

Sudden Aspen Decline in Southwestern Colorado

Results from new research evaluating causal mechanisms and implications for understory microclimates, plant communities, and aspen regeneration

Quaking aspen (*Populus tremuloides*) is one of Colorado's most emblematic and ecologically important tree species. As one of the few broadleaf trees native to Colorado, aspen provide diversity to a landscape otherwise dominated by conifers. Aspen forests are often characterized by a rich herbaceous and shrub understory, which provides habitat for a number of mammals, birds, and insects important to Colorado's wildlands (Kay 1997, Chong et al. 2001).

Following the drought of 1998-2002, large-scale dieback of aspen forests began occurring throughout Colorado (CSFS 2012). Termed Sudden Aspen Decline (SAD), the phenomenon prompted the concern of forest managers, researchers, and the general public. Much research has occurred in the last decade aimed at better understanding the causal factors of SAD and the mechanisms of aspen tree mortality. Results point to a complex set of interactions between topography, climate, and insects and pathogens in the onset and spread of SAD, whereby aspen on inherently dry sites such as low elevation, south-facing slopes are more prone to drought-stress when drought occurs. Drought-weakened individuals then become more susceptible to attack by a host of insects and pathogens, such as the poplar borer, bronze poplar borer, aspen bark beetle, and *Cytospora* canker, which disrupt important tree physiological processes, eventually resulting in tree death (Frey et al. 2004, Worrall et al. 2008, Anderegg et al. 2013).

New research from scientists at Fort Lewis College in Durango, Colorado, validates these causal mechanisms for aspen decline in Southwestern Colorado, but also takes the story a step further by evaluating consequences and implications of SAD for understory microclimates, plant communities, and aspen regeneration dynamics. Understanding the broader ecological effects of SAD is important for a number of reasons, including anticipating the impact of SAD on biological diversity and in directing management efforts to best deal with SAD. With support from the Colorado Forest Restoration Institute, the Fort Lewis College Foundation, and the San Juan National Forest Dolores District, Fort Lewis researchers set out to address the following questions in stands experiencing low, moderate, and high levels of SAD:

- How will aspen canopy loss due to SAD influence understory microclimatic conditions such as temperature, solar radiation and soil moisture?
- How will understory plant communities and associated mycorrhizae respond?
- Will aspen regenerate?



Photo: Julie Korb



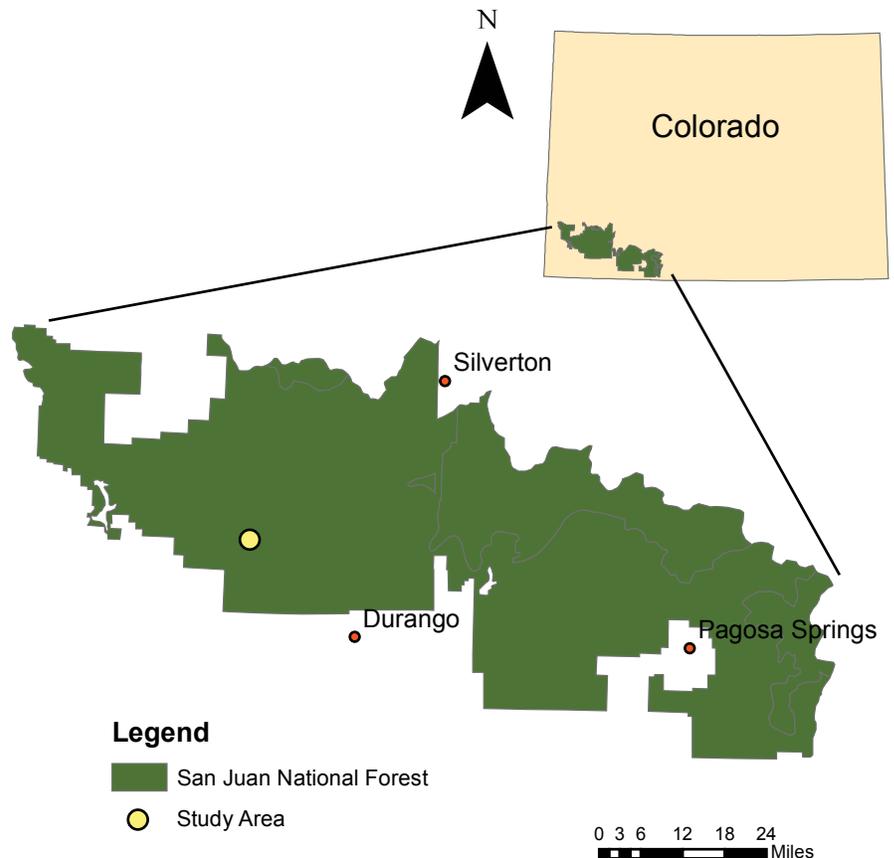
Key Findings

Fort Lewis researchers documented significantly higher surface temperatures and solar radiation at the forest floor in areas with high incidence of SAD, due to the more open canopy conditions associated with aspen mortality. No overall difference in understory plant biomass or species richness accompanied the change in microclimate, but results did show a shift in plant community composition toward grasses. Increased abundance of arbuscular mycorrhizae – typically associated with herbaceous plants – was also noted in areas with high levels of SAD, further signaling the shift from aspen to herbaceous plants as reflected in belowground processes and dynamics. The researchers noted high levels of aspen root mortality and consequent low levels of suckering (the primary regeneration mechanism in aspen) due to the loss of roots. Regeneration in high SAD areas was less than 500 stems per acre and was not considered self-sustaining, especially given the high degree of herbivory aspen often experiences as a result of ungulate browsing. Fort Lewis researchers describe a positive feedback mechanism initiated by SAD, whereby SAD-affected areas experience warmer temperatures and lower soil moisture, thus further exacerbating drought conditions and further increasing the vulnerability of surviving aspen to attack by insects and pathogens.



Photo: Julie Korb

San Juan National Forest - Study Area



Statistically significant site, stand, microclimatic variables, and insect/disease agents by level of SAD (low, moderate, high). Low SAD is defined as 0-25% crown loss, moderate SAD is 25-50%, and high SAD is 50-100%. Insect/disease agents are expressed as incidence, or frequency of stems exhibiting agent presence. Means with different letters within rows are significantly different at $p \leq 0.05$.

	<u>Low SAD</u>	<u>Moderate SAD</u>	<u>High SAD</u>
<u>Site Variables</u>			
Elevation (feet)	9374 (28) ^a	9197 (69) ^b	8971 (37) ^c
<u>Stand Variables</u>			
Stand density (stems per acre)	441 (19) ^a	298 (26) ^b	375 (22) ^c
Canopy cover (%)	82 (2) ^a	60 (4) ^b	33 (4) ^c
<u>Microclimatic Variables</u>			
PAR (μE)	48 (0.9) ^a	103 (99) ^a	371 (153) ^b
Soil water content (m^3/m^3)	0.10 (0.01) ^a	0.12 (0.03) ^a	0.04 (0.01) ^b
Daytime surface temp ($^{\circ}\text{C}$)	19 (2) ^a	20 (0.5) ^a	24 (0.9) ^b
<u>Insect/Disease Agents</u>			
Bronze poplar borer	10 (4) ^a	29 (5) ^b	73 (3) ^c
Poplar borer	13 (4) ^a	30 (5) ^b	68 (5) ^c
Cytospora canker	44 (7) ^a	56 (8) ^{ab}	76 (6) ^b
Bark beetles	7 (2) ^a	22 (4) ^b	52 (7) ^c

PAR = Photosynthetically active radiation

Photo: Rob Addington

Implications

Practitioners with the Colorado State Forest Service have mapped progressively smaller and smaller areas affected by SAD since 2008, suggesting some subsidence of SAD across the landscape attributable to several years of increased moisture (CSFS 2012). Given the close link with climate, however, SAD is likely to be a recurrent phenomenon and may worsen with climate change and increased regularity of drought (Hanna and Kulakowski 2012). Effects of the 2012 drought remain to be seen, but in all likelihood some re-initiation of SAD may become apparent throughout Colorado, particularly in aspen stands having already experienced SAD-related mortality. Low elevation aspen forests are particularly vulnerable. Aspen stands highly afflicted with SAD may be too far gone to save and may transition to grass or shrub-dominated communities, or may succeed to conifers. Despite this loss, the research community encourages the long view, recognizing that some gains in aspen forest cover may be realized at higher elevations. Aspen is uniquely positioned relative to other species to recover from multiple disturbance events also anticipated with climate change, due to its vegetative regeneration habit (Kulakowski et al. 2013). Fort Lewis researchers thus recommend that management emphasis be placed on areas with low to moderate incidence of SAD, and that management efforts be aimed at encouraging aspen regeneration and sustaining the unique microhabitats and vegetation communities that characterize the aspen understory.



For a more in-depth description of the Fort Lewis study's scope, methodology, and results see:
Korb, J.E. 2013. Predisposing and contributing factors associated with aspen mortality and the effects of Sudden Aspen Decline on ecological attributes, southwestern Colorado, USA.

Contact Julie Korb (KORB_J@fortlewis.edu) or Tony Cheng (Tony.CHENG@colostate.edu)



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Photo: Julie Korb

Colorado Forest Restoration Institute (2013) Sudden Aspen Decline in Southwestern Colorado: Results from new research evaluating causal mechanisms and implications for understory microclimates, plant communities, and aspen regeneration. Ed. Addington, R.N., Korb, J.E., Cheng, A.S., CFRI Field Study Brief, Colorado State University, CFRI-FSB-1301. Fort Collins, CO. 4 p.



in partnership with:

Forest and Rangeland Stewardship
1472 Campus Delivery
Colorado State University
Fort Collins, CO 80523-1472
970.491.1900
info@coloradoforestrestoration.org



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RESTORATION INSTITUTE
www.coloradoforestrestoration.org



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April 2013