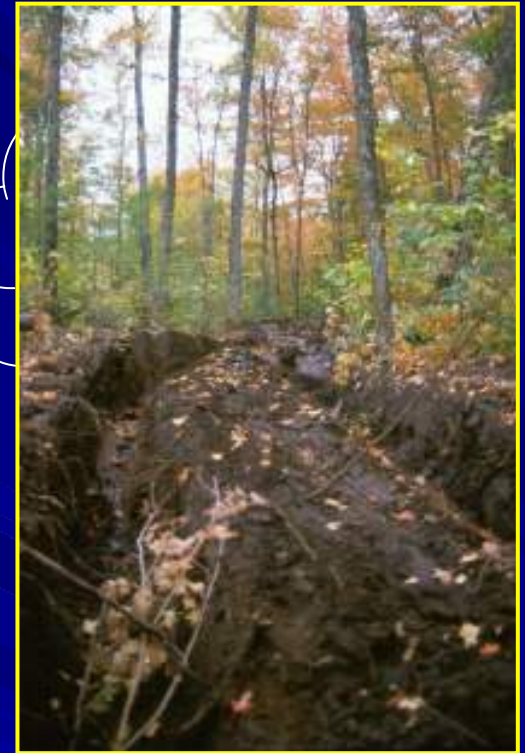


Thinking Outside the Rut:

Stem & Site Damage Implications to Tree & Stand Growth in Single Tree Selection Silviculture

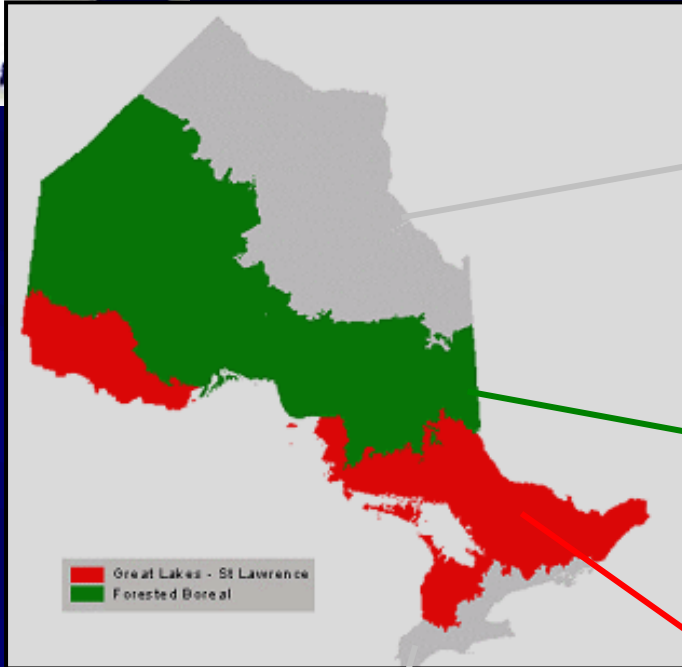
Megan Smith
Forestry Research Partnership



Objective

- Ontario's Silvicultural Picture
- Issues
- Current Standards
- Research Initiatives
- Summary

Ontario's Landbase



Hudson Bay Lowlands - sparse



Boreal - jack pine / black spruce

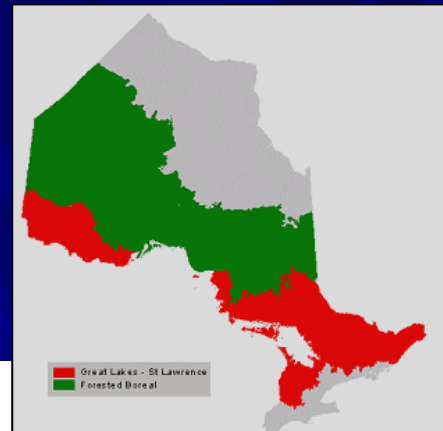


Deciduous - Tolerant Hardwood

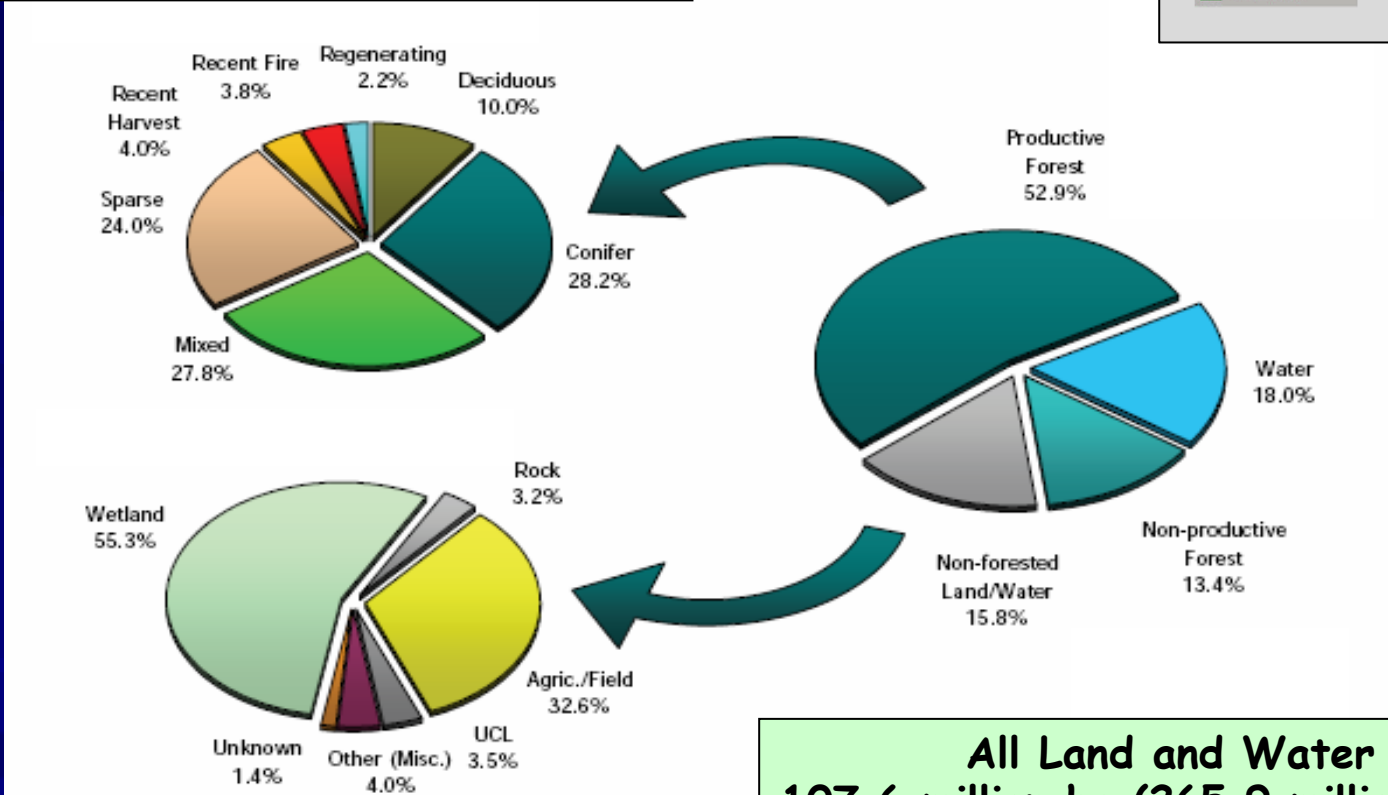


Gt. Lakes St. Lawrence - Red/White Pine

Ontario's Landbase



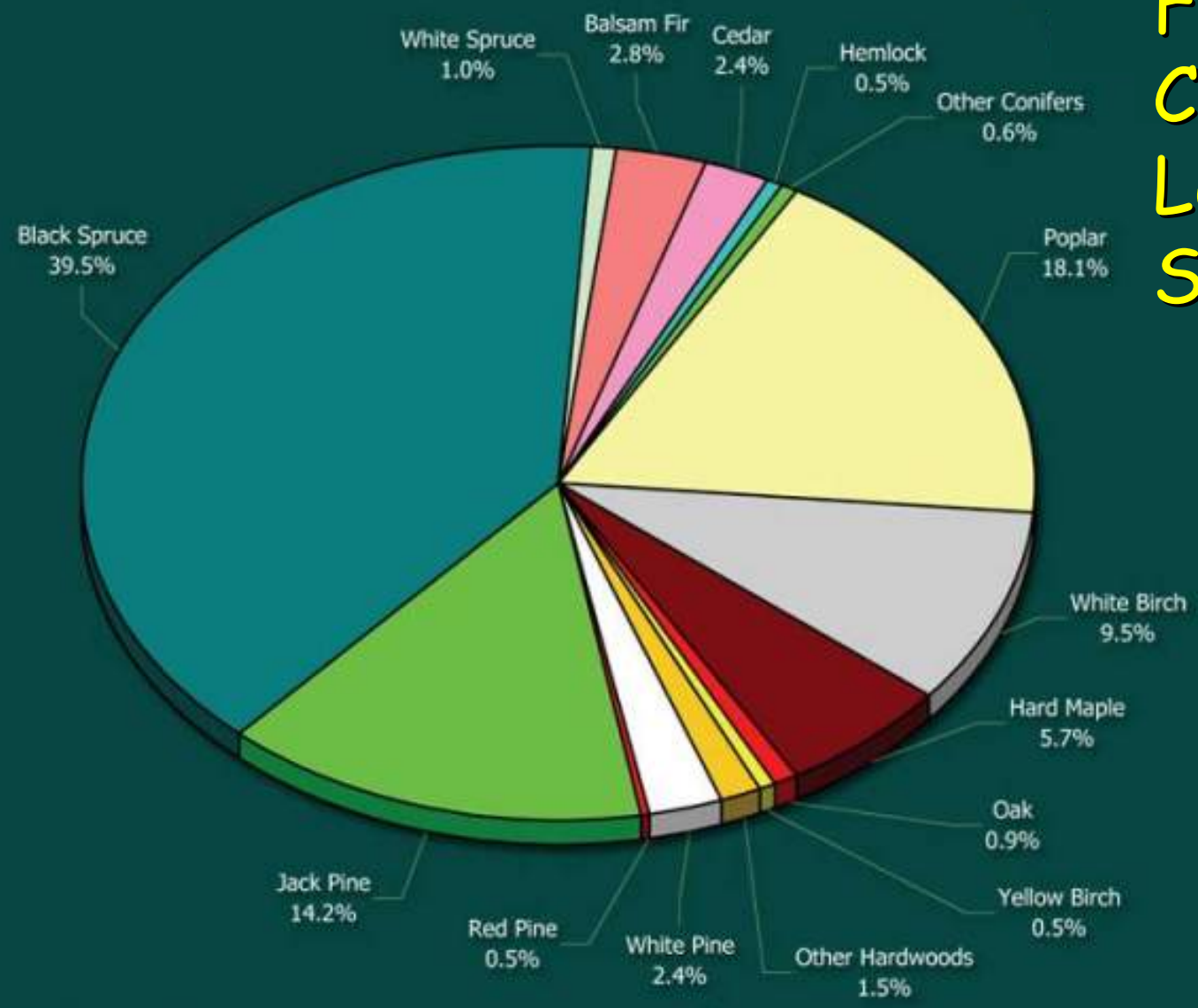
Productive Forest
56.8 million ha (140.3 million acres)



Non-Forested Land
17.0 million ha (42 million acres)

All Land and Water
107.6 million ha (265.9 million acres)

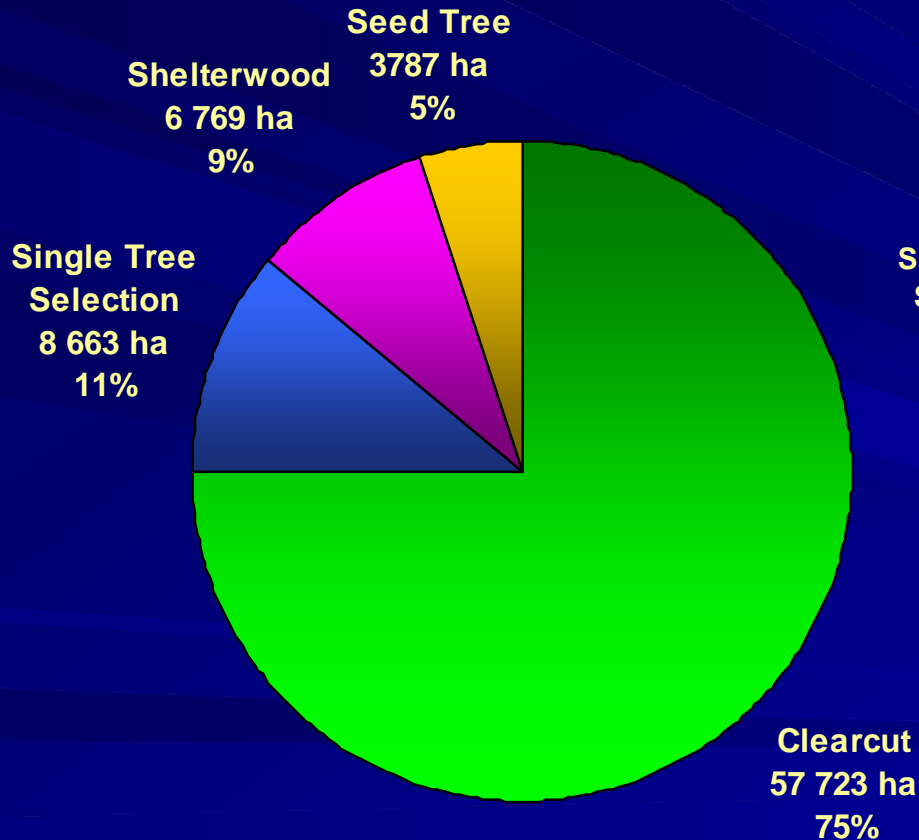
Forest Cover by Leading Species



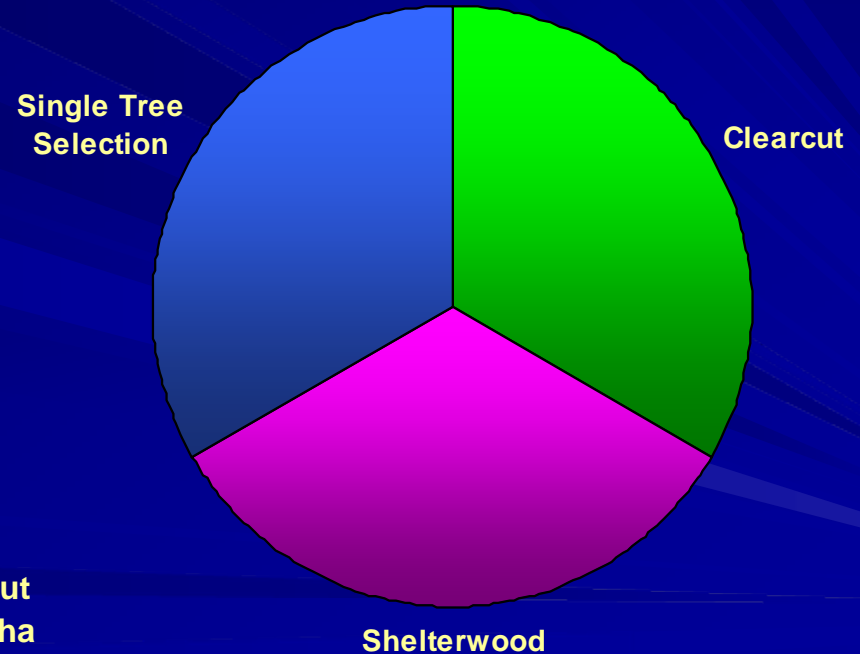
For the area of forest management

Ontario's Silvicultural Systems

Provincially Managed



Great Lakes - St. Lawrence Forest Region



Selection System

- Is the appropriate system for tolerant hardwood forests, BUT there is high potential to cause damage to residual stand with each successive logging operation
- Damage to the stand and site can result in:
 - Loss in productivity
 - Loss of value and quality
 - Negative environmental and ecological consequences (e.g. erosion, stream sedimentation)

But these can be prevented or minimized

The Issues

- Stem and root injuries (i.e. stem and root wounding, root shearing)
- Soil compaction
- Soil rutting
- Soil erosion
- Trails impassable for 20 year return



Issue: Stem and Root Injuries

- Wounds, such as bark abrasion (scraping) lead to discoloration & possibly decay especially if touching the soil
- Results in future volume and quality loss



Issue: Stem and Root Injuries

Long-term consequences...



Issue: Stem and Root Injuries

Which is worse?

- Larger the wound the greater the chance of decay
- Ground contact is BAD!!
- Gouging wounds are worse than scrapes
- Wounds on higher quality trees (AGS) are more serious than the same wound on low quality (UGS) trees



Issue: Root Shearing

Can lead to...

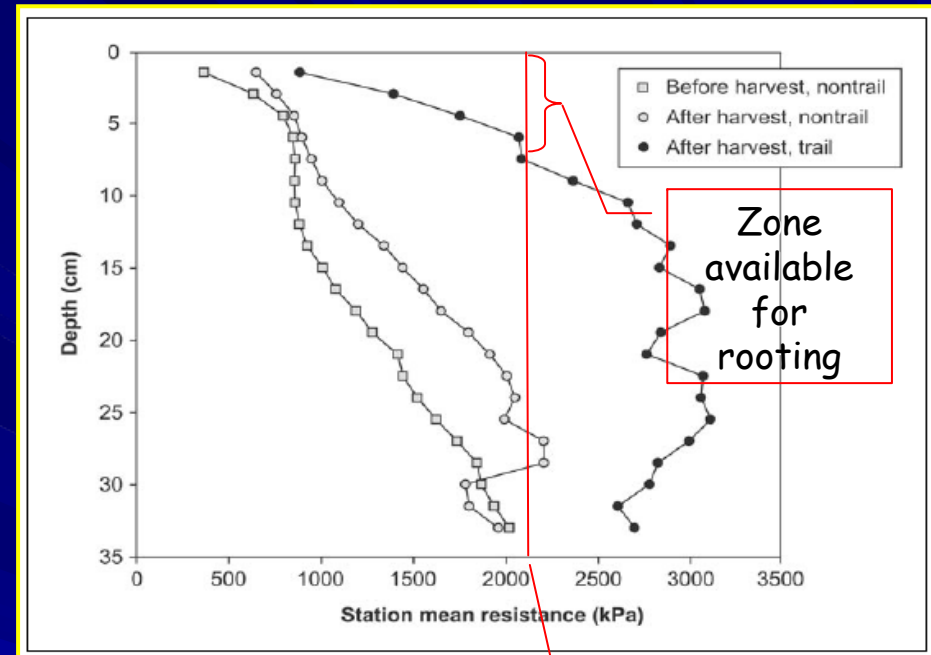
- Reduced growth rate
- Disease entry
- Dieback
- Dead branches: stain and value reduction
- Rot: volume and value reduction
- Topple: volume and value loss



Issue: Soil Compaction

"Compression of the soil caused by a load that exceeds the strength of the soil to resist it."

- Leads to increased bulk density and with that, increased soil strength
- Large pore space is lost, reducing...
 - vital gas exchange for roots
 - infiltration and drainage of water (can cause ponding and surface erosion)
 - space for growth of tree roots (roots have more difficulty penetrating the soil)



2150 kPa:
Roots can't
penetrate

Issue: Soil Compaction

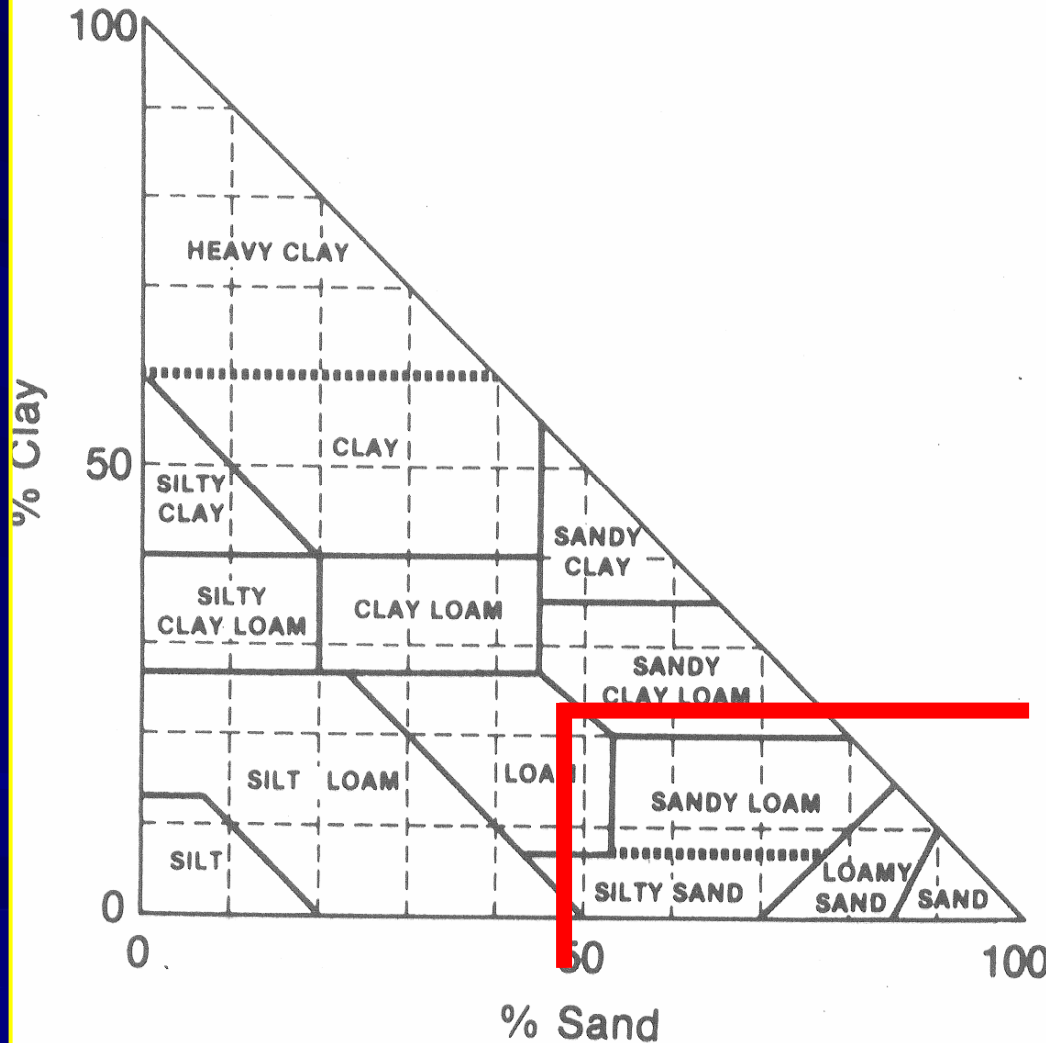
Compaction is influenced by:

- Texture, ground pressure and vibration, and most importantly - moisture content
- Most severe on medium to fine textured soils, especially during wet periods
- Greatest at 60-100% of soils' water holding capacity
- Consequences - lowland sites, wet seasons...



Issue: Soil Compaction

texture triangle



Finer-textured soils have a higher percentage of silt and clay. Soils above and to the left of the line should be deemed sensitive to rutting and compaction when moisture content is high.

Site sensitivity increases as the % clay increases.

Issue: Soil Compaction

Compaction is influenced by:

- Number of passes - the first few count

- Average 2.5 trips densities within 10% of the maximum

(Hatchell et al 1970, Ralston et al 1970)



- Bulk density increases with traffic, but much of the compaction occurs during 1st trip (Pestal, 1975)

- Slight increase after 1 pass, significant after three, max after 10, little difference between 3 and 10 (Murosky et al 1988)

Issue: Soil Compaction

- Interference with nutrient and water uptake
- Reduced tree stability
- Increased risk of infection
- Root wounds - major cause of defect in butt log



Issue: Soil Compaction

- Reduced growth - even for light traffic
- Increase in dieback when $>40\%$ of tree roots are compacted
- Stand diameter growth can be reduced by up to 15% (@25% skid trail coverage)



Issue: Soil Compaction

Soil Recovery:

32 years: 25% of area still heavily compacted

(Wert, Thomas 1981)

Up to 18 years

(Hatchell & Ralston 1971)

40 years on severely compacted areas

(Perry 1964)



The effects can last a long time...

Issue: Rutting

"Occurs when the pressure applied to the surface of the soil exceeds its load bearing capacity."



- Displaces soil and causes changes to its structure
- Occurs most easily on saturated soils of medium to fine texture
- Especially bad in the spring and fall when soils are saturated
- Makes the re-use of trails more difficult - more trails needed next time

Issue: Rutting

■ Impact of rutting on roots...

- Reduces or prevents growth
- Trees with damaged or broken roots are more susceptible to disease, and toppling during high winds



■ Impact of rutting on soil drainage...

- Site drainage blocked leading to localized ponding or pockets of saturated soil
- Saturated soil prevents gas exchange and is colder, reducing tree growth
- Can channel surface water and cause erosion and sedimentation

Issue: Erosion

"The overland movement of soil particles by water or wind following exposure (i.e. machine traffic)."



In worst cases - soil movement and sedimentation into fish habitat

Issue: Erosion

- Leads to smothering of root systems, reduced growth rates and even mortality



High Risk Areas:

- Steep or long slopes, unstable road cuts
- Sands and silts, shallow soil over bedrock
- Water crossings

Issue: Trails impassable for 20 year return

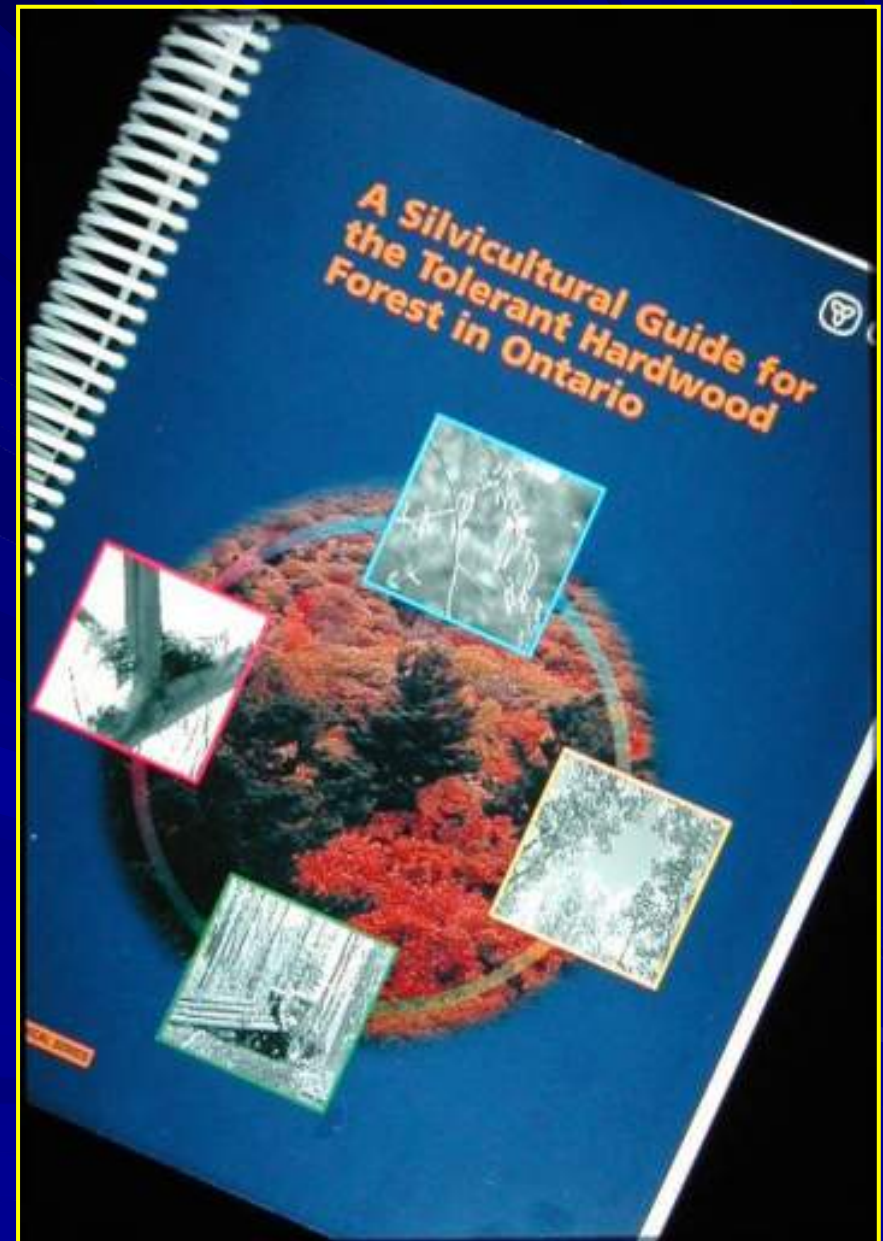
- Ideally, you would want to re-use the trails every harvest cycle (10-20 years) to minimize skid trail coverage...

...but, old rutted trails from previous "poor" harvesting practices minimize the opportunities



Ontario's Current Harvesting Impact Standards:

Selection
Silvicultural System



Ontario's Current Harvesting Impact Standards:

Damage to Residual Trees:

- Maximum 15% major damage to residual stems and 10% major damage to residual Acceptable Growing Stock.

What's considered major?

Stem: $> dbh^2$ (trees 10-30 cm dbh) or 1000 cm^2 (trees 32 cm+ dbh) or 60% of that size if there is ground contact or species is yellow birch

Roots: $> 1/4$ of the root system

Crown: $> 1/3$ of the crown

Ontario's Current Harvesting Impact Standards:



Minor Damage



Major Damage

Ontario's Current Harvesting Impact Standards:

Acceptable Growing Stock (AGS):

- AGS trees exhibit form and appearance that suggest they can reasonably be expected to maintain and/or improve their quality.
- AGS trees can be expected to contribute significantly to future crops in the form of vigorous, high quality stems.

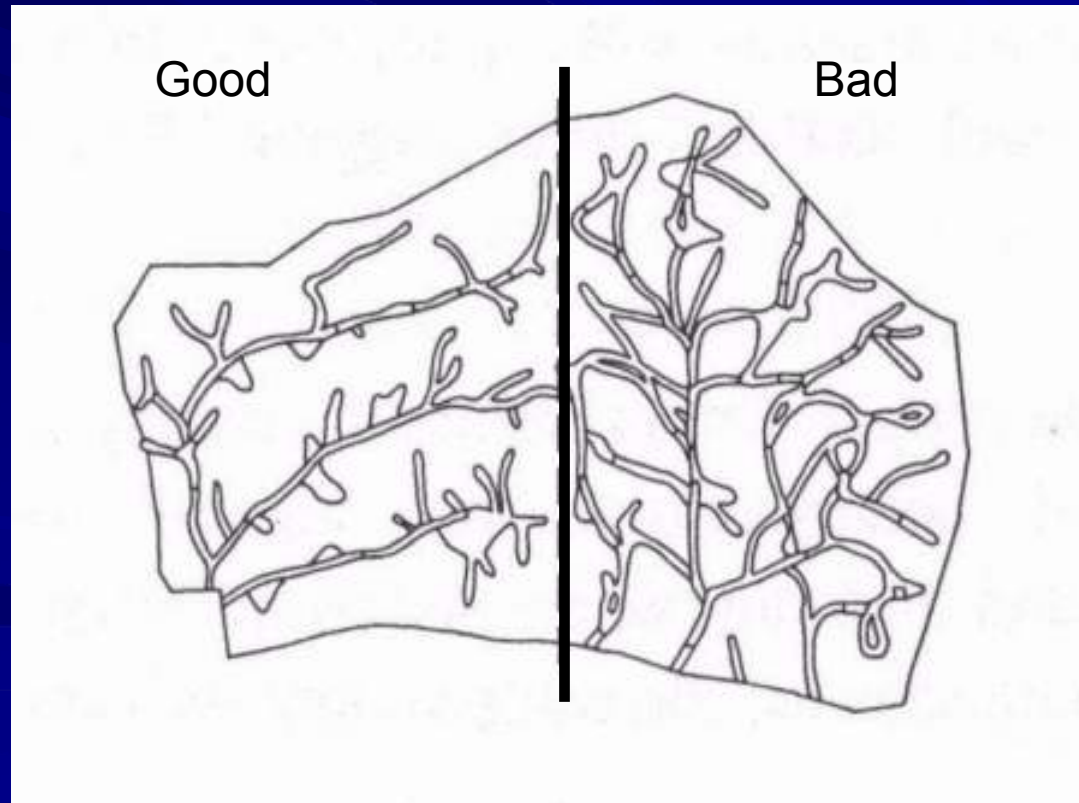
Unacceptable Growing Stock (UGS):

- UGS trees are high risk and are expected to decline during the next cutting cycle.
- UGS trees may also be of poor form and/or low quality and cannot reasonably be expected to improve in quality.

Ontario's Current Harvesting Impact Standards:

Skid Trail Coverage:

- Maximum 20% coverage of a harvest area for selection harvests



Ontario's Current Harvesting Impact Standards:

Rutting:

- Currently no provincial standards for rutting - Best management practices vary by district

Skid trail category	Maximum distance of compaction per skid trail
Minor - 15 cm or less compaction	Can be maintained over the length of the trail
Moderate - 16 cm to 30 cm of compaction	Can be maintained over the length of the trail
Major - 31 cm to 60 cm of compaction	120 metres
Extreme - compaction greater than 61 cm	30 metres

Site impact guidelines for Algonquin Park

Note: lots of evidence that 20 cm ruts result in major, long-term damage.

Ontario's Current Harvesting Impact Standards:

Rutting:

- Standards are currently under development on a provincial basis
 - Proposed provincial standard for rutting that is split by silvicultural system
 - Defined a rut (depth and length) smaller than the current guides
 - Shifted focus to the cumulative impact
 - Working on how to establish when mitigation or rehabilitation of trails is required



Research Initiatives

- Logging damage: cut and skid vs. feller buncher, season of operation
- Logging damage, lumber recovery and value
- Impact of skid trails on tree diameter increment growth
- Trail rehabilitation

Logging Damage Study:

Background:

- Knowledge gaps regarding short and long term effects of logging damage on stand quality, value and vigour
- Future growth projections have not accounted for different levels of logging damage, different machinery or season of harvest



?

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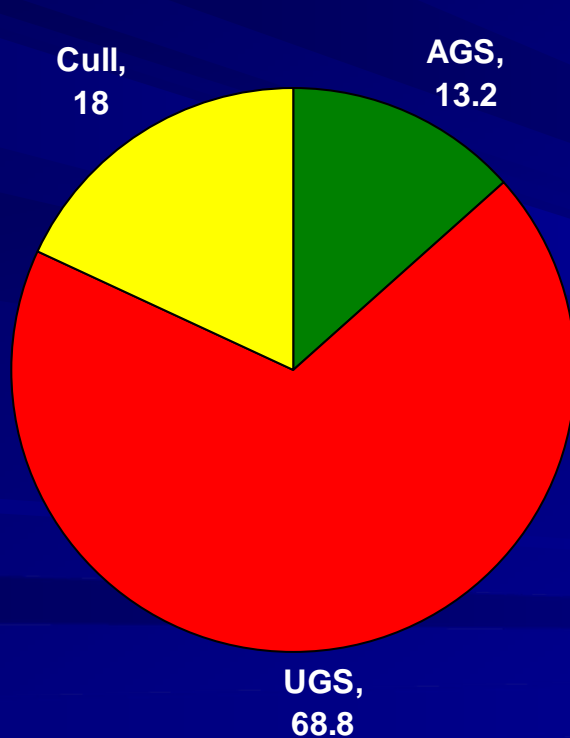


Logging Damage Study:

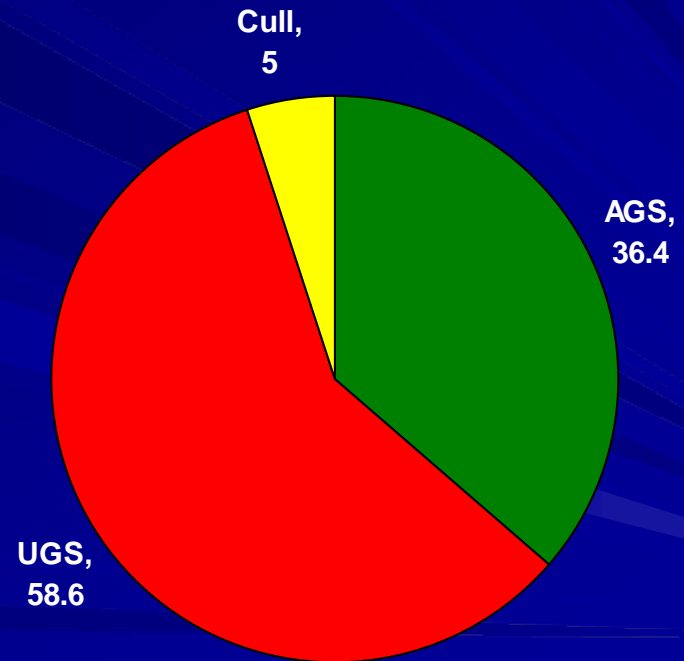
Quality Class Summary:

Parkside Gully - Swan Lake (Algonquin Provincial Park)

% Basal area by quality class (Anderson 1993)



1967: Before first cut

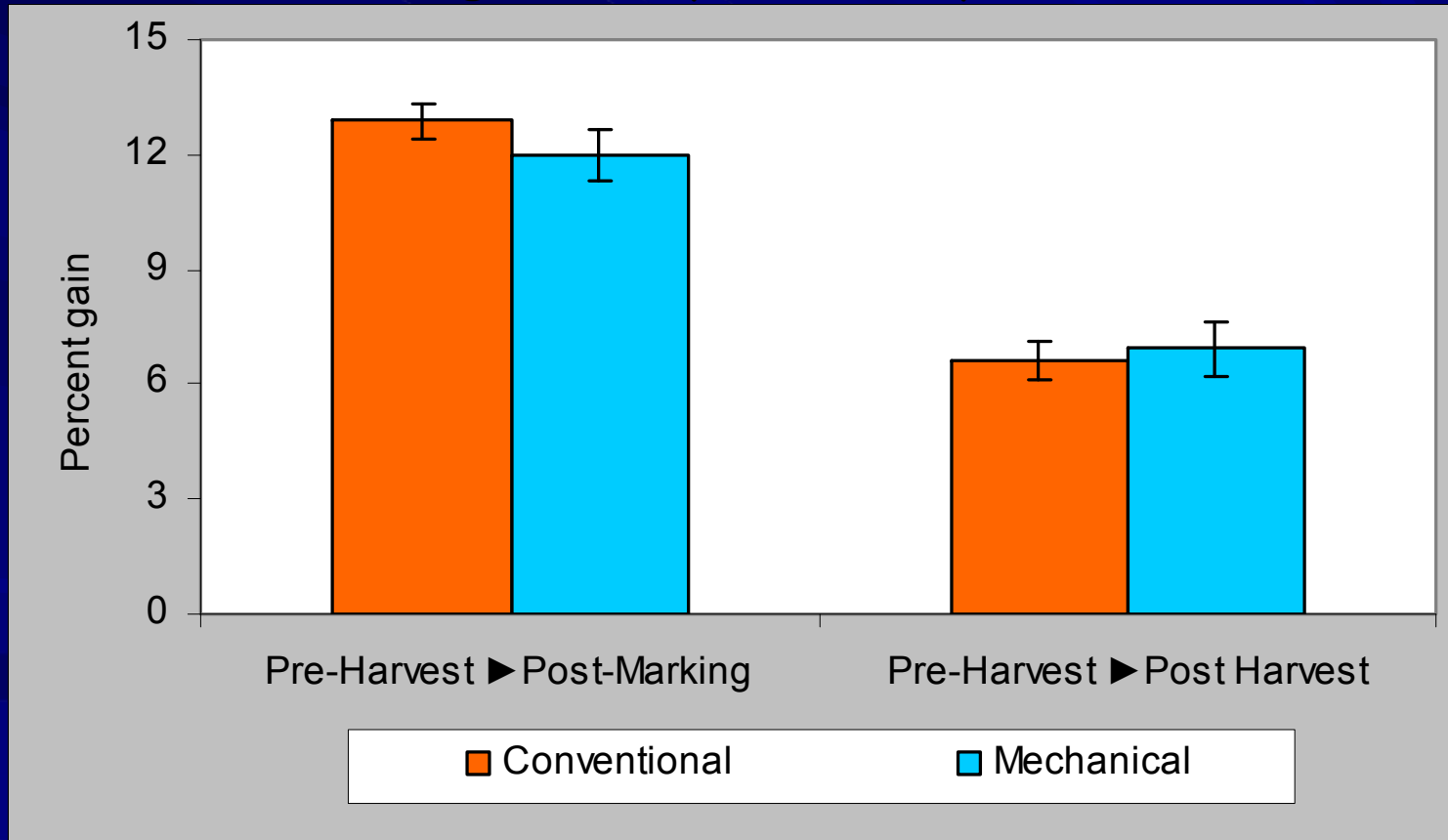


1993: After third cut

Logging Damage Study:

Quality Class Summary:

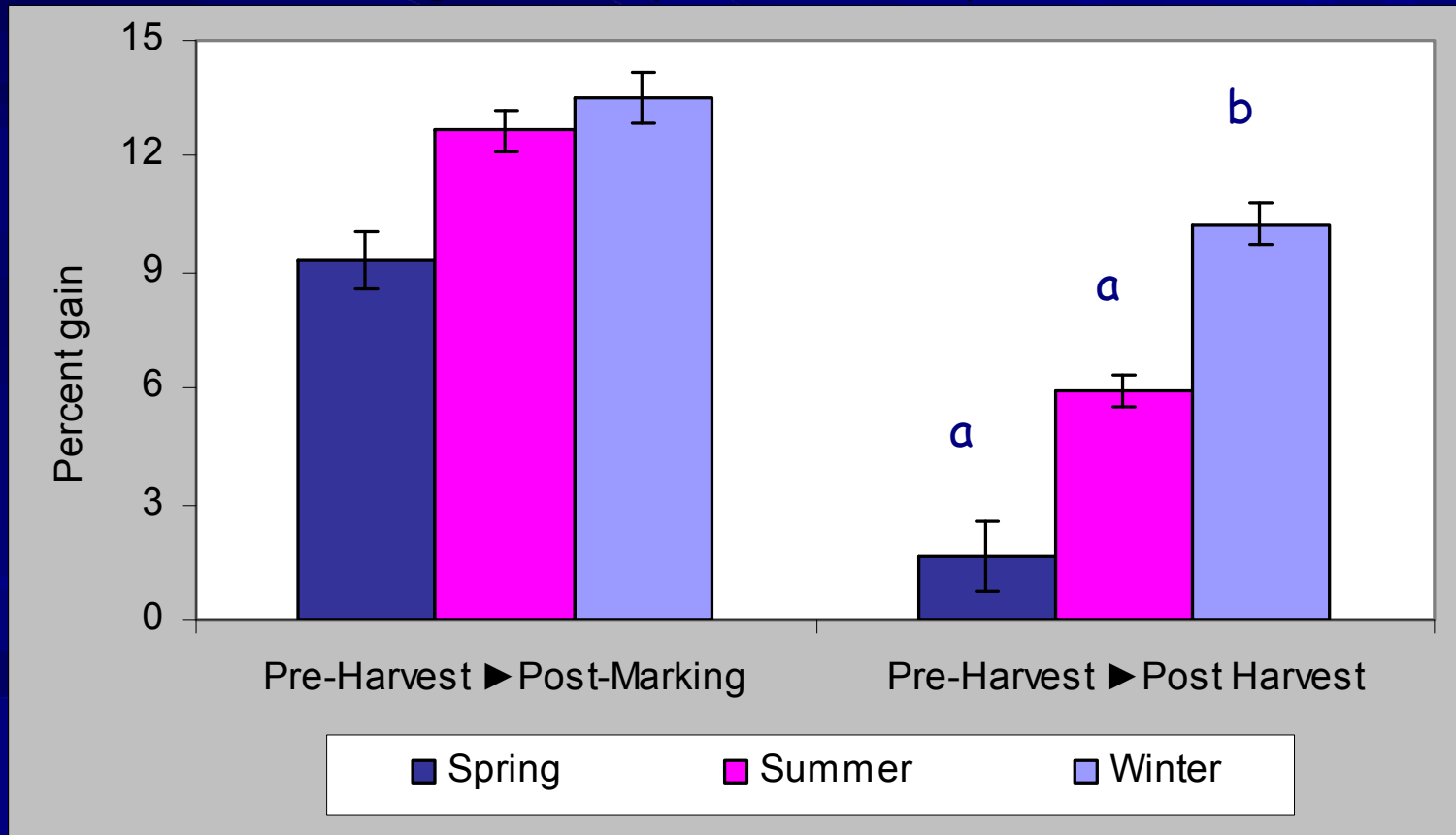
Gains in % AGS BA following stages of selection management by harvest system



Logging Damage Study:

Quality Class Summary:

Gains in % AGS BA following stages of selection management by season of operation

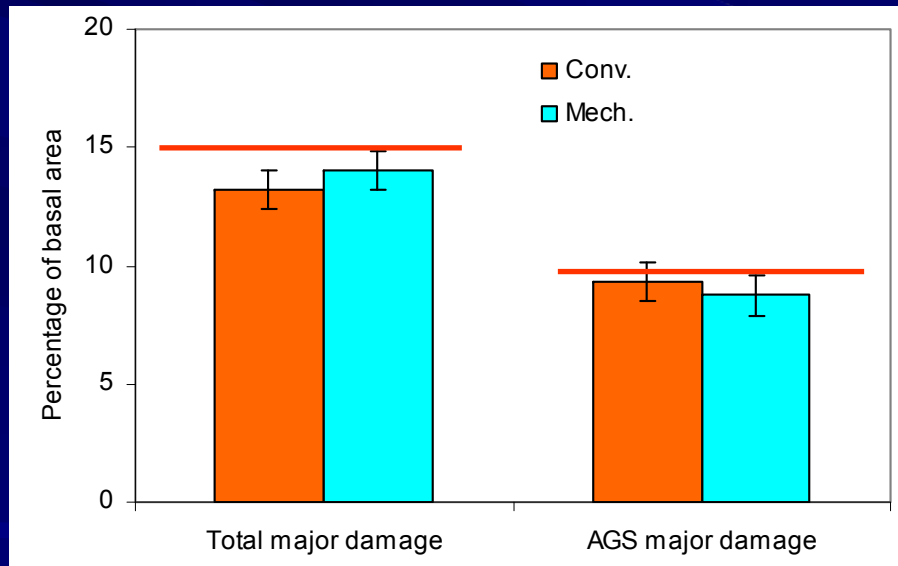


Bars with the same letter are not significantly different ($P > 0.05$)

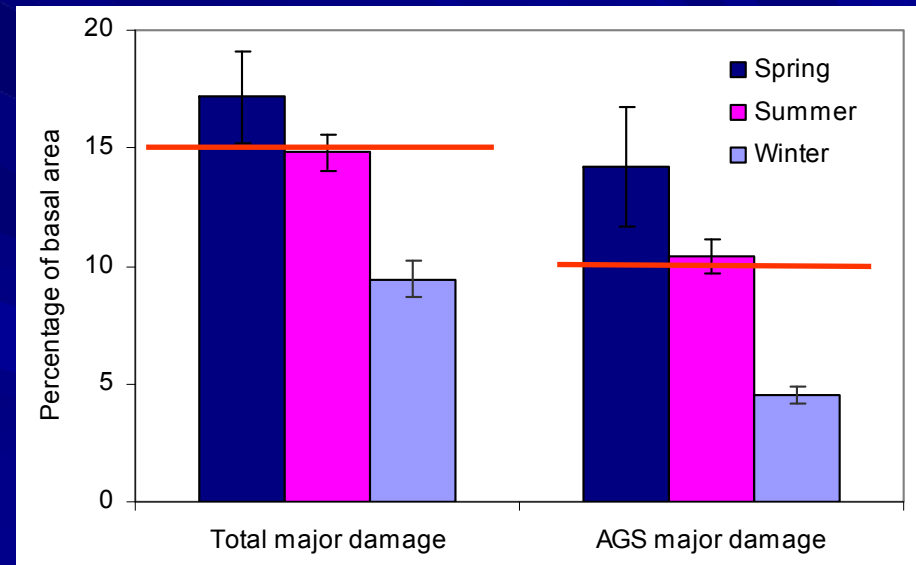
Logging Damage Study:

Major Damage to Residuals 10 cm+:

% of BA with major damage by harvest system

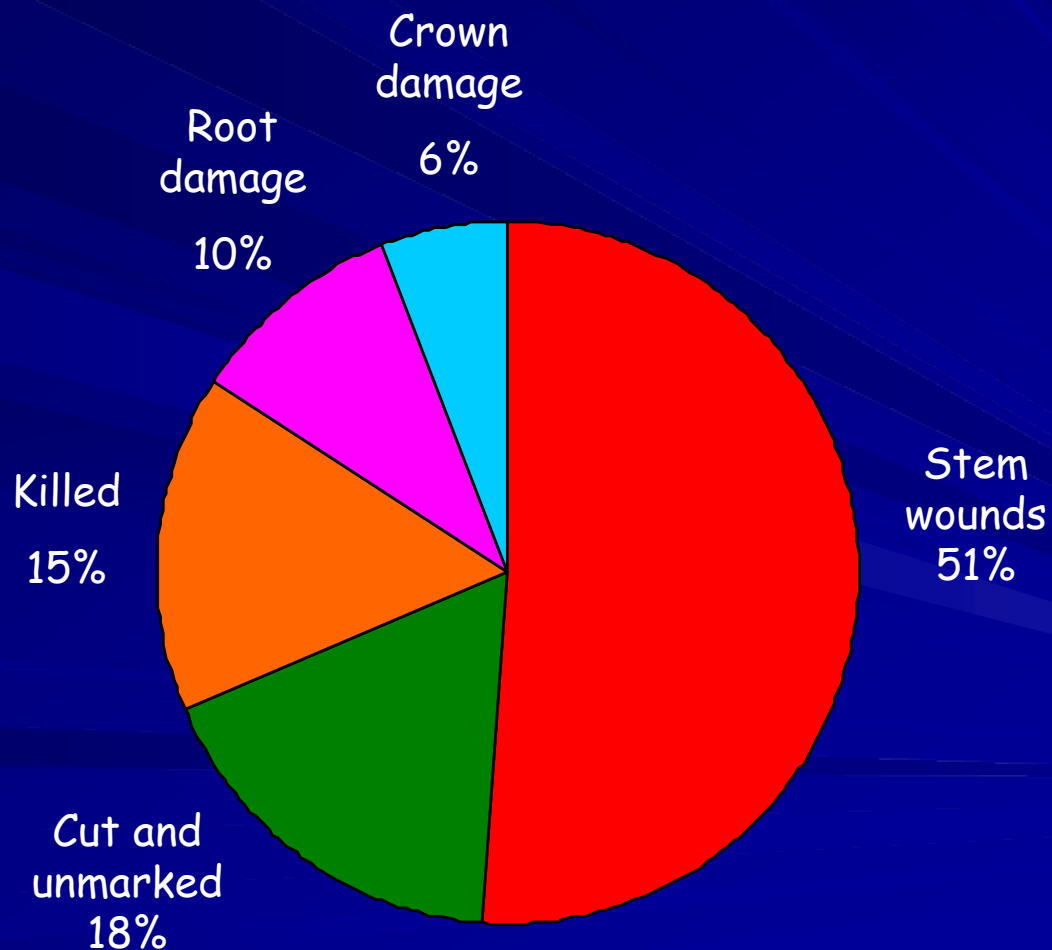


% of BA with major damage by season of operation



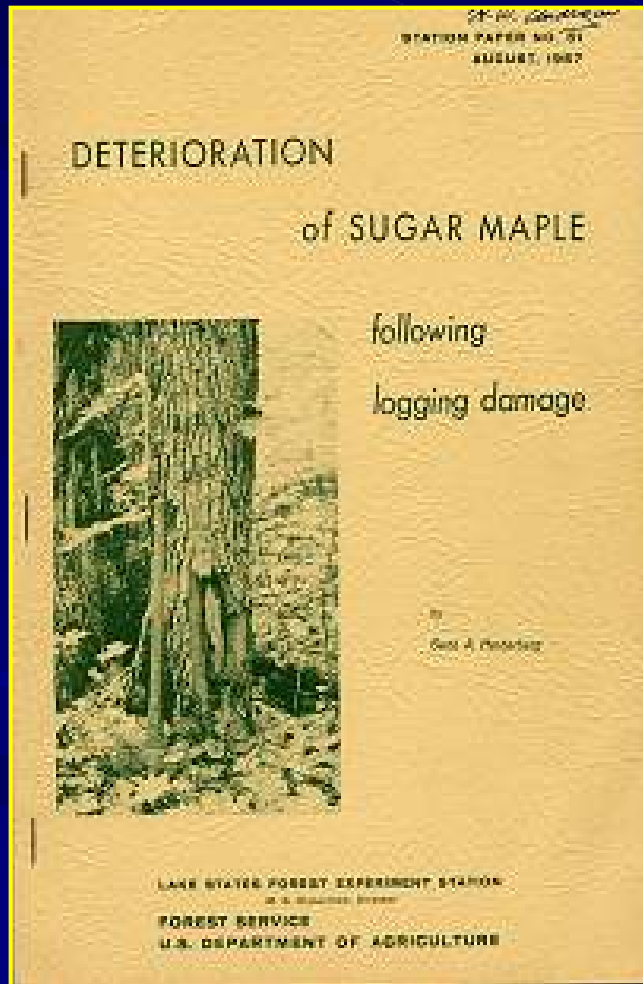
Logging Damage Study:

Summary of major damage to BA by major damage type
(for all harvest systems and seasons)

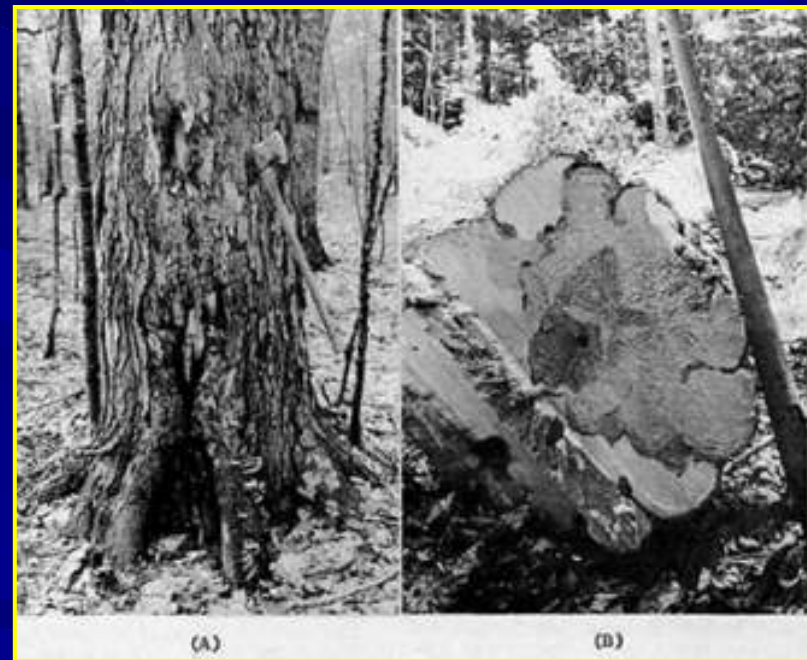


Logging Damage Study:

Stem Wounding is not new business...1957

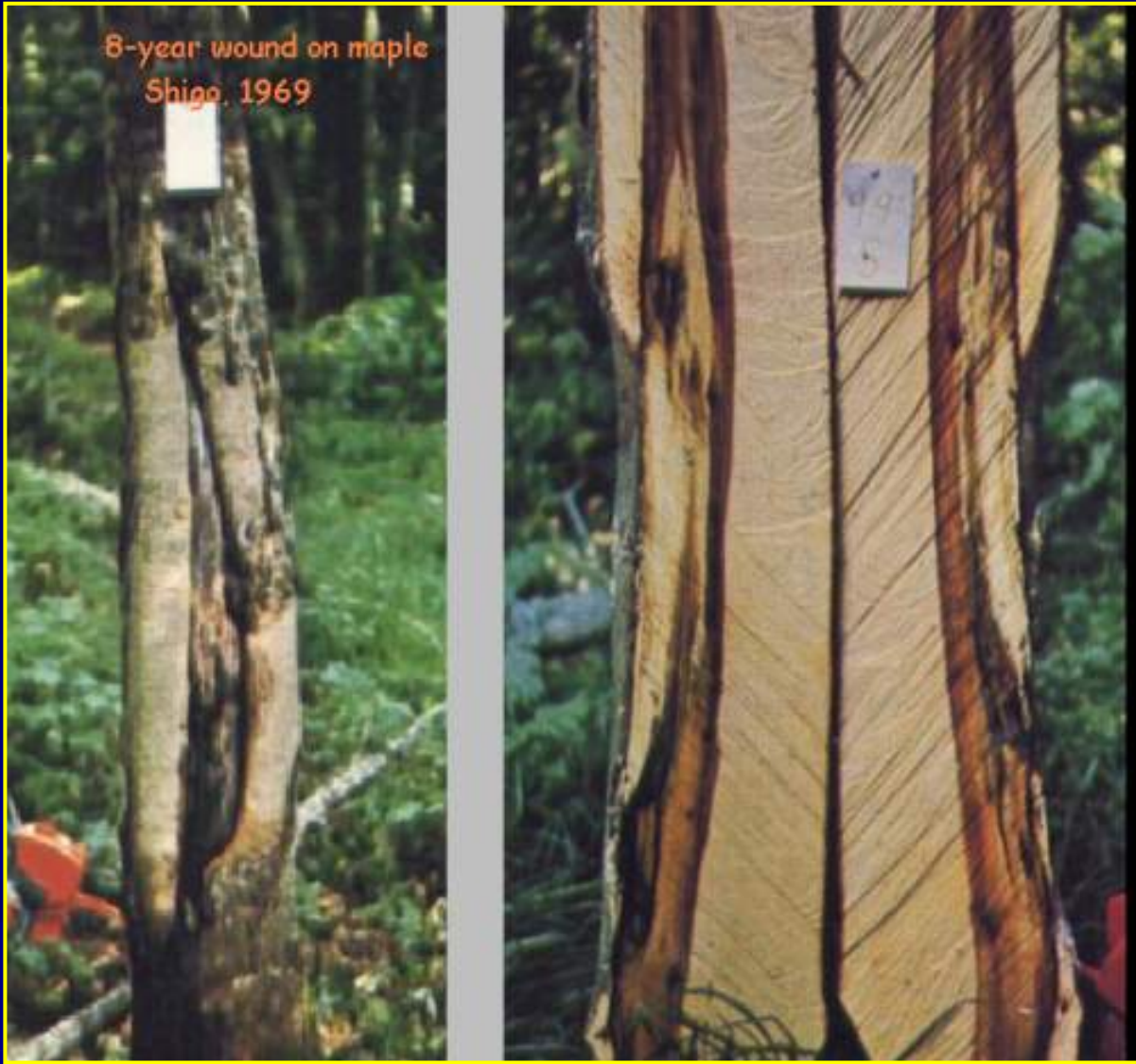


Hesterberg's work: How size of the wound affects the chance of decay developing



20 year old skidding wound
(Hesterberg 1957)

Logging Damage Study:



Logging Damage Study:



LOGGING WOUND DEFECT

ORIGINAL WOUND SURFACE AREA (sq.in.)	SCAR AGE (years)		
	10	20	30
	STAIN + ROT VOLUME (cu.ft.)		
5	0.144	0.261	0.379
50	0.285	0.546	0.806
100	0.443	0.862	1.28
300	1.075	2.126	3.176

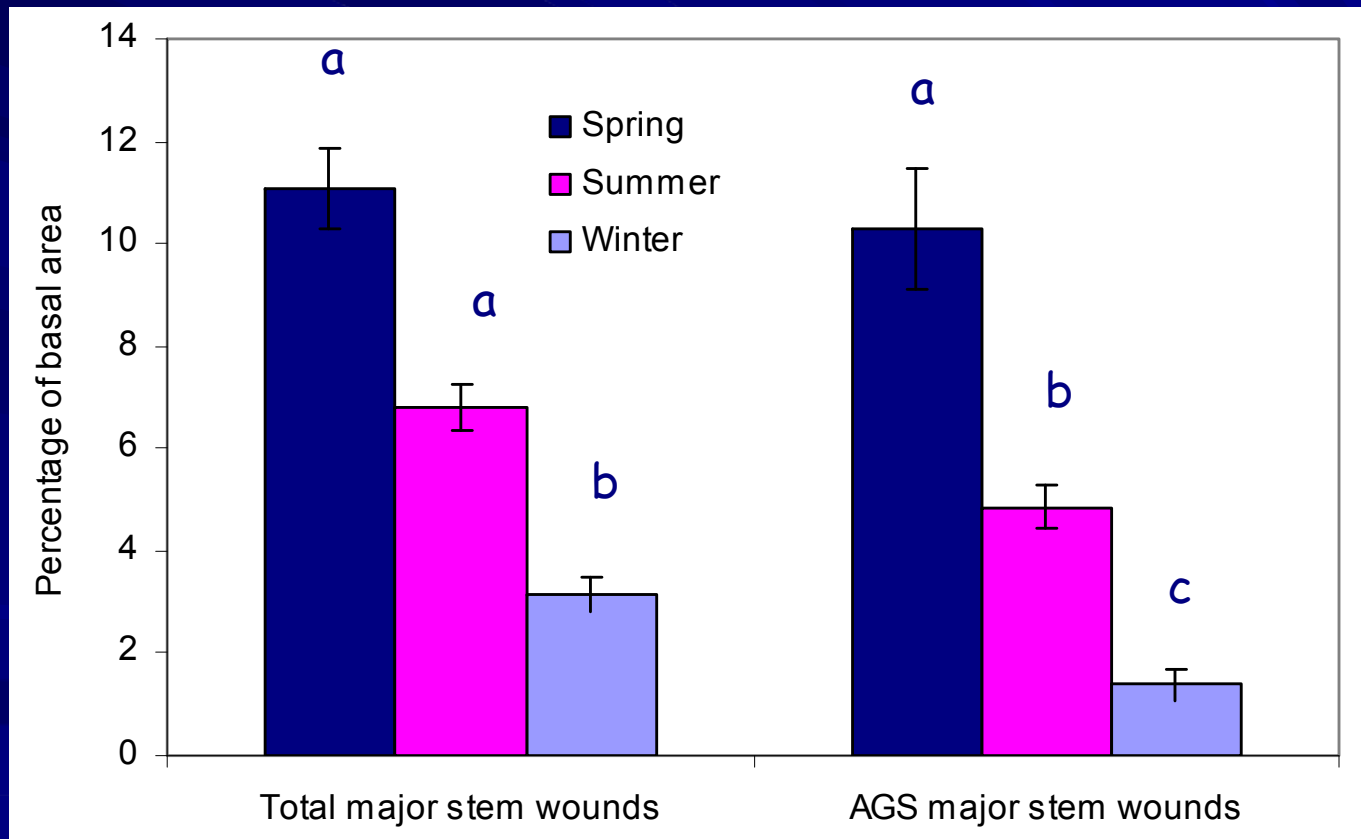
(Anderson, 1993)

Stain and rot volume doubles after 20 years and triples after 30 years

Logging Damage Study:

Major Stem Wounds to Residuals 10 cm+:

% of BA with major stem wounds by season of operation



Bars with the same letter are not significantly different ($P > 0.05$)

Logging Damage Study:

Why not spring logging?



Importance of Stem Wounding:

"Presence of bole wounds are an important concern because hardwood timber value is directly related to the occurrence of clear, unblemished wood in straight, round logs and is significantly decreased by the incidence of defects such as stain and rot " (OMNR 1998).

Logging Damage and Lumber Recovery:

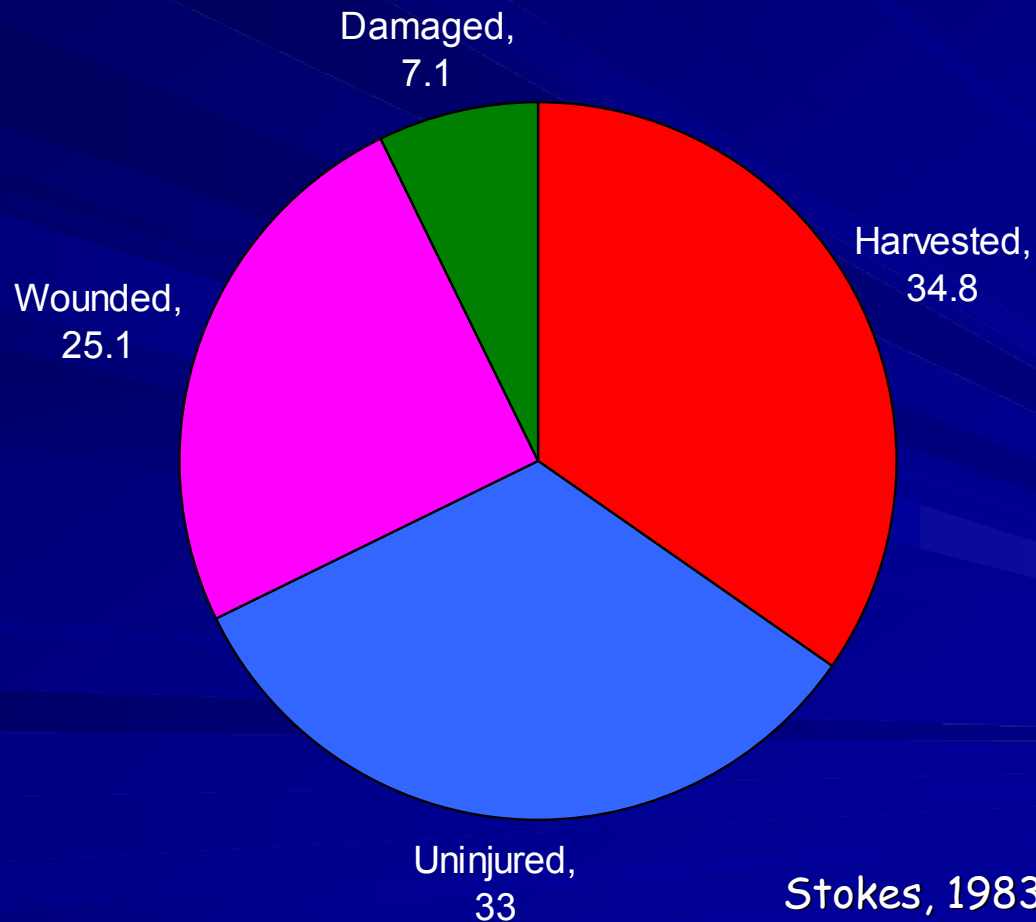
Objective:

- Evaluate growth response, lumber yield and products value of a hardwood stand one rotation after a selection cut

Logging Damage and Lumber Recovery:

Stokes Plots - Bracebridge District

% Basal area by logging damage status



Stokes, 1983

Logging Damage and Lumber Recovery:

Background:

- Single tree selection harvest conducted in the fall/winter 1983/84
- Establishment of 12 experimental plots
- 3 Plots were clear cut (as part of the study) in 2003
- Log grading and CT scanning
- Product recovery assessment

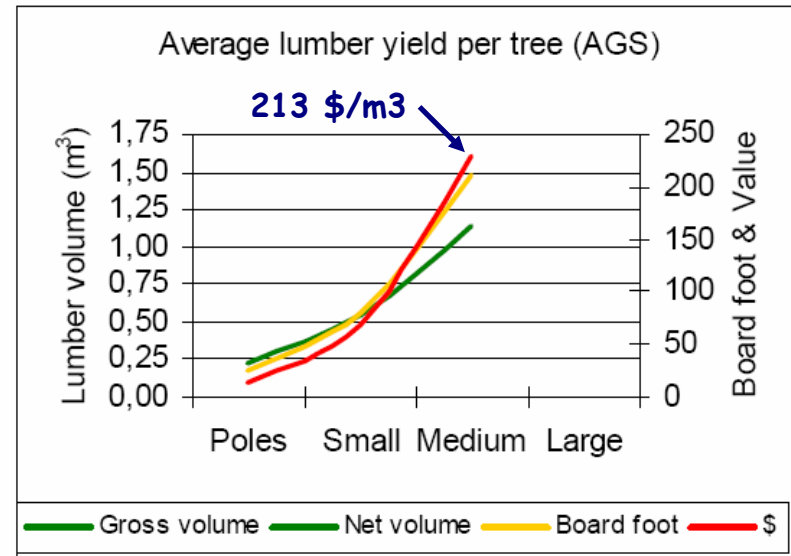
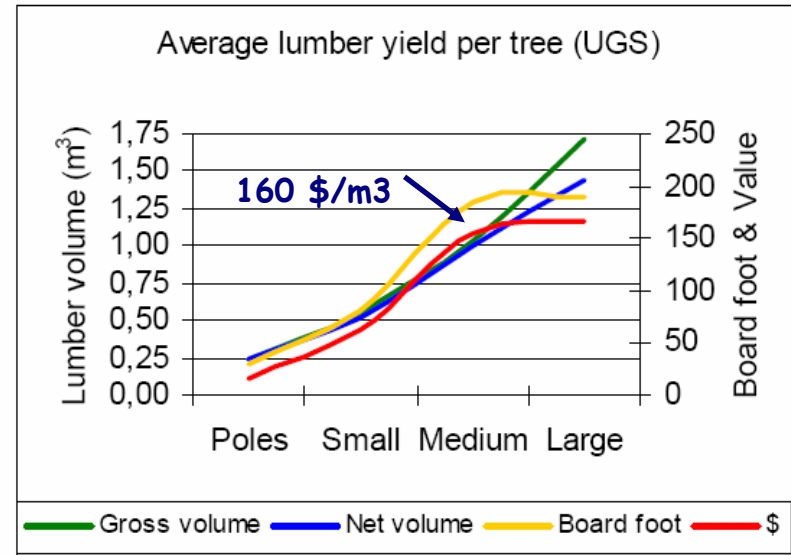


Logging Damage and Lumber Recovery:

Results:

- Quality class had a significant effect on products value in sugar maple
- AGS trees showed greater averages than UGS trees
- In sugar maple, for medium sawlogs, the value per lumber volume unit was much lower in UGS trees (\$160/m³) compared to AGS trees (\$213/m³)

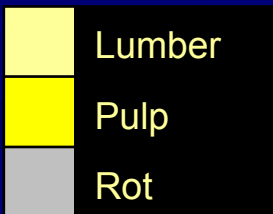
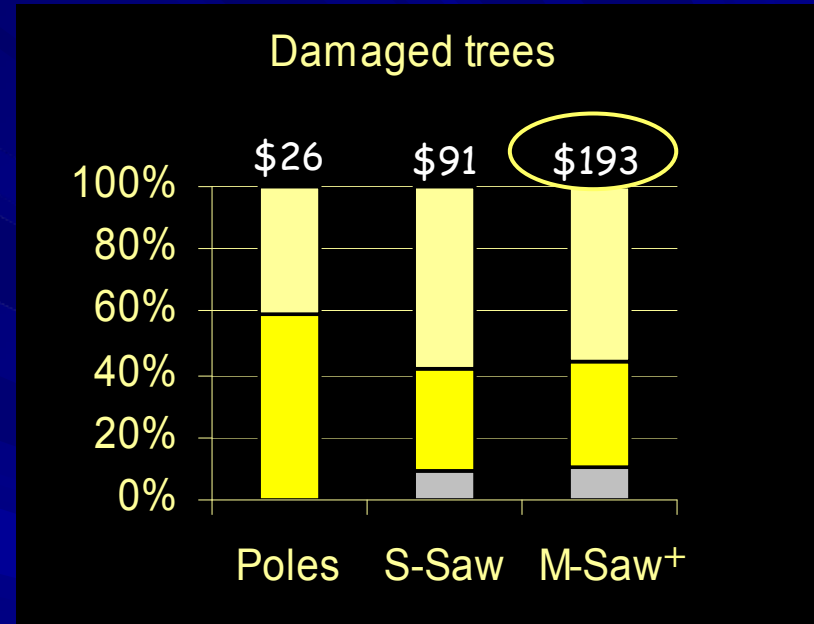
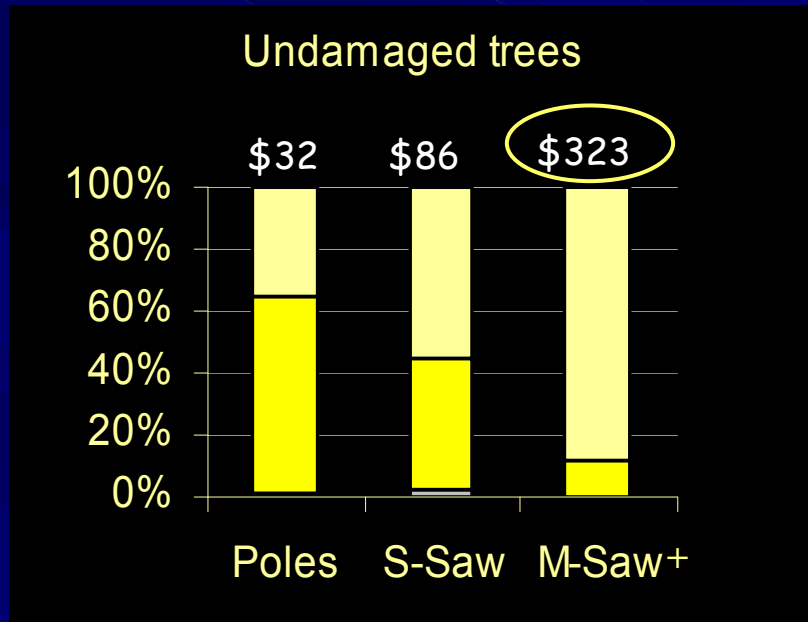
Lumber volume, board foot yield and value recovery in Sugar Maple



AGS: acceptable growing stock; UGS: unacceptable growing stock

Logging Damage and Lumber Recovery:

Results:



Medium+ undamaged sawlogs are worth, on average, 67% more than damaged ones

Quantification of Skid Trail Impacts on Tolerant Hardwood Tree Diameter Growth

Background:

- Lower than expected BA response at second entry
- Cause attributed to ???
 - over cutting
 - mediocre site quality
 - minimum limit of quality
 - logging and site damage



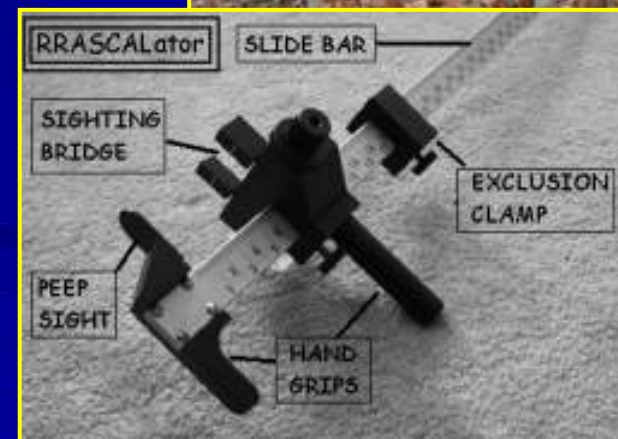
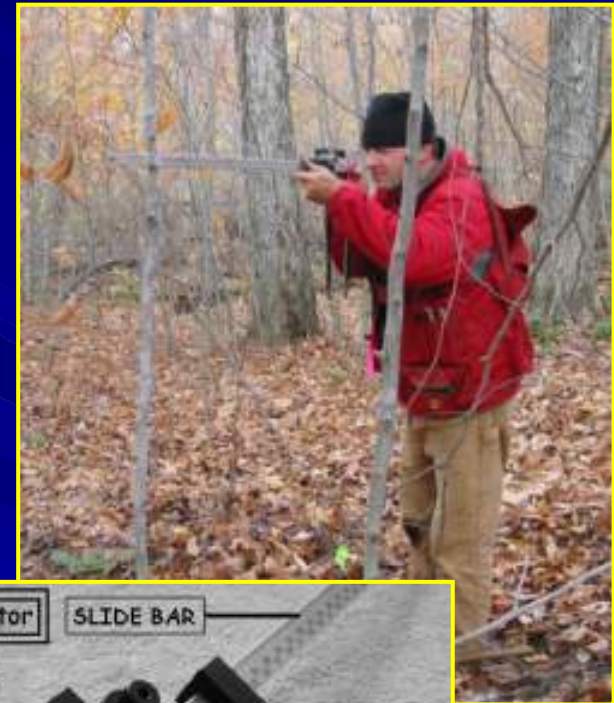
Objective:

- To quantify the impact of skid trails (including rutting, soil compaction and root shearing) on residual tree diameter increment and ultimately - *forest productivity*

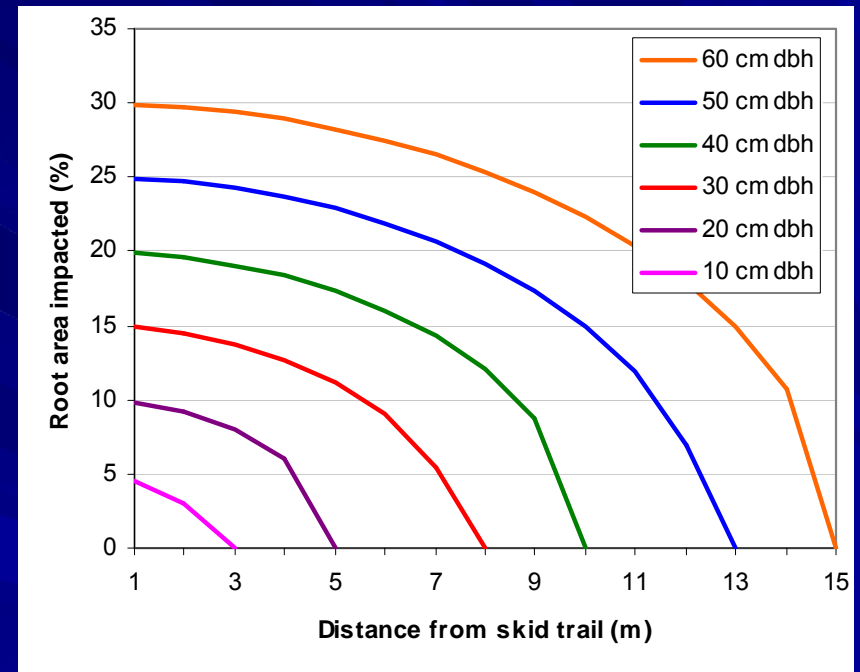
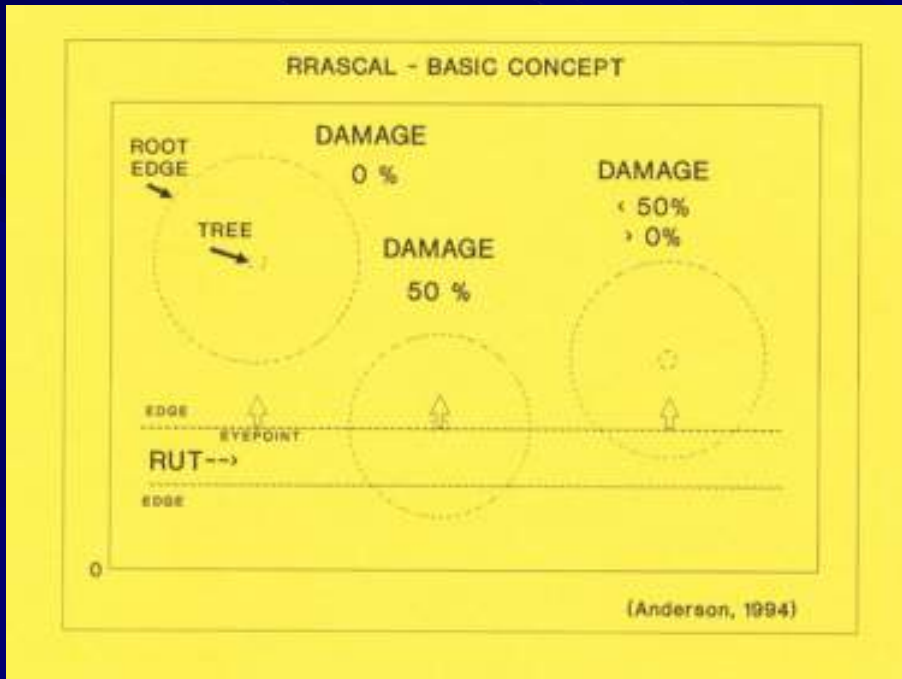
Quantification of Skid Trail Impacts on Tolerant Hardwood Tree Diameter Growth

Methodology:

- Identified single tree selection stands that were harvested 10, 15 and 20-years ago
- Sampled trees (sugar maple, yellow birch) along the skid trails
- Determined whether the tree was "impacted" or "unimpacted" using a "Rascalator"
- For every "impacted" tree - a paired "unimpacted" tree was also measured



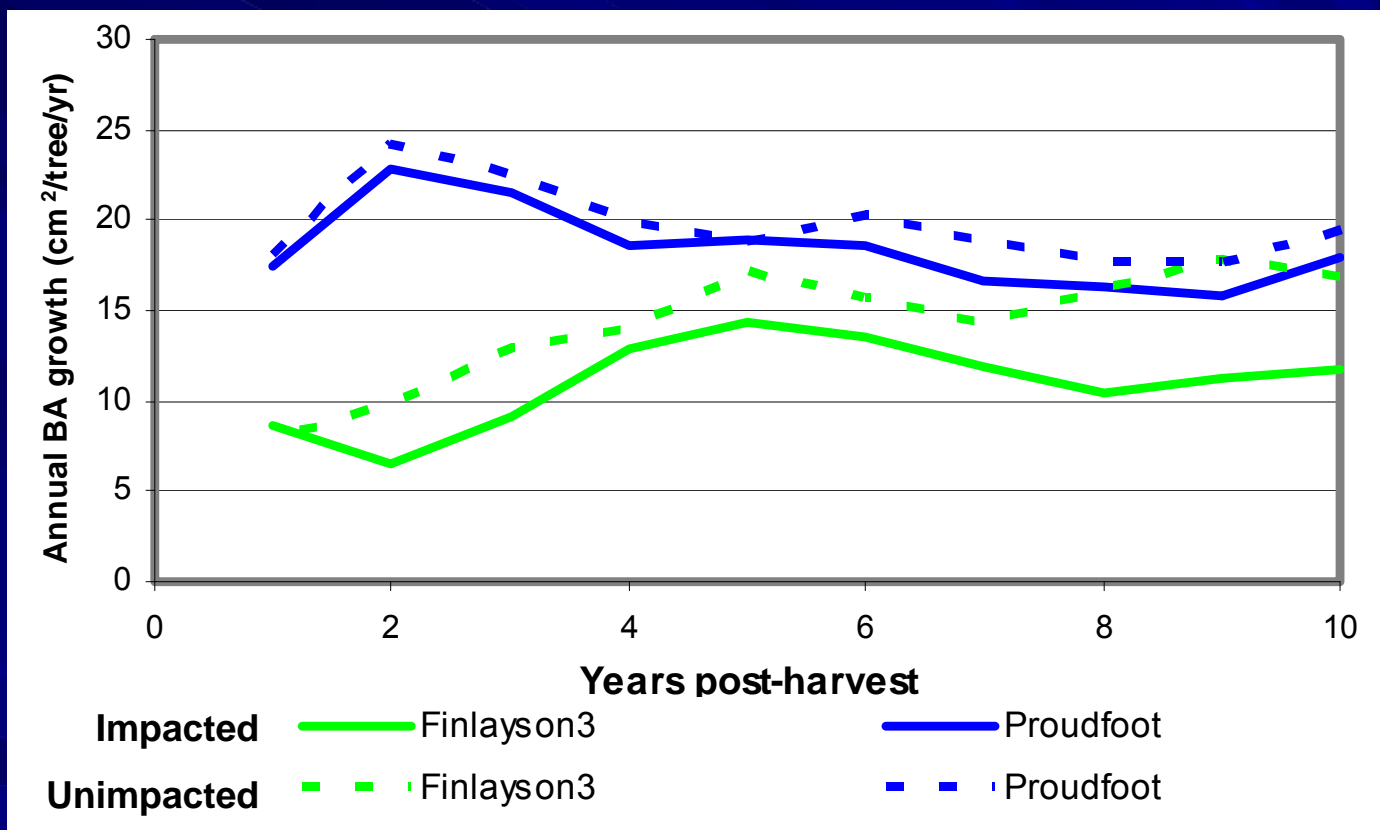
Quantification of Skid Trail Impacts on Tolerant Hardwood Tree Diameter Growth



RRASCAL (Root Rut Assessment Calculator) program approximates the potential radial root spread of residual trees. It uses DBH and distance from skid trail to estimate potential root area (%) that was impacted.

Quantification of Skid Trail Impacts on Tolerant Hardwood Tree Diameter Growth

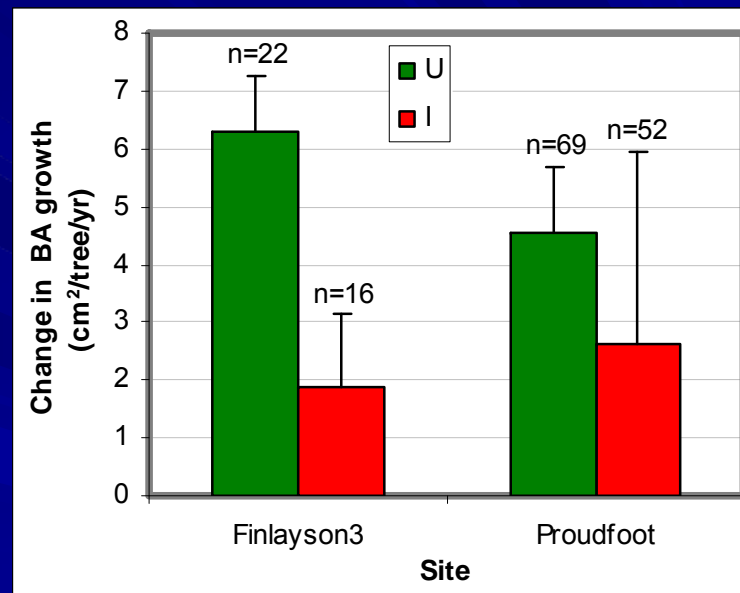
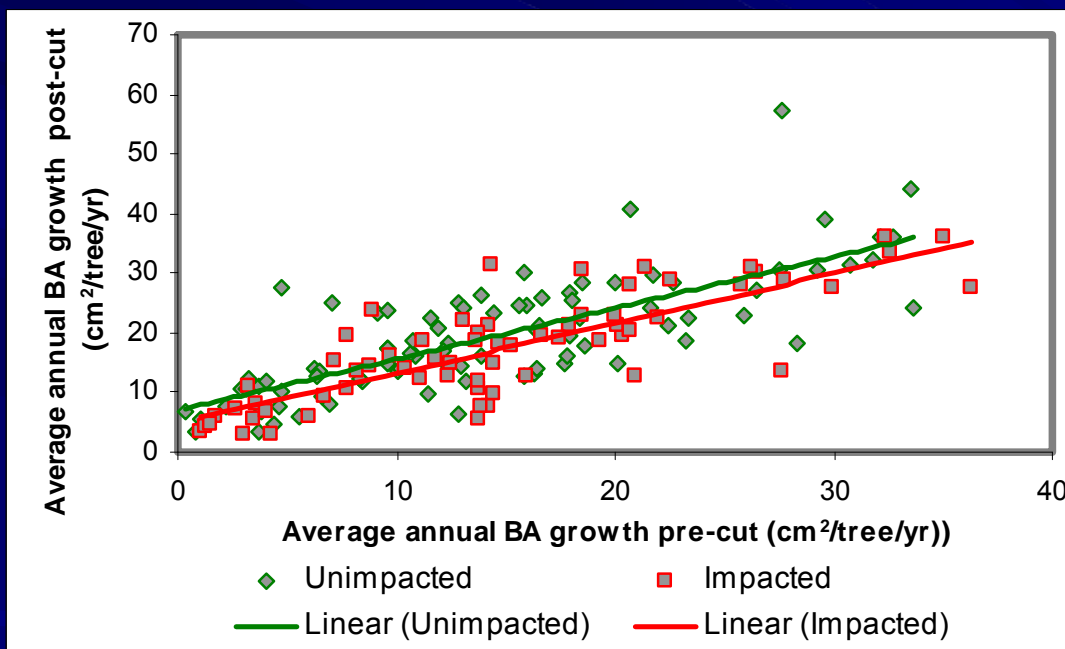
Preliminary Results:



Post-cut annual basal area growth in years since harvest

Quantification of Skid Trail Impacts on Tolerant Hardwood Tree Diameter Growth

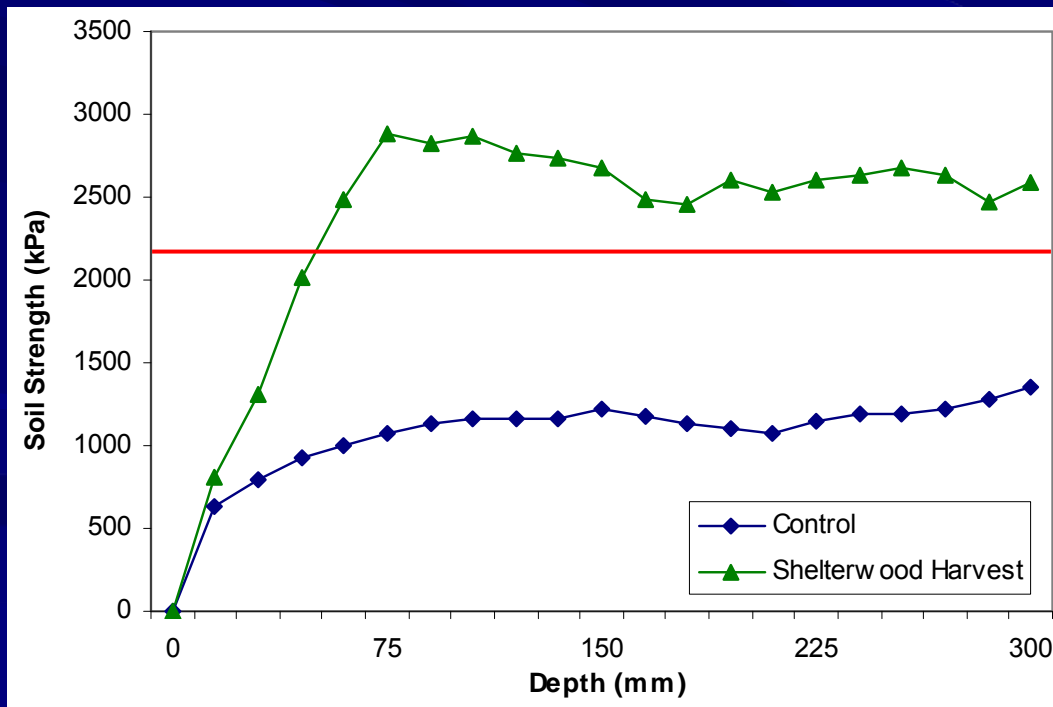
Preliminary Results:



Quantification of Skid Trail Impacts on Tolerant Hardwood Tree Diameter Growth

Soil Compaction Measurements:

- 1 year after harvest
- shelterwood (regeneration) cut
- red oak dominated forest



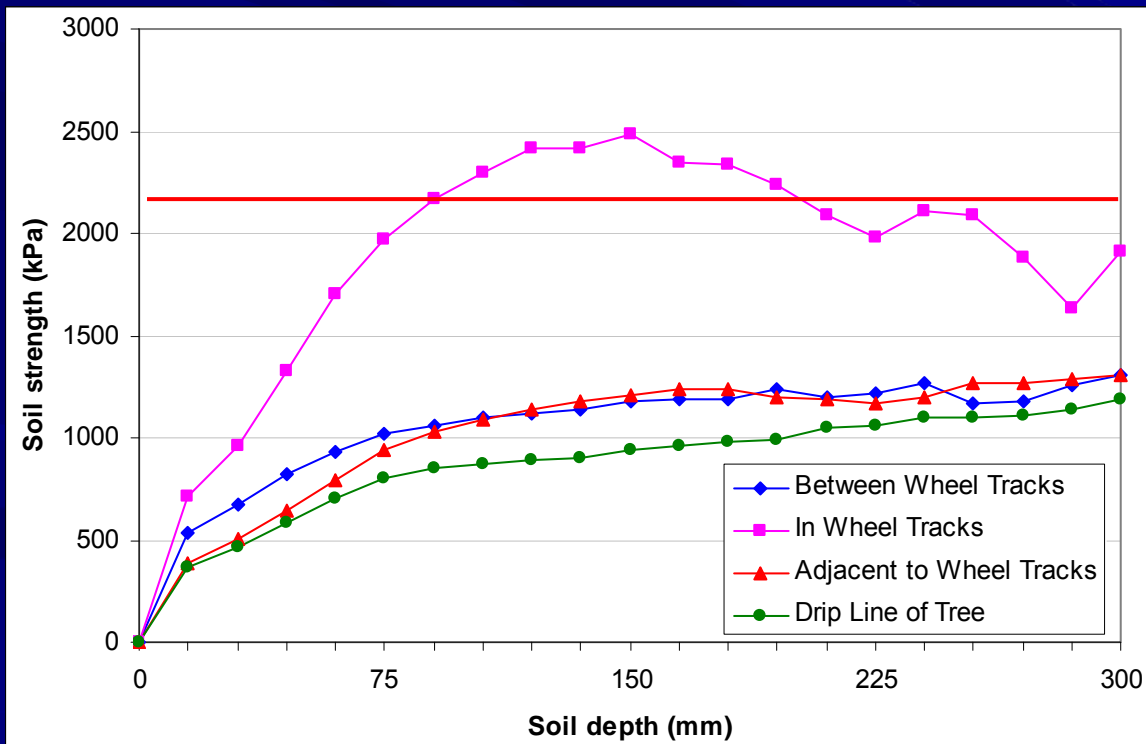
Site Description:

- Texture: loamy medium sand, loamy coarse sand, coarse sand
- Moisture regime: moderately dry
- Drainage: very rapid
- Rooting depth: 120+ cm

Quantification of Skid Trail Impacts on Tolerant Hardwood Tree Diameter Growth

Soil Compaction Measurements:

- 10 years after harvest
- single tree selection cut
- tolerant hardwood forest



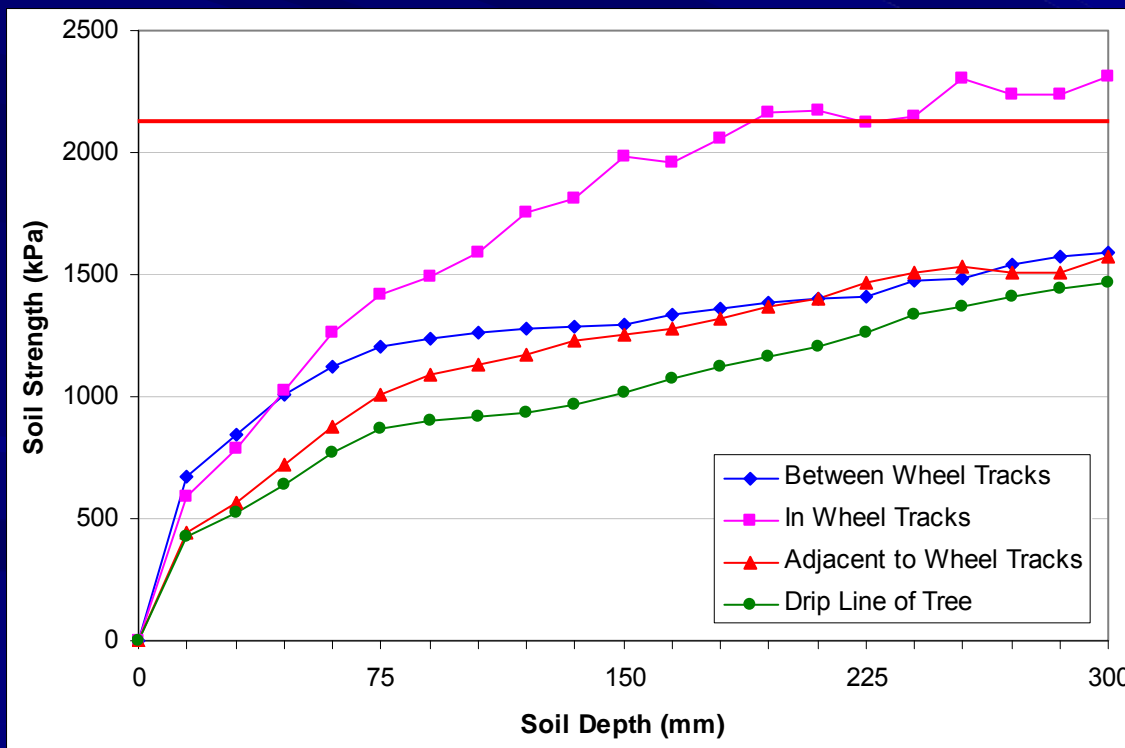
Site Description:

- Texture: fine sand
- Soil structure: fine granular
- Stoniness: common
- Rockiness: 10%
- Moisture regime: fresh
- Topography: moderate

Quantification of Skid Trail Impacts on Tolerant Hardwood Tree Diameter Growth

Soil Compaction Measurements:

- 20 years after harvest
- single tree selection cut
- tolerant hardwood forest



Site Description:

- Texture: coarse loamy
- Rockiness: 10%
- Moisture regime: fresh

Trail Rehabilitation

Post-harvest stabilization...



- Smooth out ruts to prevent channeling and pooling of water



Photos courtesy of FERIC

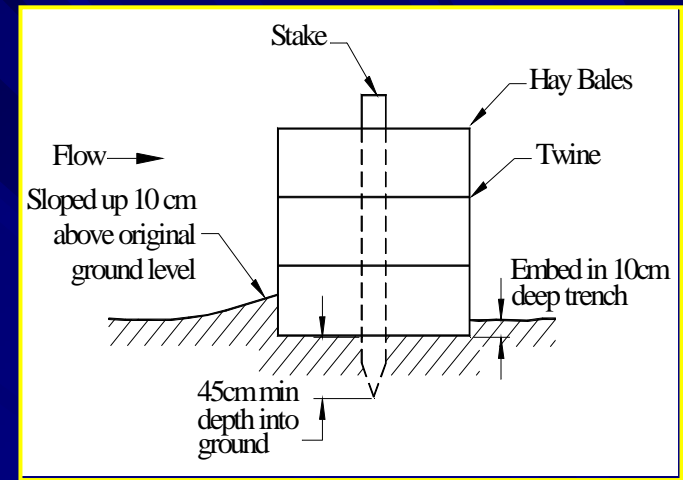
Trail Rehabilitation

Post-harvest stabilization...



Photo courtesy of FERIC

- Stabilize exposed mineral soil using hay bales
- Slows flowing water and traps sediment



Useful for 1 or 2 seasons



Photo courtesy of FERIC

You can also use fences

Trail Rehabilitation

Post-harvest stabilization...



Photo courtesy of FERIC

- Permanently stabilize exposed mineral soil using vegetation



- Best to seed in the spring or fall or immediately after rain
- Mulch on dry or erodible soils

Trail Rehabilitation

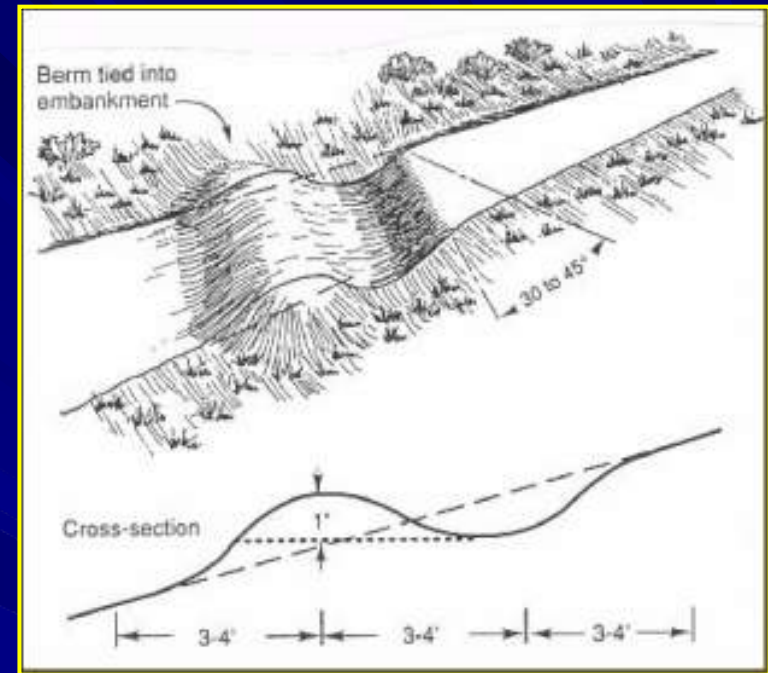
Post-harvest stabilization...

- Water bars can be installed at intervals to filter runoff water through surrounding vegetation



Photo: www.dnr.cornell.edu/.../post_waterbar.htm

Photo taken by Jeff Martin, WI DNR



Drawing from: Wisconsin's Forestry Best Management Practices for Water Quality (1995)

% Grade	Spacing (m)
5	38
10	24
20	14
30	11
40	9

Summary

What we've learned so far...

- Spring harvests result in much lower improvements in quality (AGS) than summer or winter harvests
- Currently exceeding our damage standards during spring harvests
- Stem wounding accounts for over 50% of all types of damage
- Spring harvests result in more stem wounds than summer or winter harvests

Summary

What we've learned so far...

- Wounding impacts value - undamaged medium sawlogs are worth more than damaged medium sawlogs
- Wounding impacts product recovery - undamaged medium sawlogs produce more lumber than damaged medium sawlogs
- Evidence of soil compaction can be seen 20 years after harvest

Summary

What we've learned so far...

- Sugar maple growth response peaks 3-5 years after release from harvesting
- Growth response of sugar maple 10 years post harvest was greater than the growth rate 10 years prior to cutting...likely due to release...
- BUT...impacted trees are growing less than unimpacted trees
- Trail re-habilitation is only cosmetic surgery - the neighbouring trees and site have already been damaged



Questions?