Report to Boulder County Parks and Open Space

Assessing Limber Pine Stand Conditions after White Pine Blister Rust and Mountain Pine Beetle Outbreaks in Boulder County Parks and Open Space

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Abstract:

Mountain pine beetle and white pine blister rust are causing extensive decline in populations and mortality of limber pines (*Pinus flexilis* James) throughout the Central Rocky Mountains. Ecologically valuable limber pines often grow in fragile ecosystems where little else can grow. The combined effects of mountain pine beetle, white pine blister rust, and climate change could greatly impact the biodiversity of these ecosystems. Information on stand conditions is needed to facilitate management and restoration efforts. The objectives of this study were to: (1) determine the density and health of mature limber pine trees and regeneration in areas impacted by white pine blister rust and mountain pine beetle on Boulder County Open Space lands, and (2) determine factors that impact regeneration, including site and stand characteristics, white pine blister rust and mountain pine beetle.

In 2012, fourteen plots were established in Boulder County. Evidence of bark beetle infestation was found in 9.8 percent of limber pines. White pine blister rust was found on two limber pines with an overall incidence of 0.2%. White pine blister rust was found on 4 regenerating limber pines <70cm with an overall incidence of 1.7% and no limber pine regeneration ≥70cm was infected with white pine blister rust. Future data analysis and modeling will look for relationships to explain successful limber pine regeneration, the impact of rust and bark beetle mortality on overstory trees and regeneration and provide management information to maintain limber pine in the forest ecosystem.

Introduction

Mountain pine beetle (MPB) and white pine blister rust (WPBR) are causing extensive decline and mortality throughout the Southern and Central Rocky Mountains leaving most limber pine stands at risk. MPB, the most immediate threat, kills mature, cone-bearing trees and limber pine is a more favorable host for MPB than lodgepole pine. The added impacts of WPBR, which continues to spread and intensify in limber pine, could be devastating in some areas since small trees are particularly susceptible. Information on stand conditions, regeneration, the extent and severity of MPB/WPBR and presence of alternate hosts are needed to make recommendations and to develop appropriate recovery plans. The survey of Boulder County was part of a larger study that is looking at limber pine health in Northern Colorado, Wyoming and Central Montana.

White Pine Blister Rust

In approximately 1910, *Cronartium ribicola* (Fischer), the causal agent of WPBR, was introduced via infected nursery stock imported from France to western North America near Vancouver, British Columbia. *C. ribicola* is a heteroecious rust capable of infecting all North American white pines (five-needled pines) and utilizing *Ribes* species, currants and gooseberries, and *Pedicularis* and *Castilleja* as alternate hosts (McDonald et al. 2006). The spores of this fungus are able to travel on wind currents up to several hundred kilometers to infect *Ribes* and other hosts (Tainter and Baker 1996). Primary infection of pines occurs on the needles where fungal spores land, penetrate, and grow down to branches and stems. The fungus grows in the intercellular spaces within the living phloem (bark) of white pines where the production of spores breaks apart the bark causing the girdling of branches and stems; the ultimate result of which is tree death (Welch and Martin 1974, Tainter and Baker 1996). White pine blister rust may also act to prevent regeneration of white pines by killing cone bearing branches on mature trees and rapidly killing seedlings and saplings.

The fungus has been present in northwestern Wyoming since the 1940's (Krebill 1964) and in southern Wyoming since the 1970's (Brown 1978) but has only recently moved into Colorado. WPBR was first reported in Colorado in 1998 with the area with highest infection approximately 18 km south of the Wyoming border (Johnson and Jacobi 2000). In addition, WPBR was first reported on Rocky Mountain bristlecone pine in the Great Sand Dunes National Monument in Colorado in 2003 (Blodgett and Sullivan 2004). There is concern that Colorado white pines including limber pine (*Pinus flexilis*), bristlecone pine (*P. aristata*), and southwestern white pine (P. strobiformis) located in scattered populations along the Continental Divide from Wyoming to the Colorado - New Mexico state line may be at risk as the pathogen spreads throughout the state (Johnson and Jacobi 2000, Burns 2006, Kearns and Jacobi 2007).

The bristlecone pines, limber pine, whitebark, and southwestern white pine species are widespread in the upper subalpine and timberline zones in the mountainous regions of western North America often occupying xeric, high elevation sites where cold temperatures, short growing seasons, and soil characteristics limit the growth of other conifer species. At lower elevations on mesic sites with deep soils, other conifer species are more competitive and white pines are often considered a seral component (Kendall and Arno 1990, Arno and Weaver 1990). In the Rocky Mountain Region, limber pines range in elevation from 5,250 ft to 11,482 ft which is a larger elevation range than other 5-needle pines (Schoettle and Rochelle 2000). Studies by Hunt (2005) indicate that white pines at higher elevations are less prone to WPBR than at low elevations. Evans and Finkral (2010) estimated that WPBR is spreading at a rate of 10 km per year in western North American forests.

<u>Mountain Pine Beetle</u>

Mountain pine beetle (*Dendroctonus ponderosae)* and white pine blister rust are causing extensive decline and mortality throughout the central and northern Rocky Mountain regions (northern CO, WY, and central MT) leaving most limber pine stands at risk. MPB, the most immediate threat, kills mature, cone-bearing trees and studies have shown that limber pine is a more favorable host for MPB than lodgepole pine (Gibson et al. 2008). MPB does not directly affect regeneration since the native bark beetle prefers larger diameter trees (Safranyik and Carroll 2006), but mortality of seed-producing trees may limit the opportunity for reproduction.

WPBR and drought may each predispose the tree to increased susceptibility to mortality by the mountain pine beetle (Six 2007). Blodgett et al. (2005) found that the MPB may prefer trees infected with WPBR but eventually prefer healthy trees (Schwandt and Kegley 2004) and bark and phloem thickness are not factors in beetle preference (Six and Adams 2006). It is of primary concern that the mountain pine beetle is attacking WPBR resistant trees.

From 1997-2008, the highest levels of MPB-caused limber pine mortality occurred in CO and WY (Gibson et al. 2008) and levels continued rising in 2008 and 2009. According to the 2010 Forest Health Aerial Survey of Colorado and southern Wyoming, since 1996, 4 million acres, with 400,000 occurring in 2010, are now affected by the mountain pine beetle. The Snowy

Range experienced the highest mortality and northern Wyoming also increased in mortality. Researchers predict that beetle populations will remain high until hosts are depleted or weather conditions become unsuitable to the beetles. The added impacts of WPBR, which continues to spread and intensify (Burns et al. 2008, Kearns and Jacobi 2007, Smith and Hoffman 2000) in limber pine, could be devastating in some areas since small trees are particularly susceptible.

Limber pines often grow in fragile ecosystems where little else can grow. The combined effects of MPB, WPBR, and climate change could greatly impact the biodiversity of these ecosystems. Intervention will be necessary to restore/maintain impacted stands. Information on stand conditions is needed to facilitate these efforts. Ancient trees, resistant trees, and national treasures are a few examples of threatened resources. Genetic conservation of high elevation white pines is a priority for FHP, NPS, and BLM. Limber pine was added to the BLM's sensitive species list in WY in 2010. The need for information is urgent; MPB is quickly killing mature trees and WPBR, which is particularly damaging to young trees, continues to spread and intensify.

Objectives: To provide land managers with information needed to develop, prioritize, and implement restoration strategies for limber pine stands impacted by MPB and WPBR. Specific objectives include:

1) Determine the density and health of mature limber pine trees and regeneration in areas impacted by white pine blister rust and mountain pine beetle in Boulder County.

2) Determine factors that impact regeneration, including site and stand characteristics, WPBR and MPB.

Methods

Stand selection

A population of potential plot locations was selected in Boulder County based on known records of host location, aerial detection information on MPB mortality, and local knowledge. A stratified random sample of these locations was selected so there were relatively equal number plots below and above what mid elevation is for the limber pine distribution in the study area and bark beetle infestation (yes/no). Plot locations were within 300 meters of a road to reduce travel time and facilitate remeasurement in the future. The number of plots within a study area varied depending on the amount of the area with limber pine, aerial detection data on MPB incidence, and accessibility. Attempts were made to account for two elevation ranges (low and high) and bark beetle infestation (yes/no) and six plots of each. If not enough plots are found for a particular category, then remaining plots were selected to fill the other stratification variables equally.

Survey methods

Plots were placed in stands with at least 40% limber pine based on stem/ha. Plots were randomly located on a compass bearing that placed the plot within the limber pine stand. Trees were not tagged but the beginning of each subplot and the end of the third subplot was identified by GPS and by tagging one tree at dbh. Three 60 x 6 m fixed area subplots with an invasive species/alternate host plot (30 x 6 m) placed between subplots were placed at random bearings within the stand to record size and condition of all mature trees, species composition, basal area and regeneration. Within each subplot, the following data were recorded for the overall conditions at each plot: date, tree tag number, elevation (m), subplot bearing, aspect (degrees), slope percent, slope position (backslope, footslope, shoulder, summit, toeslope, valley bottom), stand structure (closed canopy multistoried, closed canopy single story, mosaic of closed multi and open canopy scattered individuals or open canopy scattered clumps, mosaic of closed single story and closed multi or open individuals or open scattered clumps, open canopy scattered individuals and/or open canopy scattered clumps), and disturbance history (tree cutting, fire, other human disturbance, grazing).

Trees

Within each subplot, the following data were recorded for all tree species, standing dead and alive with a diameter at breast height (DBH) at 1.37 m (no minimum diameter): species, crown class (open, dominant, codominant, intermediate, overtopped/understory), DBH to nearest cm using a Biltmore stick for efficiency when possible, health status (healthy = less than 5% damage to crown or stem, declining = 6-50% of crown showing symptoms that indicates it is dead or will be, dying = >50% crown showing symptoms, recent dead [0-5 years] = no green needles but some red needles and fine twigs present, old dead [5-10 years] = no fine twigs or needles present, >50% bark still present, very old dead [>10 years] = no fine twigs, no needles, <50% bark present), percent crown dieback (percentage of dead foliage as compared to the entire crown), dwarf mistletoe rating (DMR) (Hawksworth 1977), bark beetle presence (none, unsuccessful

MPB bole attack: pitchout and beetle brood absent, MPB strip attack: galleries and brood present, successful MPB bole attack, unknown or other bark beetle). Within each subplot, the following data were recorded for only limber pine, standing dead and alive with a dbh at 1.37 m (no minimum diameter): WPBR presence and location (branch, stem, both), number of WPBR branch and stem cankers, canker length by size class on live limber pine only of the first ten representative cankers with live portions only as an estimate of canker age (<12 cm, 12-24 cm, 24.1-36 cm, 36.1-48 cm, 48.1-60 cm, 60.1-72 cm, 72.1-84 cm, 84.1-96 cm, 96.1-108 cm, =>108.1 cm) and status of branch tip with canker for each of the first ten representative cankers (alive or dead), percent of branches with green cones, and type and severity of up to two damages affecting 5% or more of the tree. Trees growing in clumps were considered individual stems if they crotched below DBH (1.37 m height) and were growing at an angle greater than 45° above horizontal. Stem cankers were defined as cankers on the main stem or branch cankers within 15.24 cm on living branches. Cankers were considered branch cankers if at least two of the following were present: abnormal swollen branch, blistered branch or stem, aecia present, roughened resin stained bark, or expanding areas of squirrel bark removal. A stem is the section of the stem that if girdled would remove more than 25% of the crown.

Regeneration

Within each subplot, the following data were recorded for all regeneration, counts of standing dead and alive with a DBH <1.37 m: species, health status (healthy = less than 5% damage to crown or stem, declining = 6-50% of crown showing symptoms that indicates it is dead or will be, dying = >50% crown showing symptoms, recent dead [0-5 years] = no green needles but some red needles and fine twigs present, old dead [5-10 years] = no fine twigs or needles present, >50% bark still present, very old dead [>10 years] = no fine twigs, no needles, <50% bark present), and height to the nearest cm. Within each subplot, the following data were recorded for all limber pine regeneration: presence of WPBR, up to two microsite objects that must be at least 10 cm tall and within 1 m of limber pine seedling (tree, stump, log, rock, shrub), up to two most prevalent ground cover types within 1 m of limber pine seedling (soil, litter, rock, tree/log, lichen/moss, grass/sedges, shrubs, forbs), type of up to two damages affecting 5% or more of the seedling, and terminal growth, in millimeters, of terminal leader for the previous two years.

Ground cover

Two circular fixed area subplots with a 3 m radius were placed 3 m from each end and within the 60 x 6 m subplots to record ground cover and understory vegetation. Within each circular fixed area subplot, the following data were recorded: groundcover (percent of area occupied by each ground cover type (soil, litter, rock, tree/log, lichen/moss, grass/sedges, forbs, shrubs), up to three of the most prevalent shrub species and percent of total shrub area occupied, microsite objects at least 10 cm tall and within 1 m of circular fixed area plot center (tree, stump, log, rock, shrub), and up to two most prevalent ground cover types within 1 m of circular fixed area plot center (soil, litter, rock, tree/log, lichen/moss, grass/sedges, shrubs, forbs). Microsite objects and ground cover in relation to circular fixed area plot center were recorded as controls for seedling microsite object and ground cover.

Interval plots (invasive species and WPBR alternate hosts)

At the end of each 60 x 6 m subplot, along the same bearing, an invasive species/alternate host plot (30 x 6 m) was established in which the presence and size in cm^2 of the ground area occupied by any invasive weed species from top 10 of the region and WPBR alternate hosts (*Ribes, Castilleja,* and *Pedicularis*) were recorded. Presence and ground area occupied by *Ribes* species were only recorded in previously non-monitored plots. Subsequent 60 x 6 m subplots were started at the end of the interval plot along another random bearing. The series of 60 x 6 m subplots containing the 3 m radius circular fixed area plot and 30 x 6 m interval plots in an area defined the plot.

Results

During the summer of 2012, fourteen plots were established in the Boulder County study area. Surveyed plots ranged in elevation from 2,568 to 2,947 m. A total of 2,393 trees were examined and of those, 850 were limber pine. Limber pine was found primarily in association with lodgepole pine, and as minor components aspen, ponderosa pine, Douglas fir, subalpine fir and Englemann spruce. Limber pine density ranged from 204 to 1,157 stems per hectare and averaged 562 stems per hectare while total stand density ranged from 250 to 4,250 stems per hectare and averaged 1,583 stems per hectare. Limber pine basal area ranged from 3.0 to 20.37 m^2 per hectare and averaged 9.9 m^2 per hectare. Limber pine DBH ranged from 7.2 to 18.2 cm and averaged 12.7 cm. Most (52.5%) limber pines surveyed were classified as healthy (up to 5% of crown or stem showing symptoms or was damaged), 24.8% were declining or dying, and 22.7% were dead. Bark beetles had killed 9.8 percent of limber pines. White pine blister rust was found on two limber pines with an overall incidence of 0.2%. Dwarf mistletoe caused the most damage to limber pines and was found on 180 (27.4%) limber pines.

Limber pine regeneration density ranged from 0 to 1,028 stems per hectare with an average of 203 stems per hectare, while total regeneration density averaged 1,136 stems per ha. Aspen regeneration was the greatest competitor with a mean density of 663 stems per ha. Limber pine regeneration (<137 cm height) averaged 50.34 cm in height. Most (90.6%) limber pine regeneration surveyed was classified as healthy, 7.0% were declining or dying, and 2.4% were dead. White pine blister rust was found on 4 regenerating limber pines <70 cm with an overall incidence of 1.7% and no limber pine regeneration ≥70 cm was infected with white pine blister rust.

Discussion and Conclusion

The assessment of plots in Boulder County is part of a wider study that encompasses an additional 26 study areas in the Central and Southern Rocky Mountains. At this time we cannot report the overall tree health of Boulder County as compared to the other study areas. However, in Boulder County most (52.5%) of the limber pines were classified as healthy with 9.8% of limber pines killed by bark beetles and WPBR incidence of 0.2% with a WPBR incidence of 1.7% in limber pine regeneration. Since WPBR was first reported in Colorado in 1998, it has continued to spread slowly throughout the state. To our knowledge, our finding is the second report of WPBR in Boulder County. While the incidence WPBR is low, it should not be overlooked and the need for continued monitoring of limber pine stands in Boulder County is great.

Currently, the most damaging agent to limber pines in Boulder County is dwarf mistletoe (27.4%). Limber pine dwarf mistletoe (*Arceuthobium cyanocarpum* (A. Nelson ex Rydberg) Coulter and Nelson) can cause severe mortality in limber pines is considered to be second in importance only to WPBR (Taylor and Mathiasen 1999). Dwarf mistletoe stressed trees may provide endemic host material for bark beetles. Spread rate is increased by multistoried, dense stands of suitable hosts. Loss of limber pine due to dwarf mistletoe could have confounding effects if WPBR were to spread and intensify. Limber pine regeneration is susceptible to both dwarf mistletoe and WPBR, while mature limber pines are susceptible to both, in addition to bark beetles.

During spring 2013 we will continue to analyze the data to determine relationships that can explain successful limber pine regeneration, the impact of rust and bark beetle mortality of overstory trees on regeneration and other questions related to maintaining limber pine in the forest ecosystem.

Acknowledgements:

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