Signs of Recovery for Colorado Forests in the Wake of the Mountain Pine Beetle

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The mountain pine beetle (MPB) has affected 2.3 million acres of Colorado lodgepole pine forests since 1996 (USFS 2009). In infested stands, live lodgepole basal area typically declines by 70% and often exceeds 90% in mature, even-aged stands (Klutsch et al., 2009; Collins et al., 2010). Lodgepole pine is well known to rapidly regenerate into dense forests after wildfire or harvesting.

Yet, in the initial phase of this outbreak, it remains uncertain how Colorado lodgepole forests will recover from MPB. Recent evidence from beetle-infested lodgepole pine forests in British Columbia found that pine seedlings failed to reestablish for more than a decade (Astrup et al., 2008). In Colorado, land managers and the public share the following general concerns about the recovery of our forests after the beetle outbreak:

- *Will poor seedling establishment be widespread in beetle-infested lodgepole forests in Colorado?*
- *Will the species composition of the forests that establish after MPB differ from the species composition of the forests prior to the outbreak?*
- *How long will it take for beetle-infested forests to recover?*

Additionally, there has been a dramatic increase in harvesting of beetle-infested trees on federal, state and private forests throughout northern Colorado to reduce the potential for wildfire and minimize risks for public safety and infrastructure from falling trees. The ultimate consequences of current management will not be clear for many years, but initial indications about how forest regeneration may differ between harvested and unharvested beetle-infested stands can guide and validate management decisions as the outbreak progresses. On-going operational-scale research can answer the following questions:

- *Does harvesting of beetle-infested stands change the density or composition of stands relative to uncut stands?*
- *Is harvesting necessary to ensure recovery of an adequate density of preferred species?*
- *Does post-harvest seedling colonization differ between beetle-infested and live lodgepole forests?*

With support from the USFS, the Colorado Forest Restoration Institute and the Colorado Water Conservation Board, Rocky Mountain Research Station scientists are collaborating with USFS and CSFS managers to design studies to address these general questions and to characterize the initial trajectory of forest recovery in the wake of the MPB.

Colorado Forest Restoration Institute

Colorado State University

Rocky Mountain Research Station

Forest Conditions

The Sulphur Ranger District was at the center of the MPB outbreak that reached epidemic levels in the late 1990s. The Fraser Experimental Forest first experienced MPB activity in 2003; by 2006, the majority of the area was infested by the beetle. In spite of the substantial management response, USFS managers expect to harvest less than 15% of the total area affected by the MPB outbreak. Century-old lodgepole pine dominates the overstory and subalpine fir, Engelmann spruce and quaking aspen are common in the understory of these study areas. In other locations, lodgepole pine forests lack the same understory species diversity and are likely to respond differently to MPB or other forest disturbance.

Key Findings

Seedling Colonization in Unharvested and Harvested Beetle-infested Stands

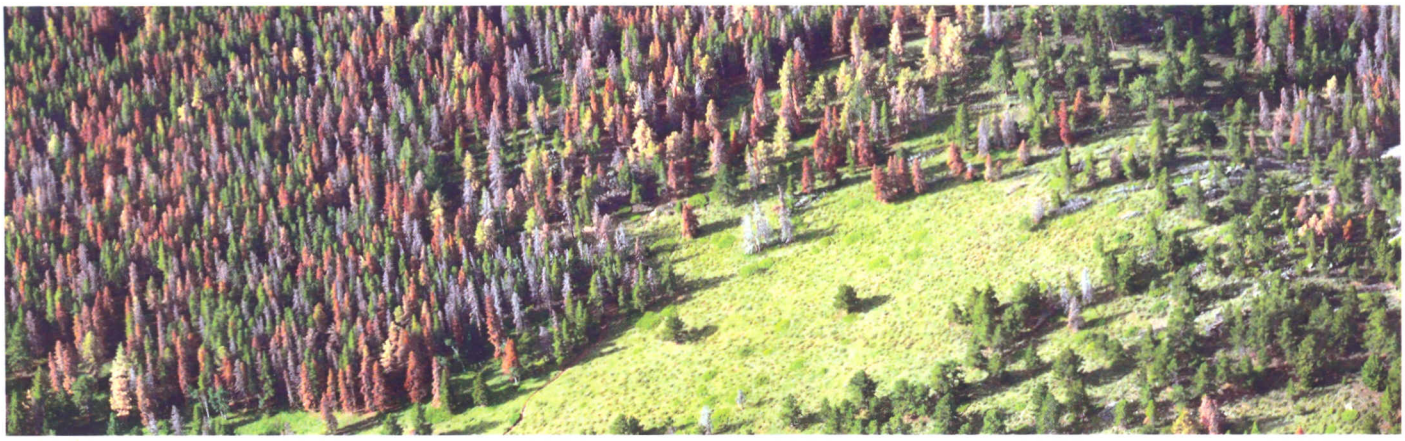
Since 2008, lodgepole pine and subalpine fir seedlings and aspen sprouts have become established both beneath the dead overstory and in recently harvested beetle-infested stands (Fig. 1); pine and aspen recruits were three times more abundant in harvested stands. Subalpine fir trees were the most common new trees in uncut stands, whereas aspen and pine trees dominated in harvested areas.

Based on these field measurements (Fig. 1), forest growth simulations suggest that in harvested areas lodgepole pine will be the dominant species. Forest structure (i.e., tree density and stand basal area) should return to pre-outbreak levels within 80 to 120 years regardless of whether stands were cut or uncut. Aspen is projected to become a significant part of the overstory in both cut and uncut areas during the first 50 years after the MPB infestation, but then be overtaken by conifers. In the unharvested stands that will occupy the majority of the area affected by the current MPB outbreak (i.e., >85%), subalpine fir will surpass lodgepole pine as the dominant overstory species.

Post-Harvest Seedling Colonization in Infested and Pre-Outbreak, Live Forests

The density of seedlings colonizing clearcuts did not differ statistically between live and beetle-infested forests (Fig. 2; Collins et al. 2010), and lodgepole pine accounted for more than 90% of post-harvest seedling recruitment during both periods.

In general, post-harvest seedling recruitment was high (4,700 trees ha^{-1}; 1,900 trees ac^{-1}) during both pre-outbreak and outbreak periods, and few plots failed to restock with new seedlings. In lodgepole pine forests of the southern Rockies, a minimum of 370 trees ha^{-1} (i.e., 150 trees ac^{-1}) is required on 70% of plots to certify that treated areas have regenerated successfully (USDA, 1997), and managers consider that development of well-stocked stands will require post-harvest seedling densities about ten-fold higher than this minimum threshold. In our study, post-harvest recruitment surpassed minimum stocking requirements in 100% and 94% of pre-outbreak and outbreak harvest units, respectively, and more than half of all harvest units were considered well-stocked.



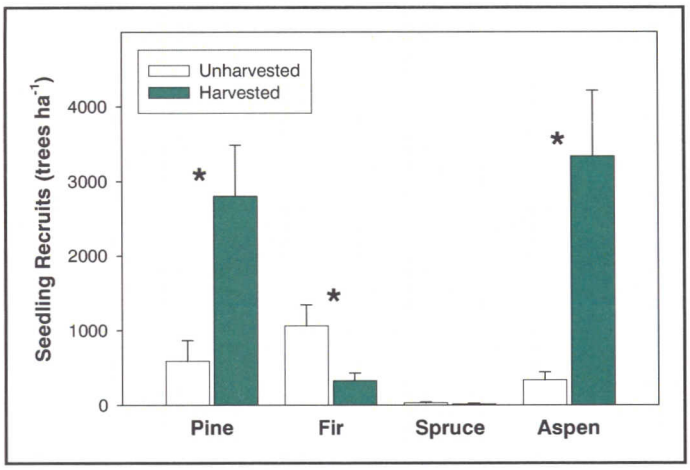


Figure 1. Mean density of seedlings that have established since 2008 in unharvested (n = 39 plots) and harvested areas (n = 75 plots) in 10 paired stands at the USFS Fraser Experimental Forest (Collins 2010). Asterisks indicate a statistically significant difference ($\alpha = 0.05$) between uncut and cut areas.

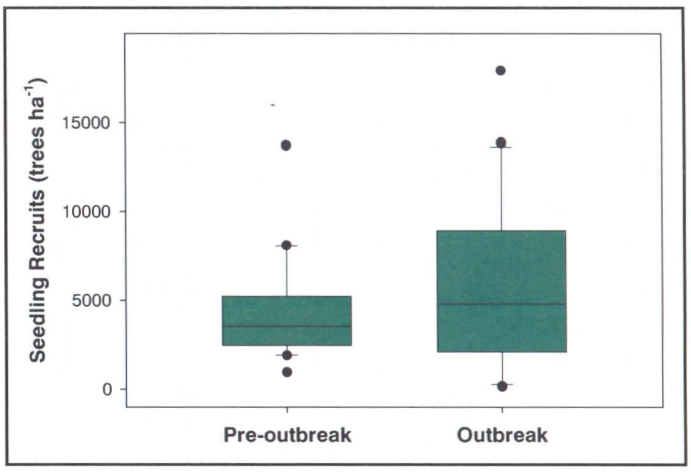


Figure 2. Post-harvest recruitment in pre-outbreak (n=32) and outbreak (n=30) stands 3 years after harvesting (Sulphur Ranger District; Arapaho-Roosevelt National Forests). Boxes show the median, 25th and 75th percentiles, whiskers represent 10th and 90th percentiles, and solid circles represent outliers (observations outside the 10th and 90th percentile). The dashed line shows the minimum of undamaged seedlings required to certify successful stocking on USFS land.

Implications for Colorado Forests

This research conducted on the Fraser Experimental Forest and Sulphur Ranger District demonstrates that some Colorado forests have begun to recover from the beetle outbreak. Our findings are relevant to forests in northern Colorado that had a pine-dominated overstory and fir, spruce and aspen understory prior to arrival of the pine beetle. In contrast, in pine forests with sparse understory trees, stand recovery will likely be delayed following overstory loss to pine beetle. In general, we can conclude the following:

- New conifer seedlings (mainly pine and fir) and aspen sprouts have colonized beneath the beetle-infested overstory.
- The density of new trees is at least as high in areas harvested in response to the beetle outbreak as in live forests harvested in the past.
- Very few harvest areas (i.e., < 6 %) are poorly-stocked.
- Beetle-infested stands appear to be on a trajectory to return to pre-outbreak forest structure in 80 to 120 years.

Our seedling surveys and growth simulations indicate that the species composition of unharvested, beetle-infested forests is likely to differ from the pine-dominated forests common at the time of the outbreak. Much uncertainty exists regarding the projections of future stand conditions; nevertheless, based on our findings we expect that:

- Subalpine fir will likely surpass lodgepole pine as the most common overstory species in the unharvested areas that will occupy much of the area affected by the outbreak.
- Aspen is projected to be a significant part of the overstory in both harvested and unharvested areas during the first 50 years after the outbreak.
- In harvested areas, lodgepole pine will be the dominant overstory species and develop into stands similar to those that were attacked by the pine beetle.

These findings document initial seedling colonization in harvested and unharvested beetle-infested forests, but raise questions about how these forests will develop in the future. For example, dwarf mistletoe affects lodgepole pine growth in these and many Colorado forests; yet it is unknown how MPB and MPB-related harvesting may alter the prevalence of mistletoe or its impact on stand development. Also, our growth simulations predict that fir will become more abundant in the Colorado High County, though mature forests dominated by subalpine fir are currently uncommon to the area. The species is relatively short-lived and is susceptible to a number of insects and diseases, so it is unlikely to form dense, even-age stands, in spite of the high density of fir seedlings and saplings we measured. It is, however, reasonable to expect a shift from the uniform age and size conditions common in lodgepole pine-dominated forests to stands with more fir and greater size, age and overstory species diversity. Future resurvey of our study sites will help to answer these questions.

The implications of greater abundance of subalpine fir on High Country forests and communities remain uncertain. These findings represent the first stage in development of new forests following the beetle outbreak during a period of dramatic change that will have consequences for Colorado ecosystems and economies for many decades to come.

Literature Cited

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For an in-depth description of research, see:

Collins, Byron J. 2010 Initial and future stand development following mountain pine beetle in harvested and uncut lodgepole pine forests. M.Sc. Thesis, Dept. of Forest, Rangeland & Watershed Stewardship, Colorado State University, Fort Collins, Colorado.

Collins, B.J., C.C. Rhoades, J. Underhill, and R.M. Hubbard. 2010. Post-harvest seedling recruitment following Mountain Pine Beetle infestation of Colorado lodgepole pine stands: a comparison using historic survey records. Canadian Journal of Forest Research 40: 2452-2456.

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