Estimating White Trunk Rot in Aspen Stands

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ABSTRACT. *Advanced decay caused by* Phellinus tremulae *was estimated in 295 trembling aspen on 30 plots in 2 Minnesota counties using existing inventory guides, and then measured by felling and sectioning the trees. In standing trees, decay volume was underestimated by 38% compared to measured decay volume in felled trees. The most reliable external indicator of decay was the presence of conks of the fungus. Results indicate that decay associated with conks in the first 16 ft of the trees accounted for nearly 70% of the total volume loss. Decay volume in trees with no conks averaged less than 2% compared to 14% in trees with conks. There was little merchantable volume lost from decay associated with poplar borer* (Saperda calcarata) *damage, closed wounds, and hypoxylon cankers. We recommend that inventory guides for estimating aspen decay in Minnesota be revised, and a suggested guide is provided. North. J. Appl. For. 15(1):33–36.*

Trembling aspen (*Populus tremuloides*) is susceptible to injury by many biotic and abiotic damaging agents. Aspen is a poor compartmentalizer, forming weak boundaries that are easily overcome by invading organisms (Shigo 1985). *Phellinus tremulae* causes white trunk rot, the most serious stem decay of aspen in North America, resulting in more volume loss than any other disease of aspen.

In order to determine the sustainability of the aspen resource and develop harvest schedules to minimize volume loss caused by *P. tremulae*, attempts have been made to correlate site, tree age and size, and clones, in aspen stands with the incidence and extent of decay. In several studies, investigators failed to find a relationship between site and incidence of white trunk rot (Brown 1934, Riley 1952, Basham 1958). On two sites, however, Wall (1971) found highly significant differences among aspen clones in the incidence and extent of decay. Genetic variation in resistance to decay and differences in the growth rates of aspen on various sites make it difficult to distinguish possible site factors that may contribute to the level of decay present in a stand. Severity of white trunk rot of aspen has been reported to increase with stand age (Schmitz and Jackson 1927, Brown 1934, Riley 1952, Basham 1958, Hinds and Wengert 1977). Basham (1987) found that tree age most often correlated with the amount of decay and proved to be more reliable as an indicator of decay than diameter, growth rate, or site in Ontario Canada .

Conks (fruit bodies of the fungus) on trees are the most reliable external indicators of the presence of decay (Basham 1958, 1987, Hinds and Wengert 1977). Several investigators have attempted to use the number, size, and location of conks on trees to predict the extent of internal decay. In Minnesota, Horton and Hendee (1934) found that the total length of decay extended from 2.0–5.0 ft above, and from 2.5–5.5 ft below conks, depending on the number and size of the conks. In Ontario, Riley and Bier (1936) also felled trees with visible conks and measured the extent of decay associated with them. They found that the presence of conks did not necessarily indicate an unmerchantable tree. Decay extended 1–6 ft above and below conks. Although they concluded that the presence of conks could be used to estimate the proportion of decay in a stand, no general rule could be developed for estimating the amount of decay volume. Hinds (1963) found that in Colorado, decay extended an average of 12 ft above and below conks, and trees having few conks or conks low on their bole had less decay than trees with many conks higher on the stem. Trees with conks averaged 82% decay volume whereas trees without conks averaged 40% decay volume (Hinds and Wengert 1977).

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Anderson and Schipper (1978) developed a method to make projections of future decay in a stand based on the application of a constant to the basal area of trees with conks. These projections were based on the finding that the basal area of total decay (trees with visible conks plus trees with hidden decay) averaged 1.9 times the basal area of trees with conks. Hidden decay was determined by taking a core sample at dbh. This system only provided predictions of basal area having some decay, but did not provide the volume of decay that may be involved. Results from these many studies, unfortunately, have been inadequate for developing a method to accurately estimate the incidence and severity of decay in aspen by field foresters and inventory personnel. Much of the difficulty in developing a reliable method in these past studies can be attributed to clonal variation in the amount of stem decay within aspen. Clonal variation complicates the determination of relationships with other variables. The failure of previous investigators to separate stained wood from decayed wood can also be a source of error, making direct comparisons among study results difficult (Basham 1987). In addition, decay in aspen develops much earlier, and trees are shorter lived in Minnesota compared to Canada where methods to estimate decay were developed (Basham 1987).

In this study, we examined the relationships between a number of tree factors and the volume of decay present in an attempt to develop a method to more accurately estimate decay in aspen in Minnesota. We tested the hypothesis that external indicators are good predictors of internal decay, and we suggest a revised guide for Minnesota and perhaps the other Lake States based on our results.

Materials and Methods

Study Areas

This study was conducted in northeastern Minnesota in Koochiching and St. Louis counties. These two counties account for nearly 30% of the aspen acreage in Minnesota (Miles et al. 1995) and are typical of the range of aspen growing conditions found in Minnesota. Thirty state-owned aspen stands ranging in age between 21 and 50 yr, with site indices greater than 49, and at least 10 ac in size were randomly selected from a population of state-owned aspen stands in the 2 counties. The stand age and site index criteria used in this study included that portion of the aspen type that will be most important for managing and harvesting during the next 2 decades.

Data Collection

One Forest Inventory Analysis (FIA) plot consisting of a cluster of 10 points (USDA Forest Service 1986) was established in each selected stand by inventory contractors during spring and early summer of 1989. During the same growing season, Insect and Disease Specialists from the Minnesota Dept. of Natural Resources and the USDA Forest Service destructively sampled 10 aspen stems on each of the 30 plots. One aspen on each of the 10 points where aspen occurred was randomly selected for sampling from all live aspen with a dbh of 5.0 in. or greater. Trees were felled, and total tree length, length of live crown, and merchantable length to a 4 in. top were measured. Total merchantable tree volumes were calculated in cubic feet using the volume formula for aspen developed by Hahn (1984). The merchantable portion of the bole was cut into 2 ft sections, and a total of 5,189 sections were cut from the 295 aspen.

Poplar borer (*Saperda calcarata*) damage, hypoxylon canker caused by *Entoleuca mammata* (*Hypoxylon mammatum*), open wounds, frost cracks, and the number and height of *P. tremulae* conks on each section were recorded as external indicators of decay. Frost cracks were cracks open wide enough to insert a pencil. Open wounds from mechanical damage were recorded if the bark had been removed and wood exposed.

The area of advanced decay on the top cross-sectional face of each 2 ft section was traced onto acetate. Spongy wood, wood with white pockets of decay, wood within dark zone lines, and missing wood caused by decay were recorded as advanced decay (Ostry and Walters 1983). The advanced decay on each acetate tracing was measured with a compensating polar planimeter to determine the cross-sectional area in square feet. Decay column length in each section was recorded as 2 ft if there was decay in the adjacent lower section or assumed to be 1 ft in length if the adjacent lower section was free of decay. The volume of decay was calculated for each section, and total tree decay volume was the sum of the decay volume in each section.

Data was analyzed in Borland's Quattro Pro for Windows 5.0. Student's t-test was used for comparing estimated and measured values, and decay volumes in trees with and trees without conks. Correlation coefficients were calculated for decay volume, number of conks, length of bole with conks, and dbh.

Results and Discussion

Eighty percent (235 trees) of the destructively sampled aspen had measurable advanced decay, but only 45% (133 trees) had external indicators of decay. Of the trees with no external indicators of decay, 73% (118 trees) had measurable advanced decay (Table 1). Fifty-five percent of the trees with decay had a decay volume less than 1% of their gross merchantable volume, and 77% had less than 5% decay volume.

Every tree with conks, open wounds, or frost cracks had advanced decay. Trees with *P. tremulae* conks accounted for 64% of the total decay but made up less than 15% of the trees.

Table 1. Percentage of the 295 destructively sampled aspen and decay volume associated with external indicators.

External indicators of decay	Trees	Trees with decay	Total decay volume	Volume reduction caused by decay
	(%)			
None	55	73	15	2
P. tremulae conks	14	100	64	14
Poplar borer	13	69	3	1
Hypoxylon canker	9	85	5	3
Open wounds	4	100	9	7
Frost cracks	4	100	4	4

Table 2. Source of decay estimation errors in 217 destructively sampled aspen.

Source of error	Trees (%)	Over estimation	Under estimation	Net difference	Volume error (%)
		(ft³)			
Hidden decay	41	—	11.6	−11.6	30
Incorrect defect	28	6.9	11.7	−4.8	12
Incorrect deduction	30	21.2	43.7	−22.5	58
Total decay volume		28.1	67.0	−38.9	

Although 73% of trees with no external defects had measurable decay, the total volume reduction due to advanced decay amounted to only 2% of their total tree volume (Table 1).

Tree decay was estimated by the inventory crew for 217 of the 295 destructively sampled trees. The remaining trees with no decay estimates occurred on fixed-radius growth plots, and decay estimates were not required for these trees (USDA Forest Service 1986). There was a significant difference ($P < 0.05$) between the estimated and measured decay. Total estimated decay for the 217 trees was 59.5 ft^3, and the measured decay was 95.2 ft^3, a 38% underestimation. Underestimation of decay was made on 141 trees (65%) and overestimation on 35 trees (16%). The 41 trees where the estimated and measured decay were the same had no measurable decay.

There were three sources of errors in estimating decay: (1) *hidden decay*: no external decay indicators, (2) *incorrect defect:* misidentifying external defects resulting in incorrect decay estimates, and (3) *incorrect deduction:* correctly identifying defects but incorrectly estimating the amount of associated decay. Hidden decay in 75 trees accounted for the greatest number of incorrect decay volume estimates. However, incorrect decay volume deductions accounted for the largest underestimation of decay volume (Table 2).

There was a total of 309 conks on 41 trees. The most conks on a single tree were 23, and measured decay in this tree accounted for a 35% reduction in the sound merchantable volume. The greatest percent reduction in merchantable volume was 40%, in a tree that had 16 conks. The correlation coefficients between percentage of decay and the number of conks on a tree and the length of bole with conks was 0.717 and 0.731, respectively.

As the number of conks increased, the length of bole with conks and the internal decay column increased. The internal decay column was always longer than the length of the bole with conks (Table 3) averaging 2.5 times longer. The decay column was always longer above the highest conk than below the lowest conk (Table 3), and on the average extended 8.1 ft above the highest conk and 5.0 ft below the lowest conk. The largest percentage of decay volume was between 4 and 8 ft with the first 8 ft of a tree accounting for more than one-third of the total decay. Nearly 80% of the conks and 70% of the decay volume occurred within 16 ft of the ground (Table 4).

There was a significant difference ($P < 0.05$) in decay volume between trees with conks and trees without conks. Percent decay volume ranged between 7 and 40%, averaging 13.8%, for trees with conks, and <1 and 7%, averaging 1.8%, for trees without conks. The amount of decay generally increased with dbh for trees with and without conks; however, the correlation coefficient between dbh and percent decay was only 0.23. This may be related to clonal differences in susceptibility to decay.

Conclusions and Applications

In our study, we found the following:

1. Decay volume was underestimated by 38%, and the largest source of underestimation was from incorrectly estimating decay severity associated with recognized external indicators of decay.
2. The most reliable external indicator of decay was conks, and 80% of the conks accounting for 70% of the decay volume were found on the lower 16 ft of the tree.
3. There was a significant difference in the average percentage of decay volume in trees with conks (14%) compared to trees without conks (2%).
4. Dbh correlated very poorly with decay volume. We believe genetic differences among clones was a major factor in the poor correlation.

Guidelines

Based on these findings, we propose new guidelines for inventory personnel and timber cruisers when estimating aspen decay in Minnesota.

1. Look for conks! Trees with conks will have a longer decay column and more decay than trees with open wounds or frost cracks.

Table 3. Decay volume percentage, length of bole with conks, and length of internal decay column associated with number of conks on 295 destructively sampled aspen.

Number of conks	Ave. decay volume (%)	Ave. length of bole with conks	Ave. length of decay column	Ave. extent above highest conk	Ave. extent below lowest conk
		(ft)			
1–3	6	1.0	16.1	11.1	4.0
4–6	9	6.0	16.3	7.0	3.4
7–9	16	9.5	24.2	6.6	8.1
10+	24	15.5	29.3	7.5	4.4

Table 4. Cumulative number of conks on 295 destructively sampled aspen and percentage of total tree decay by height above the ground.

Height above ground (ft)	Cumulative percentage of conks	Cumulative total tree decay
	(%)	
0–4	7	14
4–8	26	36
8–12	47	55
12–16	63	68
16–20	78	80
20–24	93	90
>24	100	100

2. Examine the lower 16 ft of the tree bole. The majority of external decay indicators and associated decay occur here.
3. Estimate the length of the internal decay column using the length of bole with conks. The decay column will be 2.5 times longer than the length of bole with conks. On the average, decay will extend 5 ft below the lowest conk and 8 ft above the highest conk.
4. Use the following guide to estimate the percentage of decay volume for individual trees:

Number of conks	Percentage of volume with advanced decay (%)
1–3	2–5
4–6	8–11
7–10	12–20
>10	22–32

   Use the high percentage for decay volume if
   - the tree has an open wound or frost crack, or
   - number of conks is at the top of the range.
5. Counting conks when cruising a stand is impractical. Using average stand diameter to estimate decay volume is not recommended because of the low correlation between dbh and decay volume percentage. So, for estimating the percentage of the stand volume lost to decay, we suggest the following:

   Multiply the percentage of trees with conks by 14% (average decay volume), and the percentage of trees without conks by 2% (average decay volume), add them together, and round to the next highest whole percentage.

   For example, 30% of the aspen in a stand have conks:

- *Trees with conks: 30% of the stand; 14% decay deduction*

$$0.30 \times 0.14 = 4.2\% \text{ decay deduction}$$

- *Trees without conks: 70% of the stand; 2% decay deduction*

$$0.70 \times 0.02 = 1.4\% \text{ decay deduction}$$

- *Total stand deduction*

4.2% + 1.4% = 5.7% decay deduction, or 6% stand volume deduction caused by white trunk rot.

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