Rapid Aspen Decline on the Southwestern Edge of its Range

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Introduction & Problem

Dieback and mortality of trembling aspen (*Populus tremuloides* Michx.) have rapidly increased over the past 15 years in western North America. The sudden and synchronous decline in aspen on a landscape-scale was coined "sudden aspen decline" (Worrall et al. 2008). Aspen damage in the Southwest was detected on about 71,200 ha in 2008, with 70% located in Arizona (USDA 2009). A previous study in northern Arizona showed that significant mortality occurred below 2,300 m (Fairweather et al. 2008). We compared 24 low (< 2,400 m) with 24 high (> 2,400 m) aspen sites located in the Williams Ranger District of the Kaibab National Forest in northern Arizona.

Objectives

- Determine the relationship among aspen stand structure, dieback and mortality, with elevation or damaging agent.
- Determine if aspen on the Kaibab National Forest can be placed into the context of "sudden aspen decline" observed elsewhere in western North America.

Methods & Analysis

Study area

- Williams Ranger District of the Kaibab National Forest in northern Arizona
- Majority of stands are discontinuous, small (0.1– 25 ha) and occur at lower elevations
- Larger stands occur on the north slopes of Bill Williams, Kendrick, and Sitgreaves peaks.

Stand and plot selection

We stratified aspen stands by elevation and aspect (Worrall et al. 2008). Stratified random sampling weighted by area was used to select field sites proportional to the occurrence of strata within aspen's distribution.

Analysis

We compared stand structure variables between low and high elevation sites. One-way ANOVA was used where data met all assumptions. Welch's ANOVA test was used where data violated homogeneity of variance. Damaging agents data are descriptive.

Table 1. Characteristics of the aspen overstory (stems ≥ 10.1 cm dbh) in low (n=24) and high (n=24) elevation sites.

Variable	Elevation: Low (< 2,400 m)	Elevation: High (> 2,400 m)	P-value
DBH (cm)	17.7 (3.8)	23.2 (5.9)	< 0.001 §
Height (m)	12.5 (2.8)	17.6 (3.5)	< 0.001 †
% dead	58 (27)	42 (21)	0.024 †
% dead by BA (m^2/ha)	55 (28)	33 (22)	0.003 †
% w/ > 33% dieback	58 (30)	38 (19)	0.019 §

Notes:
- Values are means, with standard deviation in parenthesis.
- § denotes Welch's ANOVA test
- † denotes one-way ANOVA test

Figure 1. Size class distribution by density of live and dead aspen stems in low and high elevation sites. Short sucker (< 5.1 cm diameter and < 1.37 m height), tall sucker (< 5.1 cm diameter and ≥ 1.37 m height), sapling (≥ 5.1 cm dbh but < 10.1 cm dbh), and overstory (≥ 10.1 cm dbh). Error bars are +/- standard error.

Table 2. Percent incidence of damaging agents reported on live and recent dead overstory and short sucker (< 5.1 cm diameter and < 1.37 m height) aspen stems in low and high elevation sites.

	Overstory: Low (n = 572)	Overstory: High (n = 1,220)	Short suckers: Low (n = 1,225)	Short suckers: High (n = 1,669)	
Shoot pathogens					
Venturia tremulae	--	--	< 1 (3)	26 (10)	Shoot blight
Canker pathogens					
Encoelia pruinosa	14 (16)	22 (23)	--	--	Sooty-bark
Cytospora chrysosperma	32 (21)	20 (22)	3 (3)	1 (1)	Cytospora
Stem decay pathogens					
Phellinus tremulae	13 (16)	10 (22)	--	--	White trunk rot
Wood and bark boring insects					
Family: Buprestidae	57 (24)	22 (22)	1 (3)	--	Flathead borers
Trypodendron retusum	8 (15)	10 (22)	--	--	Ambrosia beetle
Trypophloeus populi	16 (15)	11 (16)	--	--	Aspen bark beetle
Sucking insects					
Lepidosaphes ulmi	12 (11)	1 (2)	< 1 (3)	--	Oystershell scale
Ungulate damages					
Animal rubbing	62 (23)	43 (23)	--	--	
Animal browsing	--	--	62 (20)	51 (22)	

Notes:
- Values are %, with number of stands affected in parenthesis.
- Agents with < 10% in at least one class were not reported .

Figure 2. Major damaging agents on overstory aspen stems: a) adult flathead borers (left, bronze poplar borer; right, poplar dicera; b) white trunk rot; c) bronze poplar borer gallery; d) bark beetle galleries; and e) sooty-bark canker. Photo credits: B. Steed & T. Zegler.

Figure 3. Aspen core with marker years. The small circle marks a locally absent ring for year 2002 (major drought). Three dots indicate a century (year 2000) and single dots indicate decades. Bottom dot notation is incorrect.

Results

Structure

Compared to high elevation sites, low elevation sites have (Table 1; Fig. 1):

- more aspen mortality in all size classes (low = 46% dead, high = 31%; P = 0.024)
- more aspen mortality in the overstory
- more aspen crown dieback
- less density of live overstory aspen (low = 4.0 m^2/ha, high = 20.0 m^2/ha; P < 0.001)
- no difference between the mean dbh of dead and live overstory aspen (low dead = 17.4 cm, live = 18.1 cm; P = 0.535; high dead = 19.0 cm, live = 25.1 cm; P < 0.001).

Damaging Agents

Pathogen and insect damage to overstory stems, and ungulate damage to all stems were common, especially in low elevation sites (Table 2).

Major pathogen agents were (Fig. 2):

- sooty-bark canker (*Encoelia pruinosa*)
- cytospora canker (*Cytospora chrysosperma*)
- white trunk rot (*Phellinus tremulae*).

Major insect agents were:

- bronze poplar borer (*Agrilus liragus*)
- poplar dicera (*Dicera tenebrica*)
- aspen bark beetle (*Trypophloeus populi*).

Discussion & Conclusions

We found that the major predisposing factor for increased dieback and mortality is lower elevation, while the contributing factors are insects and pathogens that tend to invade and kill stressed trees. Except for trends in diameter and mortality, our results are similar to the etiology described for "sudden aspen decline" disease in southwestern Colorado (Worrall et al. 2010). Another major contributing factor in northern Arizona is elk damage. We suspect that the inciting factors are the acute and severe droughts that occurred during the growing seasons starting in 1996 and lasting until 2007 in northern Arizona.

Future Work

We will investigate the relationships of slope, aspect, drought, and age (Fig. 3) as factors in aspen mortality.

Literature Cited

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Acknowledgments

Funding for this project is provided by USDA Forest Service, Rocky Mountain Research Station, Award #08-JV-11221633-244 and USDA Forest Service, Forest Health Monitoring Program, Award #10-CR-11031600-026. We thank the staff of the Kaibab National Forest for their continued assistance. We also thank many people in the Ecological Restoration Institute at Northern Arizona University, especially, D. Normandin, S. Curran for field and laboratory assistance.