Spruce Sawlog Quality Changes Due to Spruce Bark Beetle Mortality

Rio Grande National Forest

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Rio Grande National Forest, Colorado

ABSTRACT:

The information gathered during this spruce deterioration study provides an insight into the factors most likely to influence sawlog quality following mortality caused by the beetles. It points out the highly variable distribution of mortality within aerial mapping polygons. It appears that time since death, moisture content, diameter and precipitation zones are the most useful indicators in predicting spruce sawlog defect following beetle mortality. These factors can be utilized to guide the development of the wildfire and hazard tree mitigation program on the forest.

INTRODUCTION:

Approximately a half million acres of Engelmann spruce has succumbed to spruce bark beetle epidemic on the Rio Grande national forest since 1996. In many cases all trees larger than five inches dbh have been killed. There is a high degree of interest in protecting watershed values and public safety by reducing wildfire and falling tree hazards by salvaging some of the dead trees in areas where the 1996 Forest Plan allows for silvicultural activities.

Developing markets for the anticipated volume of dead material is dependent upon many factors. Key among them is the rate of deterioration of the trees. How long are the trees likely to be suitable for sawlogs, the most valuable conversion scenario? Once they no longer have sawlog characteristics how long will they be viable house logs? Smaller stems are thought to deteriorate much faster and may quickly lose their value as mine props.

Knowing the rate of deterioration will facilitate developing markets for the type of material available into the future.

In the absence of specific research the “Watershed Health & Forest Biomass Opportunities Evaluation” assumed that Engelmann spruce killed by spruce bark beetle would remain viable as sawlogs approximately ten years. This assumption was based on anecdotal evidence. It is well documented that as long as the trees remain standing, dead spruce can be viable for house logs for at least twenty years. Previous research has not specifically focused on sawlog quality.

For the purposes of this report sawlogs are those logs that can be cut into boards, dimension lumber, timbers, posts or beams.

In a recent letter to the US Forest Service, Rocky Mountain Regional Forester, Intermountain Forest Association (IFA) observes that beetle-killed spruce is deteriorating much faster than anticipated. This prompted the interest in taking a closer look at beetle killed spruce deterioration over time.

Having a good understanding of spruce sawlog deterioration rates is critical to development of long term strategies for improving watershed health and forest restoration.

AVAILABLE RESEARCH FINDINGS:

There is only one author that has published observations on the influences of beetle mortality on spruce sawlog quality. A. L. Nelson, assistant Regional Forester – Rocky Mtn. Region, published two articles in the Journal of Forestry in the early fifties that discussed the impacts of the 1939 spruce beetle outbreak in Colorado. Through 1952 beetles killed an estimated 4.5 billion board feet of spruce. *"The inaccessibility of the timber and the fact that the trees remain usable for sawlogs for only 4 to 6 years precluded salvaging much of the killed trees for sawlogs or sawed forest products."* (Nelson, 1950) *"The killed trees in most cases checked badly and were unfit for sawn products within 3 or 5 years."* (Nelson, 1954) His conclusions are anecdotal but are the only references to spruce sawlog deterioration that can be found to date.

In their 1977 "Spruce Beetle in the Rockies" Schmid & Frye summarize what is known about spruces deterioration following a beetle attack. "*Salvage of beetle-killed spruce can proceed for many years after the trees are killed depending on the product to be derived. Timber for sawlogs remained merchantable for about 5 years, enough trees developed radial checking to make them unmerchantable for small sawn boards* (Nelson 1954). *Trees that have been dead for more than 5 years are currently being cut for use as house logs in log homes in southwestern Colorado. High quality particle board can be produced from beetle killed Engelmann spruce even though it has been dead for 10-12 years* (Mueller 1959*). The same timber may remain suitable for pulp for more than 20 years* (Nelson 1954).

Montrose Forest products and Rocky Mtn. Timber Products personnel have both mentioned that beetle kill much older than 5 years may be problematic because lumber recovery is significantly affected by cracks and checks.

GOAL:

Develop an understanding of how time effects sawlog quality of beetle-killed spruce.

OBJECTIVES:

1. Determine if time since mortality impacts sawlog quality in beetle-killed spruce on the Rio Grande national forest.

2. Sample at least four mortality periods that span the life of the beetle epidemic to date.
    a. 2001-2005
    b. 2007-2010
    c. 2011-2012
    d. 2013-2014

3. Determine what factors play a role in sawlog quality deterioration by looking specifically at tree size class, season checking (depth and spiral), moisture content, bark retention, blue stain, borer activity, and sap rot.

4. Document findings and develop conclusions.

5. Make recommendations on sound long term strategy for salvaging value from dead material while improving watershed condition and forest health based on findings and conclusions.

METHODOLOGY:

Field Observations:

1) Overlay CSFS annual aerial insect flight maps on existing SLV Biomass Assessment layers to identify polygons by mortality date that span the aerial mapping period from 1996 to 2014.
2) Collect basic forest metrics for each mortality plot. Locate 3 trees in each dbh size class (8”-12”, 13”-17”, and >17”).
3) Collect one increment core (12” above ground line) from a live spruce, within close proximity to the sample trees, to serve as the control for future dendrochronology dating of mortality for sample trees.
4) Fell and buck each tree and record info on the Individual Tree Record.
    a. Cut a cross section off the bottom of each 16’ segment to facilitate data gathering.
    b. Measure Moisture content for sap and heart wood and depth of all checks/cracks >1” for each cross section. Document rot and borer activity.
    c. Label the butt log cross section with plot and tree identification for future mortality dating at CSU.
    d. Photograph any notable anomalies or observations.

Data Analysis:

1) Develop Excel spreadsheet containing plot and individual tree information.
2) Calculate gross tree volume (all volume in Scribner Decimal C to a 6” top) prior to insect mortality.
3) Calculate net tree volume post insect mortality.

4) Quantify factors causing volume reduction.
5) Identify year of mortality at CSU Forestry lab.
6) Develop correlation between years since mortality and volume loss if present.
7) Develop correlation between moisture content and volume loss if present.
8) Develop correlation between tree size and volume loss if present.
9) Develop correlation between bark retention and volume loss if present.
10) Develop correlation between annual precipitation and volume loss if present.
11) Explore curiosities and wonderments that manifest during analysis.

RESULTS:

Mortality polygons were developed using CSFS aerial insect and disease maps covering the span of the present spruce beetle outbreak on the Rio Grande national forest. The first time an area was shown to have spruce bark beetle activity was used as the polygon date. We found that while this date provided a benchmark for when beetles first became active in an area it was not a reliable indicator of when individual trees within the polygon actually succumbed to beetle attack. There is, in fact, a wide variance of when specific trees died within any mortality polygon. Table 1: Variance within Mortality Polygons, demonstrates the span of demise within the various mortality polygons sampled.

Table 1: Variance within Mortality Polygons

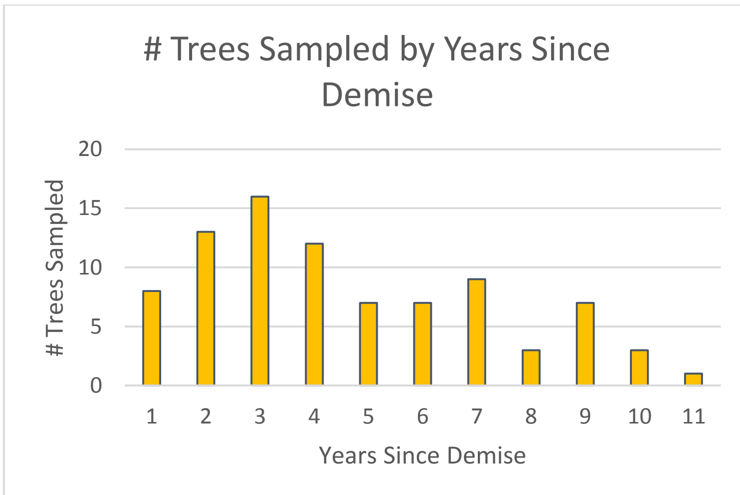
Mortality Polygon Date	Oldest Sample*	Newest Sample*	Spread in Time Since Death (years)
2001	2005	2008	4
2005	2004	2009	6
2007	2009	2013	5
2010	2005	2013	9
2011	2008	2014	7
2012	2008	2012	5
2013	2010	2014	5
2014	2012	2014	3

**Based on dendrochronology*

Since the focus of this study is to determine changes in sawlog quality over time it is important to know when individual trees actually died. Fortunately, Professor Kurt Mackes offered to determine mortality dates using the CSU Dendrochronology Lab facilities. This allowed us to reliably identify year of death.

Chart 1: # Trees Sampled by Years Since Demise, describes the distribution of individual trees sampled in the study. Relying on mortality polygons for initial study design caused long term dead trees to be under-represented in the study. Unfortunately it is almost impossible to accurately predict year of death in the field. Readily observable indicators such as bark retention, and snag condition are not reliable indicators of years since mortality. Microscopic dendrochronology analysis conducted in a well-equipped lab appears to be the only way to accurately determine year of demise.

Chart 1: # Trees Sampled by Years Since Demise



Predicting how much lumber each log will produce also proved to be an elusive endeavor. Log scaling is both a science and an art. It is influenced by a wide variety of rules and often contingent upon anticipated end products and individual sawmill practices.

Two approaches to scaling are the norm for logs on the Rio Grande forest. *Cubic foot* scaling is used by the forest service. It provides an estimate of how much total wood each log contains. Converting that into expected end products is up to the purchaser. Cubic scaling is well suited to quantifying biomass content of a log. Cubic scaling is done by direct measurement of each log or by weighing truck loads and applying conversion factors.

Scribner Decimal C log rule provides an estimate of the number of actual board feet (1” thick by 1’ square) that can be recovered from a log. It is one of three major board-foot log rules in use in the US. Montrose Forest Products and CSU provided estimates of log volume and defect using Scribner Decimal C scaling rules. Their estimates differ due to assumptions each made relative to defect deductions. CSU’s estimate of defect caused by the beetles was used for the purposes of this analysis.

Surface checks or cracks caused by drying and sap rot are the two primary sources of defect caused by beetle kill. Presence of wood boring insects was noted but not found to be causing appreciable defect at this point in time.

Chart 2: Average % Defect Since Death, compares the percent of beetle related defect to the number of years since death. It shows that defect increases from approximately twenty five percent to forty two percent over a ten year period.

Chart 2: Average % Defect Since Death

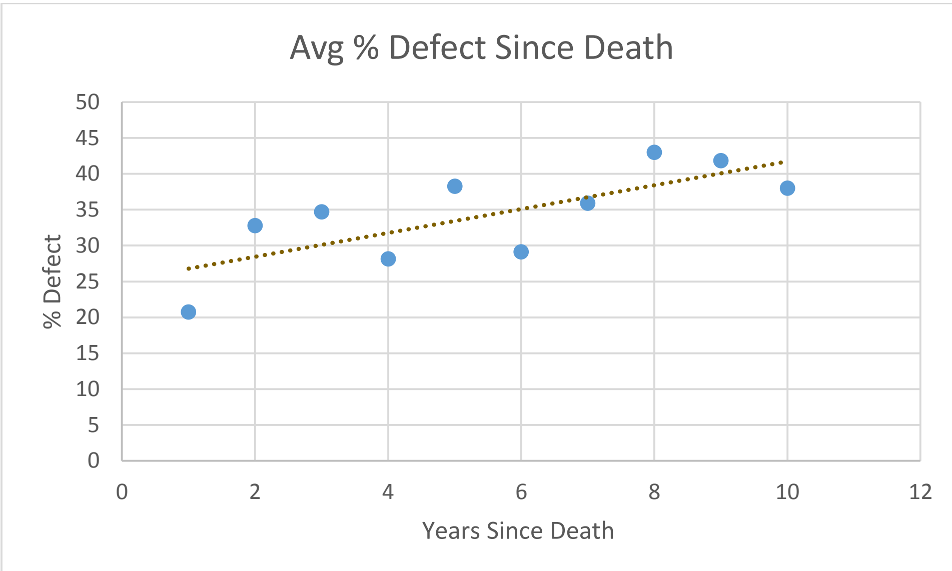


Chart 3: Bole Moisture Content vs % Beetle Defect, shows a strong relationship between tree moisture content and percent defect. As moisture content goes down defect in the form of checking or cracking goes up.

Chart 3: Bole Moisture Content vs % Beetle Defect

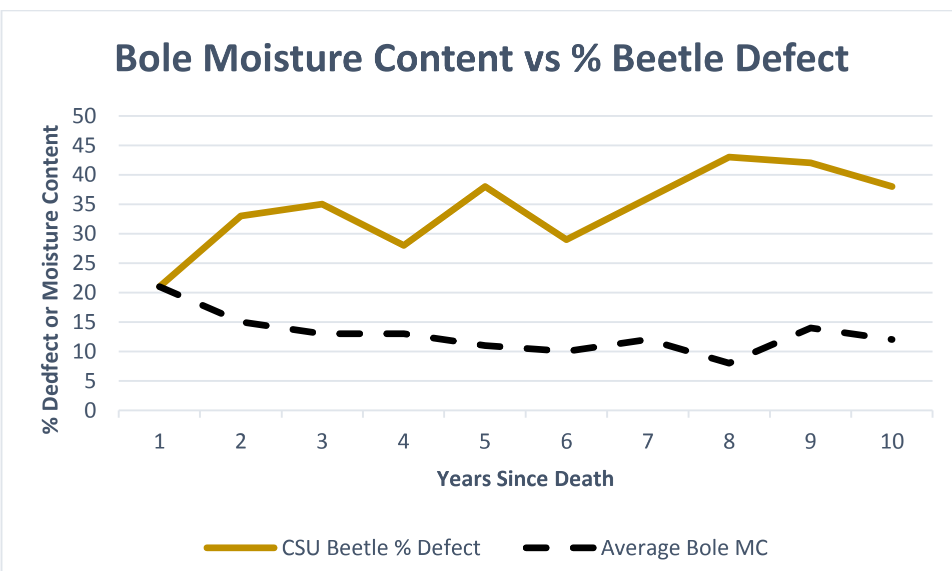


Chart 4: % Bark Retention vs % Beetle Defect, illustrates the affect bark retention has on defect. Bark serves as a barrier to bole drying and hence reduces the amount of checking. Unfortunately there does not appear to be a connection between bark retention and years since demise. Bark retention is dependent upon many factors anecdotally it appears wood pecker foraging is one of the most important. Bark retention does not change fast enough to provide insights on tree defect over a ten year period.

Chart 4: % Bark Retention vs % Beetle Defect

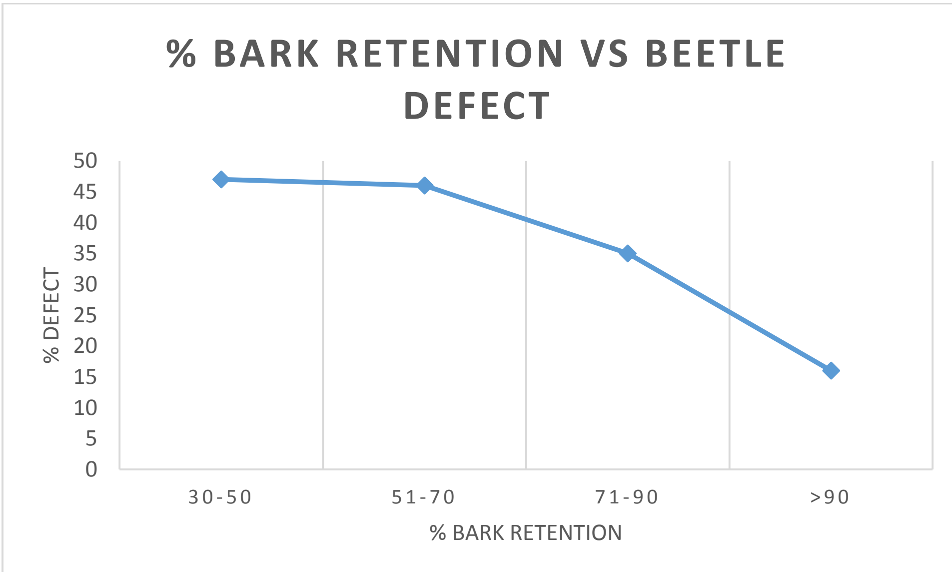


Chart 5 portrays the variability of bark retention by years since death.

Chart 5: % Defect vs Bark Retention Compared to Years Since Demise

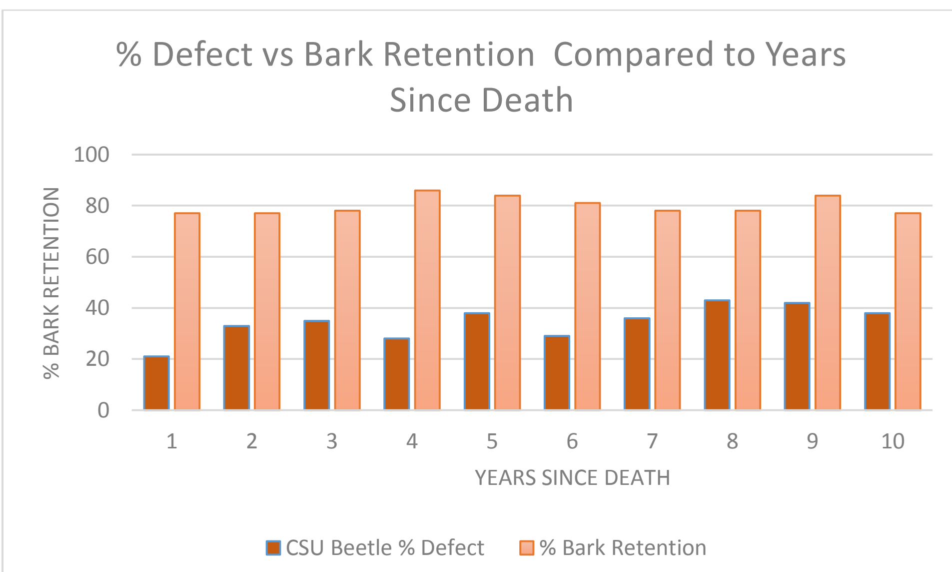


Chart 6: DBH vs Defect, demonstrates an interesting phenomenon that defies initial logic. One would normally expect checks to have disproportionate impacts on log volume in smaller diameter logs. There may well be a correlation between check depth and log diameter that needs to be explored. If checks get deeper as log size increases then there is a geometric explanation for the chart.

Chart 6: DBH vs Defect

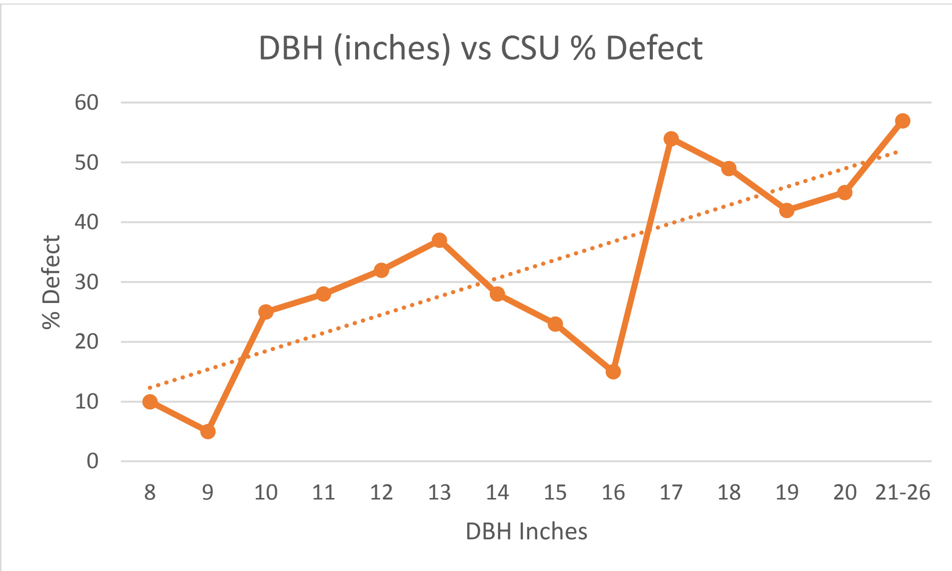
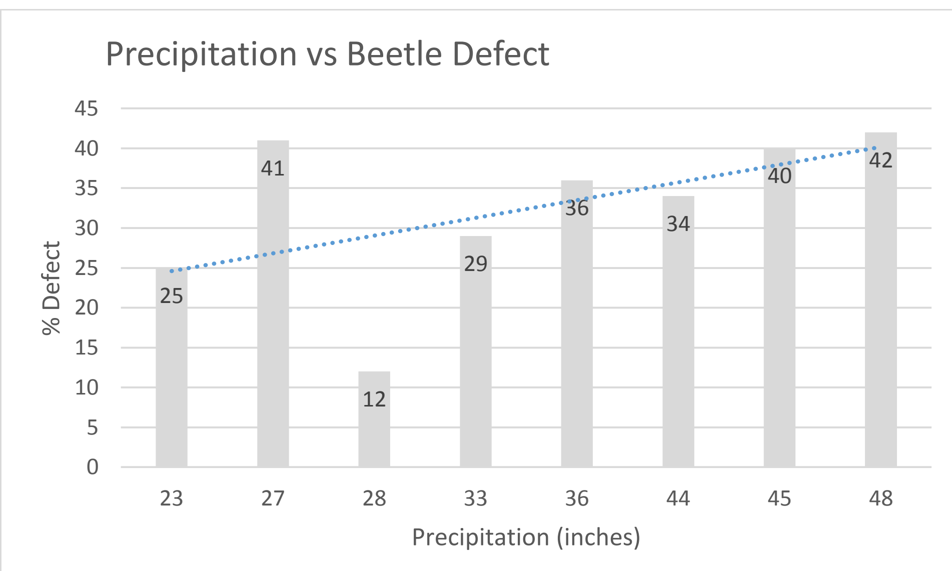


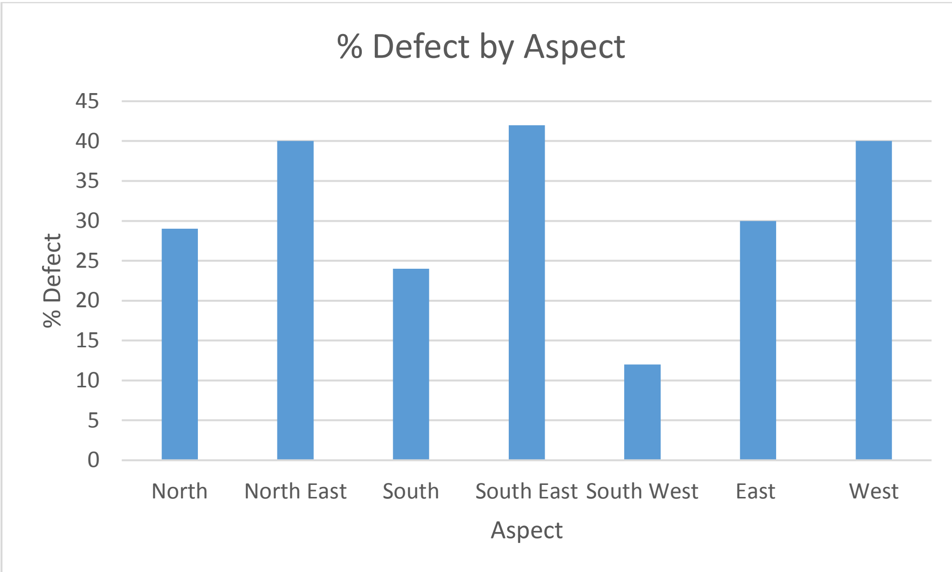
Chart 7: % Defect by Precipitation Zone



This trend line indicates that precipitation zones may be useful in prioritizing salvage area selection.

Chart 8: % Defect by Aspect, runs contrary to an assumption that southerly aspects will be dryer and have more checking and hence more defect.

Chart 8: % Defect by Aspect



DISCUSSION:

Spruce mortality is not uniform within a specific area. Aerially mapped mortality polygons are good at identifying when beetle activity was first noticeable within an area. Engelmann spruce can be completely girdled at the base and still have a green canopy. One cannot assume that most trees in any given mortality polygon died within a year or two of the initial infestation. In fact there was an average 5.5 year spread between earliest and most recent mortality within the mapping units. Forty one percent of the trees studied died prior to the date of aerial detection of the mapping polygon.

High variability of time since death of individual trees within any stand neutralizes the utility of mapping polygons to focus salvage operations on the areas with oldest mortality.

Snag condition class and bark retention were thought to be indicators of tree condition and predictors of defect or bole soundness but they do not change as rapidly as a sawlog quality deteriorates. They were not found to be useful in the context of this study.

The strongest indicators of spruce killed sawlog quality are time since death, moisture content, diameter, and precipitation zone. These indicators can be used to establish hazard reduction activities on a broad scale if one of the goals is to capture sawtimber value before it deteriorates.

Any treatment area will have a spread in time since death for individual trees and hence a continuum of sawlog conditions within the treatment unit.

Conclusions:

The information gathered in this spruce deterioration study provides an insight into the factors most likely to influence sawlog quality following mortality caused by the beetles. It points out the highly variable distribution of mortality within aerial mapping polygons. It appears that time since death, moisture content, diameter and precipitation zones are the most useful indicators in predicting spruce sawlog defect following beetle mortality. These factors can be utilized to guide the development of the wildfire and falling tree hazard mitigation program on the forest.

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