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Six-Year Post-Fire Mortality and Health of Relict Ponderosa Pines in the Bob Marshall Wilderness Area, Montana

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Abstract: *In 2003, lightning-caused fires burned through relict ponderosa pine (*Pinus ponderosa*) stands in the Bob Marshall Wilderness, Montana, after decades of fire exclusion. Since many trees in these stands had Native American bark-peeling scars, concern arose about the adverse fire effects on this cultural and ecological resource. In 2004, Keane and others (2006) began a post-fire monitoring study of the relict pine stands. In 2009, we completed a six year re-measurement of those stands. We found that many of the pines with major fire injury had recovered, and tree mortality was not as high as initially estimated. A low-intensity surface fire, prescribed or lightning-caused, within the next 10 years will help preserve the health of these stands in the future.*

Keywords: Bob Marshall Wilderness, wilderness prescribed fire, bark-peeled trees, post-fire mortality, *Pinus ponderosa*

Introduction

In 2004, Keane and others (2006) began a post-fire health and mortality assessment of two rare stands of large-diameter ponderosa pines (*Pinus ponderosa*) near White River Park and Big Prairie in the Bob Marshall Wilderness Area on the Spotted Bear Ranger District, Flathead National Forest, Montana. The study was conducted to evaluate the impacts of the Little Salmon Complex fire, which burned through the area in the summer of 2003. White River Park and Big Prairie are home to relict stands of ponderosa pine that are between 75 and 600 years old and have great cultural and ecological significance (Arno and others 2008). The stands are limited in area by both climate and elevation (Keane and others 2006), and many of the older pines have Native American bark peeling scars from historical use by the Salish, Kootenai, and Blackfeet tribes (Ostlund and others 2005). Since old-growth ponderosa pine stands in the Inland Northwest are rare because of broad-scale historical logging, the Bob Marshall stands present a unique opportunity to preserve and improve resilience of this cultural and ecological resource in a relatively undisturbed, non-fragmented wilderness landscape (Ostlund and others 2005).

After the 2003 fires, concern arose among land managers that trees in these relict stands would suffer high mortality, as the area had previously experienced prolonged fire exclusion that resulted in heavy fuels accumulation (Keane and others 2006). In 2004, Keane and others (2006) assessed the health status of 455 large-diameter (>20 inches [50.8 cm] diameter

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at breast height [DBH]) ponderosa pines with a goal of examining fire disturbance impacts to help guide preservation management decisions; in 2005, they reassessed those same trees.

In August of 2009, we completed a six-year post-fire reassessment of the White River Park and Big Prairie ponderosa pines using the same methods as Keane and others (2006). In addition to measuring DBH and assessing the health status of 482 large-diameter pines, we assessed the post-fire mortality of 891 smaller-diameter (12 to 20 inches [30.5 to 50.8 cm] DBH) ponderosa pines. This report details the changes in mortality and health of the large-diameter pines from 2004 to 2009 and discusses the status of small-diameter pines in 2009. An emphasis was placed on evaluating the survival of culturally and fire-scarred trees, and management guidance is offered.

Study Site

The ponderosa pine communities in the South Fork of the Flathead Valley are geographically limited to an 8-mile (12.9-km) stretch of riverside terraces near Big Prairie and the White River/South Fork of the Flathead confluence (fig. 1). This area receives less rain and snow than areas upstream or downstream, which are dominated by Douglas-fir (*Pseudotsuga menziesii* var. *glauca*), lodgepole pine (*Pinus contorta*), subalpine

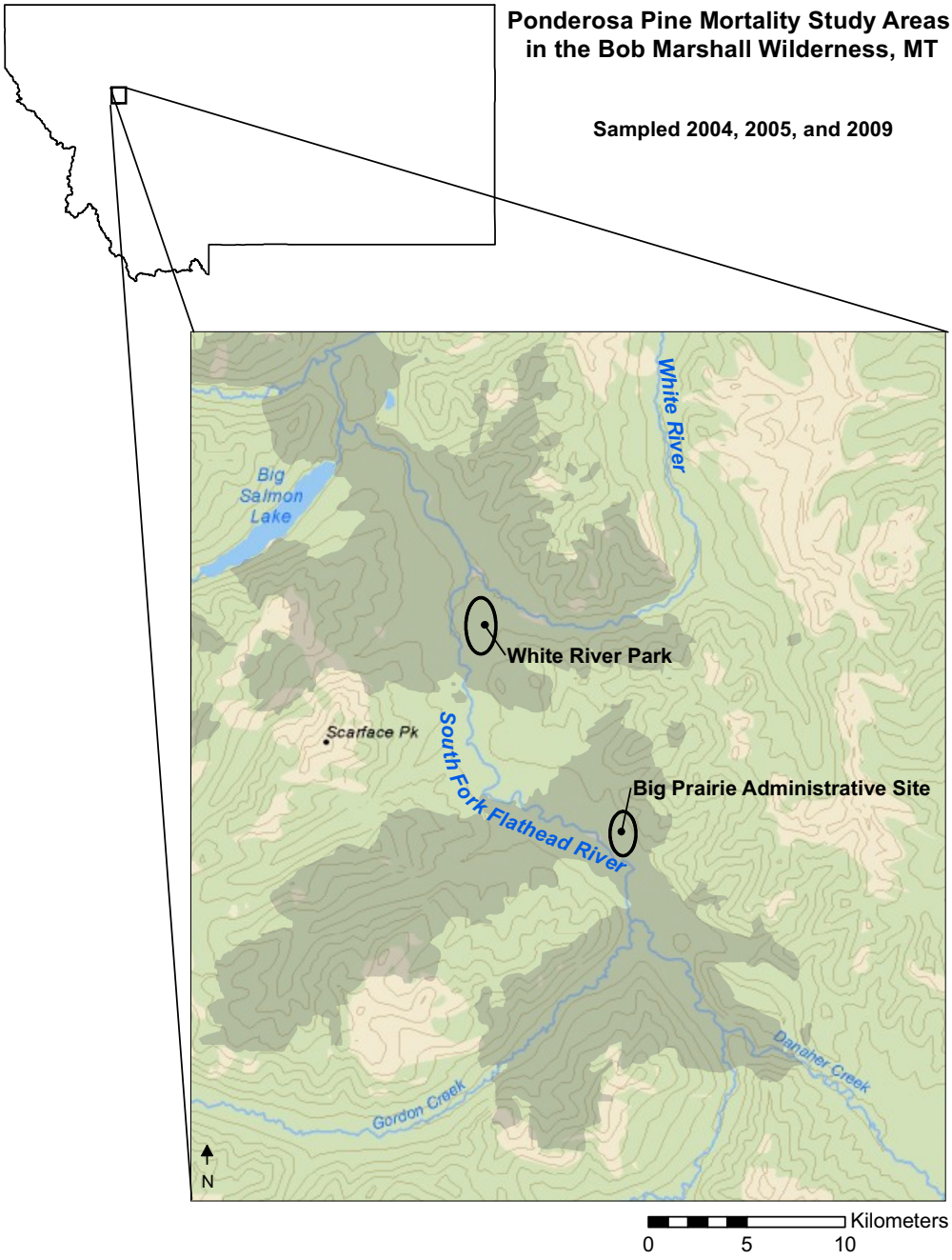

Figure 1—White River Park and Big Prairie ponderosa pine mortality study sites on the South Fork of the Flathead River; the 2003 fire perimeter is shaded gray.

fir (*Abies lasiocarpa*), and some western larch (*Larix occidentalis*). The ponderosa communities near the South Fork are limited in regenerative potential by the relatively high elevation (4400 to 4900 ft or 1350 to 1500 m) and a short, frost-free season, which hinders cone production and regeneration (Keane and others 2006). Prior to 1930, the area had a mean fire return interval of 20 to 30 years (Arno and others 1997). Observations made by Ostlund and others (2005) suggest that many of the fires may have been started by Native Americans who occupied the area prior to circa 1850. The fires are thought to have maintained ponderosa pine as the dominant tree species in this area (Ostlund and others 2005). After 1930, fire was mostly excluded from the study area until 2003 when lightning started the Little Salmon Complex fire that burned much of the South Fork Valley, including more than half of the area occupied by the relict ponderosa pine (Keane and others 2006).

Methods

In 2004, 2005, and 2009, all large-diameter (>20 inches [50.8 cm] DBH) ponderosa pines were measured in the study area boundary. Because the study area was in a designated wilderness area, we did not tag individual trees; therefore, there is some variation in sample size from year to year. Trees were measured along broad transects (approximately 328 ft or 100 m wide). For each tree, we recorded health status (healthy, minor injury, major injury or dead), DBH, and presence of fire or bark-peeling scars. In this study, a healthy tree showed little or no sign of fire injury or mountain pine beetle infestation; a tree with minor injury had some crown scorch or other fire injury but was expected to fully recover; and a tree with major injury had some combination of high crown scorch (>40%), mountain pine beetle infestation, or other fire injury that made the tree unlikely to recover. In 2004, the probable cause of mortality (for example, fire, beetle, or unknown) and percent crown scorch were also estimated, and GPS coordinates were taken for each tree (Keane and others 2006). In 2009, we also measured mortality, DBH, and presence of fire or bark-peeling scars for 891 smaller ponderosa pines (>12 inches [30.5 cm] DBH). Only small trees that had recently died (based on visual examination) were sampled in this study; pine snags that were dead before the 2003 fire were not sampled.

Though the study area boundary was approximated as closely as possible year to year, the large size of the study area meant that some trees near the boundary were included or excluded in one year and not in the next. Attempts to relocate trees in 2005 based on the 2004 GPS coordinates were made but the error in the GPS coordinates was often higher than tree spacing. In 2004, 455 large trees were measured; in 2005, 426 large trees were measured; and in 2009, 482 large trees were measured. We did not measure trees that had fallen post-fire, so it is possible that some trees fell during the study and were not re-measured. Based on observation of the study area over time, this effect is minimal.

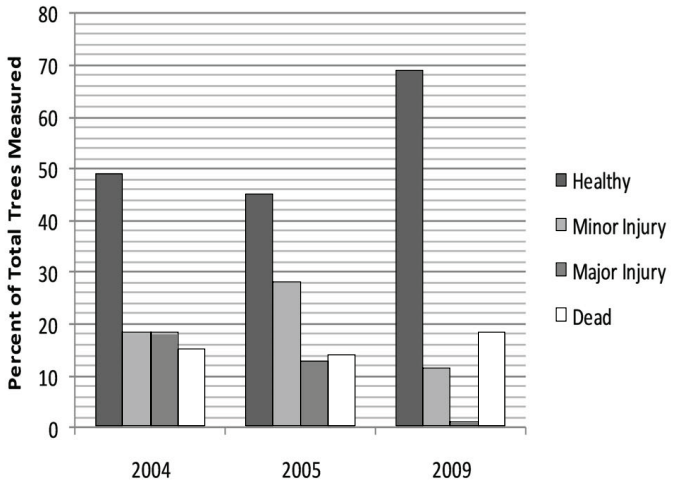

Figure 2—Status of ponderosa pines over 20 inches (50.8 cm) DBH in 2004, 2005, and 2009 as percent of total large-diameter trees.

Results

Tree Mortality

Figure 2 shows the distribution of large-diameter (>20 in [50.8 cm] DBH) ponderosa pines by year and tree status. In 2009, 69% of the measured trees were healthy, 11.5% had minor injury, 1% had major injury, and 18.5% were dead. By comparison, 26% of the small-diameter trees measured in 2009 were dead. Combined mortality for large- and small-diameter trees was 24% in 2009 based on a sample size of 482 large-diameter trees and 891 small-diameter trees. The mortality of 18.5% for large trees in 2009 was not a significant increase from 15% mortality in 2004 ($\alpha = 0.05$, $p = 0.2$).

In fig. 3, mortality by DBH is detailed by 2-inch size classes. Consistent with other studies of fire mortality (Howard 2003), there was a decrease in mortality as DBH increased, and trees at or above 40 inches (101.6 cm) DBH experienced zero mortality from the 2003 fire. The fitted regression line ($R^2 = 0.64$) might be used to estimate mortality in other Bob Marshall Wilderness Area ponderosa pine stands that have had

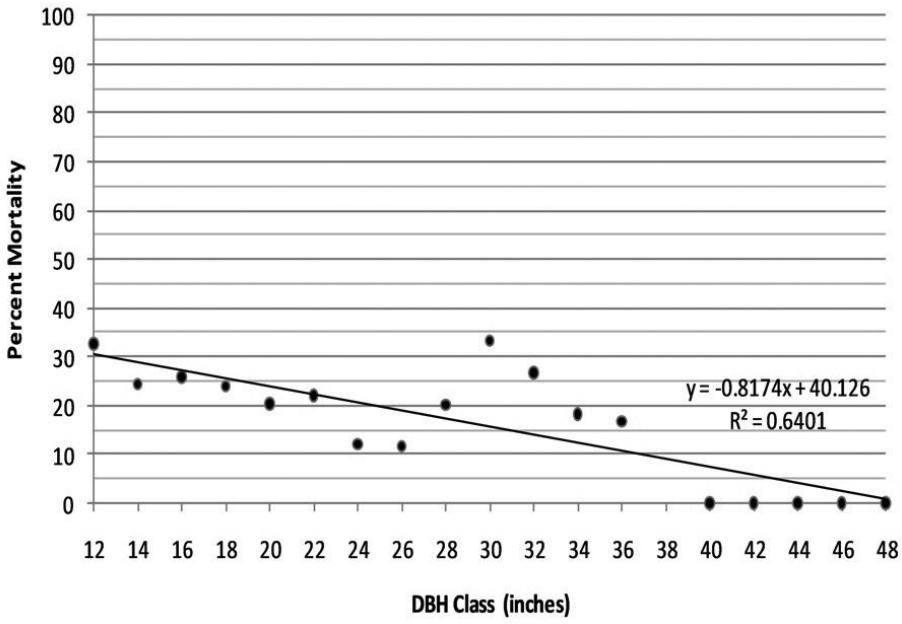

Figure 3—Percent mortality of ponderosa pines in 2009 by DBH (inches).

decades of fire exclusion. Because many factors might influence post-fire tree mortality on a given site (such as antecedent climatic conditions, burn season, bark beetle populations, and fuel loadings), this relationship should only be used as a starting point.

Changes in Large-Diameter Tree Health Status: 2004-2009

The most notable change in large-diameter tree health from 2004 to 2009 was the reduction of trees showing major injury. In 2004, it was expected that most trees in this class would not recover because of percent crown scorch, possible cambial girdling (due to heavy pre-fire duff and litter accumulation), and post-fire insect and disease invasion of the weakened trees (Keane and others 2006). Trees with major injury accounted for 18% of the total trees measured in 2004 (fig. 2), which initially led to an estimated total mortality of 34% within a few years (Keane and others 2006). We found that a substantial portion of the large-diameter ponderosa pines with major fire injury actually recovered, as shown by the significant increase in healthy trees ($\alpha = 0.05$, $p<0.0001$) and the significant reduction in trees showing signs of major injury ($\alpha = 0.05$, $p<0.0001$) between 2004 and 2009 (fig. 2). While the 2009 mortality of 18.5% for large-diameter ponderosas was lower than expected, it is possible that some, but not many, dead trees could have fallen or been blown over since 2004 and were not accounted for in the 2009 measurements.

Status of Scarred Trees

Large Diameter

Of the trees measured in 2009, there was no significant difference in mortality between culturally or fire-scarred trees and unscarred trees ($\alpha = 0.05$, $p = 0.5$). In contrast, scarred trees measured in 2004 had a significantly higher mortality than unscarred trees ($\alpha = 0.05$, $p = 0.0001$) (Keane and others 2006). This suggests that most fire-caused mortality of scarred trees occurred in the year immediately following the fire, while unscarred trees experienced more delayed mortality. This trend is also shown by the significant increase in unscarred tree mortality between 2004 (11%) and 2009 (19%), where $\alpha = 0.05$ and $p = 0.01$.

Small Diameter

Because the small-diameter pines were not measured in 2004 or 2005, we could not compare mortality over time. In 2009, 44% of all small-diameter scarred trees were dead, which was significantly higher than the mortality of 26% for small-diameter, unscarred trees ($\alpha = 0.05$, $p = 0.02$).

Discussion

Heavy duff and litter accumulations (>4 inches or 10 cm deep) and encroaching conifer ladder fuels were mostly consumed in the 2003 fire in both the White River Park and Big Prairie stands (Keane and others 2006).

In general, this was a desirable effect because few of the large pines were killed by severe soil heating from burning duff and litter (Keane and others 2006) and fire risk to the nearby Big Prairie administrative site was reduced. Post-fire forest structure in White River Park is now open and park-like with a grass understory and very few ponderosa pine seedlings, as reproduction is limited by the relative dryness of the site compared to surrounding stands (Keane and others 2006). Periodic fire, lightning-caused or prescribed, on a 10 to 30-year interval would be beneficial to this site to limit duff and litter accumulations and prevent future ponderosa mortality caused by soil heating and cambial girdling.

In 2009, an abundance of lodgepole pine seedlings were observed in the burned ponderosa pine stands at or near Big Prairie, indicating that the future forest structure, in the absence of fire, will again be widely spaced ponderosa pine with a dense developing understory of lodgepole pine. This will result in the possibility of higher fire risk to these stands and a return of higher fire risk to the Big Prairie Administrative Site. A prescribed, low-intensity surface fire within the next 10 years might be warranted to reduce lodgepole pine densities to maintain ponderosa pine health and to reduce the increasing fire risk. It is critical that fire treatment occur before the lodgepole pines develop viable cones, which is usually within 5 to 15 years (Anderson 2003). Much of the success in restoration of forest structure as a result of the 2003 fire could be lost if these lodgepole seedlings reach maturity. Considering the close proximity of these stands to the Big Prairie Administrative Site, periodic fire to reduce lodgepole density might also prevent the need to use heavy fire suppression tactics in this area in the future.

Despite the optimistic 2009 results, close to 30% of culturally scarred ponderosa pine were lost to the 2003 fire (Keane and others 2006). This number is substantial considering the rarity of these intact, undisturbed stands. Historically, fires burned through these and most other ponderosa stands on a regular basis, keeping fuel accumulation and encroachment from other conifer species to a minimum (Arno and others 2008). If fire is once again excluded for an extended length of time, conditions conducive for high ponderosa pine mortality will increase, and more culturally and ecologically significant trees might be lost.

This study only measured the effects of one fire on two relict stands. There are a number of other variables that influenced the health and recovery of these trees, including post-fire climatic conditions, bark beetle populations, and weather events (for example, wind and snow damage). While the results of the 2009 measurement are encouraging in terms of survival of large ponderosa pine trees, active management of these stands should still be carefully considered due to their cultural and natural significance. Taking into consideration the fact that fire use by Native Americans likely allowed this stand condition to develop and exist for centuries (Ostlund and others 2005), prescribed fire is an appropriate tool to maintain these stands while still adhering to wilderness values.

Conclusion

Overall, the large-diameter ponderosa pines in White River Park and Big Prairie are experiencing much better survival than expected after the 2003 fire. Many of the trees with notable fire injury and that appeared to be dying in 2004 and 2005 have recovered and delayed mortality has been minor. As expected, the mortality rate for small trees (26%) was significantly higher ($\alpha = 0.05$, $p = 0.01$) than that of large trees (18.5%), which is a desirable trend when considering health and vigor of the stand (fig. 3). A high proportion of scarred trees were lost immediately post-fire, but that trend appears to have stabilized.

Land managers on the Spotted Bear Ranger District in the Flathead National Forest have a considerable cultural and ecological resource under their jurisdiction. The results of the 2003 fire provided a first step toward restoration and now present a unique opportunity to preserve this resource well into the future through the use of innovative wilderness management. In the absence of lightning-caused fire and considering the history of Native American fire use in this area, wildland fire and manager-ignited fire might be warranted as tools to help protect and enhance these relict stands in the Bob Marshall Wilderness Area.

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