Natural Resource Network

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# Proceedings
# Residual Stand Damage Workshop

August 16, 2001

Bartlett, NH

**UNH Cooperative Extension**

**131 Main Street, 214 Nesmith Hall, Durham, NH 03824**

## Residual Stand Damage

Each year, New Hampshire's Forest Health Program assesses forest health issues. Recent years have seen increased dieback and decline associated with timber harvesting. Is there reason for concern?

The **Residual Stand Damage** workshop was held on August 16, 2001 and was designed to answer the question, "Is there a problem out in the woods?". It focused on the impact of residual stand damage to forest health and vigor; the economic and silvicultural implications; and ways to assess harvesting damage.

These proceedings were prepared as a supplement to the workshop. Papers submitted were not peer-reviewed or edited. They were compiled by Karen P. Bennett, Extension Specialist in Forest Resources. Inge Seaboyer, Forester with the NH Division of Forests and Lands was the driving force organizing this workshop. Readers who did not attend are encouraged to contact authors directly for clarifications. Workshop attendees received additional supplemental materials.

**Agenda**
**NH Post Harvest Decline Study**- Kyle Lombard, Forest Health Program, NH Division of Forests and Lands

**The Biology of Decay**- Kevin Smith, USDA-Forest Service, Northeastern Research Station

**Vermont's 15 Year Sugar Maple Wounding Study**- Ron Kelley, VT Department of Forests, Parks and Recreation

**The Consequences of Residual Damage; Management Issues and Assessment**- Bill Ostrofsky, University of Maine

**The NH Timber Harvest Assessment: Residual Stand Damage Findings**- Ken Desmarais and Matt Robblee, Fox Forest, NH Division of Forests and Lands

**Damage Assessment Video**

**Bartlett Experimental Forest Field Trip**- Bill Leak, USDA-Forest Service, Northeastern Research Station, joins the morning's speakers, and others, to discuss silvicultural implications, assessment techniques, and more.

## Workshop Cosponsors

Granite State Division/ Society of American Foresters
New Division of Forests and Lands
University of New Hampshire Cooperative Extension

# A Look at Logging Damage to Residual Trees in New Hampshire

By
Matthew Robblee and Ken Desmarais[1]

## Introduction

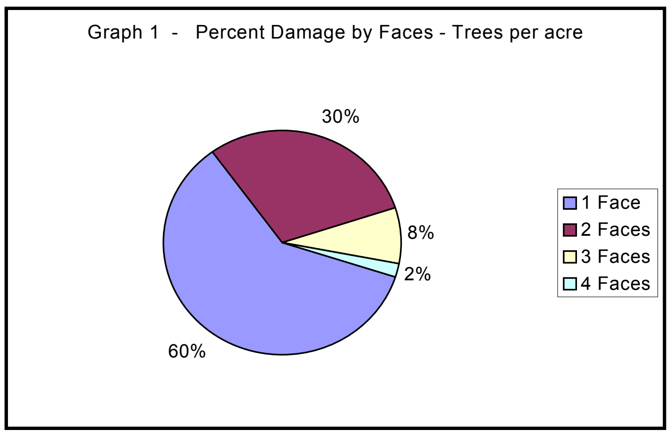
In 1999, the Fox Research Forest conducted a study of timber harvesting in New Hampshire. Fifty-seven randomly selected timber harvests were visited and sampled for various characteristics. Each harvest contained 15 circular plots, each 0.1 acres in size. The location of each plot was established by pacing a fixed distance down a skidder trail and then off-setting a random distance to the left or right of the trail. For each tree within each plot the field crew recorded species, dbh, merchantable height, stem quality, and the presence or absence of cavities. Any damage to the residual stems was recorded by the number of faces incurring a scar penetrating the sapwood as well as whether the tree was located along a skidder trail or not.

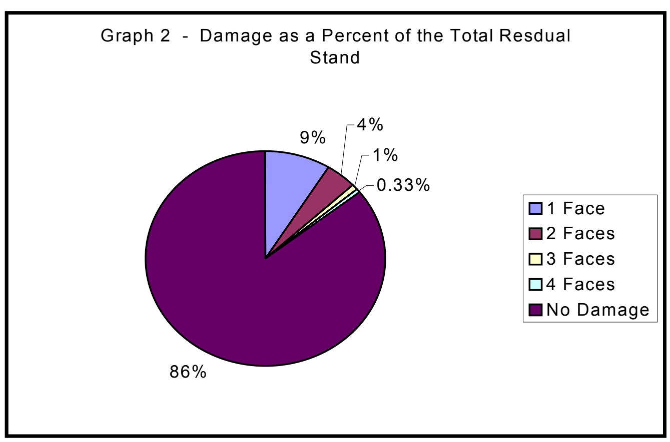
The data was processed using NED-1 software provided by the USDA Forest Service. Statistical analysis was done using Excel™.

## Results

*Trees per Acre*

The 57 harvests averaged 19 damaged trees per acre (TPA) or 14.3% of the residual trees. This can be further broken down into four damage classes determined by the number of damaged faces. The mean for trees with 1 damaged face is 12 TPA. This accounted for 60% of the total damage found. This also accounted for 9% of the total residual stand. Trees with 2 damaged faces averaged 5 TPA. This accounts for 30% of the total damage and 4% of the total residual stand. Combined together, trees with 1 or 2 damaged faces accounts for 90% of all damage and 13% of the total residual stand. Trees with 3 damaged faces averaged 1 TPA. This accounts for 8% of the damage and 1% of the total residual stand. Less than 1 TPA is the mean for trees with 4 damaged faces. These trees account for 2% of all damage and less than 1% of the total residual stand. Together trees with 3 damaged faces and 4 damaged faces account for



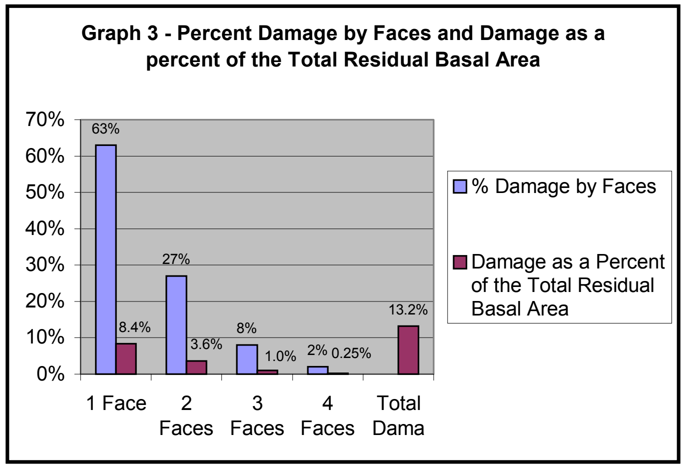

[1] Forest Technician and Forester respectively, Fox Research Forest, State of New Hampshire - DRED, Division of Forests and Lands, Forest Management Bureau. PO Box 1175 Hillsboro, NH 03244, e-mail foxforest@mcttelecom.com.

10% of all damage and less than 2% of the total residual stand. See Graph 1 for a breakdown of % damage by faces and Graph 2 for breakdown of damage as a % of the total residual stand.

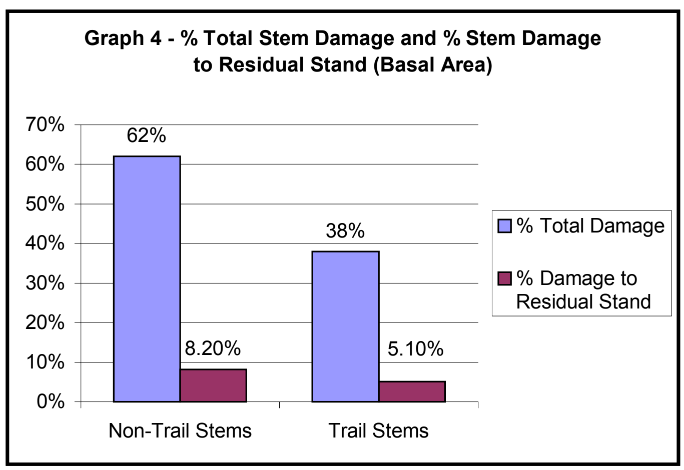
Trees growing beside skidder trails accounted for 7 TPA, equaling 35% of all damage, and 5% of the total residual stand. Damaged trailside trees account for 68% of all trailside trees. Trees not growing beside skidder trails contributed 12 TPA of the damage found, equaling 65% of all damage. Non-trailside trees incurring stem damage accounted for 9% of the total residual stand.

*Basal Area*

From the 57 sampled stands, the mean basal area per acre of trees with stem damage is 8.9 $ft^2$ /ac. Stem damaged trees account for 13.2% of all residual basal area. The mean basal area per acre for trees with 1 damaged face is 5.6 $ft^2$/acre, and equals 63% of the total damage by basal area. These trees account for 8.3% of the total residual stand basal area. Trees with 2 damaged faces account for 27% of all stem damage by basal area and have a mean basal area of 2.4$ft^2$/acre. Trees with 2 damaged faces account for 3.6% of the total residual stand basal area. 8% of all stem damage by basal area is attributable to trees with 3 damaged faces. These trees have an average basal area of 0.7$ft^2$/acre, and account for 1% of all residual basal area. Trees with 4 damaged faces account for 0.2 $ft^2$/acre and 2% of all damage by basal area. These trees account for less than 1% of all residual basal area. A summary of this information can be found in Graph 3.

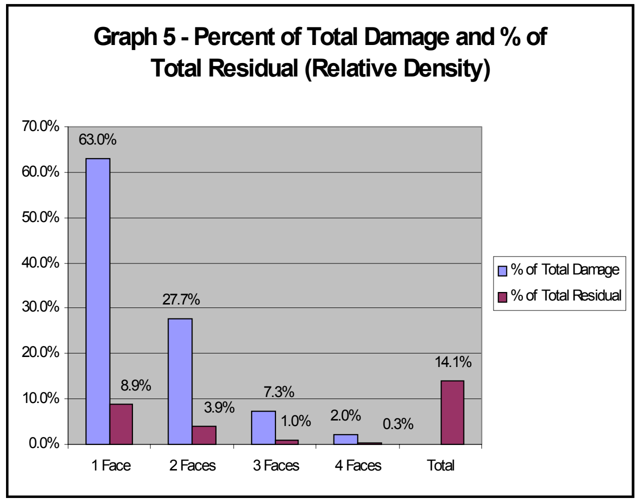



Stem damaged trees growing beside skidder trails have a mean basal area 3.4$ft^2$/acre and account for 38% of the stem damaged basal area. Stem damaged trailside trees account for 5.1% of the total residual stand. Stem damaged non-trailside trees accounted for 5.5$ft^2$/acre and 62% of all stem damage by basal area. Stem damaged non-trailside trees account for 8.2% of the total residual stand. Graph # 4 contains a summary of this information.




*Relative density*

The average relative density of stem damage for all 57 stands sampled is 5.6% of full stocking. This accounts for 14.1% of the total residual stand relative density. The breakout by faces is as follows. The relative density of trees with 1 damaged face is 3.5. This accounts for 8.9% of the total residual stand and 63% of the damage by relative density. Trees with 2 damaged faces have a relative density of 1.6. This accounts for 4.1% of the total residual stand and 27.7% of the damage by relative density. Trees with three damaged faces account for 0.4 relative density. This accounts for 1% of the total residual stand and 7.3% of the stem damage. Trees with 4 damaged faces account for 0.1 relative density and less than 1% of the total residual stand. These trees also account for 2% of the damage by relative density. Graph 5 has a summary of this information.



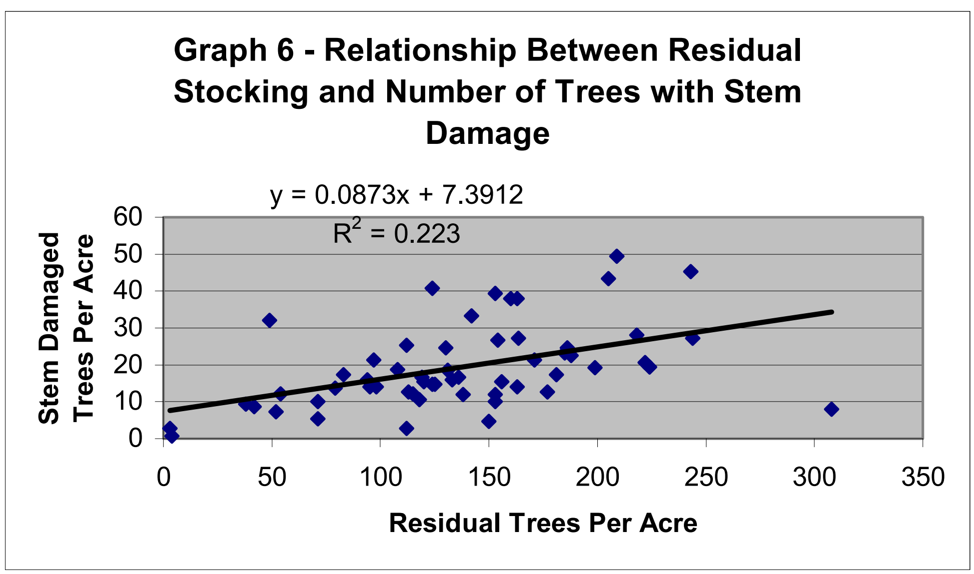

Stem damaged trees growing beside skidder trails have a mean relative density of 2.1 and account for 37.5% of the stem damaged relative density. Stem damaged trailside trees account for 5.3% of the total residual stand. Stem damaged non-trailside trees accounted for 3.5 relative density and 62.5% of all stem damage relative density. Stem damaged non-trailside trees account for 8.8% of the total residual stand. Graph # 5 contains a summary of this information. Table 1 gives an overall summary of the results covered above.

**Table 1. Summary of the 1999 THAP Data**

| | 1 Face | 2 Faces | 3 Faces | 4 Faces | Total | NTS | TS |
|---|---|---|---|---|---|---|---|
| **Trees/acre** | 12 | 5 | 1 | <1 | 19 | 12 | 7 |
| **% Damage** | 60.00% | 30.00% | 8.00% | 2.00% | 100.0% | 65.00% | 35.00% |
| **% Residual** | 9.00% | 4.00% | 1.00% | <1% | 14.30% | 9.00% | 5.00% |
| **Basal Area** | 5.63 | 2.4 | 0.66 | 0.18 | 8.87 | 5.5 | 3.4 |
| **% Damage** | 63.00% | 27.00% | 8.00% | 2.00% | 100.0% | 62.00% | 38.00% |
| **% Residual** | 8.40% | 3.60% | 1.00% | 0.25% | 13.20% | 8.20% | 5.10% |
| **Relative Density** | 3.50% | 1.60% | 41.00% | 0.12% | 5.63% | 3.5 | 2.1 |
| **% Damage** | 63.00% | 27.70% | 7.30% | 2.00% | 100.0% | 61.70% | 38.30% |
| **% Residual** | 8.90% | 3.90% | 1.00% | 0.30% | 14.10% | 8.70% | 5.26% |

## Discussion

New Hampshire stem damage estimates were compared with similar studies from other states. Table 2 clearly shows that overall stem damage from the New Hampshire study was well below damage rates reported in other studies. However, our study looked at all stocking levels including clearcuts and stands with very little residual stocking. When stands with residual relative densities of 40 or greater were looked at, the average number of



stem damaged trees per acre decreased to 12%, a statistically insignificant drop of 2.3 %. Stands with relative densities ranging from 20 to 39 slightly increased to 17.7% stem damaged trees per acre, still favorable compared to other studies. Graph 6 is a scatterplot of the 57 timber harvests sampled in the 1999 New Hampshire study showing the relationship between residual stocking in trees per acre and the number of stem damaged residual trees per acre. The regression line passes close to the origin suggesting a possible slight increase in damage as residual stocking decreases. In other words, heavier cutting may have resulted in slightly increased stem damage. However, even heavier levels of damage found in New Hampshire were well below many other studies. Verrier (1976) looking at 113 timber harvests in New Hampshire found that 59% of the harvests had stem damage on less than 15% of the residual trees (Minimal). Nineteen percent contained damage levels of 15 to 40% (Moderate), 15% of the harvests contained damage levels exceeding 40% (Extreme), with 6% of the harvests being not applicable. Verrier notes that the data are for damaged crop trees on non-random 10 BAF points. Damage includes barking, top breakage and trees felled to get out of the way.

**Table 2. THAP Data vs Other Similar Projects**

| Project Date | Source | Type | % Damage | Units |
|---|---|---|---|---|
| 1976 | Biltonen et al. (1976) | Chain saw | 10.00% | Tree/Acre |
| **1999** | **Desmarais et al (2001)** | **Mixed** | **14.30%** | **Tree/Acre** |
| 1984 | Miller et al. (1984) | Thinning (69% Rel Den) | 16.00% | Tree/Acre |
| 1995-2000 | Han & Kellogg (2000) | Skyline | 16.90% | Trees |
| 1976 | Biltonen et al. (1976) | Mechanized | 20.00% | Tree/Acre |
| 1995-2001 | Han & Kellogg (2000) | Tractor | 20.60% | Trees |
| 1984 | Miller et al. (1984) | Thinning (56% Rel Den) | 21.00% | Tree/Acre |
| 1995-1997 | Han & Kellogg (2000) | Skyline | 22.90% | Trees |
| 1984 | Lamson et al. (1984) | Thinning (69% Rel Den) | 25.00% | Tree/Acre |
| 1978 | Kelley (1983) | Shelterwood | 26.90% | Tree/Acre |
| 1995-1998 | Han & Kellogg (2000) | Cut-to-length | 29.40% | Trees |
| 1979 | Kelley (1983) | Shelterwood | 33.53% | Tree/Acre |
| 1995-1999 | Han & Kellogg (2000) | Skyline | 37.30% | Trees |
| 1995-1998 | Han & Kellogg (2000) | Skyline | 37.40% | Trees |
| 1984 | Miller et al. (1984) | Thinning (40% Rel Den) | 39.00% | Tree/Acre |
| 1979 | Kelley (1983) | Thinning | 41.32% | Tree/Acre |
| 1977 | Kelley (1983) | Thinning | 45.70% | Tree/Acre |
| 1984 | Lamson et al. (1984) | Thinning (53% Rel Den) | 46.00% | Tree/Acre |
| 1984 | Lamson et al. (1984) | Thinning (37% Rel Den) | 59.00% | Tree/Acre |

| Study | Minimal | Moderate | Extreme |
|---|---|---|---|
| Verrier | 59% | 19% | 15% |
| Desmarais et al | 59.6% | 36.8% | 3.6% |

Overall, we suggest that stem damage from harvesting is improving, with the greatest movement from extreme damage to moderate. Verrier's results reflect well results from other studies at that time. Although the number of harvests with minimal stem damage has not increased, a large improvement in stem damage from extreme to moderate is obvious. We do not know if this improvement is due to logger education programs, increased skidder operator experience, better equipment design, skidder road layout prior to harvesting or a greater awareness of the importance of residual stand quality. Probably all of the above reasons impact these results in some way.

## Literature Cited

Biltonen, F.E.; Hillstrom, W.A.; Steinlib, H.M. and Godman, R.M. 1976 **Mechanized thinning of northern hardwood pole stands: Methods and economics.** Research paper NC-137. St. Paul, MN. USDA Forest Service, North Central Forest Experiment Station, cited by Nyland, R. D. 1986 **Logging damage during thinning in even aged hardwood stands.** In: Proceedings: Guidelines for managing immature Appalachian hardwood stands. SAF publication 86-02.

Desmarais, K.M. and Robblee, M.J. **A timber harvest assessment for New Hampshire.** In progress, Caroline A. Fox Research and Demonstration Forest, State of NH – DRED Division of Forests and Lands, Forest Mgt. Bureau.

Han, H.-S. and Kellogg, L. D. 2000 **A comparison of sampling methods for measuring residual stand damage from commercial thinning.** Journal of Forest Engineering, Volume 11, No. 1

Kelley, Ronald S. 1983 **Stand damage from whole tree harvesting in Vermont hardwoods.** Journal of Forestry, Volume 81, Number 2. Society of American Foresters.

Lamson, N.I. and Smith H. Clay 1984 **Resudual stocking not seriously reduced by logging damage from thinning of West Virginia cherry-maple stands.** Research paper NE- 451. Broomall, PA. USDA Forest Service, Northeastern Forest Experiment Station, cited by Nyland, R. D. 1986 **Logging damage during thinning in even aged hardwood stands.** In: Proceedings: Guidelines for managing immature Appalachian hardwood stands. SAF publication 86-02.

Miller, G.W.; Lamson, N.I. and Brock, S.M. 1984 **Logging damage associated with thinning central Appalachian hardwood stands with a wheeled skidder.** In: Peters, P.A.; Luchok, J., eds. **Proceedings, Mountain Logging Symposium**, 1984 Morgantown, W.V. West Virginia University, cited by Nyland, R. D. 1986 **Logging damage during thinning in even aged hardwood stands.** In: Proceedings: Guidelines for managing immature Appalachian hardwood stands. SAF publication 86-02.

Verrier, Philip 1976 **A look at timber harvesting in New Hampshire with recommendations for improvement.** Caroline A. Fox Research and Demonstration Forest, Bulletin Number 18.

# Pilot Study To Evaluate Tree Decline Associated with Partial Harvest Silviculture Within Northern Hardwood Forest Types

**By**

**Kyle Lombard, Forest Health Section, New Hampshire Division of Forests and Lands**

## INTRODUCTION

The New Hampshire Division of Forests and Lands, Forest Health Section, has conducted aerial sketchmapping surveys for the past forty years. Over this period the Division has identified and mapped millions of acres of damage caused by a multitude of forest pests and forest health stressors. During recent years, when widespread insect damage has been low, crown dieback and decline in some timber harvested areas has become one of the more noticeable damages on the landscape. With the acreage of "residual stand decline" seemingly on the increase, or at least more noticeable, we felt it necessary to implement a ground based evaluation project to better document this decline and make a preliminary determination of causal agents. To increase the reliability of this study, timber-sale areas not designated as declining sites where also selected for ground evaluation. These non-declining sites were publicly managed properties having had a timber sale, matching as close as possible, the silviculture and timing of the decline sites. Decline figures from both data sets were summarized and compared to a "control" data set. The control was New Hampshire's *Forest Health Monitoring* data set, which is an annual statewide survey pertaining to forest health indicators.

## PLOT SELECTION

Aerial sketch-maps, from the 1998 and 1999 summer season, were inventoried for polygons designated as "harvest area decline" in northern hardwood forest types. These mapped locations were then visited in the field. Timber sales less than five years old or over 10 years old were eliminated from the project. Likewise, any timber sale that was not implemented using partial harvest silviculture was thrown out. This site selection process, produced sites in which the forester or logger clearly left overstory trees to grow and harvest at a later date, yet there seemed to be an unusually large amount of crown dieback in the residual trees. The non-declining sites were selected from past timber sales conducted by the Division of Forests and Lands. These sites were 5-10 years old, had a plurality of northern hardwood species, and were operated using some type of partial harvest silviculture. The control sites, or Forest Health Monitoring (FHM) plot locations, are distributed in a grid format uniformly across all 5 million forested acres of New Hampshire.

## PLOT PROTOCOL

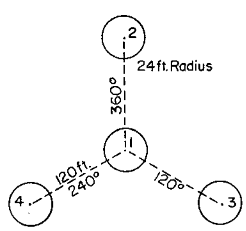



**Diagram 1.**

Data collection on the FHM plots, decline plots and non-decline plots, was carried out by nationally certified forest technicians within the New Hampshire Division of Forests and Lands. At each of the selected decline and control sites, a four-point plot cluster was established in the geographic center of the sale area. The plot design follows the national FHM mensuration protocol, calling for a four (4) subplot cluster (see diagram 1 for layout). Each subplot is a 24$^{th}$ acre fixed radius plot, and all trees over 5 inches at breast height were evaluated. The accumulation of data from these four subplots equals one plot and represents one site.

Within each plot there are data collection groupings. These groups are: General plot data, Mensuration data, Mechanical damage, Tree crown data, and Root compaction.

**General plot data** consists of "% slope", "aspect", and "elevation". Each of these items were measured at all four subplots and combined to create an average for the site. Aspect could range from 1 degree to 360 degrees, depending on the direction the land faced. Elevation was taken from the 7.5min. topographic maps.

**Mensuration data** consists of tree species, and tree diameter at breast height. All living trees over 5 inches, and trees that have died since the timber sale, were measured.

**Mechanical damage** is physical damage done to the boles of the tree. The most common mechanical damage is a logging wound. This data was collected using a three step coding system. The three steps identify 1.) location of damage, 2.) type of damage, and 3.)severity of damage. Severity is expressed as a percentage (%) of total tree circumference affected.

**Tree crown data** consists of "live crown ratio"(LCR), "density", "transparency", "dieback", and "light". Live crown ratio is the % of total tree height taken up by the live crown. Crown density is the % of total crown area blocking light with branches, foliage, or other reproductive structures. Transparency is the % sunlight coming through the foliated portion of the tree. Dieback is defined as the % of total crown area that has died from the terminal portion of the branch inward. Dieback is only recorded in the upper and outer portion of the crown to eliminate normal "self pruning" from shading. "Light" represents the number of sides of the crown that are exposed to direct sunlight. There are four sides and a top to every tree, therefor the maximum number that could be assigned is five(5).

**Root compaction** consists of estimating the percentage of total root area compressed, torn up, or exposed by logging equipment. The total root area is the area within the drip edge of the live crown.

## RESULTS

Crown dieback may be the most dramatic, visual indicator of a decline in tree health. Crown dieback is the symptom that precipitated this study. For this reason, we are using "% dieback" as the key indicator of tree vigor at each site. We've inserted mean plot dieback figures within the far right column of each table in this report to provide valuable comparison between other measured indicators and their relationship to tree dieback. For the following tables, the decline sites are labeled in the left-hand column, and the non-decline sites are shaded. The non-decline sites are not a statistically significant sample of timber harvests in New Hampshire; however, they're included within this study to give perspective to the data generated from the decline sites.

**General plot data:** This combination of data provides a description of where sites were found on the landscape. Landscape position is an important element in evaluating the stress response of a forest. Weather conditions and soil profiles vary greatly depending on the geographic position. For example, trees at high elevation are more stressed from early and late frosts, shallow soils, harsh winter storms, and increased acid deposition. These stressed trees and forests should respond differently to logging stress than a forest with more ideal environmental characteristics at lower positions on the landscape. The elevation at these study sites ranged from 700 feet above sea level, to 2000 feet above sea level. This range is well within the normal range for northern hardwoods in New Hampshire.

**Table 1**
General Plot Data

| Plot | % slope | aspect | elevation | % dieback |
|---|---|---|---|---|
| **Middleton** | 0 | 360 | 850 | 41 |
| **Orange S** | 5 | 340 | 1500 | 40 |
| **Jefferson** | 0 | 360 | 900 | 39 |
| **Orange N** | 12 | 230 | 2000 | 34 |
| **Goffstown** | 10 | 270 | 700 | 23 |
| **Errol** | 8 | 150 | 1700 | 16 |
| **Millsfield** | 18 | 90 | 1300 | 14 |
| **Pittsfield** | 4 | 45 | 950 | 11 |
| **Alstead** | 10 | 90 | 1200 | 11 |
| **Tamworth** | 3 | 90 | 700 | 7 |
| **Orange C** | 10 | 180 | 1500 | 7 |
| **Colebrook** | 13 | 120 | 1800 | 4 |

**Mensuration data:** With this information, we can evaluate post harvest residual trees per acre, tree mortality since harvest, and the post harvest basal area.

**Table 2**
Decline and Control Site Mensuration Data

| | POST HARVEST | | | mortality | |
|---|---|---|---|---|---|
| **Plot** | **trees/ac.** | **ave. dbh** | **ba./ac.** | **trees/ac.** | **% dieback** |
| **Middleton** | 36 | 12.2 | 30 | 0 | 41 |
| **Orange S** | 42 | 8.9 | 20 | 0 | 40 |
| **Jefferson** | 108 | 6.8 | 27 | 12 | 39 |
| **Orange N** | 102 | 10.6 | 62 | 30 | 34 |
| **Goffstown** | 180 | 8.1 | 64 | 12 | 23 |
| **Errol** | 132 | 10.4 | 77 | 24 | 16 |
| **Millsfield** | 162 | 7.9 | 55 | 42 | 14 |
| **Pittsfield** | 162 | 8.3 | 61 | 12 | 11 |
| **Alstead** | 174 | 9.8 | 91 | 0 | 11 |
| **Tamworth** | 174 | 11.0 | 114 | 6 | 7 |
| **Orange C** | 204 | 8.4 | 78 | 0 | 7 |
| **Colebrook** | 144 | 8.3 | 54 | 0 | 4 |

**Mechanical damage:** The range in amount of basal wounding varied greatly. One site had no logging injuries, while at another site, 100% of the trees were damaged.

**Table 3**
Mechanical Tree Damage

| Plot | % of trees with logging damage | ave. tree severity | % dieback |
|---|---|---|---|
| **Middleton** | 50 | 30 | 41 |
| **Orange S** | 43 | 30 | 40 |
| **Jefferson** | 100 | 30 | 39 |
| **Orange N** | 25 | 40 | 34 |
| **Goffstown** | 32 | 30 | 23 |
| **Errol** | 10 | 50 | 16 |
| **Millsfield** | 0 | 0 | 14 |
| **Pittsfield** | 15 | 30 | 11 |
| **Alstead** | 6 | 40 | 11 |
| **Tamworth** | 38 | 20 | 7 |
| **Orange C** | 14 | 20 | 7 |
| **Colebrook** | 12 | 30 | 4 |

**Tree crown data:** With ten years of baseline data from the FHM program, we're now able to realize data ranges, for each of the crown indicators, which would suggest a tree is healthy. The FHM "healthy" data ranges for each crown indicator are located, in italix, at the top of table 4. The results suggest only the dieback figures are considerably higher than the state-wide FHM range for healthy northern hardwoods. The live crown ratio, density, and transparency at these sites is only slightly below the normal range.

**Table 4**
Tree Crown Data

| Plot | LCR | Light | density | transparency | % dieback |
|---|---|---|---|---|---|
| *New Hampshire FHM** | *(30-60)* | *(1-3)* | *(40-60)* | *(5-25)* | *(0-10)* |
| **Middleton** | 28 | 5 | 30 | 23 | 41 |
| **Orange S** | 38 | 4.4 | 24 | 10 | 40 |
| **Jefferson** | 37 | 5 | 36 | 28 | 39 |
| **Orange N** | 31 | 4.2 | 32 | 19 | 34 |
| **Goffstown** | 60 | 2.5 | 50 | 17 | 23 |
| **Errol** | 43 | 3.6 | 40 | 22 | 16 |
| **Millsfield** | 57 | 4.3 | 50 | 19 | 14 |
| **Pittsfield** | 61 | 2 | 50 | 19 | 11 |
| **Alstead** | 38 | 2.1 | 45 | 20 | 11 |
| **Tamworth** | 52 | 2.8 | 55 | 19 | 7 |
| **Orange C** | 50 | 1.2 | 47 | 19 | 7 |
| **Colebrook** | 48 | 2.8 | 54 | 14 | 4 |

** state-wide data range for healthy, forested trees in the northern hardwood forest type*

**Root area compacted :** Most trees in this study had some amount of root compaction. The key element seemed to be the overall amount of compaction at each site. The sites with the highest dieback all had 100% of the tree root systems compacted to some degree, and the average amount of damage on each tree was over 60% of the total root area. Conversely, the four decline sites with the least dieback all had less than 50 % of the root area compacted and less than 90% of the trees affected. The non-decline sites further supported this trend. The dieback was low, not all trees were affected, and the overall root area compacted was under 40%.

**Table 5**
% Total Root Area Compacted

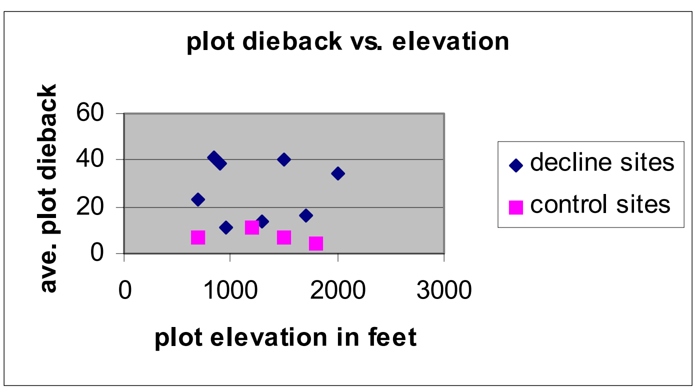
| Plot | % trees w/compaction* | mean comp/tree** | plot dieback |
|---|---|---|---|
| **Middleton** | 100 | 67 | 41 |
| **Orange S** | 100 | 63 | 40 |
| **Jefferson** | 100 | 70 | 39 |
| **Orange N** | 90 | 65 | 34 |
| **Goffstown** | 83 | 41 | 23 |
| **Errol** | 87 | 28 | 16 |
| **Millsfield** | 53 | 49 | 14 |
| **Pittsfield** | 52 | 33 | 11 |
| **Alstead** | 69 | 20 | 11 |
| **Tamworth** | 90 | 31 | 7 |
| **Orange C** | 62 | 28 | 7 |
| **Colebrook** | 91 | 26 | 4 |

**percentage of all trees on the plot*
*** average area of compaction for all trees on the plot*

## COMPARATIVE ANALYSIS

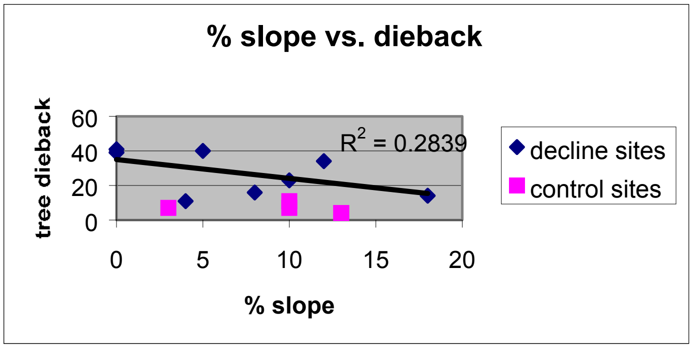
A comparison between the measured plot data and the crown dieback should be made to evaluate the relationship between a particular measure and its effect on dieback. ***The R-Squared test will be utilized throughout to describe the strength of correlation between other indicators and tree dieback***.
The heaviest dieback occurred on a wide range of elevations. The data (fig.1.) seems to indicate that the increase in dieback was independent of an increase in elevation.

**Figure 1.**
Dieback Relative To Elevation



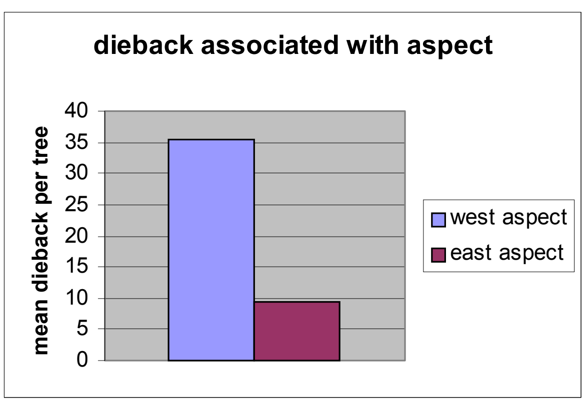
The general plot data indicated a weak relationship between the amount of dieback and the amount of slope on the plot. This weak relationship is describes in Figure 2., with an *R-Squared* value of .28, meaning, only 28% of the decline could be related to the slope. The decline sites with moderate slopes had less dieback than the sites with shallow to no slope. Survey sample size may be a factor in making any conclusions however, because no truly steep sites were observed.

**Figure 2.**
Dieback Relative To Ground Slope




Plot aspect, unlike the other general plot data, did show a strong relationship to plot dieback. The aspect at these decline sites ranged from 45 to 360 degrees. As shown in Figure3., the plot dieback is significantly greater in the westerly zone. With the belief that the west and north aspects are the coldest ecozones, these result seem to support Canadian Forest Service research which has concluded deeper than normal frosts contribute to hardwood decline (Robitaile 1997). Harvesting must exacerbate this phenomenon by reducing thermal cover in the form of reduced stocking and crown closure, exposing soils and roots during winter operations, and compressing moist soils.

**Figure 3.**
Mean Dieback Of All Plots In Westerly And Easterly Aspects



Crown indicator data such as LCR and density were only slightly lower than the state-wide "normal" range, but as Figure 6., and Figure 7., suggests, both LCR and crown density are highly influenced by an increase or decrease in crown dieback. This data further supports the notion that the change in crown dieback is a critical forest health indicator that needs to be monitored closely before and after any forest management practices.

**Figure 6.**
LCR As Dieback Increases

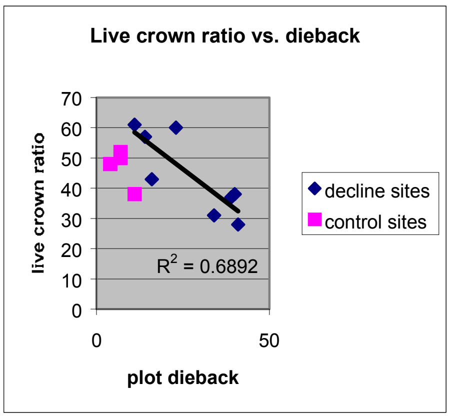
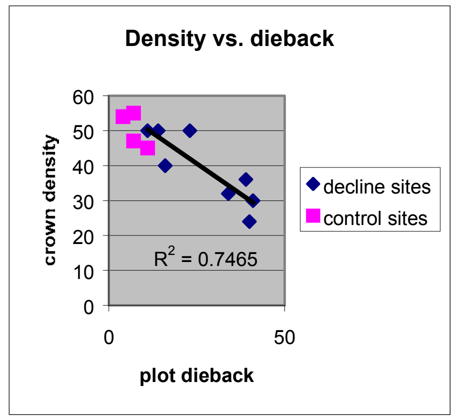
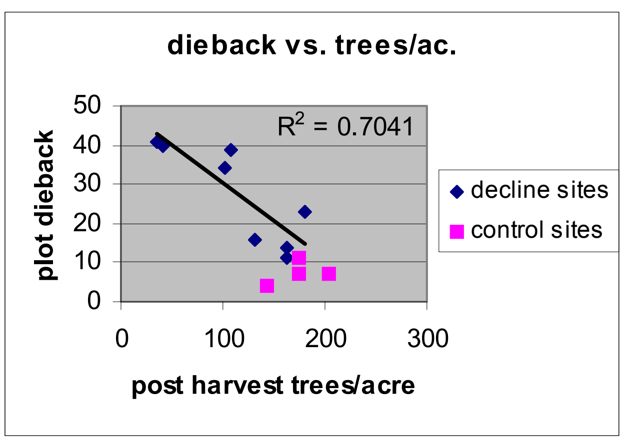



**Figure 7.**
Crown Density As Dieback Increases




**Mensuration data** indicates a strong relationship between the residual number of trees per acre and the amount of post harvest dieback. As described in Figure 8., the dieback increases as the number of trees remaining per acre decreases.

**Figure 8.**
Tree Dieback Related To Stand Density

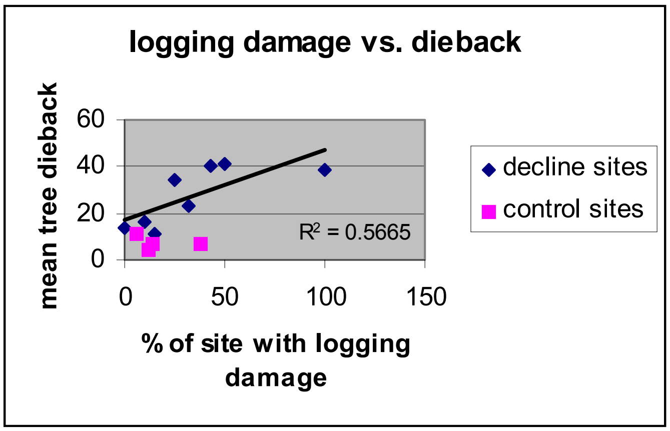


Tree dieback may not be directly related to stocking, however, when you remove fewer trees per acre, you reduce the skid trail abundance and impact fewer of the remaining tree root systems. With fewer remaining root systems compacted, the overall tree dieback declines. Additionally, well-stocked stands tend to better resist damage done by other forest stressors, such as heavy winds, ice storms, and sun-scald.

**Mechanical damage** from the logging operation was moderately correlated to the increase in dieback. As described in Figure 9., the amount of dieback increases as the amount of trees damaged increases. Hardwood trees, more so than softwoods, depend on the annual flow of energy from the roots to the foliage, and back, to maintain a healthy vigor. For this reason, hardwoods are very sensitive to root damage and basal wounds.

**Figure 9.**

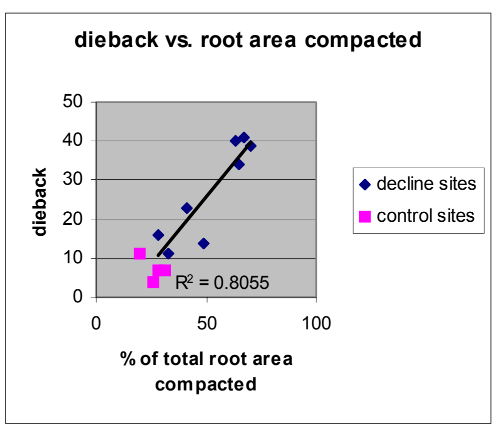
Dieback Related To Logging Wounds




The amount of **Root area compacted** was another highly correlated indicator of tree dieback. Mean tree dieback increased dramatically when there was an increase the amount of root compaction per plot. As shown in Figure 10., this strong relationship is represented with a *R-square* value of .80. There is a distinct jump in tree dieback when more than 40% of the tree root systems are compacted.

**Figure 10.**

Dieback As The Area Of Root Damage Increases



## CONCLUSION

As crown dieback increases, the photosynthetic area of the tree decreases. With this change comes a decrease in tree vigor. If the decline in vigor occurs uniformly throughout a particular stand, overall forest health and productivity suffers. It seems from this evaluation project, there is a strong relationship between the total area of root compaction, during logging operations, and the amount of subsequent tree dieback. Also, there seems to be a moderate correlation between aspect, and tree stocking, to the increase in tree dieback. It seems that the northern hardwood sites with the highest risk of tree dieback following a timber harvest, are lightly stocked residual stands on west slopes, with over 40% of the harvest area compacted by heavy equipment. On these sites it seems leaving fewer than 125 trees per acre, and damaging more than 25 % of the residual stems, could set the forest health into serious decline. Forest soil types and hydrology, while not studied in this report, must play some role in the tree response to heavy logging stress. Future monitoring projects should do more to investigate the subtle effects soil textures, hydrology and chemistry have on the trees response to stress. The data from this study seems to support the notion that the amount of dieback is sensitive to, and dependent upon many factors, both biological and mechanical. For this reason, it is important to measure and monitor tree dieback before and after forest management operations.

**Author:**
Kyle Lombard
Forester, Division of Forests and Lands
603-271-7858
*klombard@dred.state.nh.us*

## REFERENCES

Robitaile, G., Boutin, R., and Lachance, D. 1995 **Effect of soil freezing stress on sap flow and sugar content of mature sugar maples (Acer saccharum Marsh.). Can. J. For. Res.**

# Practices to Minimize Logging Injuries

**By**

**William Ostrofsky, Department of Forest Management**
**University of Maine-Orono**

Harvesting is the necessary and critical part of forestry by which numerous products required and demanded by society are obtained. As long as forests are managed for the extraction of wood products, the potential exists for trees and stands to be mechanically damaged. Unlike pathogens, insects, or undesirable climatic conditions, injury to residual trees is one forest health factor under substantial control by landowners, foresters, and harvest operators.

All harvesting does not result in unacceptable damage levels, nor does it often result in widespread stand decline. However, constant attention must be paid to avoid those factors or conditions which can result in unacceptable levels of damage to forests by harvesting activities. Consider the following:

1. Plan skid trails and layout landings
2. Know the site and stand characteristics
3. Assess current (pre-harvest) stand health and tree vigor
4. Clearly identify the crop (residual) trees – use extra precaution when working near them
5. Use branches/slash in trails as a protective roadbed
6. Use bumper trees – designate them before harvesting begins; consider “artificial” bumpers
7. Consider season of harvest – usually less damage during winter (frozen) months
8. Equipment to match site and stand conditions
9. Multiple injuries are especially damaging – know pattern of previous harvest
10. Bark is easily injured during spring and summer; “tight” bark develops quite late in summer
11. Use high-flotation tires/tracks on the more fragile sites, as appropriate
12. Limit or concentrate machine activity on skid trails and access corridors
13. Increase awareness of consequences of mechanical injuries to trees and forest stands
14. Use silvicultural prescriptions which concentrate harvesting activity, as appropriate
15. Landowner, forester, and harvesting contractor share job performance responsibilities
16. Agree to be more “weather sensitive” when harvesting – delay harvesting earlier if too wet
17. Minimize the number of stand entries
18. Recognize that sapling/pole stages are most vulnerable to damage(size and time)
19. Prioritize efforts to reduce injuries to roots/soil first, upper bole/crown next, then root crown
20. Extraction of larger pieces has higher potential for causing damage than that for smaller
21. Extraction of heavy loads has higher potential for causing damage than that for smaller
22. Use crop tree selection methods rather than area-wide thinning techniques
23. Avoid harvesting large “wolf” trees whenever possible – girdle and leave for wildlife
24. Mark skid trail locations prior to harvest
25. Assess risk of sunscald to residual trees and consider trail/access corridor orientation

**Notes:**

## The Natural Resource Network Research Reports

The Natural Resource Network presents this material as a part of a series of research reports and publications of interest to educators, resource professionals, landowners and the public. Additional copies are available from the University of New Hampshire Cooperative Extension Publications Center, 16 Nesmith Hall, UNH, Durham, NH 03824

The mission of the Natural Resources Network is to enhance interaction among the natural resource research, teaching, and outreach communities in New Hampshire by providing an ongoing mechanism for identifying, addressing and communicating natural resource issues.

Natural resource professionals are working toward improved ways to conserve and use the natural resources of New Hampshire. The Natural Resource Network was formed to improve the interaction among researchers and those who provide outreach education in many kinds of programs. Teachers, outreach professionals and resource managers can bring research-based education to diverse audiences. At the same time, those audiences, or consumers, identify issues and needs for educational programs which can be addressed by controlled research. Well informed and knowledgeable professionals, free-flowing exchange of information, an advantageous and gratifying professional environment, and natural resource planning are goals of the Natural Resource Network.

Karen P. Bennett
Extension Specialist
Forest Resources