Northwest Science Notes

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Old Lower Stem Bark Lesions Apparently Caused by Unsuccessful Spruce Beetle Attacks Still Evident on Live Spruce Trees Years Later

Abstract

We examined old bark lesions on Lutz spruce in young stands on the Kenai Peninsula, Alaska, to determine their cause. Distribution of these lesions along lower stems was similar to the distribution of spruce beetle attacks during epidemics. These lesions apparently resulted from unsuccessful attacks by spruce beetles during the late 1980s and early 1990s and appear to be symptomatic of conifer tree resistance reactions to cambial zone injury by *Dendroctonus* beetles.

Introduction

For two decades beginning in the early 1980s, spruce beetles (*Dendroctonus rufipennis* [Kirby]) ravaged spruce stands in south-central Alaska. By the time this infestation ended, over 2 million acres of mature white spruce (*Picea glauca* [Moench] Voss) and Lutz spruce (*Picea x lutzii* [Little]) were infested and the majority of mature spruce was dead. At the time, this was the largest bark beetle epidemic ever recorded in North America (Werner et al. 2006). On the Kenai Peninsula, where the beetle infestation was most severe, spruce beetle distribution ceased when beetles ran out of suitable trees for colonization. In many mature stands, tree mortality levels reached 90% or more. A few vigorous young stands, however, avoided these impacts. We describe trees in one of these stands on a bench of the Kenai River near Cooper Landing. During a visit to the stands in 2004, most trees were still alive with little or no evidence of new spruce beetle attacks. However, many trees had unusual looking bark scars (Figure 1), often associated with copious dried resin on

Figure 1. Bark surface indicators of underlying unsuccessful bark beetle galleries.

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their lower boles. Initially, a pathogen was the suspected cause of the stem scars, but examination of scars by a forest pathologist failed to reveal a pathogen. From the observations and data gathered in this study we hypothesize that these macroscopic symptoms are linked to underlying resistance reactions of trees to previous aborted attacks by spruce beetles.

Methods

This study was conducted in a 58-year-old Lutz spruce stand growing on the Kenai Peninsula near Cooper Landing (60°29.01′ N and 149°56.37′ W). Part of this stand was thinned and pruned in 1991 by seasonal Chugach National Forest personnel with the aim of increasing resistance of residual trees to further beetle attacks (Hard and Holsten 1985). Bark lesions and subtending xylem ring tissues on individual felled trees were dissected for observation until a suspected xylem lesion formed years earlier was revealed.

In 2007, three radial increment cores were removed from each of 18 trees representing a range of stem diameters along a meandering transect in the previously thinned portion of the stand. Cores were extracted from the mid-points of three bark scars of variable length on the lower two meters of each tree bole for a total of 54 cores. One core from each tree penetrated to near stem center to determine a) tree age near breast height, and b) depth in years since suspected unsuccessful beetle attack. The remaining two cores were taken to determine intervening years since suspected egg galleries, or xylem lesions, were formed. Ten additional trees in a nearby previously unthinned and unpruned part of the formerly contiguous stand were each bored once near breast height for increment core extraction. The midpoint of a single bark scar on each tree was the chosen site for core removal to determine number of ensuing years since unsuccessful beetle attack for comparison with years since apparent attacks on trees at the pruned and thinned portion of the stand.

Results and Discussion

It was noted that the distribution of scars on individual trees resembled the orientation and dispersal pattern characteristic of recent spruce beetle attacks (Knight 1960, Hard 1987), but removal of scarred bark showed no obvious injury at the year 2004 cambial zone (Figure 2). Successively older xylem rings were removed from beneath the bark scar until a narrow, elongated, resin-filled lesion appeared (Figures 2 and 3). Invariably, a paralleling xylem lesion was observed that was approximately

Figure 2. Excavated resin-filled xylem lesion corresponding to a bark lesion on the surface of a Lutz spruce.

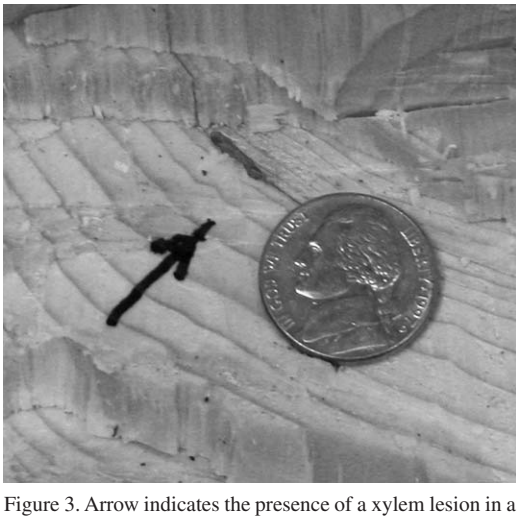

Figure 3. Arrow indicates the presence of a xylem lesion in a crosscut section of a Lutz spruce.

as long as the associated bark lesion. The lesion resembled an aborted but grown-over spruce beetle egg gallery because of its length, width, stem-axis orientation and shallow etching of the xylem unlike the deeper etching of engraver beetles such as *Ips* sp. Similar symptoms have been noted with *Abies grandis* where bark is disfigured 12 to 15 years after aborted attacks by the fir engraver (*Scolytus ventralis*) (Andris Englitis, U.S. Forest Service, personal communication).

Spruce beetle attacks may be followed by profuse resin flow from vertical resin ducts in the xylem and bark cortex and horizontal unconnected ducts in phloem and xylem rays (Thomson and Sifton 1925), a well-recognized mode of resistance to bark beetle attack in conifer stem tissues (Vite 1961). When healthy, well-hydrated spruce trees are attacked by spruce beetles, the network of resin-filled ducts under pressure may be severed or ruptured, and flood attacking beetles from their newly mined egg galleries in tunneled phloem and etched xylem. Each abandoned gallery is an unsuccessful attack or "pitchout" because the beetles abandon the gallery. Eggs, if any, laid in the gallery before adult abandonment would be inundated by copious resin flow that eventually hardens. These events are mostly confined to the inner bark and usually unseen except for pitch tubes composed of dried resin and beetle borings that may remain on the bark surface. Little emphasis has focused on later years' delayed macroscopic symptoms that may result from preceding beetle-caused injury.

Mean age of trees on the thinned and pruned site was 58.3 yrs (range = 51 to 66 yrs); mean stem diameter was 24.9 cm (18 to 41 cm); and mean size of 54 bark scar lengths was 12.9 cm (5 to 25 cm); mean basal area was 24.0 m^2/ha (4.7m^2 to 45.9 m^2). Mean number of years since suspected unsuccessful beetle attacks was 17.3 yrs (15 to 19 yrs). This indicates that the damage we observed occurred before the stand was thinned and pruned, not later. A strong resinous response may have been caused, in part, to stand age of about 40 yrs at that time.

Mean diameter of trees on the unthinned and unpruned site was 27.9 cm (range = 23 to 34 cm); mean bark scar length was 16.5 cm (8 to 25 cm); mean basal area was 33.1 m^2/ha (18.3 m^2 to 50.6 m^2); and mean years since individual unsuccessful spruce beetle attacks occurred was 16.4 yrs (14 to 19 yrs). Apparently, both the thinned and unthinned sites were under attack by spruce beetles in the late 1980s and early 1990s, but both have not been attacked significantly, if at all, since then.

Based on our observations, we hypothesize that the stem scars developed as follows: beetle-caused injury remains in place in the xylem and is overgrown by successive annual xylem rings, but the associated injury to the inner phloem is pushed farther toward the bark periphery; each new annual ring of phloem is crushed or phloem cells collapse. Unlike annual xylem rings, annual phloem rings are functional for only two years in spruce (Gregory 1971). Phloem injuries appear years later at the bark outer surface in the form of a ragged and sometimes swollen bark lesion depending on resin abundance (Figure 1).

Repeated attempts to locate beetle remains within the xylem lesions were unsuccessful. Bark lesions were also examined closely for entombed beetles, but none were found. However, strong circumstantial evidence suggests that the bark scars and the xylem lesions are signatures of old, unsuccessful spruce beetle attacks.

Acknowledgements

We thank Andy Graves, Richard 'Skeeter' Werner, and Tiphanie Henningson for their assistance in collecting tree samples for further examination. John Lundquist, John Schmid, 'Skeeter' Werner, Rick Kelsey, Mark Schultz, Greg Filips, and Andris Eglitis reviewed early versions of this manuscript.

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Received 4 May 2009
Accepted for publication 25 November 2009

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