Chapter 4—Forests in transition: Post-epidemic vegetation conditions

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Introduction

More than 23 million acres of lodgepole pine forests across the western U.S. have experienced overstory mortality following the recent mountain pine beetle (MPB) epidemic (USDA Forest Service 2013). Unknowns regarding the immediate and long-term consequences of the epidemic challenge the ability of managers to make informed decisions aimed at sustaining forest health and delivery of ecosystem services. There is a large body of research regarding the recovery of lodgepole pine forest following fire and logging; however, the trajectory of stand development in beetle-killed forests is poorly understood. Research presented in this webinar aims to better understand forest recovery following the MPB epidemic, including the impacts of management options on regeneration, fuel loads, and potential fire behavior.

Lodgepole pine forests in the central and southern Rocky Mountains can be broadly classified into two main types: pure lodgepole pine and mixed-species lodgepole pine stands (Fig. 4.1). Pure lodgepole stands are those where the majority of the overstory is composed of lodgepole pine, and understory vegetation and advanced regeneration is sparse. Pure lodgepole pine forests generally exist on drier and warmer landscape positions and are also found in frost pockets. Mixed-species lodgepole pine stands generally exist on wetter sites and have a mixture of overstory species including lodgepole pine, Engelmann spruce, subalpine fir, and/or quaking aspen. The relative percentage of these species depends on a variety of factors, including site conditions and disturbance history. Mixed-species lodgepole pine stands usually have significant advance regeneration that reflects overstory composition.

Figure 4.1. Lodgepole pine forests in the central and southern Rocky Mountains can be broadly classified into two main types: pure lodgepole pine (top), typically occurring on drier sites, and mixed-species lodgepole pine stands (bottom), often found on wetter sites (photos courtesy of USDA Forest Service).

The MPB has caused significant overstory mortality in both pure and mixed-species lodgepole pine stands. The original stand structure, species composition, and management treatments will influence the post-beetle trajectory of forest recovery in these ecosystems.

Research findings

Research finding #1: Research and management observations in Colorado and Wyoming suggests there is adequate regeneration in beetle-affected forests to ensure forest recovery.

Management Implications

- Tree planting is unnecessary in many stands impacted by the MPB. Advanced regeneration and seedling recruitment are adequate to ensure recovery to pre-epidemic basal areas.
- Some mixed-species lodgepole pine forests may experience a shift in their dominant tree species from lodgepole pine to subalpine fir and aspen.

Future forest growth trajectories in MPB affected forests may differ substantially from stands that have experienced disturbance from wildfire or logging. In beetle-killed lodgepole pine forests, pine establishment can be inhibited by limited seed source and/or the absence of exposed mineral soil. The uncertainty of forest growth trajectories has led to a strong research effort to evaluate the role of seedling recruitment and advance regeneration in the recovery of beetle-killed forests.

Multiple studies suggest that forests will recover in the wake of this MPB epidemic:

- Pelz and Smith (2012) re-sampled pure and mixed species lodgepole pine stands that had experienced a MPB outbreak in the 1980's. Thirty years following the outbreak, pure lodgepole pine stands had recovered 91 percent of pre-mortality basal area and 93 percent of overstory tree density. In many stands, the dominant species in the understory switched from pine to subalpine fir and aspen. In mixed-species stands, basal area and overstory tree density remained significantly reduced, and subalpine fir and Engelmann spruce continued to dominate the understory.
- Collins and others (2011) sampled 24 mixed-species lodgepole pine forests in northern Colorado that had been impacted by the recent MPB epidemic. They found that average seedling recruitment and advance regeneration exceeded regional stocking requirements of 150 trees/acre (Fig. 4.2).
- Research in Rocky Mountain National Park suggests that remaining live trees and understory saplings are sufficient to ensure forest recovery, in spite of an average reduction in overstory basal area of 64 percent. Residual live trees, saplings, and seedlings averaged 1,600 stems/acre in both pure and mixed-species stands, with a slight increase in the abundance of subalpine fir, Engelmann spruce, and aspen (Diskin and others 2011).
- Across the Medicine Bow Range in Wyoming, advance regeneration of lodgepole pine exceeded acceptable stocking levels (780 stems/acre) in 19 of 20 pure and mixed lodgepole pine stands following the current MPB epidemic (Kayes and Tinker 2012).

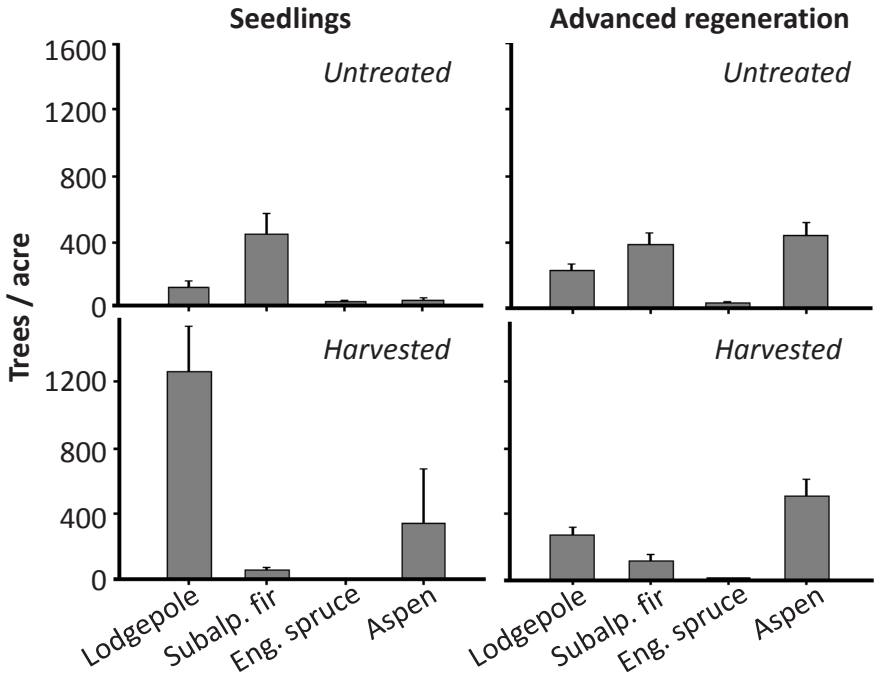

Figure 4.2. Density of seedlings and advance regeneration in harvested versus untreated forests across four MPB management areas in northern Colorado (figure adapted from Collins and others 2011).

Research finding #2: Residual overstory and understory trees are growing faster following the MPB epidemic.

The MPB caused a significant loss of lodgepole pine overstory, resulting in increased availability of light, water, and nutrients for surviving vegetation. Increased resource availability can facilitate growth and recovery of residual vegetation. Surviving trees increased growth by a factor of two to three following a MPB outbreak in the late 1960's and early 1970's in Yellowstone National Park (Romme and others 1986).

Preliminary research at the Fraser Experimental Forest in northern Colorado found increased growth in residual overstory subalpine fir and Engelmann spruce after the most recent MPB epidemic. In a three-year period following the epidemic, more than 35 percent of sampled overstory trees showed an increase in growth relative to ten years prior to the epidemic, and 16 percent grew faster than any other time during their life span. In addition, advanced regeneration of lodgepole pine and subalpine fir more than doubled their height growth since the beginning of the MPB epidemic (Collins and others 2011).

Research finding #3: Alternative management practices create a range of regeneration scenarios.

The current MPB epidemic has raised concern about wildfire and threats to public safety from falling trees, prompting an unprecedented management response in MPB impacted areas. Rates of post-epidemic timber harvesting are greater than at any other time since the 1970's. However, the epidemic is so extensive that only about 15 percent of the landscape will be treated (Collins and others 2010).

Management Implications

- Decisions about slash retention and soil disturbance create tradeoffs between water delivery and seedling establishment.
  - Greater slash retention can enhance water delivery by promoting snow accumulation. This can enhance seedling growth, but the absence of bare mineral soil can inhibit seedling establishment.
  - Removal of slash and exposure of mineral soil can enhance seedling establishment, but it reduces surface roughness and snow accumulation.
- Fuels reduction treatments in mixed-species lodgepole pine stands might result in future forests dominated by lodgepole pine, whereas untreated stands might be dominated by subalpine fir.

Forest managers have a suite of management alternatives available for treating beetle-killed stands. These alternatives result in different amounts of aboveground structure (*i.e.,* snags), surface roughness, and soil disturbance:

- "No action" option retains standing snags, downed wood, and maximum surface roughness.
- Watershed protection / delivery treatments maximize water delivery by retaining logging residue on site. Slash maintains surface roughness, increasing snow accumulation, and helps avoid soil disturbance.
- Fuel reduction treatments focus on removing snags and slash.
- Forest regeneration treatments combine slash reduction and mechanical scarification to enhance seedling establishment.

All four of these management options are likely to impact soil resources and seedling recruitment and growth. Research across four MPB management areas in northern Colorado found that watershed protection and water delivery treatments increased seedling height growth by approximately 20 percent relative to the other treatments (Chuck Rhoades and others, USDA Forest Service, *unpublished data*). This is possibly due to increased water availability. Survival of seedlings experimentally planted by researchers was generally greater in the forest regeneration treatments, but natural seedling recruitment was greater in fuel reduction treatments.

Treatments can also result in different species compositions in mixed-species lodgepole pine stands. Research in northern Colorado found that about 75 percent of new seedlings in cut areas were lodgepole pine, where about 70 percent of new seedlings in untreated stands were subalpine fir (Fig. 4.2; Collins and others 2011). Cut areas had about ten times more new pine seedlings and seven times more aspen sprouts than untreated stands.

Stand development projections using the Forest Vegetation Simulator (FVS) suggest that significant aspen sprouting will increase the proportion of aspen in both untreated and harvested areas. Lodgepole pine will become the dominant species in harvested areas after aspen declines, while subalpine fir and lodgepole pine will dominate in untreated areas a century after the MPB epidemic (Fig. 4.3).

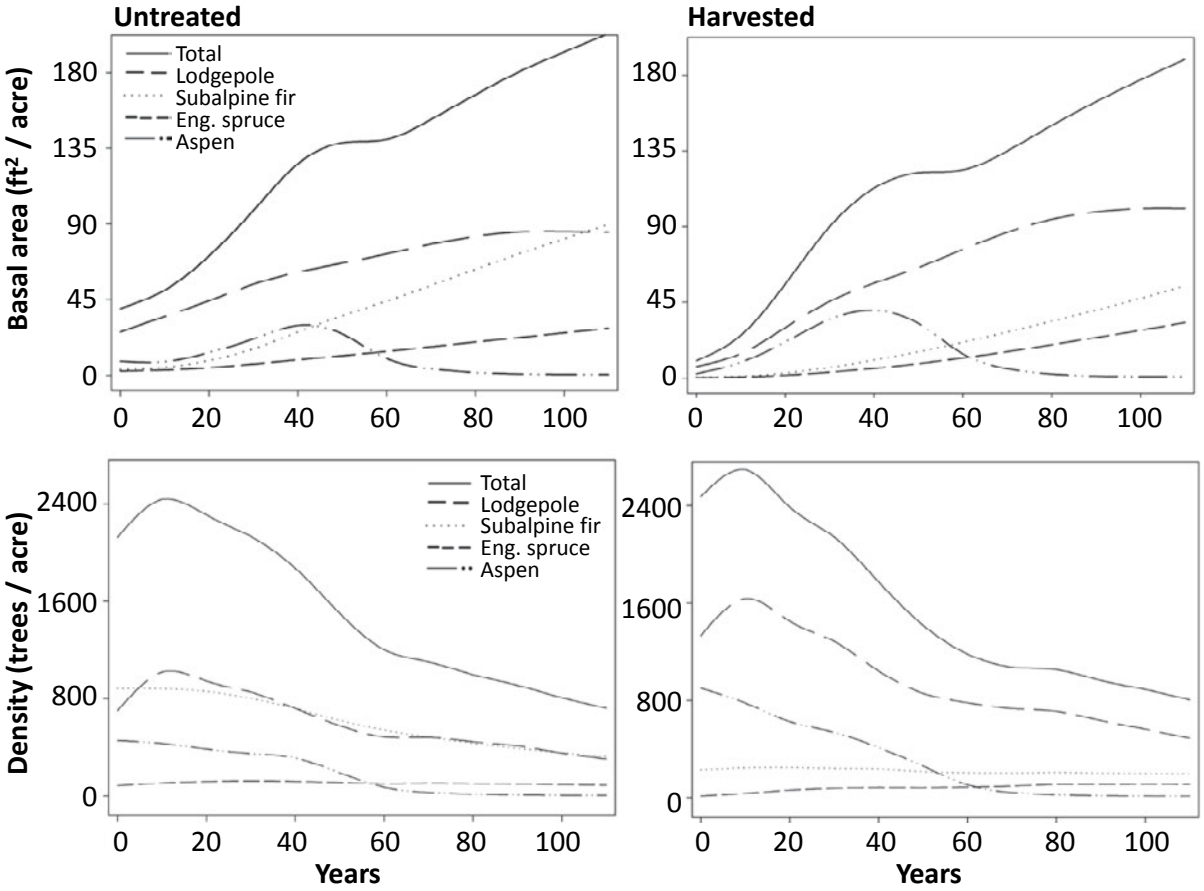

Figure 4.3. Projected stand development based on initial observations in harvested (n = 24) and untreated stands (n = 24) across northern Colorado. Growth was simulated using the Forest Vegetation Simulator. Projections were based on observed regeneration, overstory conditions, and site index (reprinted from Collins and others 2011).

Research finding #4: Tree mortality from the MPB epidemic and post-epidemic harvesting will influence fuel loads and fire behavior for many decades to come.[6]

The MPB epidemic and subsequent harvesting substantially alter fuel loads with potential implications for fire behavior. Salvage logging in beetle-infested Colorado forests is expected to affect future fires by favoring regeneration of pine and aspen over subalpine fir, a species with a dense crown and branches that extend to the ground. Abundant subalpine fir in untreated, beetle-killed stands could act as ladder fuels that allow fires burning on the surface to spread into the forest canopy.

Researchers at the Rocky Mountain Research Station explored this possibility using FVS and its Fire and Fuels Extension. They compared forest composition and fuel loads in 24 paired treated and untreated stands in northern Colorado and projected stand structure characteristics and potential fire behavior over the next 100 years (Collins and others 2012a,b). They found that:

[6] *This research finding reinforces material presented in Research Findings 2 and 3 of Chapter 3.*

Management Implications

- Fuel loads are initially greater in harvested stands, but research suggests this does not increase the potential for crown fires.
- Untreated stands will accumulate greater coarse fuel loads (≥3 inches in diameter) over time, increasing the potential for larger and more severe wildfires across beetle-killed landscapes.
- Abundant subalpine fir regeneration in untreated, beetle-killed stands could act as ladder fuels that facilitate the transition from surface fires to crown fires.

- Surface fuel loads (1, 10, 100, and 1000-hr size classes) were about 3 times greater in harvest units compared to untreated stands.
- Coarse fuel loads (≥3 inches in diameter) will accumulate over time, increasing the potential for larger and more severe wildfires. Higher coarse fuel loads increase soil heating, increase the production of airborne embers, and hinder fire suppression.

Differences in tree species composition and the higher fuel loads in untreated, beetle-killed stands create the potential for more extreme fire behavior compared with harvested areas (Fig. 4.4). Fire behavior might become more similar between untreated and harvested areas when trees lose their needles and transition into the gray-stage. However, as the forest overstory develops, abundant subalpine fir will increase the canopy bulk density and lower canopy base height of untreated stands. These crown conditions allow for torching at lower wind speeds and increase active crown fire potential during extreme weather (Fig. 4.5). As a result, passive crown fires (*i.e.,* fires that ignite individual tree crowns but do not spread between canopies) are expected to occur in untreated stands under average weather conditions (*i.e.,* 50th percentile weather). In contrast, surface fires are predicted for harvested areas under similar weather conditions (Collins and others 2012a).

Remaining Questions & Knowledge Gaps

- How adequate are forest growth projections from the Forest Vegetation Simulator, given that it was developed for stands that had not experienced significant bark beetle disturbances?
- How do standing dead snags and subsequent tree fall impact stand development over time?
- To what degree can an abundance of herbaceous vegetation in some post-epidemic understories impact seedling recruitment and establishment?
- How will future disturbances from insects, diseases, and fire influence stand development in treated and untreated pure and mixed-species lodgepole pine forests?

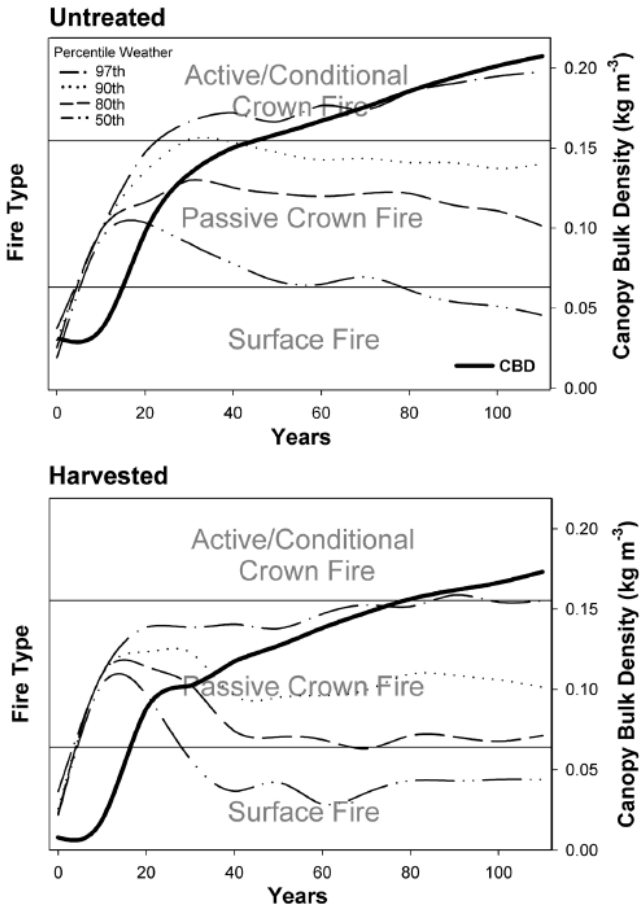

Figure 4.4. Changes in surface fuel loads in harvested and untreated MPB management areas as estimated by the Forest Vegetation Simulator Fire and Fuels Extension. Projected changes based on initial observations of fuel loads in 24 untreated and 24 harvested areas across northern Colorado (reprinted from Collins and others 2012a).

Figure 4.5. Removing beetle-killed trees can increase surface fuel loads for several years following treatments, but over time, coarse woody fuel loads will be greater and ladder fuels more abundant in untreated forests. Untreated forests might have greater potential for crown fires in the future, increasing safety concerns for firefighters during fire operations (image of the 2010 Church's Park Fire near Fraser, CO, courtesy of InciWeb).

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Meet the chapter presenters and authors

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