Sudden Aspen Decline in Southwest Colorado: Site and Stand Factors and a Hypothesis on Etiology

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Abstract

An initial assessment of rapid dieback and mortality of aspen in southwest Colorado suggests that it represents a decline disease incited by acute, warm drought. Predisposing factors include low elevation, south and southwest aspects, droughty soils, open stands, and physiological maturity. Contributing factors include Cytospora canker, two bark beetles, poplar borer, and bronze poplar borer. Because this is a true decline disease distinct from "aspen decline" as often discussed in the literature, we refer to it as sudden aspen decline. There has been little regeneration response to overstory loss.

Introduction

Since about 2004, rapid dieback and mortality of trembling aspen stems have been increasingly observed in Colorado. By 2006 it became clear that the damage was substantial and that it was not the type of mortality typically seen in older aspen stands. The results of our initial assessment of the problem are presented here. Based on this assessment, we use the name sudden aspen decline (SAD) for this phenomonen.

Since the WIFDWC meeting, much of the data in this presentation has been published (Worrall and others 2008). Therefore, the information here will be abbreviated, with emphasis on aspects not presented in the publication.

In: McWilliams, M. G., comp. 2008. Proceedings of the 55th Western International Forest Disease Work Conference; 2007 October 15-19; Sedona, AZ. Salem, OR: Oregon Department of Forestry.

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Methods

This study was conducted in southwest Colorado, where aspen spans an elevation range of about 2100 to 3300 m. Detailed observations were made of sites with recent aspen dieback and mortality in the area.To analyze landscape patterns of damage, we used geographic information from the 2006 aerial survey on aspen damage, together with the aspen cover type from databases of Rocky Mountain Region, USDA Forest Service. Analyses were restricted to Forest Service land, where continuous cover-type information was available. The Grand Mesa, Uncompahgre and Gunnison National Forests, and the Mancos-Dolores District of the San Juan National Forest were analyzed. Healthy aspen was considered to be the aspen cover type after removing damaged aspen (from the aerial survey). Digital Elevation Model (DEM) data, including elevation, aspect and slope, were compared between healthy and damaged aspen.

Stand data, using standard methods, were taken from 31 stands on two sites (Haycamp Point and Turkey Knolls) on the Mancos-Dolores Ranger District east of Dolores. These stands were pure or nearly pure aspen. Data presented here include only aspen. Per stand examination protocol, stems ≥ 12.7 cm DBH are considered part of the overstory; smaller stems are considered regeneration.

Results

Before 2005, aspen damage noted in aerial survey totaled less than 10,000 ha each year in Colorado. By 2006 that figure had reached 58,374 ha, of which 56,091 was recorded as "aspen decline." Even taking into account the increased attention paid to aspen, clearly there was a rapid and substantial increase in damage area.

Ground Observations
Ground observations revealed the following:

Recent and rapid—The great majority of the damage appeared to be very recent and had occurred rapidly. Some stands were nearly completely dead, with intact bark and fine twigs still on the stem, almost as if they were dormant. Others had similarly recent mortality along with stems that had dieback and/or thin foliage.

Landscape scale—Where damage was common, extensive landscapes, including many stands, were similarly affected. Damaged areas of several kilometers in extent have been seen.

Sparse regeneration—Many stands had understory stems (< 12.7 cm DBH), but generally these were sparse and most were large enough that they appeared to have arisen before the current mortality event.

Biotic agents—Agents that typically cause the most mortality of mature aspen in Colorado, most notably sooty-bark canker (Hinds 1964; Juzwik and others 1978), were observed infrequently. Instead, a group of secondary, stress-related agents was found associated with dieback and mortality. Typically a few of them were found together in each deteriorating stand, but in various combinations. They were *Cytospora* canker, poplar borer (*Saperda calcarata*), bronze poplar borer (*Agrilus liragus*), and two species of bark beetles (*Trypophloeus populi* and *Procryphalus mucronatus*).

Effect of prior management—In damaged areas, patches that were cut in the past consistently stood out as solid green, healthy areas, often surrounded by dead and dying residual, unmanaged overstory.

Geographic Analysis

Elevation—The frequency distribution of aspen vs. elevation forms regular bell curves on all four forests that were studied (figure 1). The damaged aspen (expressed as a proportion of the cover type) was generally highest at low elevations and decreased to nearly zero at high elevations. However, the Grand Mesa was anomalous in this regard, with a peak of mortality near the upper end of the elevational range. The Grand Mesa is capped with a thick layer of basalt derived from lava flows (figure 2). Around the cap is a "landslide bench" derived from broken fragments of basalt (Yeend 1969). The landslide bench is a coarse jumble of basalt fragments with poor soil development. The anomalous high-elevation aspen mortality on the Grand Mesa occurs precisely on this landslide bench, most likely as a result of its droughty soil characteristics.

Aspect—Aspen cover type was most frequent on north aspects at low elevation and south aspects at high elevation. Damaged aspen tended to be most frequent on south and southwest aspects at all elevations.

Slope—On all forests and all elevation bands, damaged aspen consistently occurred on flatter slopes than did healthy aspen.

Stand Data

In the 31 measured stands, mortality ranged from 0 to 100% of standing trees. Findings were as follows:

Mortality associated with open stands—Stands of high density (up to 1200 stems ha-1) had low levels of mortality. Open stands (as low as 200 stems ha-1) had more variable levels of mortality. As a result, mortality was significantly and negatively correlated with density (R = -0.38, P = 0.033.

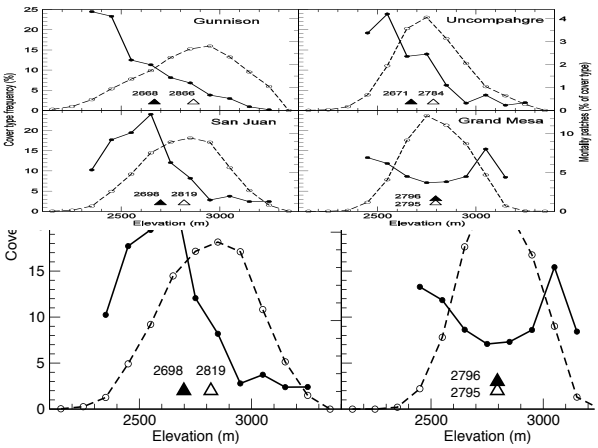

Figure 1—Elevation distributions of aspen cover type (dashed lines) and damage (solid lines; as a percentage of cover type) on four national forests. Triangles indicate mean elevations of healthy (hollow) and damaged (solid) aspen).

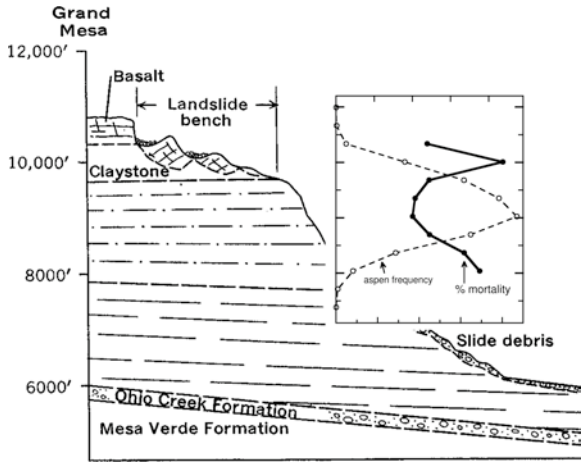

Figure 2—Geological profile of the Grand Mesa, showing the landslide bench, made of coarse fragments broken from the basalt cap of the Mesa (Yeend 1969). The anomalous high-elevation peak of mortality in the superimposed graph of aspen damage frequency (derived from figure 1 and scaled to the diagram) occurs on the landslide bench.

Larger stems affected—Overall, current mortality (recently dead and dying) was skewed to large trees (>30 cm DBH). Size of affected trees, relative to remaining healthy stems, was strongly correlated with incidence of current mortality in the stand ($R = 0.64$, $P < 0.001$).

Sparse regeneration—Regeneration averaged about 2500 stems ha-1, and did not increase with mortality. That level of regeneration is the average expected under intact, undisturbed stands in southwest Colorado; after a clearcut, the average density of suckers is 76,600 ha-1 (Crouch 1983).

Discussion

Cause—Colorado and much of the interior West recently experienced an acute drought that has been termed a "global-change-type drought" because it was exacerbated by extremely high temperatures (Breshears and others 2005). Aspen is intolerant of drought (Niinemets & Valladares 2006), and drought and high temperatures have been tied to deterioration of aspen often in the past (Frey and others 2004; Gitlin and others 2006; Shields & Bockheim 1981). In our study, the preponderance of damage at low elevations and on south and southwest aspects is consistent with moisture stress as an important cause. In addition, the association of stress-related biotic agents with the mortality strongly indicates the existence of a prior stressor. We suggest that this syndrome is consistent with the features of a true decline disease (Guyon 2006; Manion 1991; Manion & LaChance 1992) and propose the following etiology in that context:

Predisposing factors—Site factors that predisposed aspen to inciting factors include low elevations, south and southwest aspects, and droughty soil conditions. Stand factors that increased susceptibility include physiological maturity (large stem size) and low density.

Inciting factors—The acute drought with high temperatures during the growing season was the key event that triggered SAD.

Contributing factors—The biotic agents associated with SAD are secondary, stress-related agents. They seem to be interchangeable and can each play a similar role in different areas that are affected. This is one of the key features of a true decline.

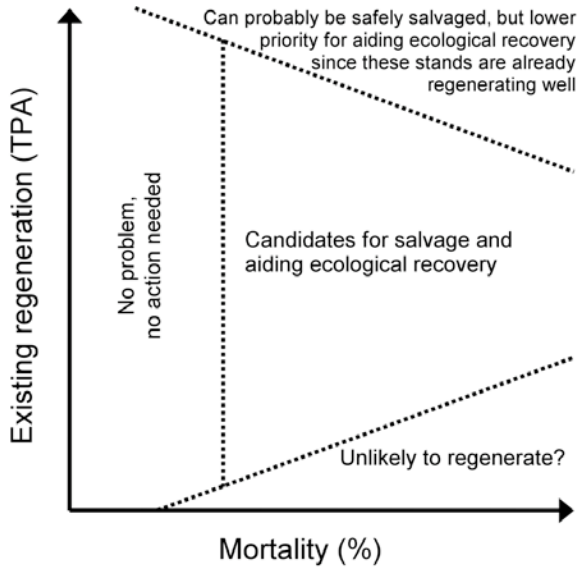

Figure 3—Conceptual diagram for selecting stands for treatment based on incidence of mortality and density of existing regeneration. Quantification of the axes is best done by silviculturists with survey data in hand.

Sad vs. Aspen decline—"Aspen decline," as generally described, refers to a long-term loss of aspen cover type due to succession under an altered fire regime, often exacerbated by ungulate herbivory of suckers (Kulakowski and others 2004; Ripple & Larsen 2000; Rogers 2002). Sudden aspen decline is distinct from that process for a number of reasons: (a) although both may result in succession to other vegetation types,

aspen decline is driven by succession whereas SAD is driven by damage to aspen; (b) SAD occurs on a landscape scale rather than on a stand scale; (c) SAD is rapid, resulting in large areas of mortality in just a few years; and (d) the mortality agents associated with SAD are different from those that typically kill mature aspen in Colorado.

Regeneration—Evidence from two sites suggests that there is often little or no regeneration response in aspen stands that are being opened up by SAD. This is confirmed by more recent results over a wider area (unpublished). Apparently, in many stands the cumulative stress has exceeded the regenerative capacity of root systems. The result may be conversion to other vegetation types, particularly if ungulates remove the sparse regeneration that is present.

Management—Although we have ample experience with management and regeneration of healthy aspen stands, we have little experience with stands deteriorating from SAD. We may be able to provide an abrubt disturbance through cutting or burning that will stimulate optimal suckering by the remaining root system, maximizing the likelihood of recovery. However, there is probably a point of deterioration, beyond which suckering will be inadequate, regardless of disturbance. A conceptual diagram (figure 3) has been offered to managers to use in prioritizing stands for treatment. We will learn from the results of such treatment and adapt management accordingly.

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Proceedings of the 55th Annual Western International Forest Disease Work Conference

Radisson Poco Diablo Resort
Sedona, Arizona
October 15 to 19, 2007

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