Status Report on Plot Study of Sudden Aspen Decline in Southwestern Colorado

We completed field work on this project in 2007 and 2008. The field data are entered, and we have conducted some preliminary summaries and analyses. Much analysis still remains. We are working on dendrochronology, and are also gathering and organizing spatial climate data to link with the plot data.

Briefly, here is the sampling design. Sampling was on national forest land on the Mancos-Dolores District of the San Juan NF and on the Grand Mesa, Uncompahgre and Gunnison NFs. Using aspen damage polygons from the 2006 and 2007 aerial survey, we randomly selected damaged plot locations within 1 km of roads. To be considered a damaged plot, it had to be an aspen stand with > 25% crown loss. We then selected a nearby, paired "healthy" plot (≤ 25% crown loss).

Here are the types of data that we have:

1. Plot location (Fig. 1), elevation, topographic position, slope, and aspect
2. Plot vegetation, including:
   a. identity and mean height of the three herbs/grasses with the greatest cover
   b. identity and mean height of the three shrubs with the greatest cover
3. Soil pit (one per plot), from which we get:
   a. soil classification
   b. depth of mollic horizon
   c. water-holding capacity of the soil profile
   d. stoniness, etc.
4. Aspen root trench (one per plot; roots > 4 mm diam) from which we get:
   a. numbers of live and dead roots
   b. diameters of live and dead roots
   c. volumes of live and dead roots
5. Tree data
   a. Stand structure (single-story, two-story, multi-story, mosaic, or unknown)
   b. Prism plot (for trees ≥12 cm DBH or about 5 inches) with DBH and species
   c. Each aspen (except old snags) is examined for insects, diseases, and other damage
   d. Each aspen (except old snags) has crown loss estimate
      i) old snags and non-aspen are not counted in crown loss estimates
      ii) recent dead aspen are counted as 100% crown loss
      iii) crown loss is averaged to get value for the plot
   e. Cores and height measurements from four dominant and codominant trees
6. Fixed-area regeneration plot (for stems < 12 cm DBH, 0.01 ha). All species counted:
   i) by live and dead
   ii) by species
   iii) by size class:
      (1) Small: 0.30 m (about a foot) to 1.4 m (BH) tall
      (2) Medium: > 0 to 3 cm DBH
      (3) Big: ≥ 3 to 12 cm DBH

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Preliminary Results

We completed 162 plots, examined 2643 trees, and collected approximately 650 increment cores. The crew proudly dug and analyzed soil pits to a cumulative depth of 419 feet, and exhumed, examined and measured 4264 aspen roots.

In damaged plots, mean aspen crown loss was 52.9 % and mean aspen mortality (including snags) was 45.2 %. Below, the results are itemized and roughly grouped under categories (although the categories overlap). We have graphs and statistics for these if you want to see them. If a statement points out a difference or correlation, it is statistically significant unless noted otherwise.

These results and conclusions are preliminary and tentative.
Please do not consider them or pass them on to others as fact.

Stand Conditions

Basal area/density and crown loss/mortality. Damaged stands had lower basal area than healthy stands. The crown loss vs. basal area relationship was weak but also significant. This relationship is consistent with the Dolores stand exam data, showing that current mortality was negatively correlated with total aspen density (2). In our plots, there are trends of decreasing crown loss and decreasing mortality with increasing density, but they are not significant.

DBH and crown loss/mortality. There was no relationship between DBH and recent crown loss, either among individual trees or among plot averages. There was also no relationship between mean DBH and % mortality in plots. Nor was there any significant difference in DBH among healthy, dying, and recently dead aspen. This is somewhat at odds with a result from Dolores stand exams (2) in which relative size of current mortality within stands was correlated with the amount of mortality in that stand, but we have not replicated that analysis with these data. All this, of course, refers only to trees ≥12 cm DBH.

Roots

Root status vs. crown loss. Root condition is clearly tied to crown loss. Damaged plots had both fewer live roots and more dead roots than healthy plots. Damaged plots had a greater volume of dead roots than healthy plots, but the volume of live roots was not significantly different. As crown loss increased, so did the % of roots that were dead and the % of root volume that was dead, while the total number of roots decreased.

Root diameters vs. crown loss. In damaged plots, both live and dead roots were larger than in healthy plots. This may be because smaller dead roots are decomposing rapidly, increasing the average diameter of residual roots. This is supported by the fact that, in both healthy and damaged plots, mean diameter of dead roots was greater than that of live roots.

Regeneration

Regeneration and crown loss. There was no significant relationship between crown loss and aspen regeneration (Fig. 2), and regeneration did not differ significantly between healthy and damaged plots. This is consistent with the limited data we had from the Dolores stand exams. It indicates that, as damage increases, there is no corresponding regeneration response from the root system. Only the smallest size class of aspen regen (< 1.4 m tall) was more abundant in damaged than in healthy plots. However, the difference was small, the significance was marginal, and a correlation of overstory crown loss and small regen was not significant.

Regeneration and roots. There was no significant relationship between aspen regeneration and root mortality. Although this may seem counterintuitive, since healthy roots should result in good regeneration, keep in mind that healthy roots tend to occur in healthy, intact stands, which are not expected to regenerate.

Regeneration mortality. Mortality of regeneration (standing dead) was much lower than that in the overstory in damaged stands. It probably resulted from normal thinning processes in healthy stands and perhaps SAD process in damaged stands; it was not correlated with crown loss of the overstory.

Soils

Soil methods and interpretation are being conducted in cooperation with Dr. David Dearstyne, NRCS, Montrose.

Mollic depth and regeneration. Regeneration did not vary significantly with depth of mollic horizon.

Soil type and crown loss. Crown loss did not vary significantly among soil types. Among mollisols, there is a series showing the least crown loss in the moister suborders (aquic and oxyaquic) and greatest crown loss in the driest suborder (ustic). However, the number of plots in these types (136 of 162 plots were mollisols) did not allow detection of significant differences.

Other soil conditions and crown loss. Crown loss did not vary significantly with water-holding capacity of the soil, with depth of mollic horizon, or with rockiness of the soil. We plan to subdivide the data by forest, aspect, elevation, etc., and further explore this.

Vegetation types

Using ordination, we divided the plots into eight vegetation types. We have not yet fully characterized the types, nor have we compared them in terms of SAD effects. However, the types vary substantially in average crown loss, so it does appear there will be differences.

Dendrochronology

We have begun measuring ring widths on cores and subjecting them to dendrochronological study (with cooperation of Dr. Jonathan Coop, Western State College), and have no complete results yet. However, based on preliminary aging of some cores, it did NOT appear that mean crown loss of plots was related to stand age (estimated from the cored trees). This is consistent with the lack of relationship to DBH.

Agents

Agents and crown loss. Among the agents previously identified as contributing factors in SAD (bark beetles, poplar borer, bronze poplar borer, and Cytospora canker), the frequency of most was strongly correlated with crown loss class of trees. This was not true of most agents not associated with SAD: white trunk rot, poplar leafhopper, black canker, defoliators, etc.

Poplar borer. The frequency of poplar borer was not strongly correlated with crown loss, though the relationship over all plots was significant. This suggests that poplar borer may be a less important contributing factor in SAD than previously considered. An interesting phenomenon was that, independent of the crown loss of individual trees, those in damaged plots were attacked more frequently than those in healthy plots. Also, trees of small DBH tended to be attacked more frequently than larger trees in healthy plots, but in damaged plots large trees were also attacked.

Bark beetles and contagion. For bark beetles, unlike the other contributing factors, the relationship between frequency of infestation and crown loss class was steeper in damaged plots than in healthy plots. In other words, as crown loss of a tree increased, those in damaged plots were more likely to have beetles than those in healthy plots. This probably indicates that local contagion is a more important issue for the bark beetles than for the other agents.

Agents and DBH. Frequency of Cytospora canker was not related to DBH class of trees. Frequency of poplar borer and bronze poplar borer were weakly or not clearly related to DBH class. Frequency of bark beetles, white trunk rot, and to some extent black canker increased strongly with DBH class.

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Preliminary Conclusions

1. Roots are dying in many SAD-affected stands.
2. There is no significant regeneration response to crown loss and mortality. Individual stands vary in regeneration, and some stands may have experienced a regeneration response since they were affected by SAD. However, this is not the overall trend.
3. Among trees ≥12 cm DBH, SAD is not related to tree size, and possibly (based on partial results) not related to stand age either. This contradicts hypotheses that the phenomenon is a manifestation of the old age of aspen.
4. There are interactions among many factors. Other than factors shown in the earlier SAD paper (especially elevation) single site or stand factors may not correlate strongly with SAD over the whole study area. More analysis, employing multiple regression and segmentation of the data, will be needed to find combinations of factors that are connected with the occurrence and severity of SAD.
5. No “new” damage agents were identified during 2007-2008 field work.

Figure 1. Locations of 81 SAD plot pairs in the Mancos-Dolores District (SJNF) and on the GMUG.

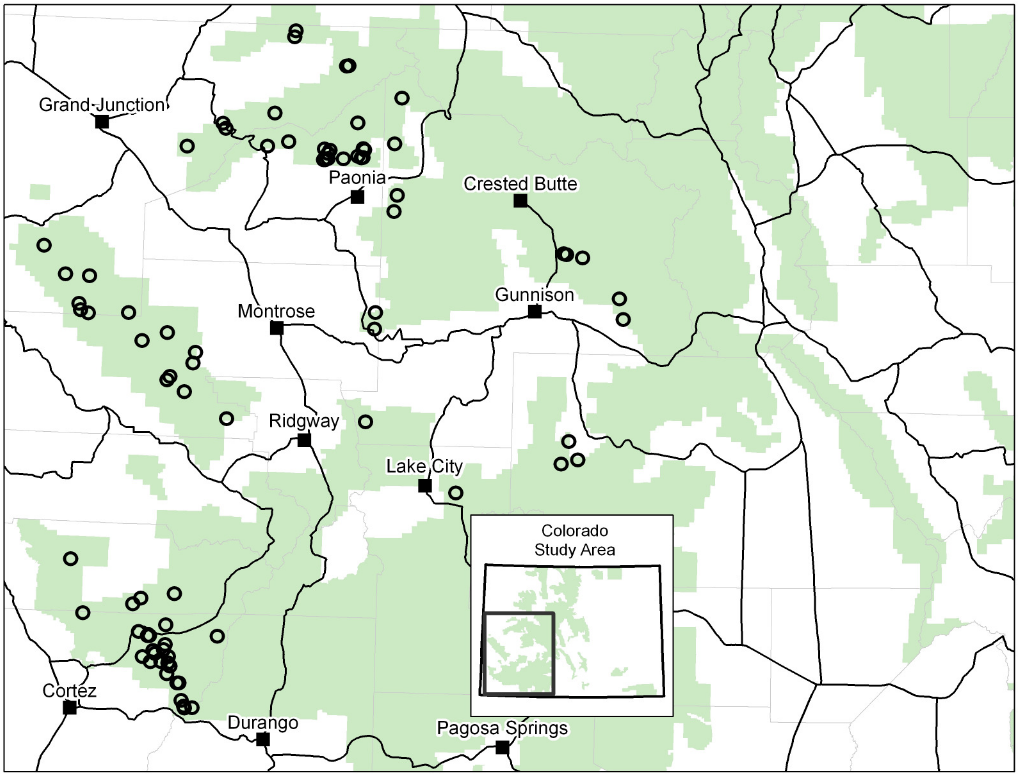

Figure 2. No significant increase in aspen regeneration with crown loss in 162 plots.

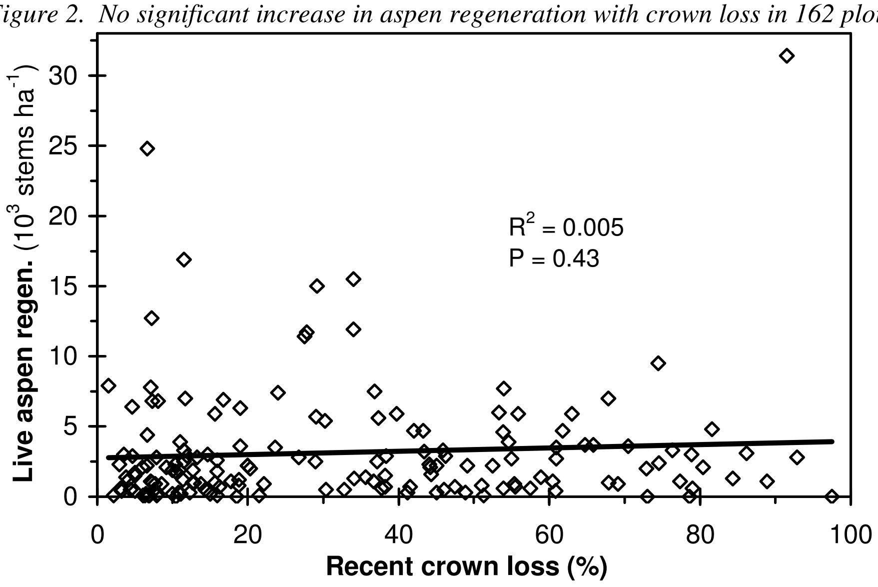

Table 1. Mean density (stems·ha^{-1}) of live aspen regeneration in healthy and damaged plots, by forest.

Nat'l Forest	Healthy plots (≤25%) crown loss	Damaged plots (>25% crown loss)	P
GMNF	3314	3423	0.942
GNF	1712	3729	0.054
SJNF	2904	4559	0.162
UNF	2507	1860	0.471
Mean of all plots	2691	3577	0.153

Addendum: Questions from Managers

How does percent mortality compare to regeneration response, and how is that different from traditional disturbance?
As noted above, there is little to no regeneration response to overstory crown loss (nor to overstory mortality). We don't have data at hand about responses to natural disturbance under normal circumstances. Certainly response to cutting and fire would normally be much greater. Clearcuts in southwestern Colorado result in an average of 76,500 suckers ha^{-1} in one year (1).

What is the average # of suckers or per acre data you have on healthy vs diseased plots? What is the future of these stands given the level of regeneration; i.e. if a stand dies and the regeneration sits around 1,000, 1,500, or 2,000 or even 3,000 trees per acre, how many of these stems will survive and grow into mature trees? What would be the future stocking?
See Fig. 2 and Table 1.[a] The plots we studied had an overall mean regen density of 3134 live stems ha^{-1} (1268 $acre^{-1}$). It would be up to a qualified silviculturist to determine the implications of these numbers for the future of a stand. We can provide the breakdown by regen size class if that is helpful.

Is there some level of regeneration, such as less than 1,000 per acre or less than 500 per acre where we could assume none of the stems would survive over time? Are any of the plots showing numbers that low?
Again, a silviculturist is best qualified to estimate future stocking based on current regeneration density and stand condition. Most of our plots had regen density at or below the range indicated. The median of all plots was 2000 stems ha^{-1} (809 $acre^{-1}$), and 61% of plots had ≤2500 stems ha^{-1} (≈ 1000 $acre^{-1}$).

I'm curious about any differences seen between this year and last year's data - is mortality still progressing on these plots? Were there green healthy trees last year that have fading crowns this year? What is the rate of spread of mortality? Given the onset of any disease or insect, how long does it take to kill the tree? What amount of fading of the crown will you see by year?
Unfortunately, the study was not designed to do repeated measurements, and we have no data on changes over time. This year's plots were in different locations from last year's plots. Also, due to limitations of aerial survey, one cannot assume that appearance or expansion of a polygon is an absolute change from the previous year. We do have change data from the Dolores exams of four stands at Turkey Knolls, originally done in 2002/2003 (< 10% mortality) and repeated in 2006 (30-60% mortality) (2).

[a] To convert stems per hectare to stems per acre, divide by 2.471 or, roughly, 2.5.

Is there a different regeneration response depending on the types of insect/disease agents? i.e. are beetles killing quicker and root systems responding better than death by fungal agents?
This is a good question, but we have not addressed it yet. We would expect that, once well established, the bark beetles and Cytospora canker would kill trees more rapidly than the wood borers. This could possibly lead to less root mortality and better regeneration response.

What were the associated conifer types in the plot areas?
Specifically in the Dolores District, we had 54 plots, 22 of which had conifers in the overstory. Numbers are in Table 2. Regeneration is not included.

Table 2. Numbers of plots with conifers in overstory on the Mancos-Dolores District. There were a total of 54 plots (27 pairs) on the District.

Tree species	Healthy plots (≤25%) crown loss	Damaged plots (>25% crown loss)
Engelmann spruce	7	3
Ponderosa pine	4	6
Blue spruce	1	1
Subalpine fir	2	2
Any conifer	11	11

Map or GIS coverage of the location of the paired plots would be helpful to pinpoint where the plots are located within the analysis area [Dolores District project].
We can provide jpeg maps or GIS files on the plot locations in any area.

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1. Crouch GR. 1983. Aspen regeneration after commercial clearcutting in southwestern Colorado. Journal of Forestry 83(5): 316-319.
2. Worrall JJ, Egeland L, Eager T, Mask RA, Johnson EW, Kemp PA, Shepperd WD. 2008. Rapid mortality of *Populus tremuloides* in southwestern Colorado, USA. Forest Ecology and Management 255(3-4): 686-696.