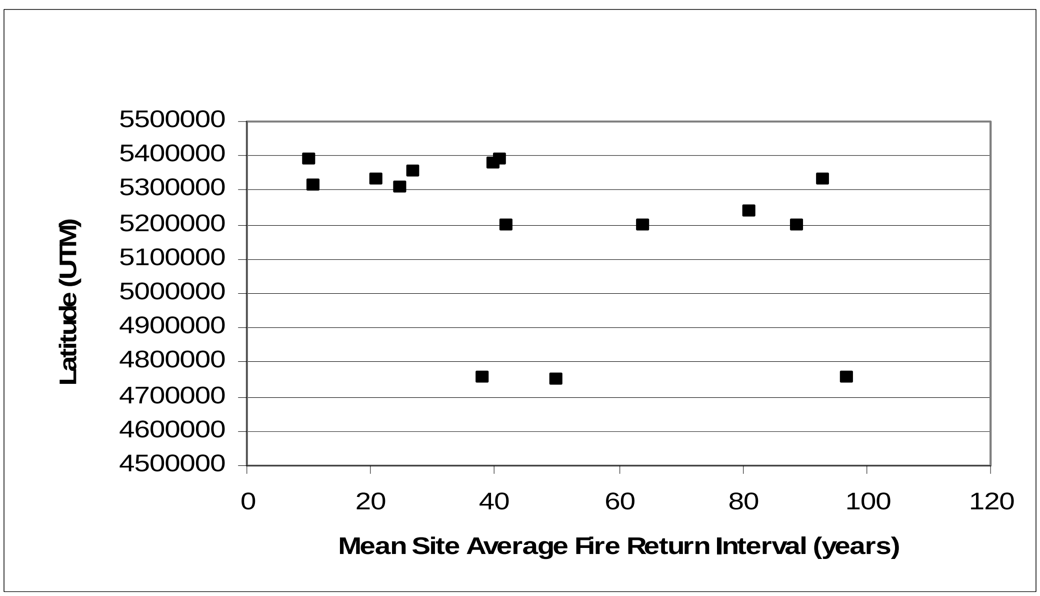

Figure 4—A moderate correlation between latitude and fire intervals in the Cascades based on three study areas (Crater Lake, Mt. Rainier, and North Cascades).

Comparison with Rocky Mountains

In comparing Cascadian fire ecology with the Rocky Mountains, the similarities are notable. The tendency of whitebark pine to readily colonize and develop significant volume in burned sites is well-documented in the Rockies (Arno and Hoff 1989; Murray 1996; Tomback 1994). On most acreage that is not too high and harsh for competitors, late-seral species gradually increase in proportion to whitebark pine in the absence of disturbance (Keane and Arno 1993; Murray and others 2000). Another similarity is the mixed-severity regime (Arno 2001), although as indicated above (Severity section), Pacific Coast fires tend more towards stand-replacing behavior. Fire return intervals are extremely wide-ranging in both regions. For example, in the Rockies, Barrett (1994) found non-stand replacing events to range between 66 and 204 years. Murray (1996) found these fires every 42 – 256 years. However, Cascadian fires appear to be skewed towards shorter intervals, at least in the north where frequencies *average* as low as 10 years northeast of Winthrop, WA (fig. 5). Examining two similar covertypes, the mean frequencies are alike (Table 1). It should be noted again that many whitebark pine stands have evidence of only a single fire and a small percentage have no dateable events. Whether these instances represent longer intervals or where fire simply failed to leave evidence is not known. In general, mixed severity regimes are especially challenging to sample, characterize, and convey to an audience (Agee 2005).

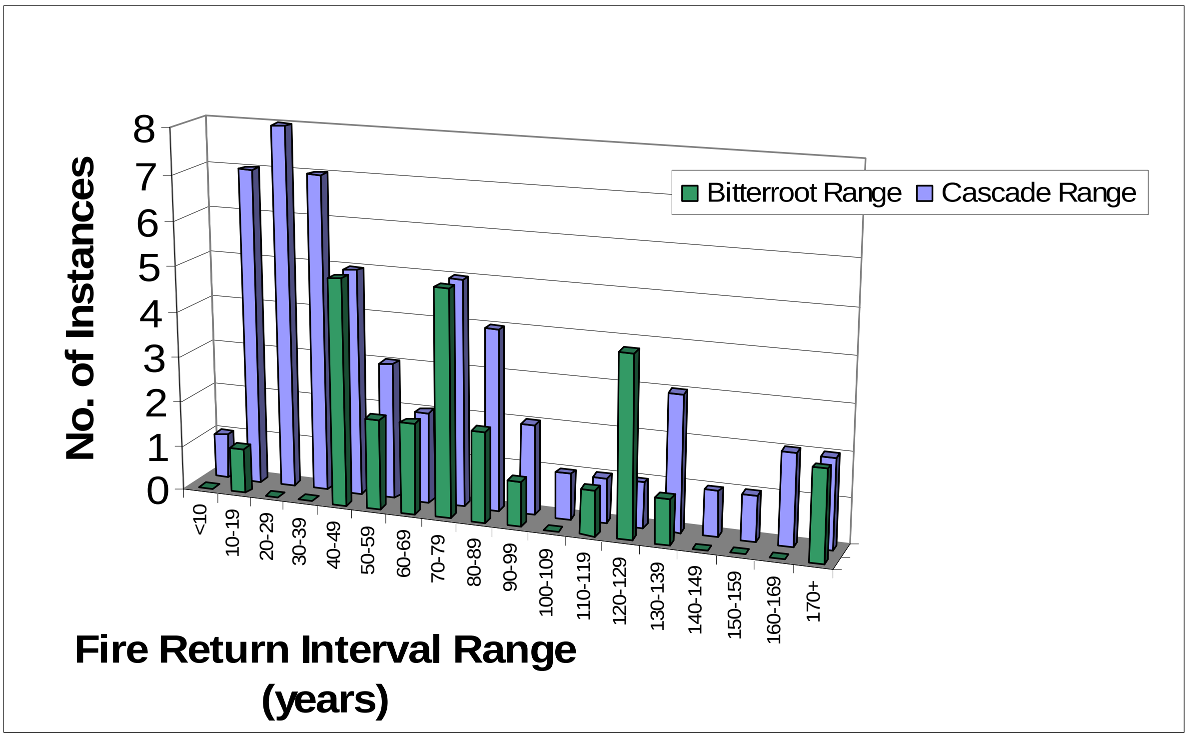

Figure 5—A comparison of fire interval distributions between Bitterroot (Murray 1996) and Cascade (Siderius and Murray 2005) regions.

Table 1—A comparison of average fire return intervals between the Bitterroots (Murray 1996) and Cascades (Siderius and Murray 2005).

Overstory	Location	No. of Plots	Mean Fire Return Interval (years)
Pure Whitebark Pine	Cascades	11	85
Pure Whitebark Pine	Bitterroots	3	96
Whitebark Pine – Lodgepole Pine	Cascades	9	73
Lodgepole Pine – Whitebark Pine – Douglas-fir	Bitterroots	64	92

Are whitebark pine declining due to lack of fire?

Fires have diminished since the early 19th century in the Cascade Range (Siderius and Murray 2005). During the time period of 1800-1900, we found 51 fire events. The period of 1900-2000 supported only 22 fires. This represents a decrease of approximately 57%. Few recent fires (post-1950) were documented in this study.

The marked decline in fire may be yielding an increase in the abundance of fire-sensitive late-seral tree species and a decrease of openings conducive to whitebark pine regeneration. By applying stand reconstruction methodologies, we estimate that late-seral species, especially Shasta and subalpine fir, have increased volume at dramatic levels. Since 1924, these two species have increased 4181% and 2888% respectively. Surprisingly, whitebark pine has also increased about 280%. This result may be due to recovery from widespread fires in the late 1800s, shortcomings in the spreadsheet model, and/or high growth rates for saplings/seedlings. Estimates of stem area volume alone may not be the best measure of historical abundance. Regardless, our results indicate late-seral species have taken over 12.5% of former whitebark pine dominated stands. Therefore, although fire exclusion has not led to the reduction of whitebark pine, it is likely allowing competing species to replace whitebark pine as the dominant species. This trend has already been observed in the Rocky Mountains where subalpine fir is actually reducing whitebark pine through competition (Keane and Arno 1993).

Recommendations for Fire Management

Opportunities for Lightning-caused Fires

With the knowledge that fire has been an important historic component of Pacific Coast whitebark pine forests, it's time to carefully consider where and how to reintroduce this missing element. When presented with the opportunity, *allowing lightning-ignited fires to burn whitebark pine stands is the preferred scenario for re-introducing fire* (fig. 6). First, the location is determined by nature, and not biased by human selection. Since most whitebark pine is remote from human development, there is rarely a hazard. Second, the pattern of fire will be more natural. Management-ignited fires tend to create a much larger ignition area (e.g. aerial ping-pong balls, drip torch striping) than would occur naturally. This can result in extensive stand-replacing burns which may not be typical for the target area's fire regime. Third, lightning fires occur at the time of year when forest communities are best adapted to burn. Thus the appropriate seasonality is achieved. Fourth, lightning-ignited fires are typically much less expensive to manage than prescribed or suppression fires (USDA 2006).

Figure 6—Attendees of this conference's field trip observe a fire at Crater Lake NP as it reaches the whitebark zone. Started by lightning on July 23, 2006, this fire (Bybee Complex) was managed as "wildland fire use for resource benefits." (Photo by Michael Murray.)

Unfortunately, due to management and political constraints, the vast majority of lightning fires, even in remote whitebark pine habitats continue to be suppressed in Canada and the U.S. (CFS 2006; NIFC 2006). Relying solely on the occasional administerial approval of a lightning fire may not reintroduce fire at a meaningful scale. Thus, prescribed fire, if carefully applied, can provide ecological benefits to whitebark pine ecosystems (Arno 2005).

Prescribed Fire

Given the inherent high variability of fire in these ecosystems, local Natural Resource Specialists should tailor prescriptions with Fire Managers to match site-specific regimes. Evaluating fire history and fuel conditions of individual stands prior to any management-ignited burning is critical for the appropriate application of fire in these sensitive forests.

Priority should be given to sites characterized by historically frequent non-stand replacing fire.

It's likely that these stands are most affected by decades of fire exclusion. Moreover, fire behavior is less risky to manage than stand-replacing regimes. Conversely, applying human ignitions in stands with little or no evidence of historic frequency may actually do more harm than good to the ecological integrity of the stand.

To select and define burn units, Natural Resource Specialists should first assess candidate stands for visual clues indicating frequent fire which include extensive grass or shrub cover and fire scars. Stands with low fire frequency are often characterized by mountain hemlock, sparse understory vegetation and/or exposed rocks or mineral soil (often pumice).

Don’t Burn Disease Resistant Trees

Fire managers should always be cognizant of the unique status and threats to whitebark pine – a ‘sensitive species.’ Fire-induced mortality of potentially disease resistant trees should be strictly avoided. They are the life-link to the species’ future. Where blister rust infection is high, it’s strongly recommended that pathologists or trained technicians survey for healthy mature trees prior to burning operations or during lightning-fires (safety permitting). Managers can protect these trees from flames by mitigating ladder and surface fuels in their immediate vicinity. Depending on the particular fire incident, other options such as water dropping, wet lining, or foil wraps could be considered.

As an example, during the 2006 Bybee Complex Fire, a two-person crew searched for healthy trees as the fire reached the whitebark pine zone. Twenty-six healthy mature individuals were identified as possible disease resistant trees as the fire crept close by. Beneath each tree, we removed dead and down fuel, and then established hand lines near each tree crown’s drip line (fig. 7). Fire Managers were very supportive and none of the candidate trees suffered fire injury.

Figure 7—The 2006 Bybee Complex Fire threatened about 26 disease-resistance candidate trees. For this tree, we removed woody debris and constructed a handline beneath its canopy to the unburnable meadow edge. (Photo by Michael Murray.)

Information Gaps

Overall knowledge of fire effects, size, spatial pattern, and seasonality is lacking for the Pacific Coast ranges. Investigation of historical frequency in California, British Columbia, and the Olympic Range will prove useful. Questions remain pertaining to the relationships between fire and blister rust disease incidence, and its alternate hosts. Whitebark pine’s tolerance (survivorship) of fire under various environmental conditions is poorly understood. Improved knowledge of interrelationships between mountain pine beetle and fire is also needed.

Conclusions

Fire is an historical influence on whitebark pine of the Pacific Coast mountain ranges. A mixed-severity regime with a broad range of fire return interval lengths indicate complex relationships between fire and the pine. Late-seral competitors appear to be overtaking whitebark pine at some locations. Re-introducing fire can benefit whitebark pine, but it must be undertaken with extreme care. Managers should promote lightning-caused fire whenever possible and plan prescribed fires based on site-specific stand histories. In the face of a non-native plague, protecting healthy and potentially disease-resistant trees from lethal burning is imperative.

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