



191009/65
F O R E S T P R A C T I C E S

BEDNESTI SITE

**Testing the Biological Effectiveness of
Mechanical Site Preparation Equipment
(15-year Results)**

MSP Tour Guide

Northwest Forest Soils Council Field Trip

July 8-11, 2003

DRAFT NOT PEER REVIEWED

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ACKNOWLEDGEMENTS

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PLACEHOLD FOR SITE MAP

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SITE HISTORY

Previous stand:	Pl dominant, Sb (minor Sw) in subcanopy, medium-low site quality
1963–64	Strip logged – 10 chain clearcuts with 2 chain leave strips
1971	Leave strips summer logged; slash spot piled and burned
1986	Stocking survey –NSR
1987	Rehab. treatments: January/February – knockdown and windrow October – windrows burned
1988	Boot screefed and planted: April 25–May 5, 1988 with Pl PSB211 1+0 stock

SITE DESCRIPTION

Elevation:	850 m
Latitude/Longitude:	53° 52' N – 123° 29' W
Slope:	0–10%
Aspect:	mainly level
Moisture regime:	predominantly mesic (4)
Nutrient regime:	poor (submesotrophic B)

Biogeoclimatic Classification

The research site is located in the Stuart Dry Warm Sub-Boreal Spruce variant (SBSdw3) (Delong *et al.* 1993). It is situated on a landscape dominated by deep (>1 m) morainal till, with a combination of well- to poorly drained soils. The elevation is approximately 850 m. Experimental plots have been classified as belonging to the 05 PLSb – Feathermoss site series. The 05 site series has a broad edatopic amplitude. Soil moisture regimes may range from 3 to 5 (submesic to subhygric), and soil nutrient regimes from A to B (very poor to poor).

The 01 SxwFd – Pinegrass site series may occasionally be found as a very minor component at the research site. In depressional areas, where the soil moisture regime is 6 (hygric) or wetter, the ecosystems can best be characterized as non-forested wetlands (site series “31”).

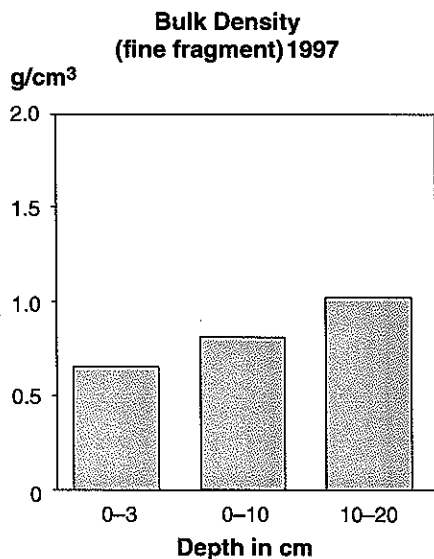
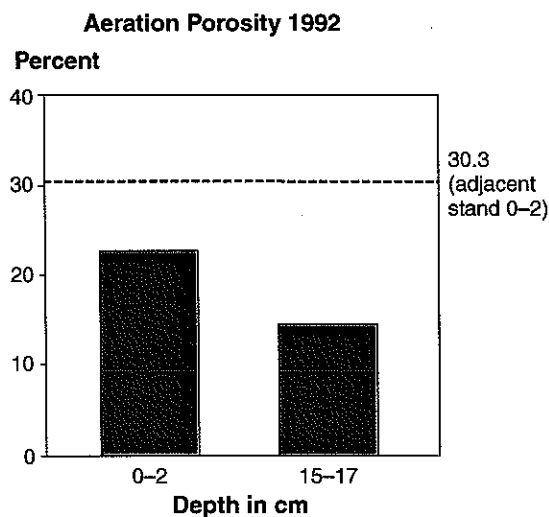
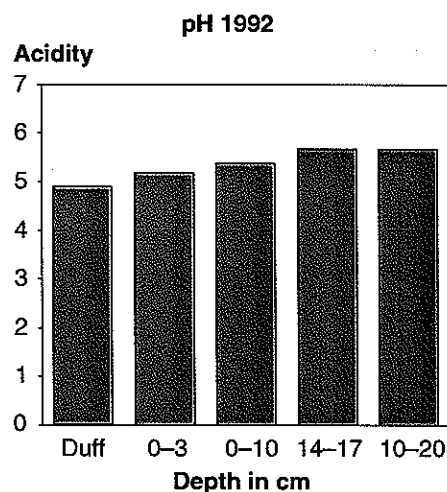
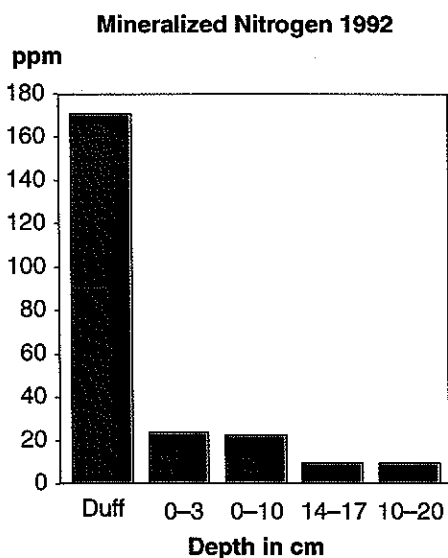
SOILS

Parent material:	fine-loamy basal till; some areas have an upper layer of sandy-gravelly material reworked by fluvial action
Soil texture:	loams (silty clay loam to sandy loam)
Coarse fragments:	10–20% gravels, up to 30–50% in some areas
Organic layers:	3–6 cm mor-to-moder, poorly decomposed, with thin H layer
Limiting factors:	shallow rooting zone with low nutrient availability; compacted layer at 40–50 cm restricts root growth and water movement; poor soil drainage and aeration in depressions and drainage channels

Soil Characteristics

Soil moisture and drainage are influenced primarily by surface topography, and depth to compact basal till (see Appendix 1). The better drained soils are found on mid, upper, and crest slope positions. Imperfect to very poorly drained soils are found in lower, toe, and level slope positions. Soils in lower to level slope positions may remain very wet during the early growing season, and then become dry later during the growing season. Soil colour is a good indicator of the duration of soil moisture at this site. The bright coloured B horizons are found in the better drained sites, while dull coloured B horizons indicate prolonged wet conditions in the poorer drained sites.

The dense basal till may be found at depths of 25 to >50 cm on the mid to crest slope positions, and at depths as shallow as 10 to 25 cm in the lower to level slope positions. Faint to distinct mottling is generally found in the basal till, which may also have evidence of clay accumulation. Upper soil profile horizons are generally sandy loam to loam textured, becoming somewhat finer textured with depth. Coarse fragments generally range from 20–35% by volume, but may range as high as 50%.



GROWING SEASON

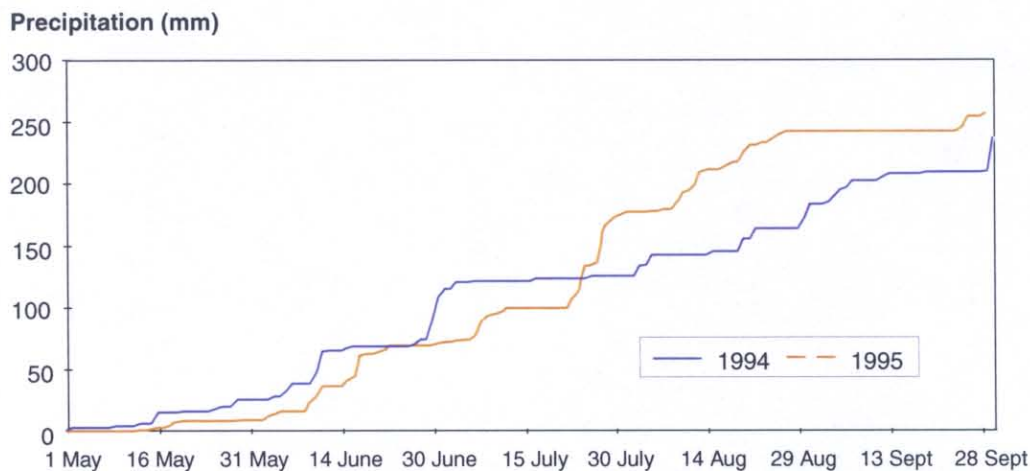
Climate

Short growing season, warm days, but cold (frosty) nights common

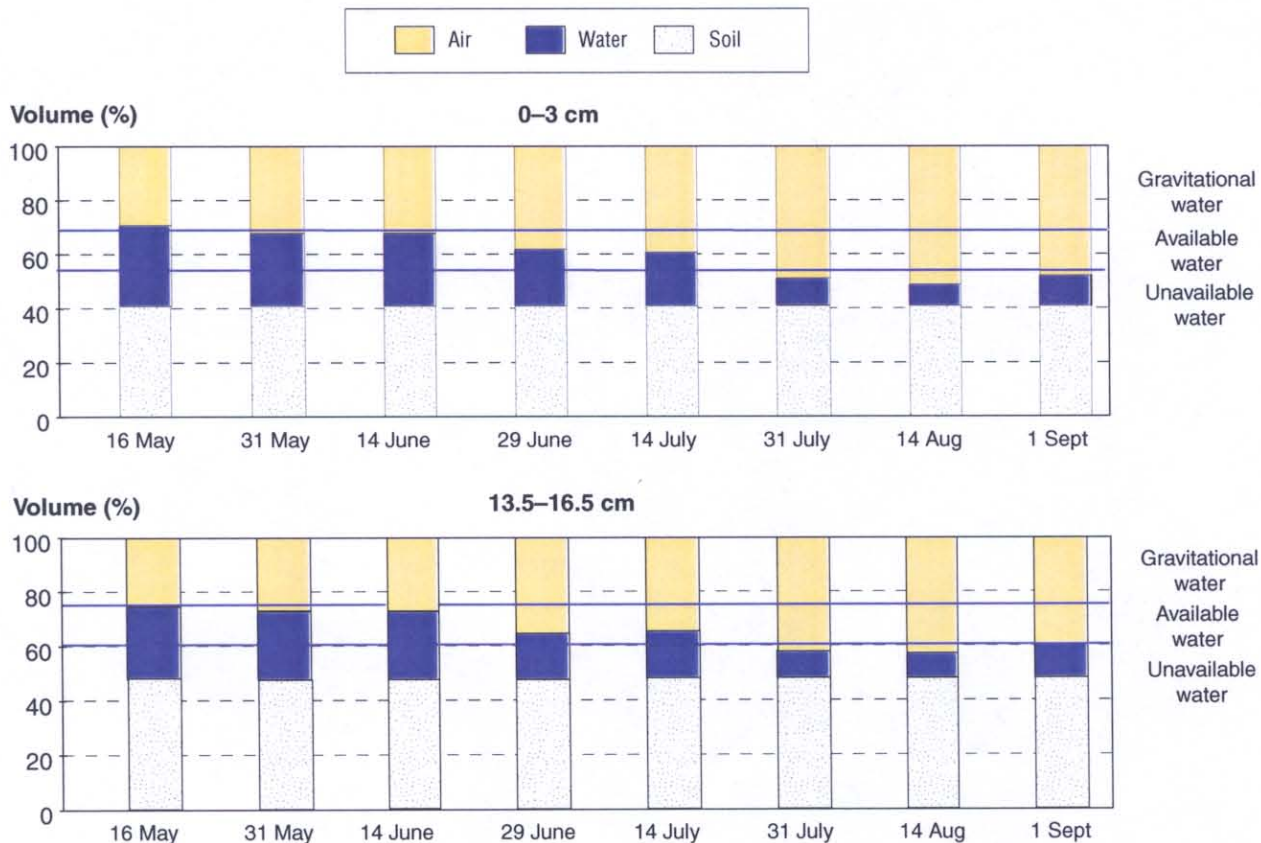
Significant risk of summer drought on mesic and drier sites

Cold winters with low snowpack, deeply frozen soils

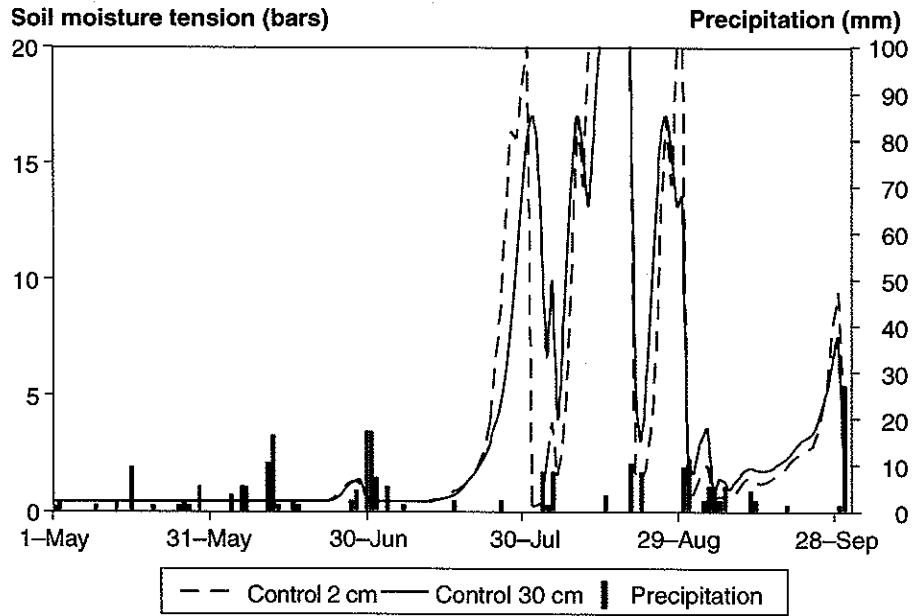
Bednesti – Cumulative Precipitation



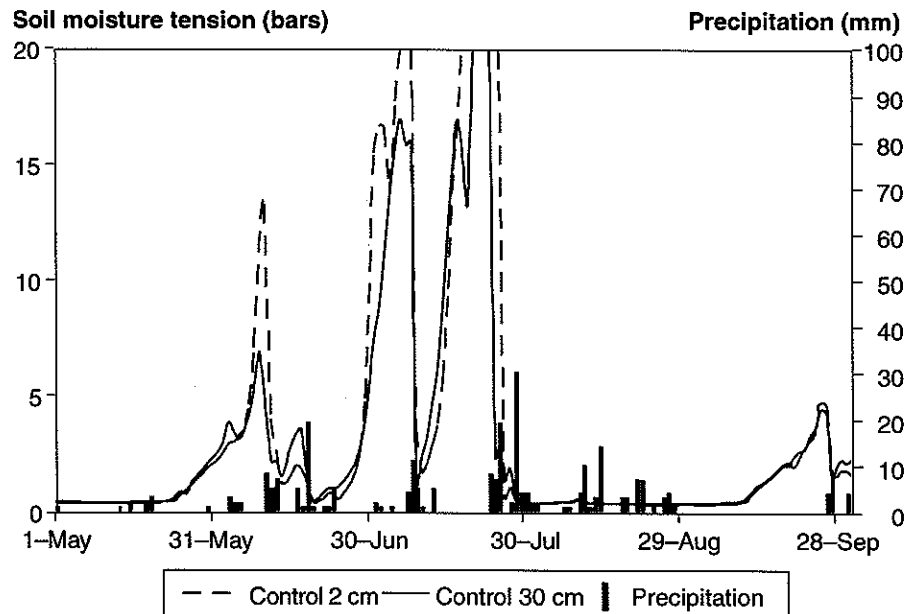
Bednesti – Control 1994



Bednesti 1994
Soil Moisture Tension

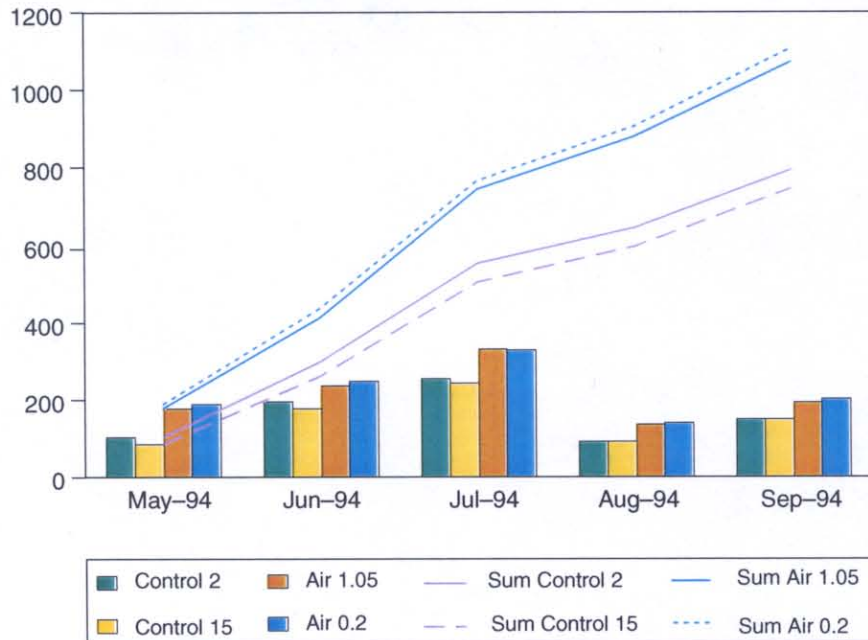


Bednesti 1995
Soil Moisture Tension



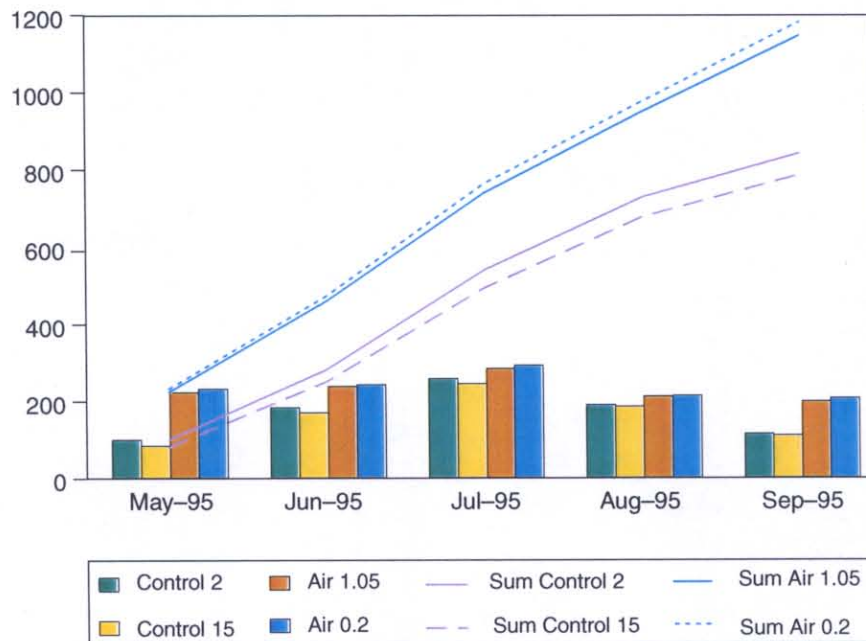
Bednesti 1994
Growing Degree Days (5°C)

Growing degree day (base 5°C) calculated hourly



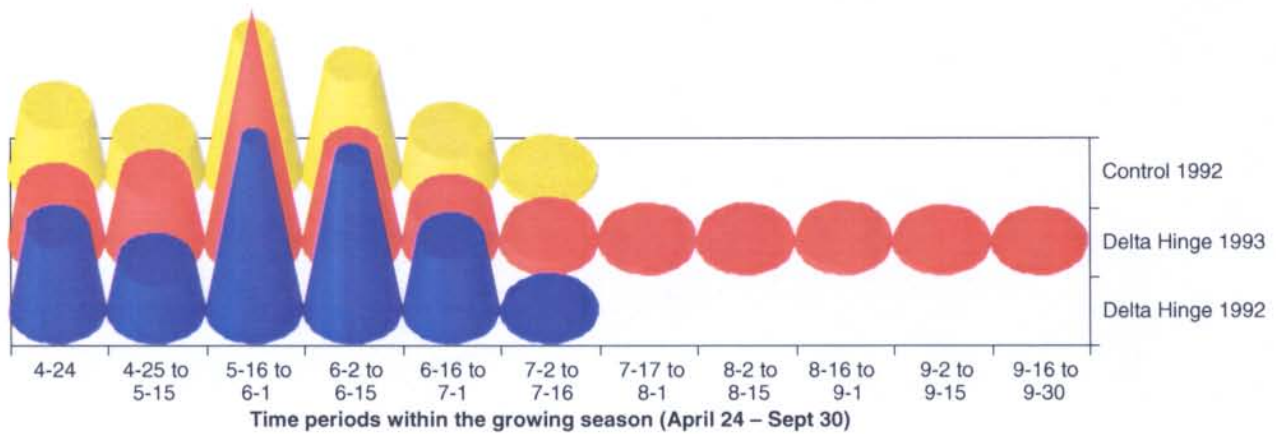
Bednesti 1995
Growing Degree Days (5°C)

Growing degree day (base 5°C) calculated hourly

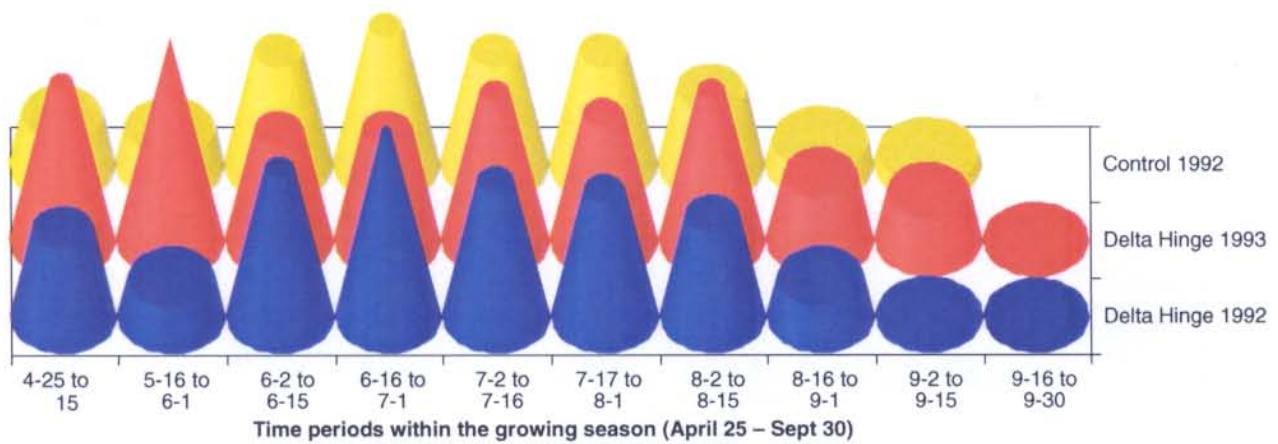


Seedling Growth

Seedling Height Growth
1992 and 1993 Growing Seasons

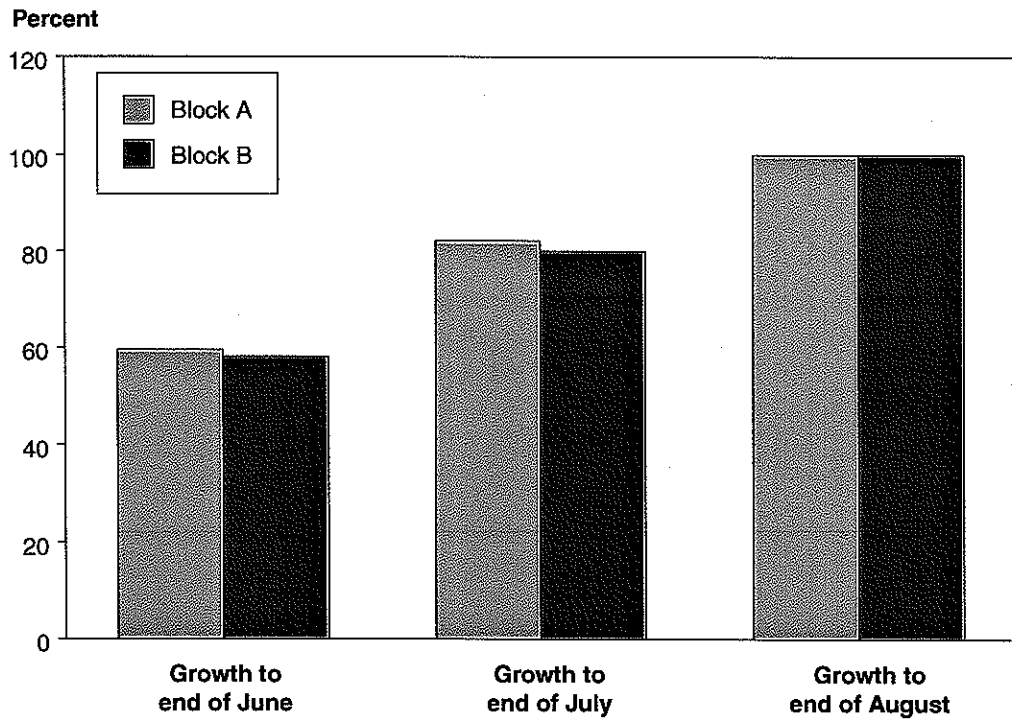


Seedling Diameter Growth
1992 and 1993 Growing Seasons



Needle Growth

Bednesti (North Side) – Fall 1995
Needle Growth Over Time
Total Percent Growth



VEGETATION

Low-moderate brush potential. For more information on vegetation, refer to Appendix 2.

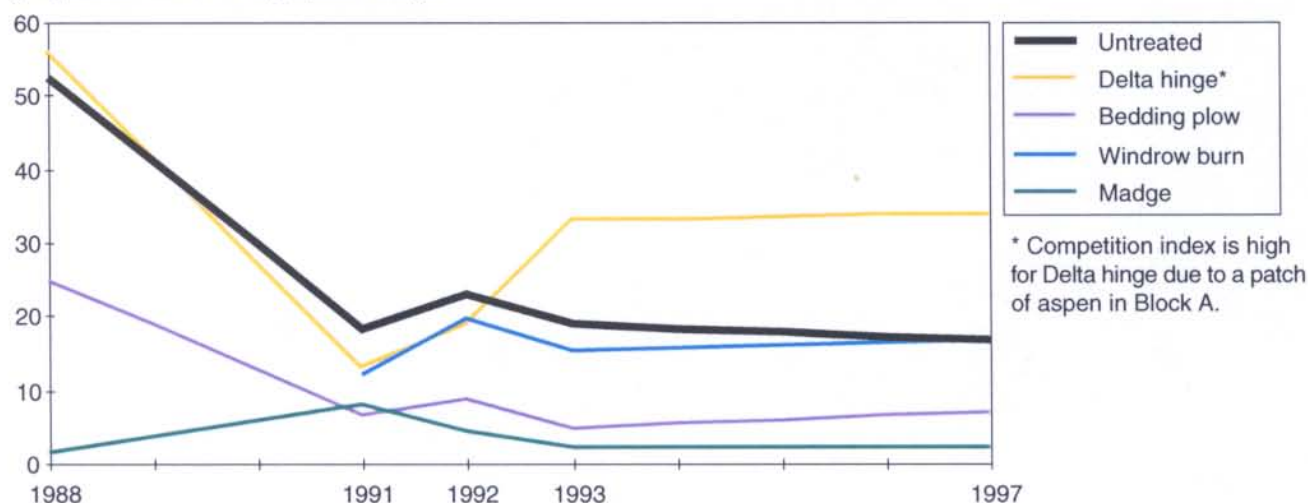
Major non-crop species present:

green alder	(<i>Alnus viridis</i>)	nitrogen-fixer
trembling aspen	(<i>Populus tremuloides</i>)	moose browse
willows	(<i>Salix</i> spp.)	moose browse
velvet-leaved blueberry	(<i>Vaccinium myrtilloides</i>)	important berry producer
hawkweeds	(<i>Hieracium</i> spp.)	native and introduced weeds

Vegetation Description

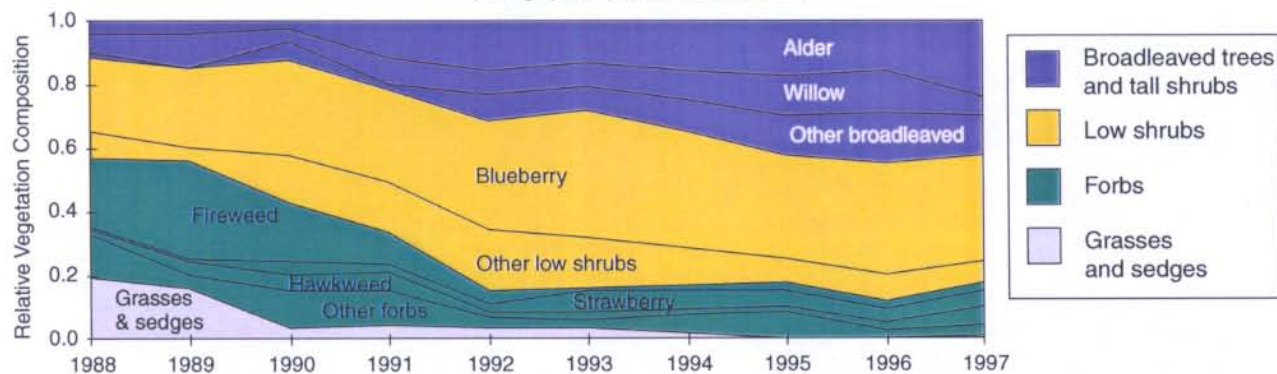
Bednesti: Seedling Competition Index 1988–1997

(Vegetation cover × height)/tree height



The vegetative competition index [(% cover × height of competing vegetation)/seedling height] on all treatments is low and is not greatly affected by the type of mechanical site preparation. The competition index on the Delta hinge treatment appears high because one of the disc trenched plots is located within an aspen clone.

Tenth-year Plant Community Development on Untreated Plots
(Lodgepole pine not included)



Changes in plant community composition. The y-axis indicates the frequency of occurrence of leading species on fifty 1–1.26 m radius tree seedling-centred subplots.

TREATMENTS

TRENCHING (HINGE AND FURROW)

Operational Details – Delta Hinge

Equipment: TTS Delta powered disc trencher, mounted on John Deere 740A (115 kW) rubber tired skidder

Operator: Brown Bros. Contracting, Prince George

Similar machines: Donaren 180D or 280D disc trenchers

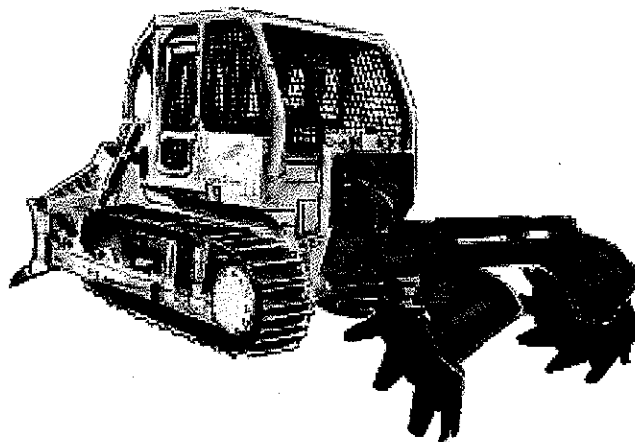
Treatment date/conditions: August 19, 1987; dry soil

Operability: no significant constraints; very easy ground

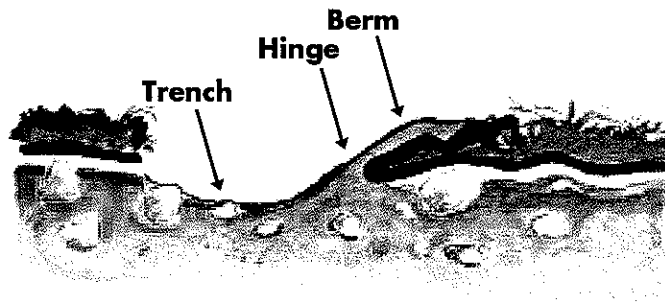
Typical productivity on similar sites: group discussion

Typical costs on similar sites: group discussion

Plantability: easy planting with no screening, well-marked trail; sometimes difficult in rocky areas. Berm planting more difficult than other planting positions. Reduced planting costs pay for part of site preparation.

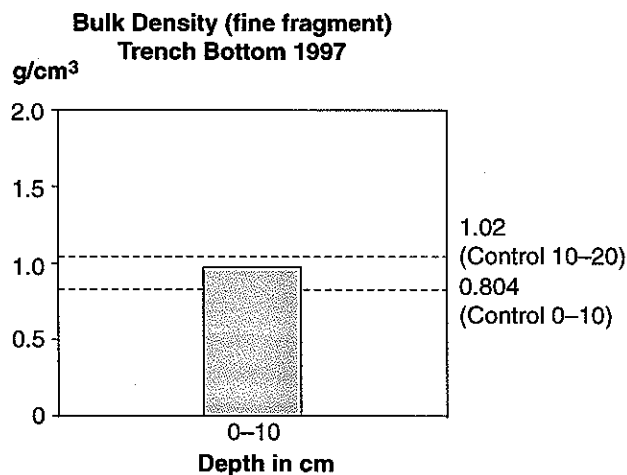


*A John Deere 740 A skidder was used on site.
The illustration shows a crawler tractor.*



A disc trencher creating two trenches.

Soil Characteristics, Trench Bottom – Delta Hinge



Rooting Characteristics – Delta Disc Hinge

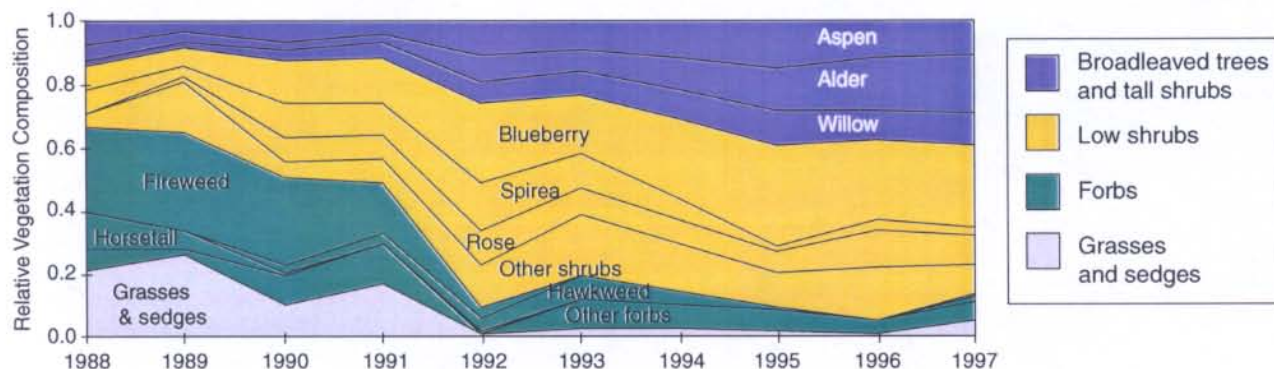
At age 10, lodgepole pine seedlings growing on the hinge of Delta disc trenching had well-developed root systems, with roots that were symmetrically distributed around the stem (slightly less so than seedlings growing in untreated ground), and which readily crossed the trench to continue growing on the other side. The one exception was the root system of a seedling excavated from a microsite where there was evidence of standing water in the trench. This seedling had developed roots in the berm only, with absolutely no root growth in the direction of the trench.

In 1997, little forest floor material remained in the berms of disc trenches at Bednesti, and the majority of larger roots (mean diameter of 3.1 cm next to the stem) were growing in mineral soil, regardless of whether they were found in the berm, under the trench, or extending into untreated ground. Roots in berms were found at an average depth of 10 cm, compared to 6 cm when growing under trenches or in untreated ground. Total length of these larger roots ranged from 2.8 to 3.8 metres.

See Appendix 7 for a discussion of rooting characteristics at the Bednesti site.

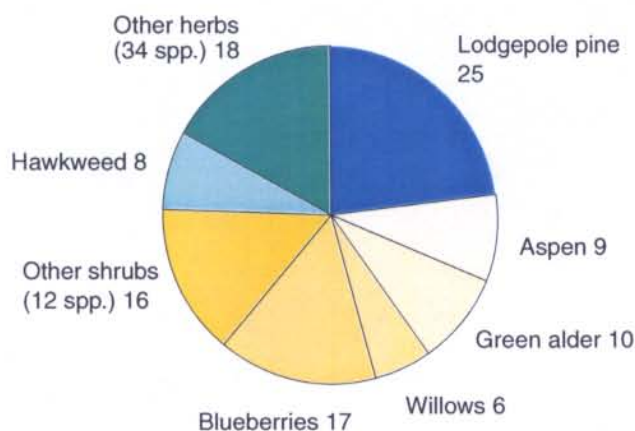
Vegetation Description – Delta Hinge

- The plant community is very similar to the untreated plant community, with no significant change in species diversity.
- Regeneration of hardwoods like birch and aspen can be stimulated by trenching.



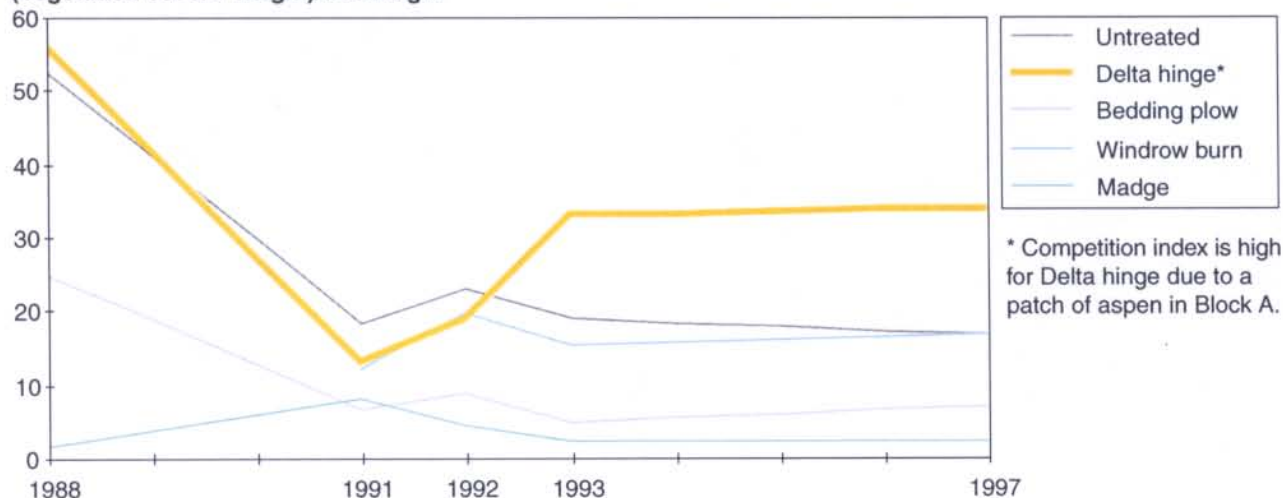
Impact of Delta Hinge treatment on changes in plant community composition. The y-axis indicates the frequency of occurrence of leading species on fifty 1–1.26 m radius tree seedling-centred subplots.

Percent Cover – Delta Hinge 1997



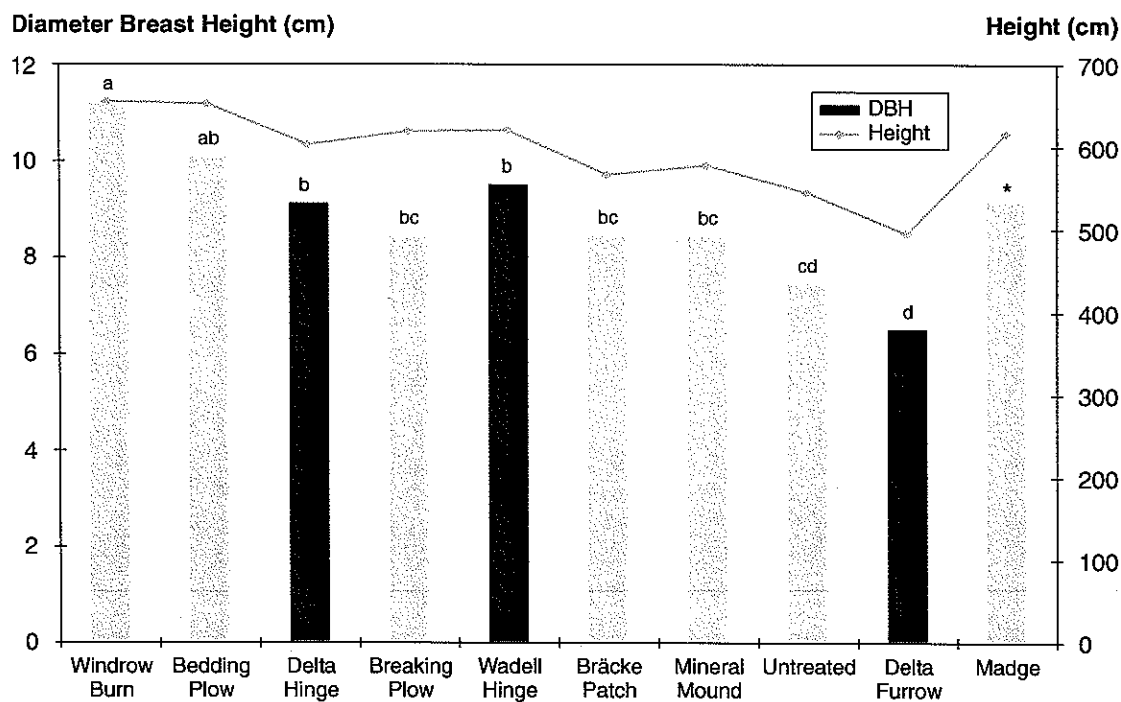
Bednesti: Seedling Competition Index 1988–1997

(Vegetation cover × height)/tree height



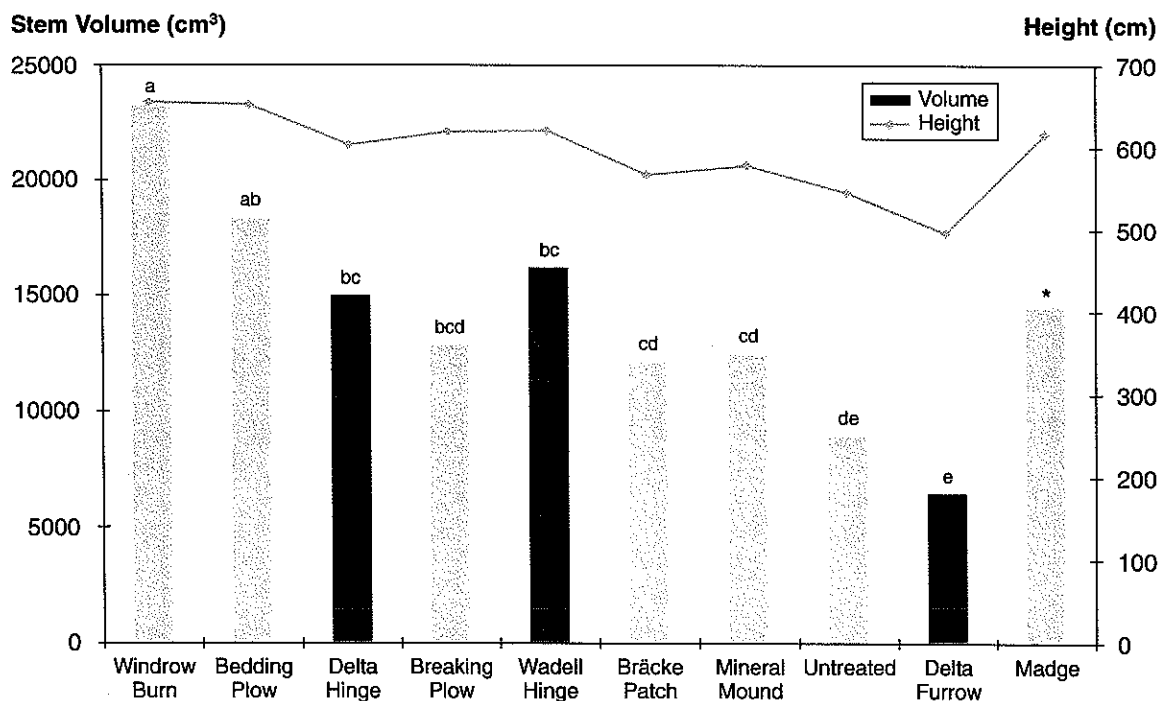
15-year Results – Disc Trenching (Hinge and Furrow)

15-year Diameter (Fall 2002)



* 14th-year (2001) data for Madge. 15th-year (2002) data not available.

15-year Volume calculated from DBH (Fall 2002)

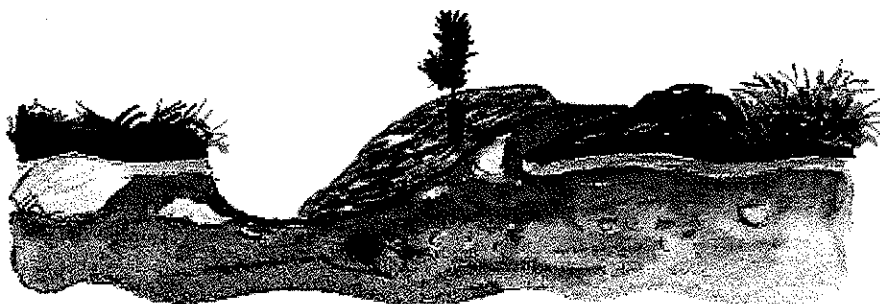


* 14th-year (2001) data for Madge. 15th-year (2002) data not available.

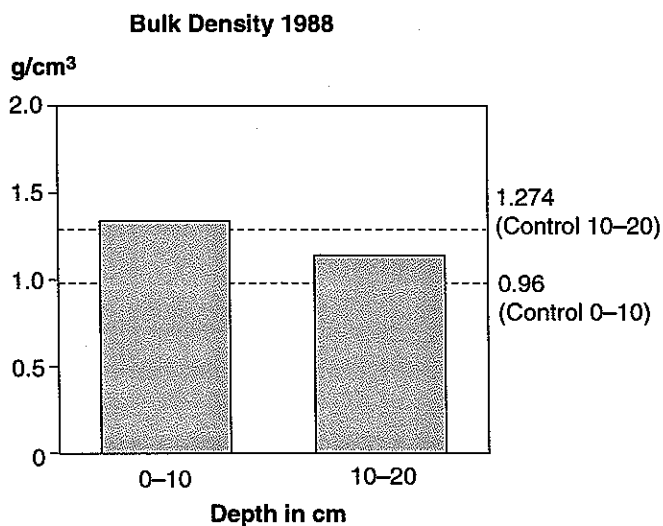
MINERAL MOUND

Mound Planting

Hand-made mineral mounds were added to the hinge position of some of the Bräcke patches. The mounds were made with a 14 cm deep mineral soil capping, containing approximately 20 litres of soil. To avoid drought, seedlings were planted deep.



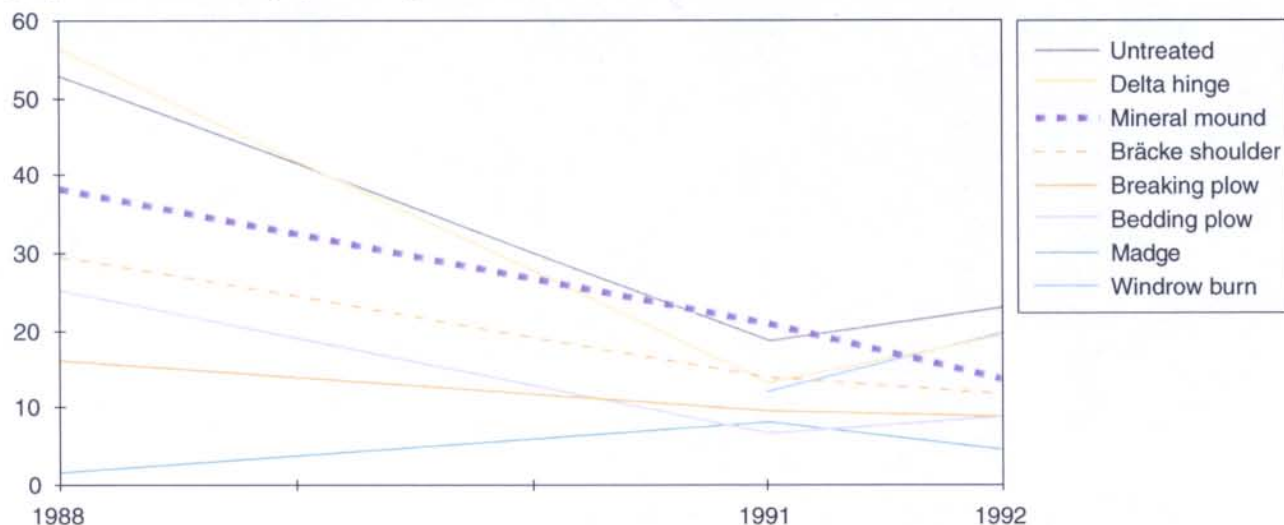
Soil Characteristics – Mineral Mound



Vegetation Description – Mineral Mound

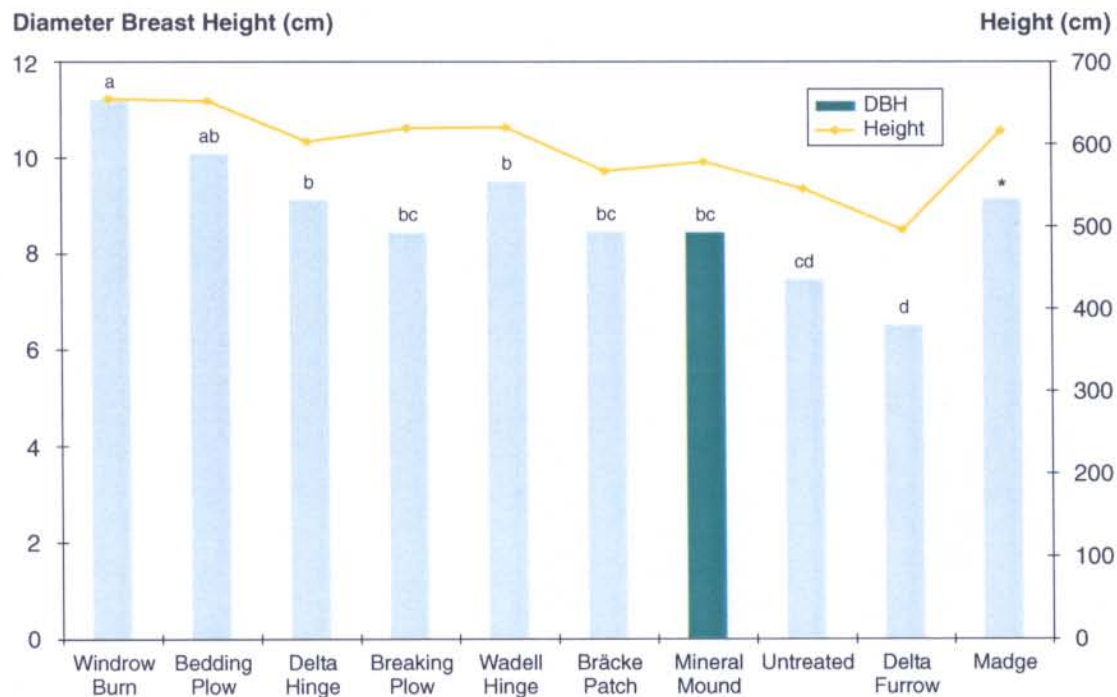
Bednesti: Competition Index 1988–1992

(Vegetation cover × height)/tree height



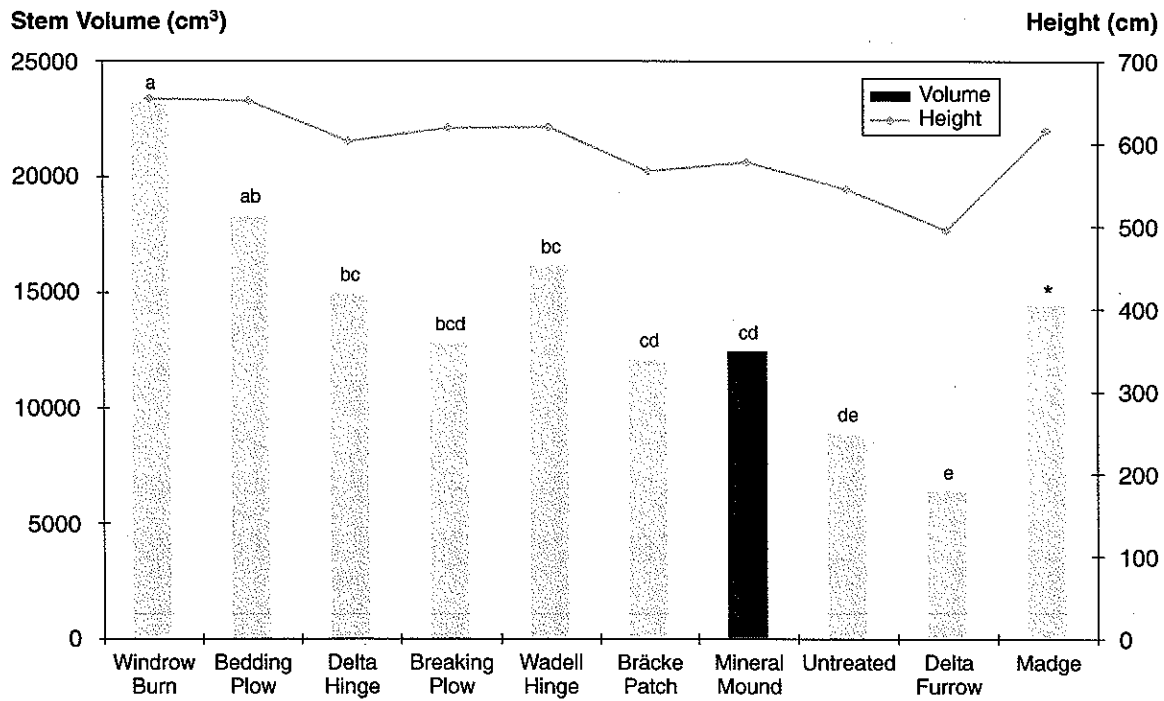
15-year Results – Mineral Mound

15-year Diameter (Fall 2002)



* 14th-year (2001) data for Madge. 15th-year (2002) data not available.

15-year Volume calculated from DBH (Fall 2002)



* 14th-year (2001) data for Madge. 15th-year (2002) data not available.

VH MULCHER

Operational Details – VH Mulcher

Equipment: VH Mulcher mounted on excavator

Operator: Tim Van Horlick Contracting

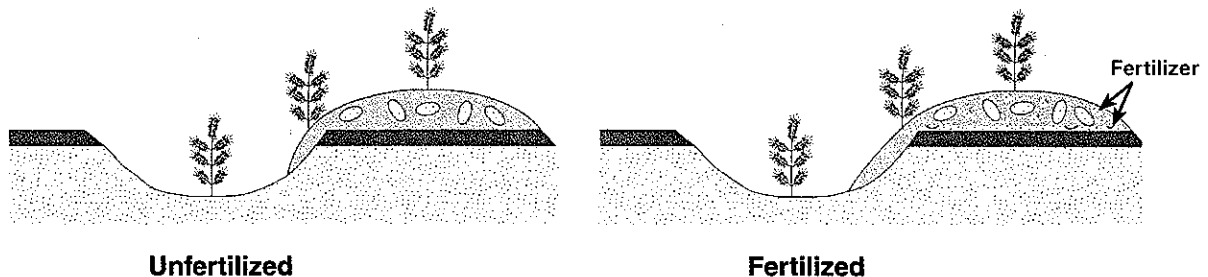
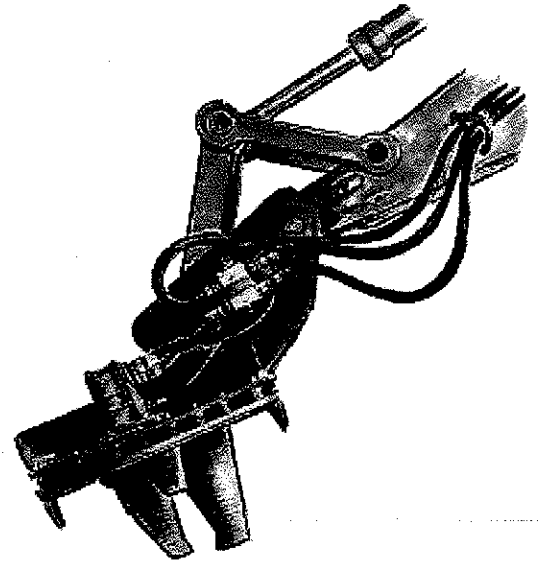
Treatment date/conditions: May 2, 1992

Operability: some low vegetation but no significant constraints.
Treatment done on wet and dry microsites.

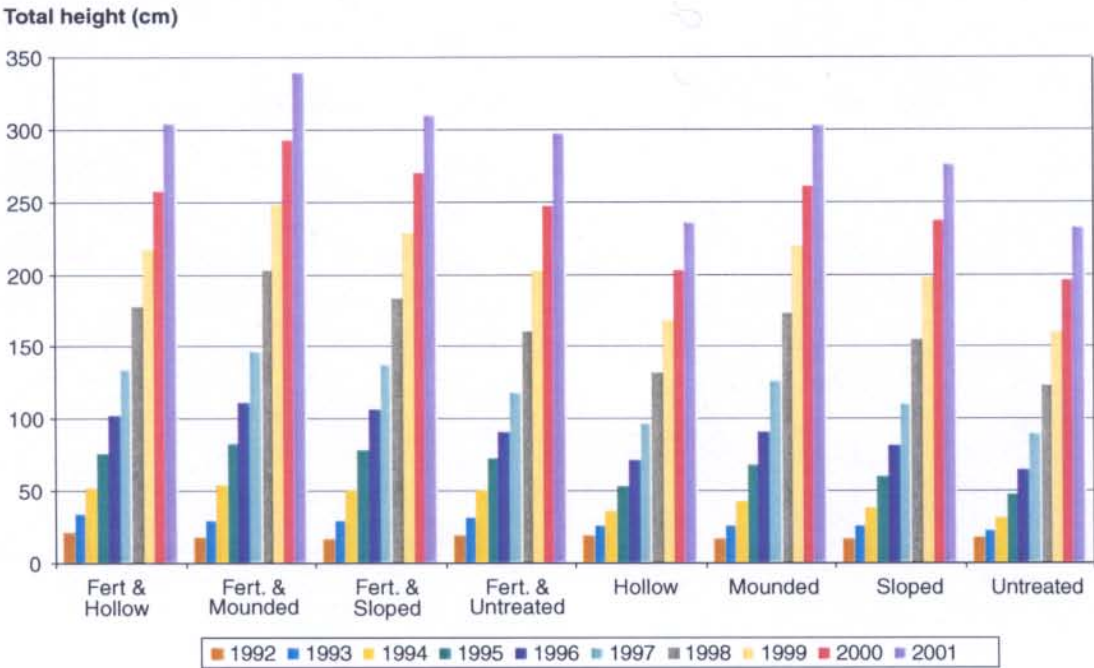
Treatment technique: *Unfertilized* – a spot was mixed with a VH Mulcher. The mixed material was then pulled up into a mound resulting in three microsites; a hollow, a mixed hinge, and a mixed mound over undisturbed humus.

Fertilized – treatment was the same as for the unfertilized sites but Osmocote (20 g) was spread evenly on two areas: first on the area to be mixed and second, on the area adjacent to the initial spot. The mixed (fertilized) mound was then deposited on top of the second fertilized area.

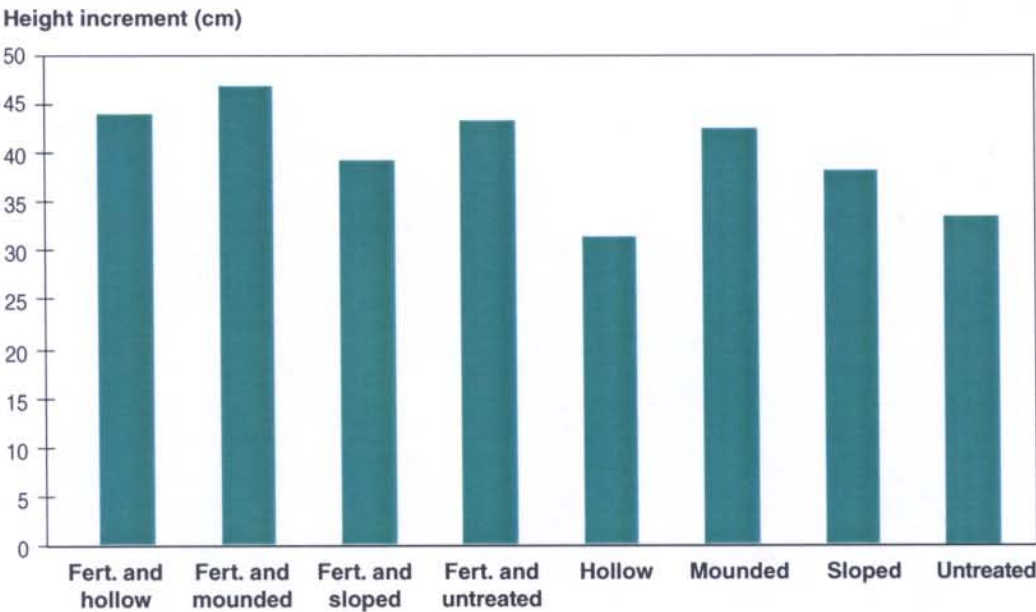
Planting stock/Date: planted May 14, 1992 with PCT 211A 1+0 Pl. Seedlings were planted in the hollow, on top of the mound, and on the hinge.



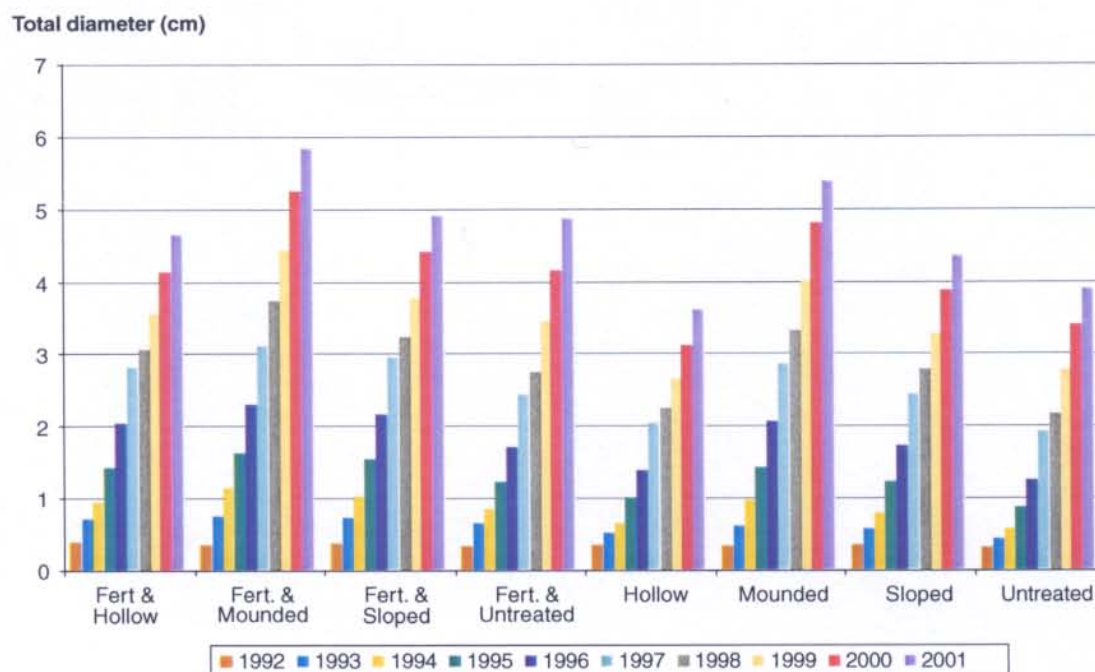
Height Change Over 10 Years (1992 to 2001) – VH Mulcher



Height Increment in the 2001 Growing Season – VH Mulcher

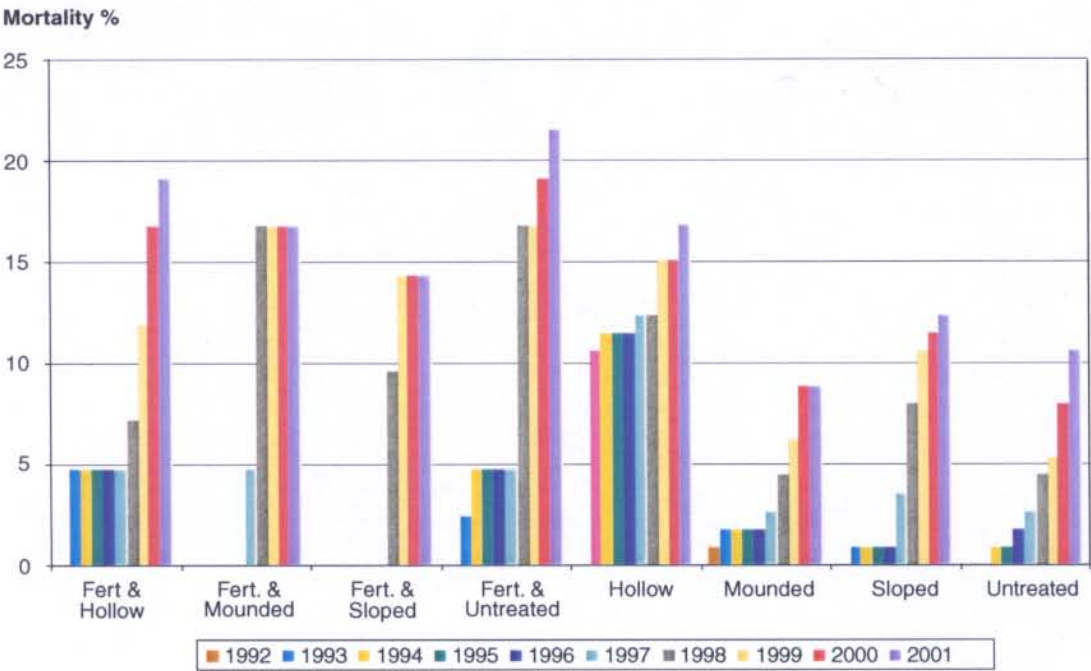


Diameter Change Over 10 Years (1992 to 2001) – VH Mulcher



Notes:

Change in Total Mortality Over 10 Years (1992 to 2001) – VH Mulcher



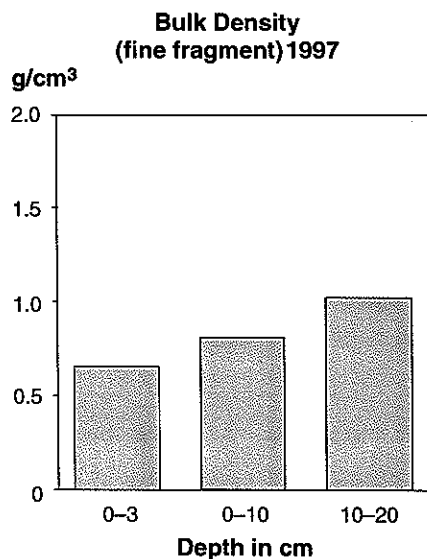
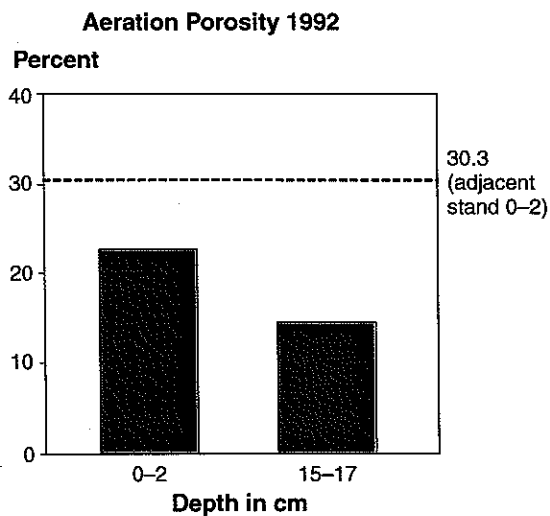
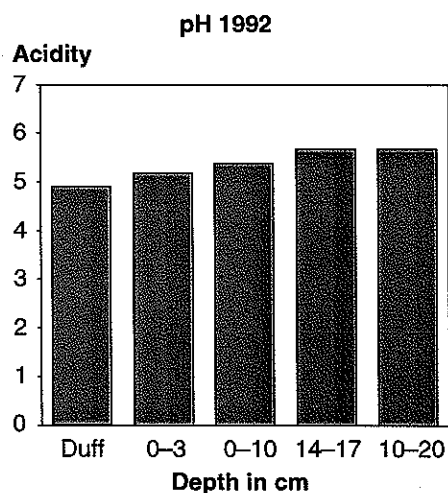
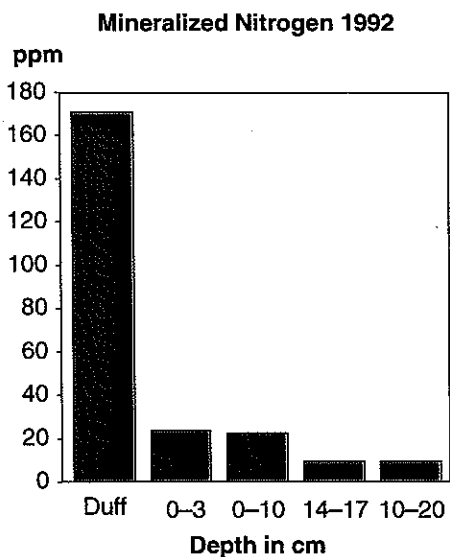
Notes: _____

UNTREATED (SHEARED AND PILED) [CONTROL]

Operational Details – Untreated

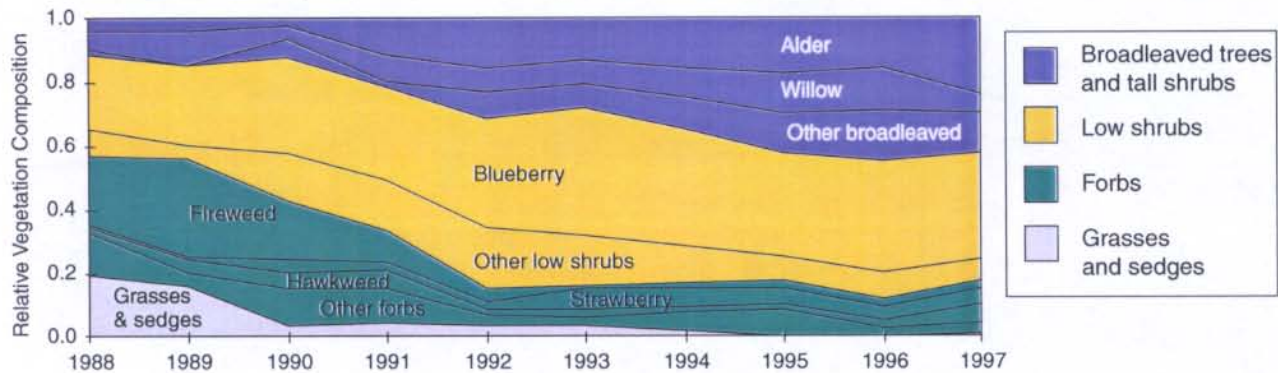
1987	Rehab. treatments:	January/February – knockdown and windrow
		October – windrows burned
1988	Boot screefed and planted:	April 25–May 5, 1988 with Pl PSB211 1+0 stock

Soil Characteristics – Untreated

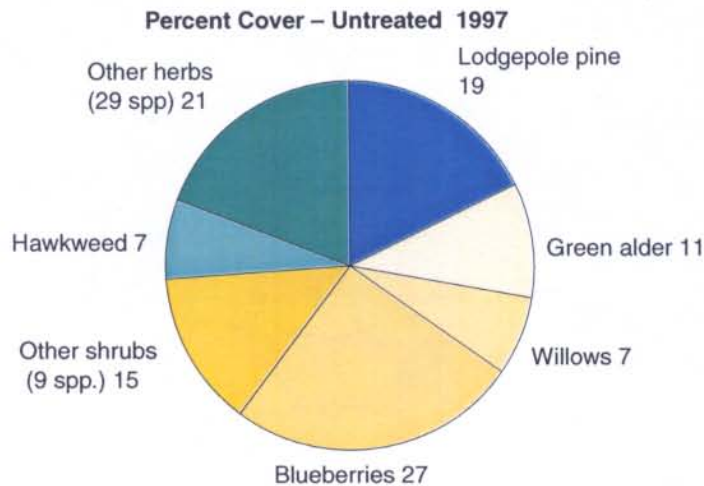


Vegetation Description – Untreated

- The untreated plant community has changed least in the 10 years of the study.
- It has higher species diversity than mechanically treated areas and more woody and late successional species.
- Velvet-leaved blueberry is most abundant in untreated areas.

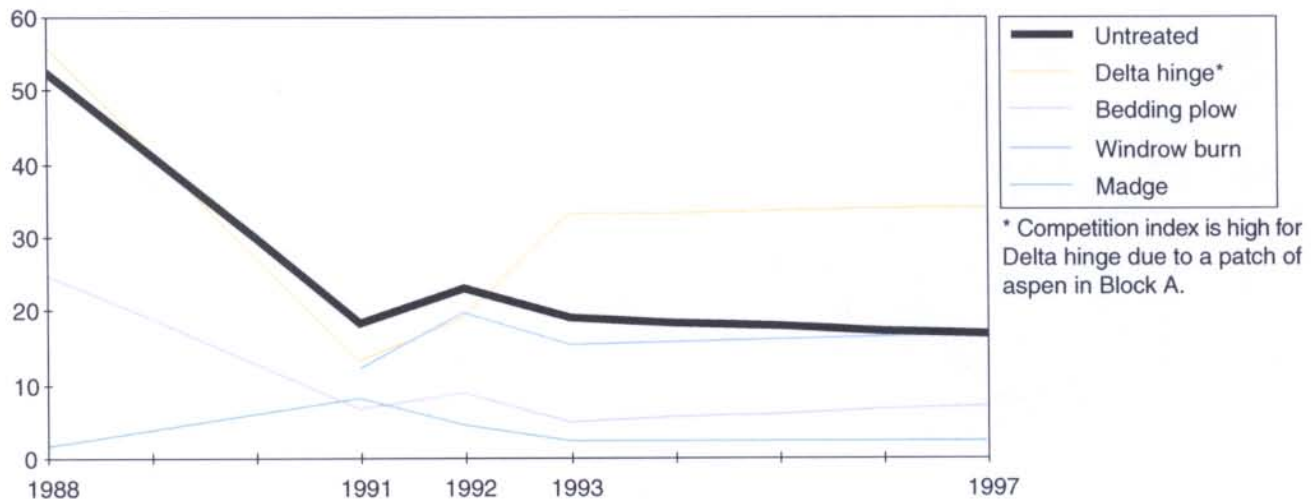


Changes in plant community composition. The y-axis indicates the frequency of occurrence of leading species on fifty 1–1.26 m radius tree seedling-centred subplots.



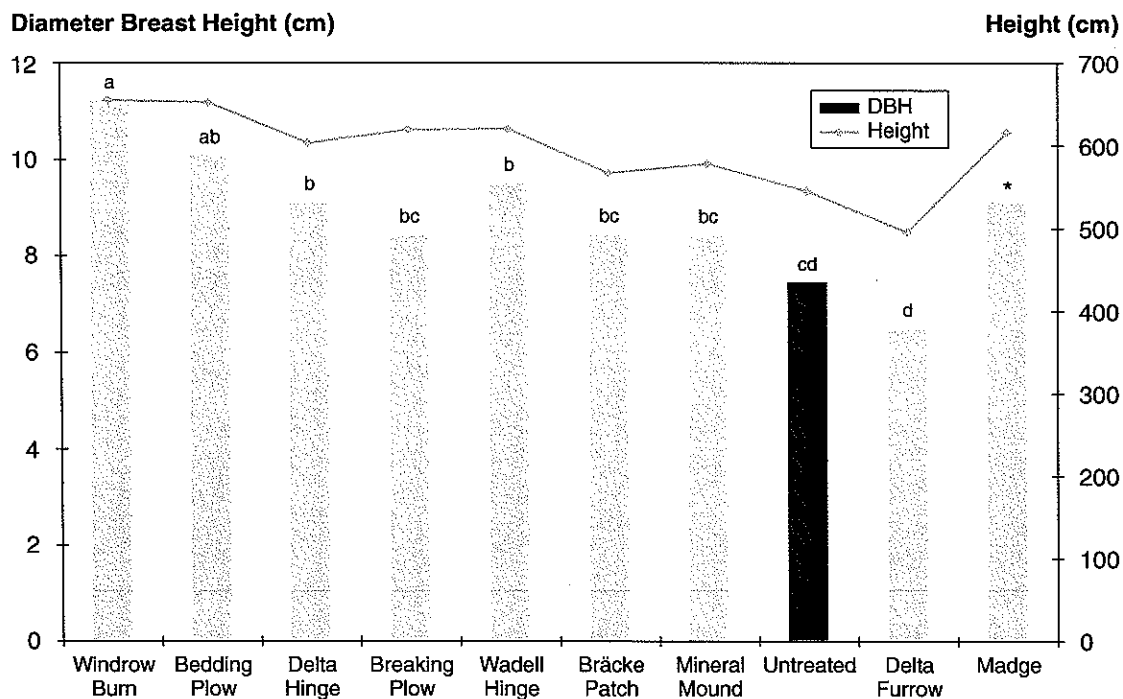
Bednesti: Seedling Competition Index 1988–1997

(Vegetation cover × height)/tree height



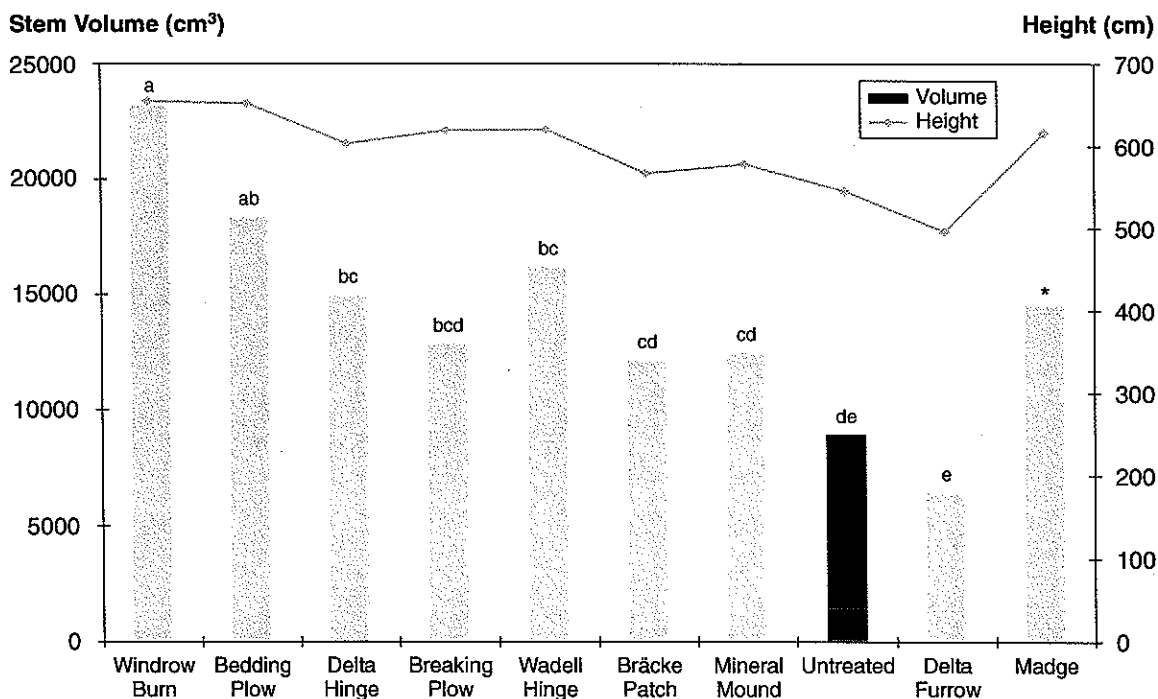
15-year Results - Untreated

15-year Diameter (Fall 2002)



* 14th-year (2001) data for Madge. 15th-year (2002) data not available.

15-year Volume calculated from DBH (Fall 2002)



* 14th-year (2001) data for Madge. 15th-year (2002) data not available.

Rooting Characteristics – Untreated

Root systems of 10-year-old lodgepole pine growing in untreated ground were well developed. Most of the larger roots (mean diameter of 2.4 cm next to the stem) were found in mineral soil, at a depth of approximately 6 cm. These roots ranged from 2.9 to 4.3 metres in length. The root systems of these seedlings were slightly more radially symmetric than root systems of seedlings growing on the Delta hinge. All seedlings excavated from untreated ground were growing in well-drained soil.

Notes: _____

WINDROW BURN

Operational Details – Windrow Burn

Equipment: D8 Cats with flat blades (used by ranchers for agricultural land clearing) were used for windrowing and piling.

Operator: Ron Fawcett

Similar machines: D7 Cats were slightly more expensive due to size.

Treatment date: Piling Jan/Feb 1987, windrows burned October, 1987

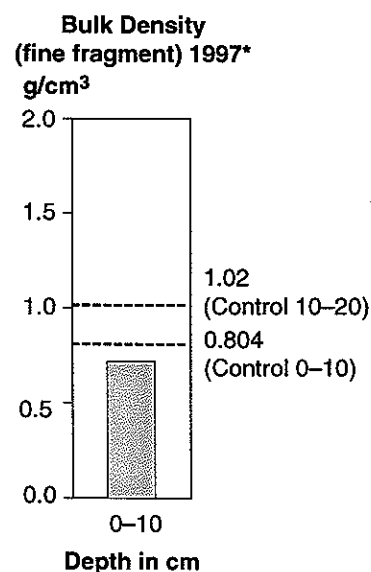
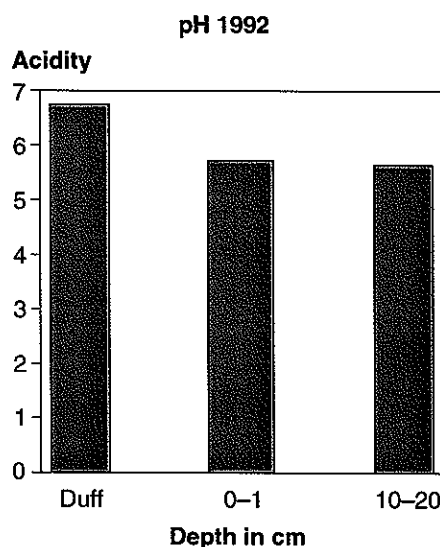
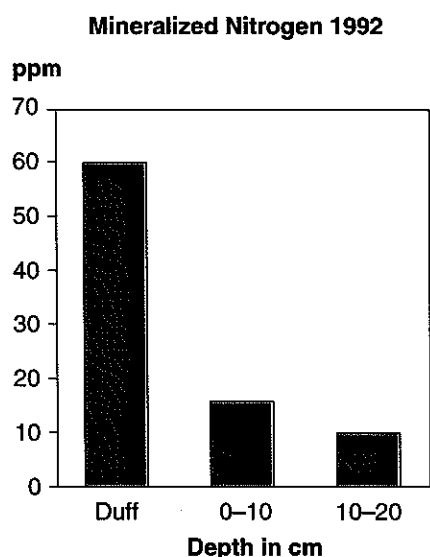
Operability: good conditions for piling but occasional scalping; piles burned very well in fall while it was snowing. Piles were lit by helicopters. Piling was done on snow pack to cause less disturbance to the windrows.

Typical productivity on similar sites: Group discussion.

Typical costs on similar sites: Group discussion – \$250–300/ha.

Plantability: Good, seedlings planted to root collar in ash with no screening.

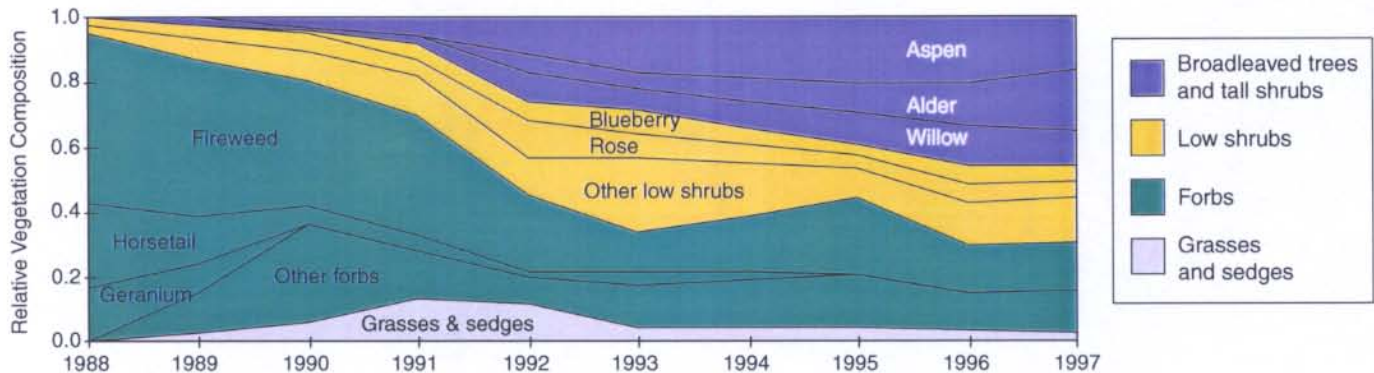
Soil Characteristics – Windrow Burn



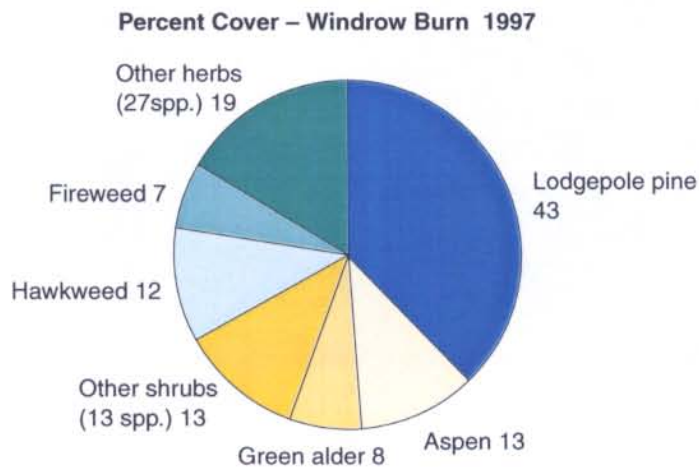
* Taken from the top of new layer of mineral soil, including buried forest floor. 1992 samples showed the mineral soil below the original forest floor was slightly compacted relative to the control, possibly from machine traffic associated with windrows.

Vegetation Description – Windrow Burn

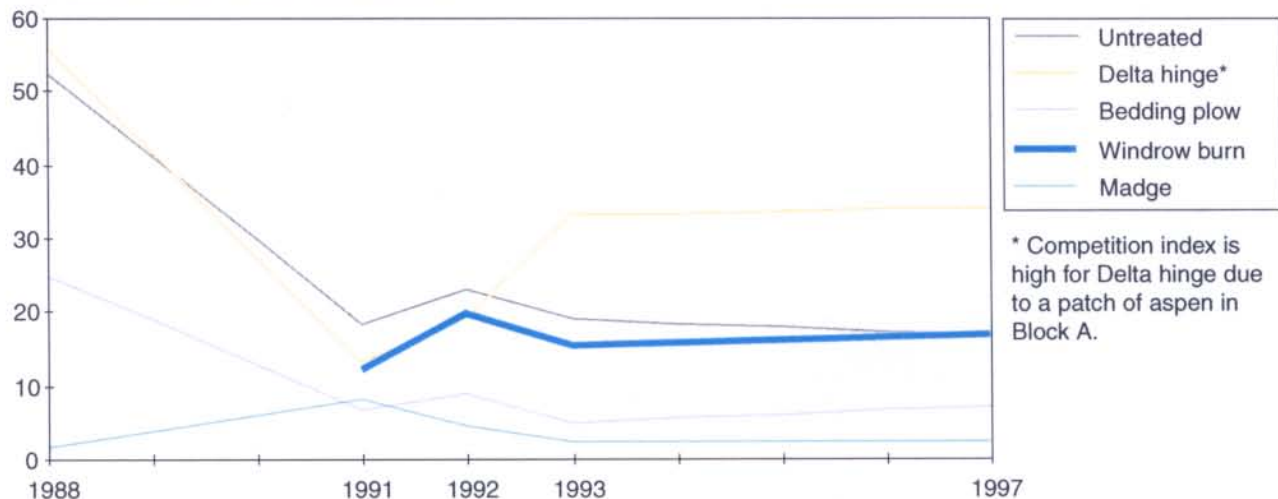
- This treatment dramatically changed the plant community and reduced species diversity.
- Revegetation after the hot fire was mainly from seeds and spores and is dominated by pioneering species.
- A variety of hardwoods are now present, but they do not compete strongly with planted lodgepole pine.



Impact of burned windrow treatment on changes in plant community composition. The y-axis indicates the frequency of occurrence of leading species on fifty 1–1.26 m radius tree seedling-centred subplots.

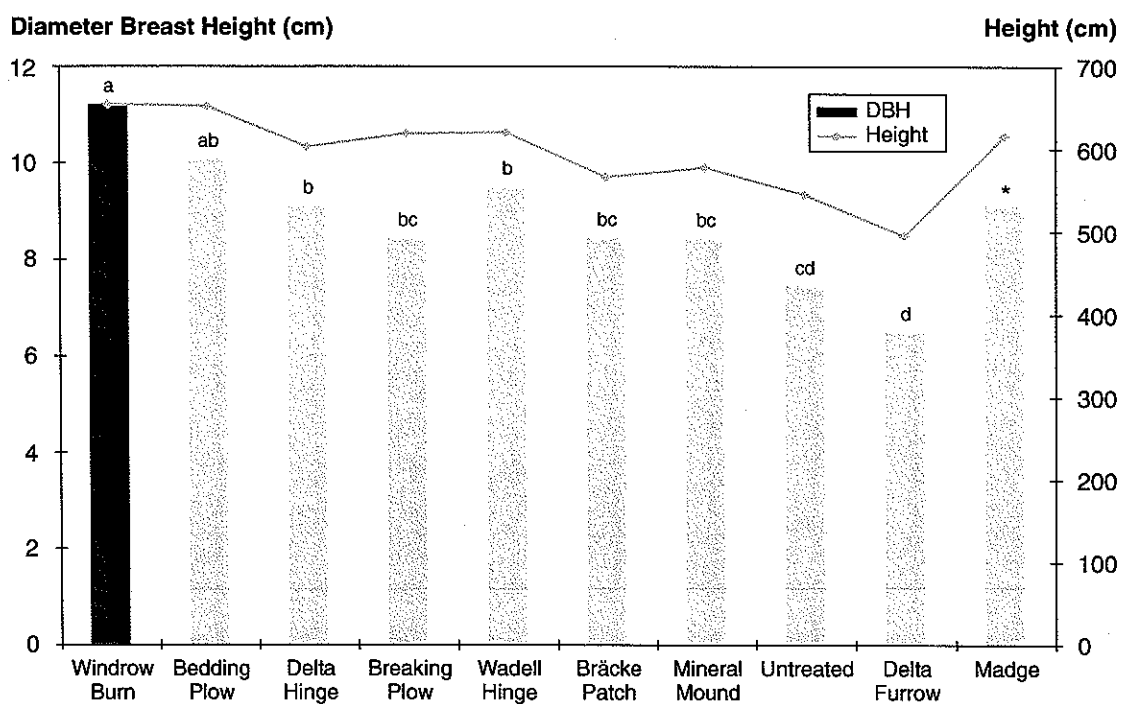


Bednesti: Seedling Competition Index 1988–1997
(Vegetation cover × height)/tree height



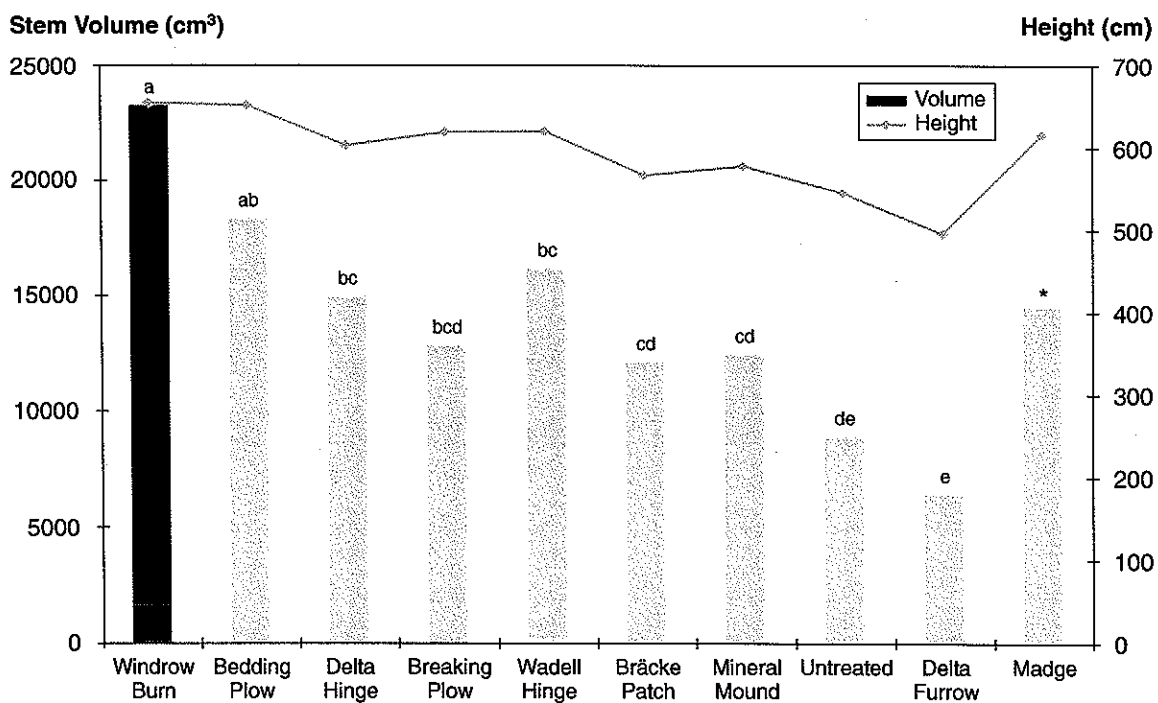
15-year Results – Windrow Burn

15-year Diameter (Fall 2002)



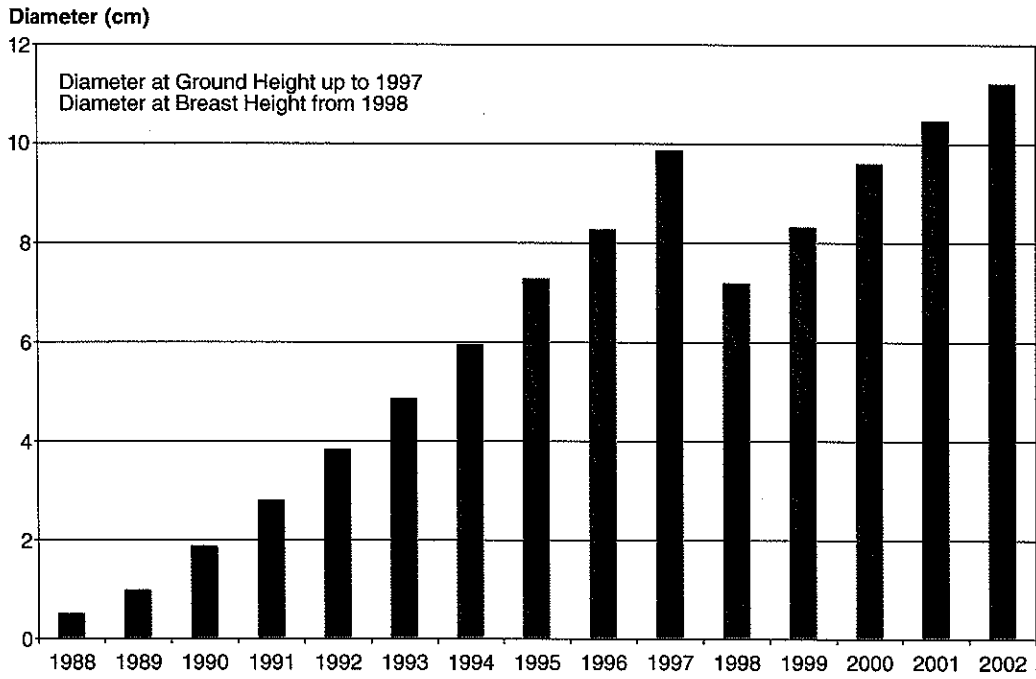
* 14th-year (2001) data for Madge. 15th-year (2002) data not available.

15-year Volume calculated from DBH (Fall 2002)



* 14th-year (2001) data for Madge. 15th-year (2002) data not available.

Diameter Growth Over Fifteen Years in Windrow Burn



Notes: _____

BEDDING PLOW

Operational Details – Bedding Plow

Equipment: Eden relief bedding plow pulled by a 4890 Case tractor.

Operator: Lyle Cazes

Similar machines: two variations to standard bedding plows are available; the first has two centrally mounted, outward turned discs which “turn out” the center area in front of the main discs and the second has a centrally mounted sub soiler located ahead of the discs to loosen the soil prior to bedding

Treatment date/conditions: October, 1987

Operability: conditions were appropriate for bedding (i.e., minor slash and good soil conditions). Acceptable, but somewhat loose, beds were achieved with a single pass.

Typical productivity on similar sites: Group discussion.

Typical costs on similar sites: Group discussion.

Plantability: Moderate to poor – difficult to firm seedlings into rough mixed mineral soil and chunks of forest floor, even though deep planted leaving only 2–5 cm of seedling exposed.



Closely resembles a heavily constructed agricultural disking plow.

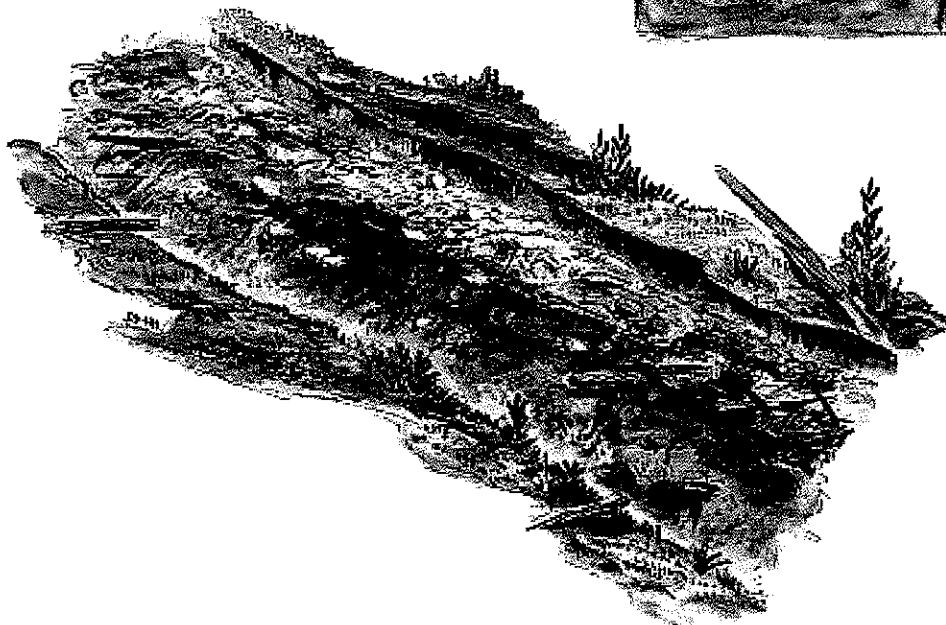
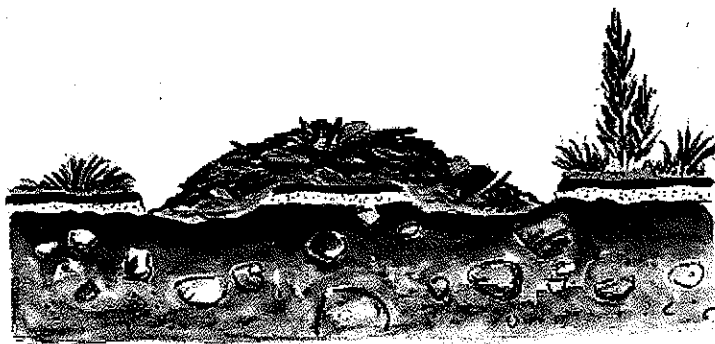
Theme: Creating Continuous Planting Beds on Cold, Well-drained Pine Sites

Biological objectives on cold, well-drained sites are:

- to increase soil temperature.
- to reduce frost damage by exposing a large mineral soil surface.
- to improve soil texture/tilth for better root growth.
- to increase nutrient availability.

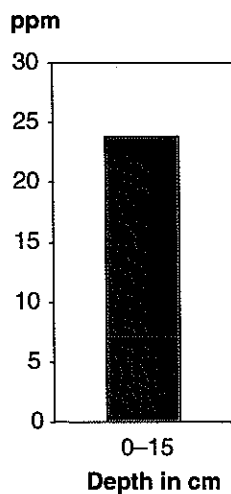
Eden Relief Bedding Plow

The bedding plow (not really a plow) provides a raised, rough-mixed planting bed of mineral soil and chunks of organic matter.

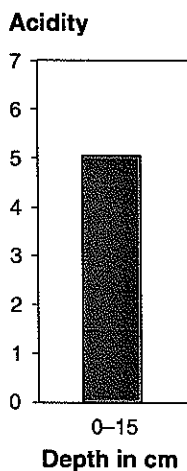


Soil Characteristics – Bedding Plow

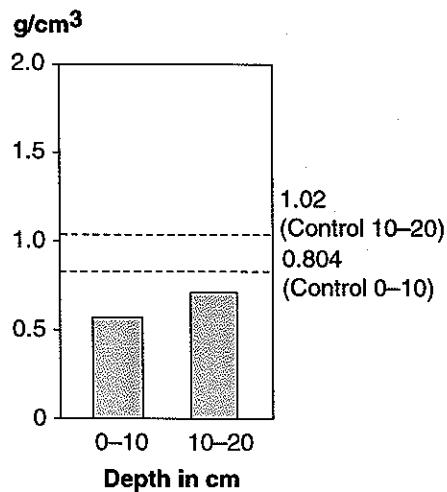
Mineralized Nitrogen 1992



pH 1992

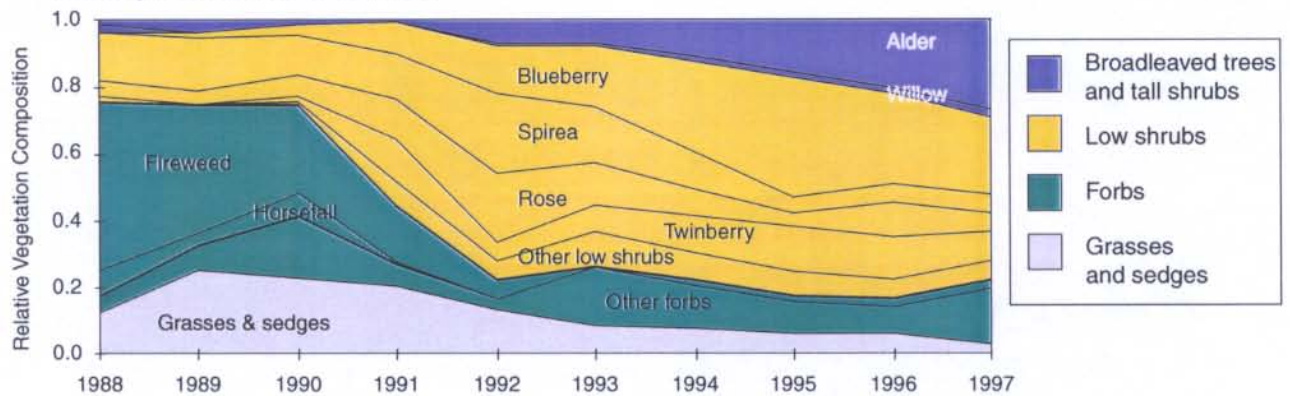


Bulk Density
(fine fragment) 1997



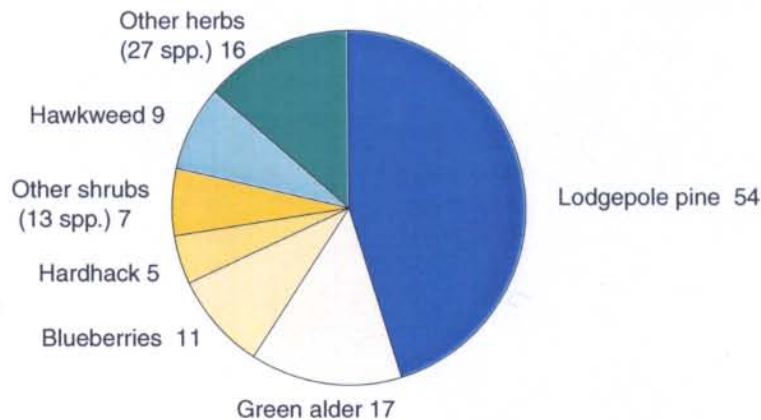
Vegetation Description – Bedding Plow

- Plowing had moderate impact on species composition and diversity and was effective at suppressing hardwood regeneration.
- Note how the plants, notably green alder, are oriented in rows, with resprouting vegetation on the berms and seed regeneration in the trenches.



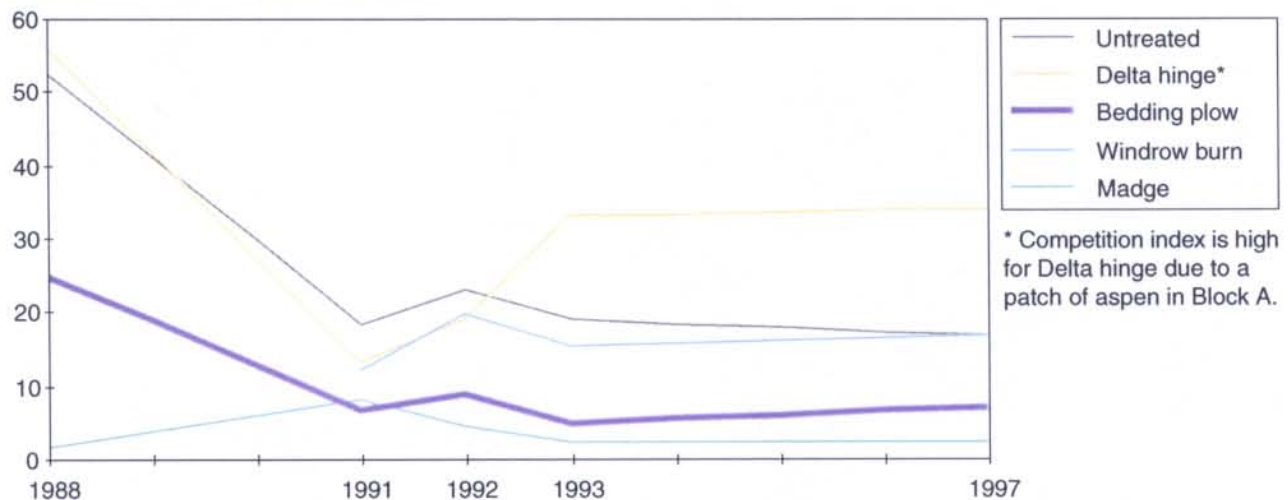
Impact of Bedding Plow treatment on changes in plant community composition. The y-axis indicates the frequency of occurrence of leading species on fifty 1–1.26 m radius tree seedling-centred subplots.

Percent Cover – Bedding Plow 1997



Bednesti: Seedling Competition Index 1988–1997

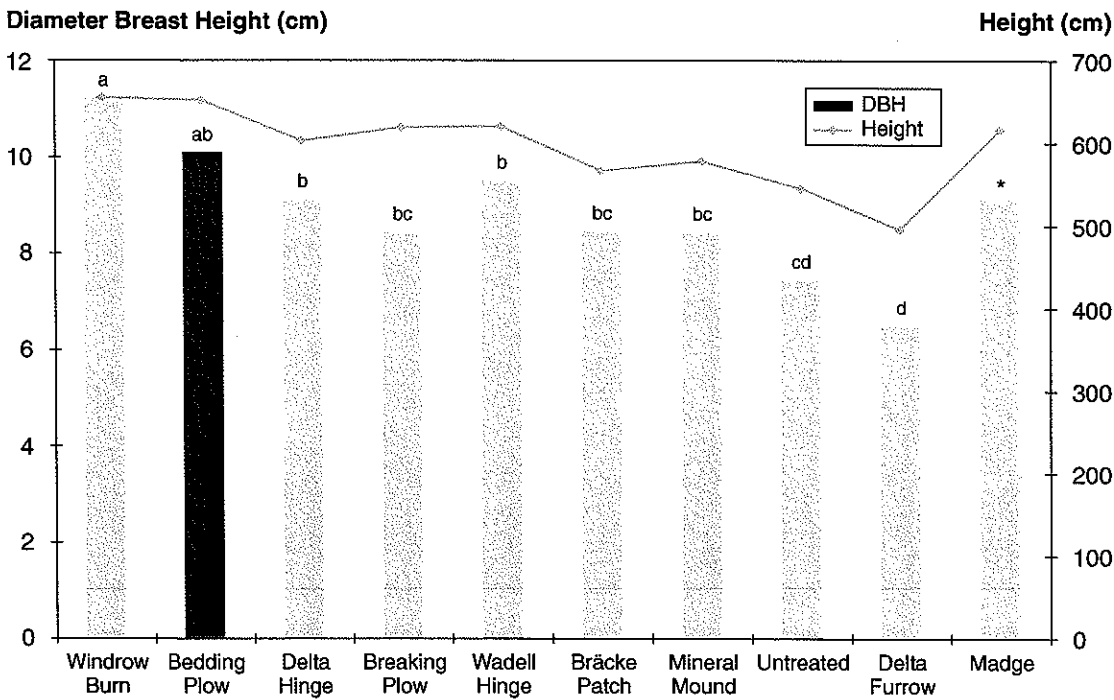
(Vegetation cover × height)/tree height



* Competition index is high for Delta hinge due to a patch of aspen in Block A.

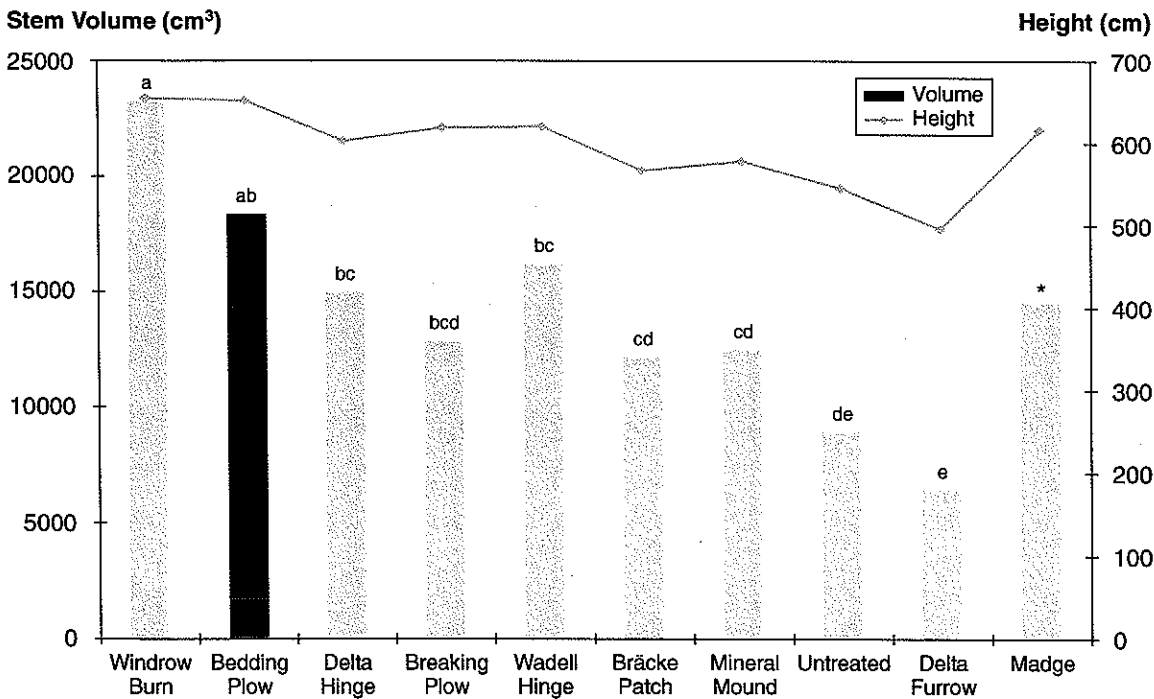
15-year Results – Bedding Plow

15-year Diameter (Fall 2002)



* 14th-year (2001) data for Madge. 15th-year (2002) data not available.

15-year Volume calculated from DBH (Fall 2002)



* 14th-year (2001) data for Madge. 15th-year (2002) data not available.

BREAKING PLOW

Operational Details – Breaking Plow

Equipment: double-bottom agricultural breaking plow, agricultural disc, pulled by D7 crawler tractor

Operator: John Tereshuk, Prince George

Similar machines: single and triple bottom plows are also available.

Treatment date/condition: October, 1987

Operability: Site conditions were appropriate, however, the plow was drawn in a back and forth configuration rather than in a circle. This resulted in groups of abutting double inverted berms separated by furrows rather than the intended successively abutting berms consisting of a single layer of inverted humus.

Typical productivity on similar sites: Group discussion

Typical costs on similar sites: Group discussion

Plantability: Difficult, seedlings planted into berms of mineral soil overlaying inverted forest floor. Only 2–5 cm of seedling left exposed. Considerable stomping required as material still loose after overwinter settling.

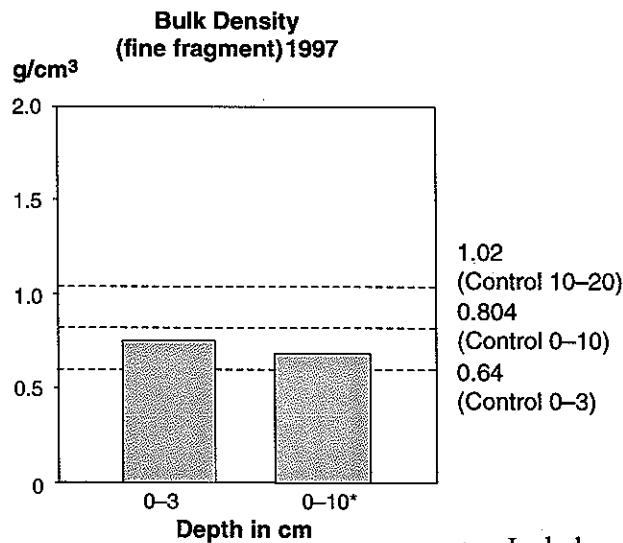


*A double-bottom plow was used on site.
The photograph shows a single-bottom plow.*

Theme: Site Prep Options for Reforestation on Brushy Spruce Sites

Plowing created side-by-side furrow slices to produce a raised mineral soil berm over a single layer of inverted humus.

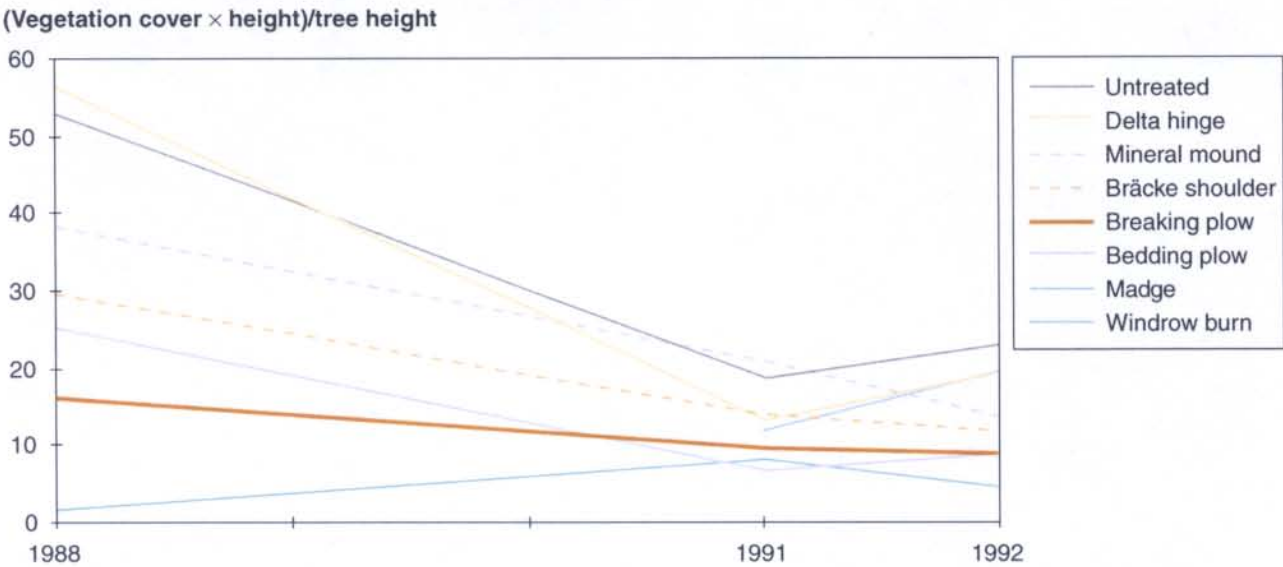
Soil Characteristics – Breaking Plow



- Includes a portion of inverted humus.

Soil Characteristics – Breaking Plow

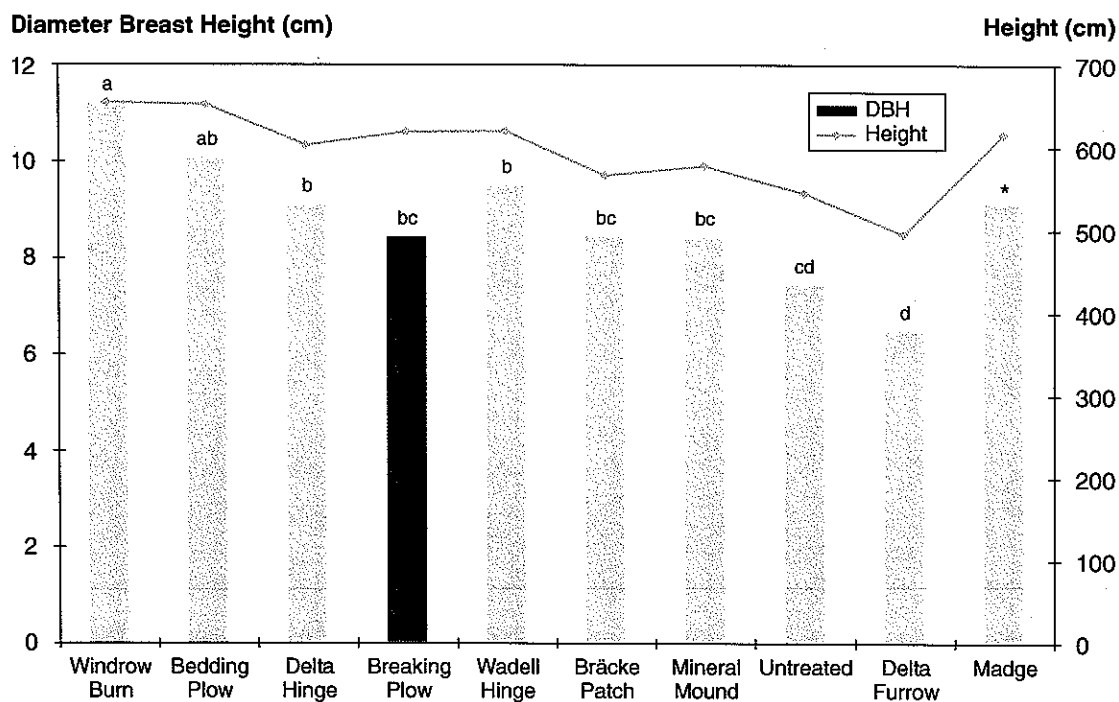
Bednesti: Competition Index 1988–1992



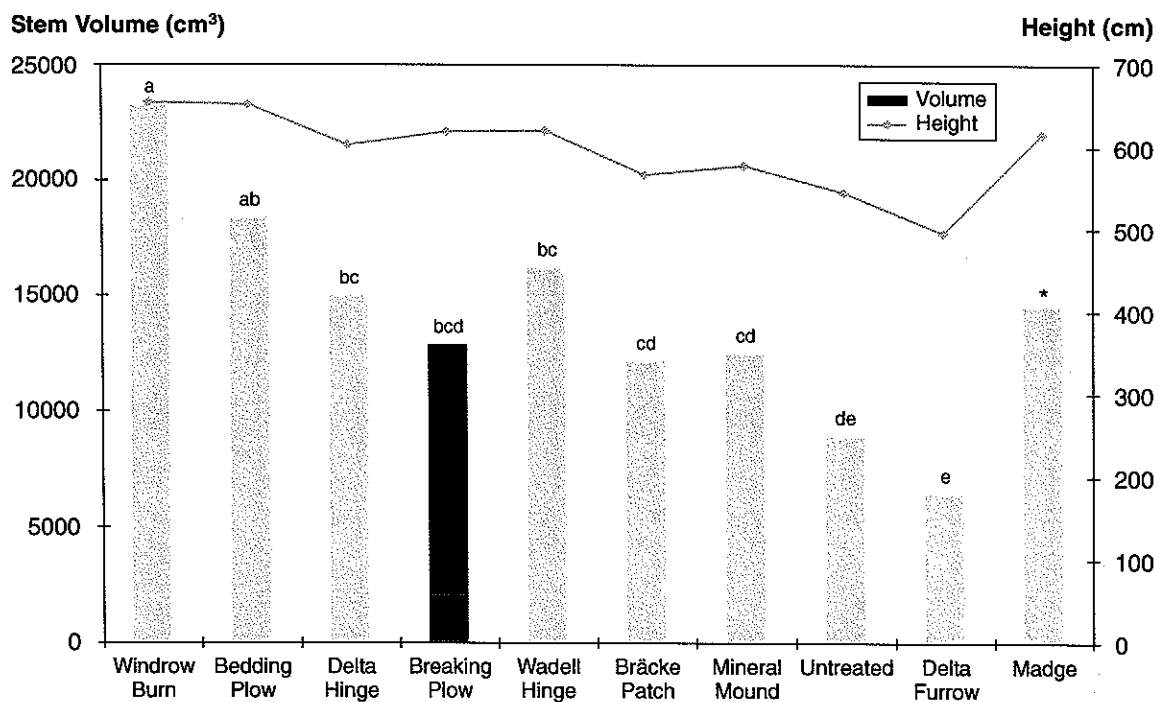
Notes: _____

15-year Results – Breaking Plow

15-year Diameter (Fall 2002)



15-year Volume calculated from DBH (Fall 2002)



PATCH SCARIFICATION (BRÄCKE SHOULDER)

Operational Details – Patch Scarification

Equipment: A Bräcke moulder with a three-pronged mattock wheel pulled by a Clark 668 skidder.

Operator: Integrated Silviculture Services Ltd.

Similar machines: Donaren 870H moulder, Bräcke Donaren 296 moulder and the Bräcke 390 (3-row) and Bräcke 290 (2-row).

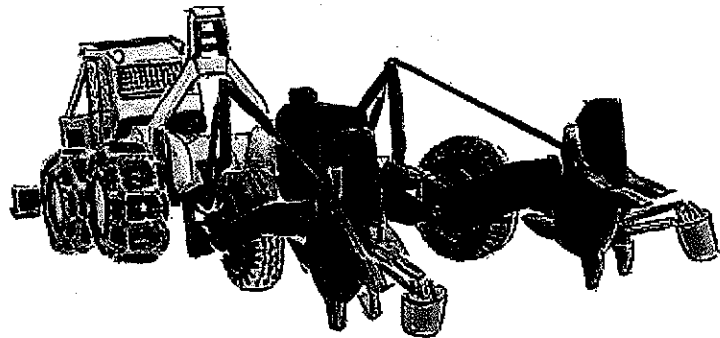
Treatment date/condition: September 4, 1987

Operability: good

Typical productivity on similar sites: Group discussion

Typical costs on similar sites: Group discussion

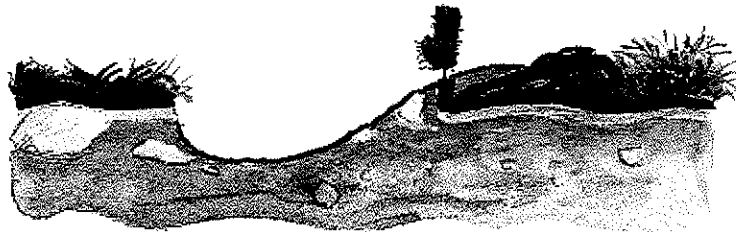
Plantability: Seedlings were planted in the hinge position, adjacent to the forest floor.



*A three-pronged mattock wheel was used on site.
The illustration shows a four-pronged wheel.*

Patch Planting

The planting spot used was the hinge position adjacent to the inverted LFH layer at the highest location in the patch.



First-year Results – Patch Scarification

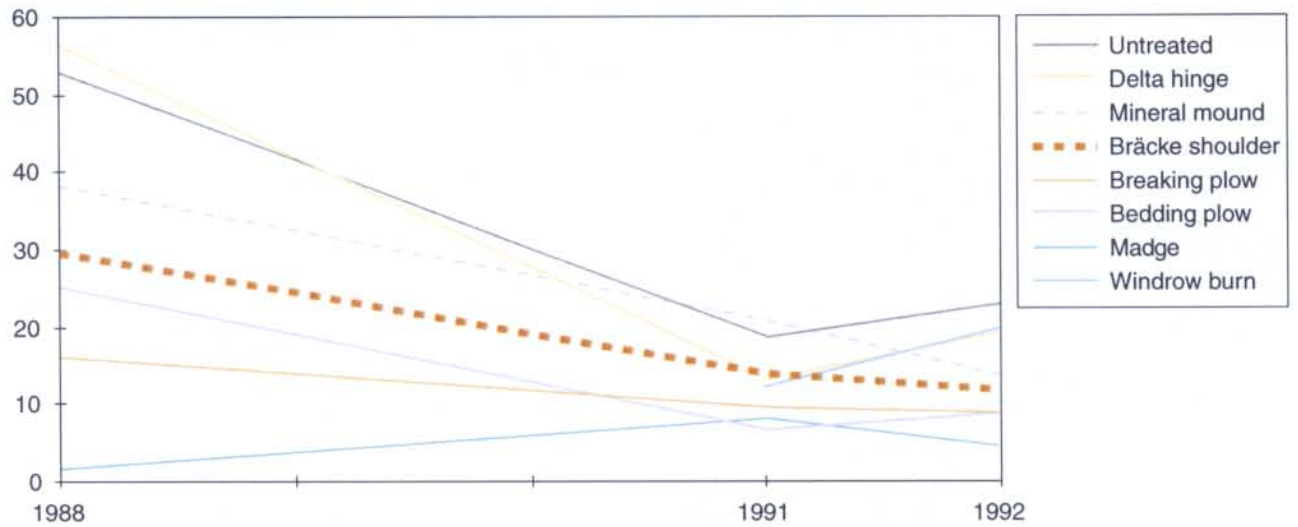
Seedlings planted in the Bräcke patch had the highest rate of growth at the end of the first growing season.



Soil Characteristics – Patch Scarification

Bednesti: Competition Index 1988–1992

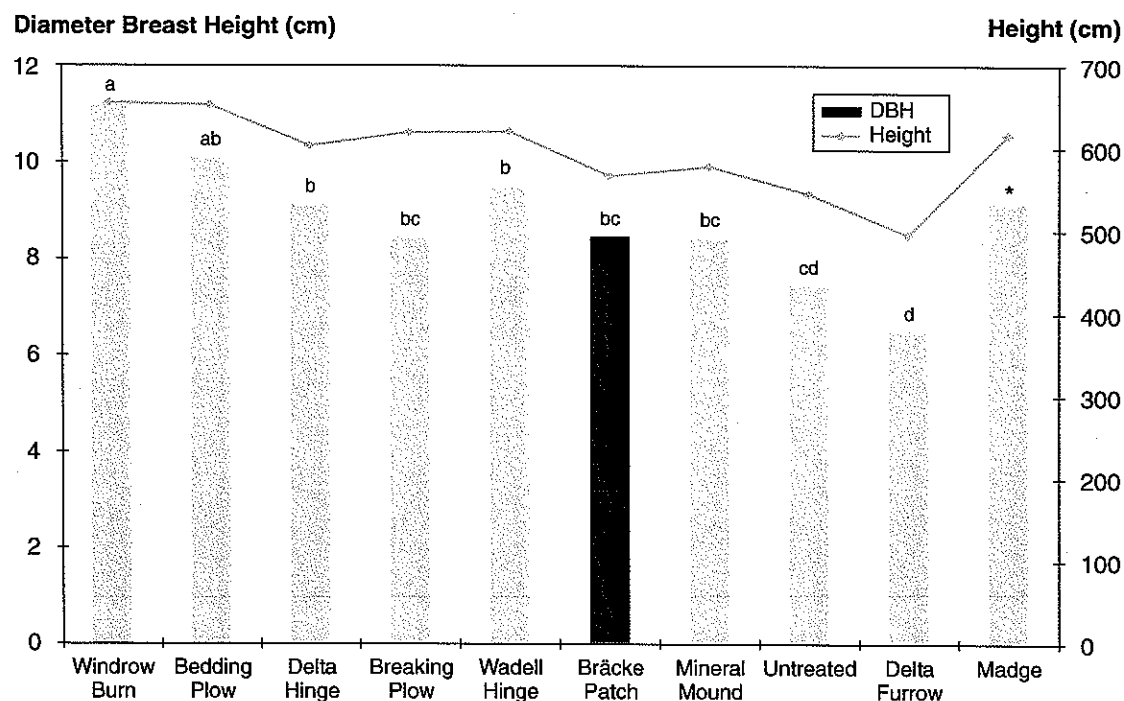
(Vegetation cover × height)/tree height



Notes: _____

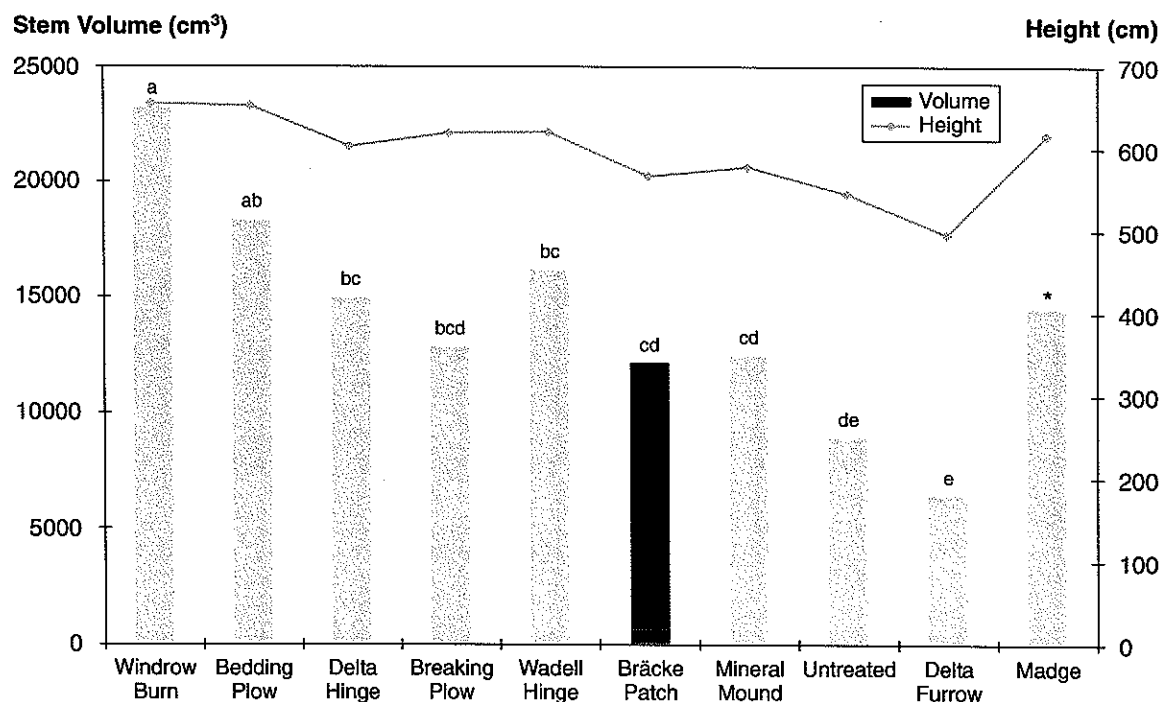
15-year Results – Patch Scarification

15-year Diameter (Fall 2002)



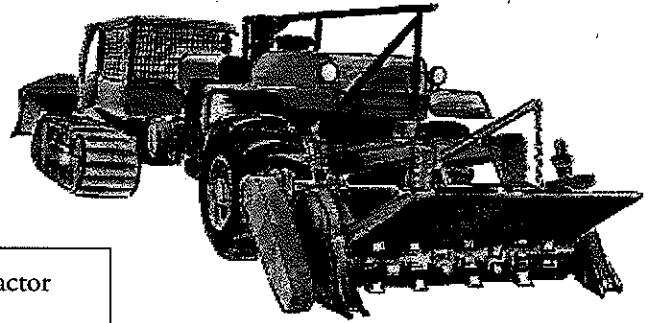
* 14th-year (2001) data for Madge. 15th-year (2002) data not available.

15-year Volume calculated from DBH (Fall 2002)



* 14th-year (2001) data for Madge. 15th-year (2002) data not available.

MIXING (MADGE)



Operational Details – Mixing

Equipment: Madge Roto-clear pulled by D6E crawler tractor
Operator: Dressler Services, Fort St. John
Similar machines: A2 Forester (larger model)
Treatment date/conditions: October; moist lightly frozen soil
Operability: Not suitable, too many rocks—damages teeth
Typical productivity on similar sites: Group discussion
Typical costs on similar sites: Group discussion
Plantability: Easy planting, very fast pace, loose ground with no obstructions—planters' favourite on this site

Theme: Ecological Benefits of Mixing

Mixing (or mulching) provides more-or-less complete site preparation and potentially offers the following ecological benefits:

- improved soil texture/tilth
- improved nutrient availability
- increased moisture holding capacity
- soil warming
- vegetation control

Concerns:

- accelerated leaching losses?
- nitrogen tied up in unavailable form (green manuring)?

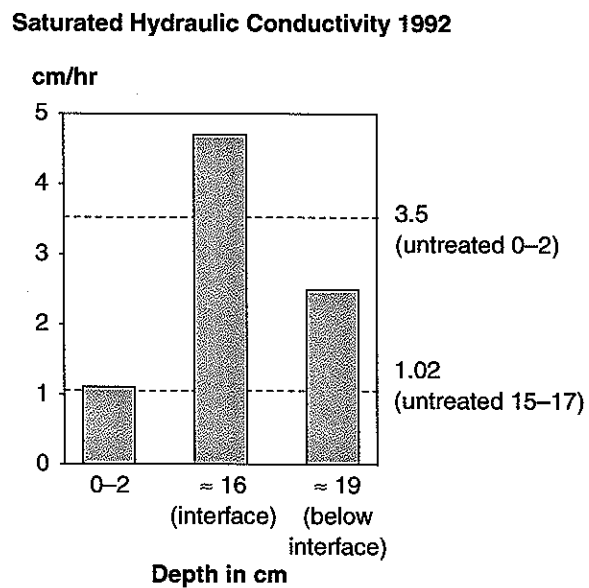
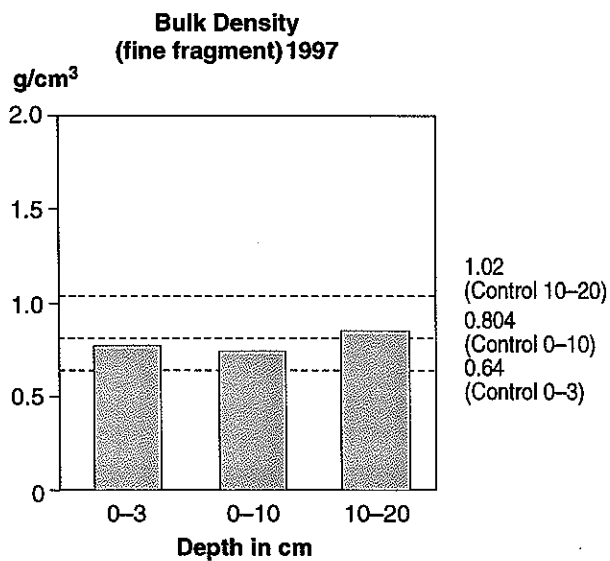
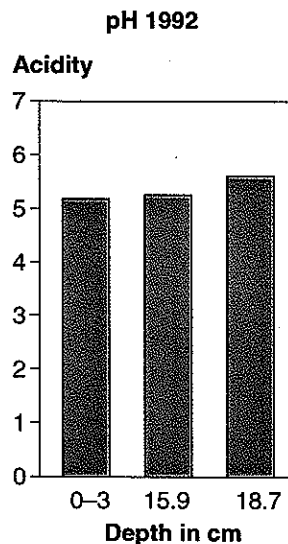
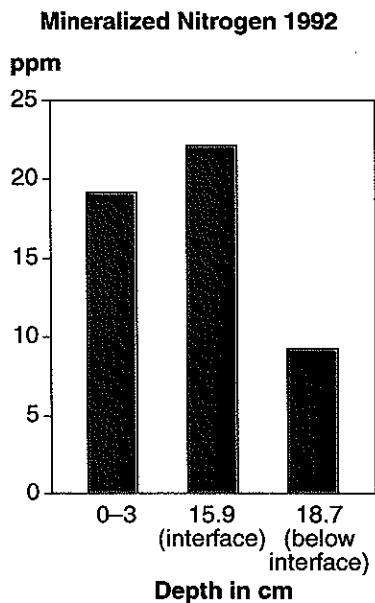


First-year Results – Mixing

Nutrient Availability

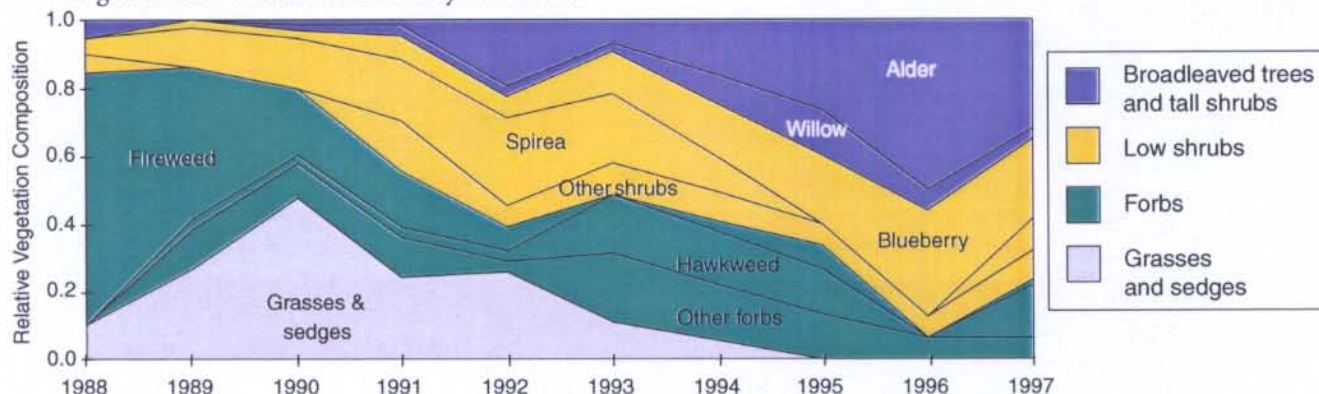
- Mineralizable N: Madge significantly higher than untreated.
- Carbon/nitrogen ratio: no difference between untreated and Madge.

Soil Characteristics – Mixing

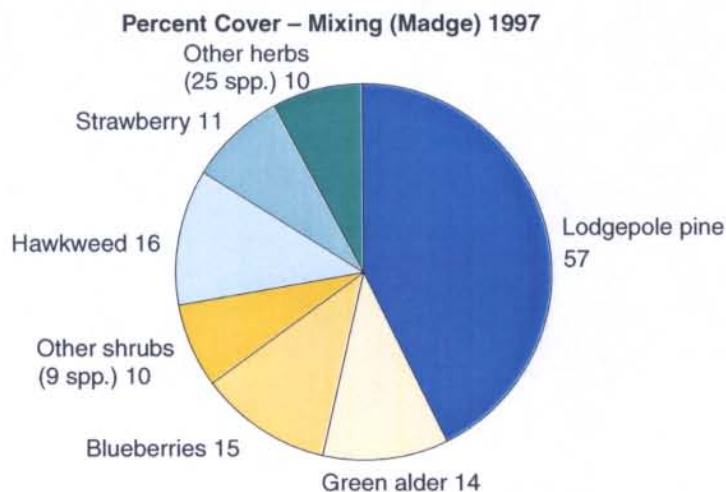


Vegetation Description – Mixing

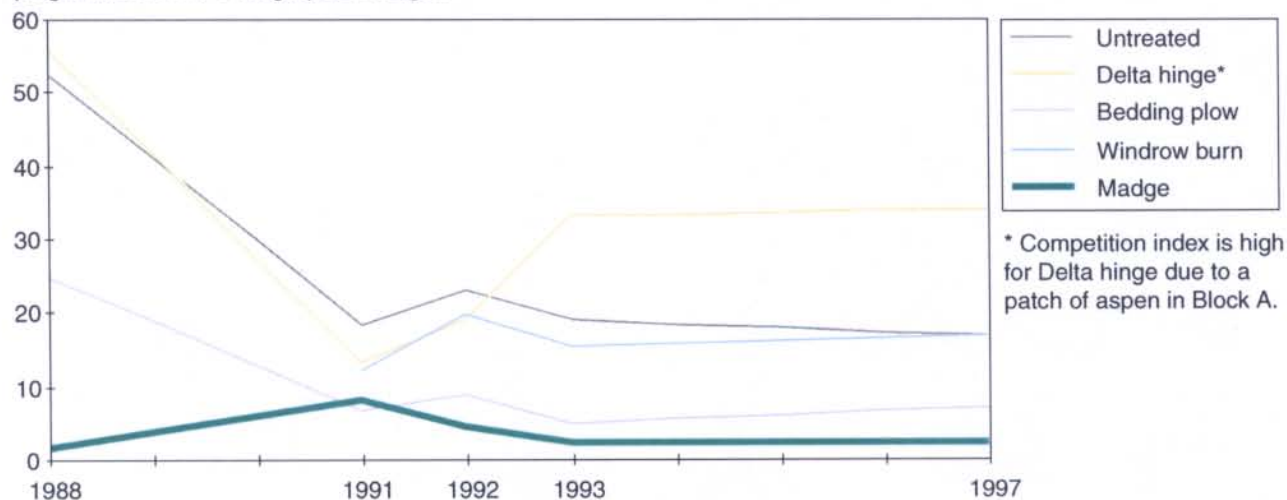
- This treatment has moderate species diversity, but few hardwoods.
- High speed mixing typically reduces woody species and encourages grasses and forbs. On this site, mixing was incomplete due to rocky soils. Also, the herbaceous growth was not sufficiently vigorous to suppress shrub regeneration. Shrubs have steadily recovered.



Impact of Madge treatment on changes in plant community composition. The y-axis indicates the frequency of occurrence of leading species on fifty 1–1.26 m radius tree seedling-centred subplots.

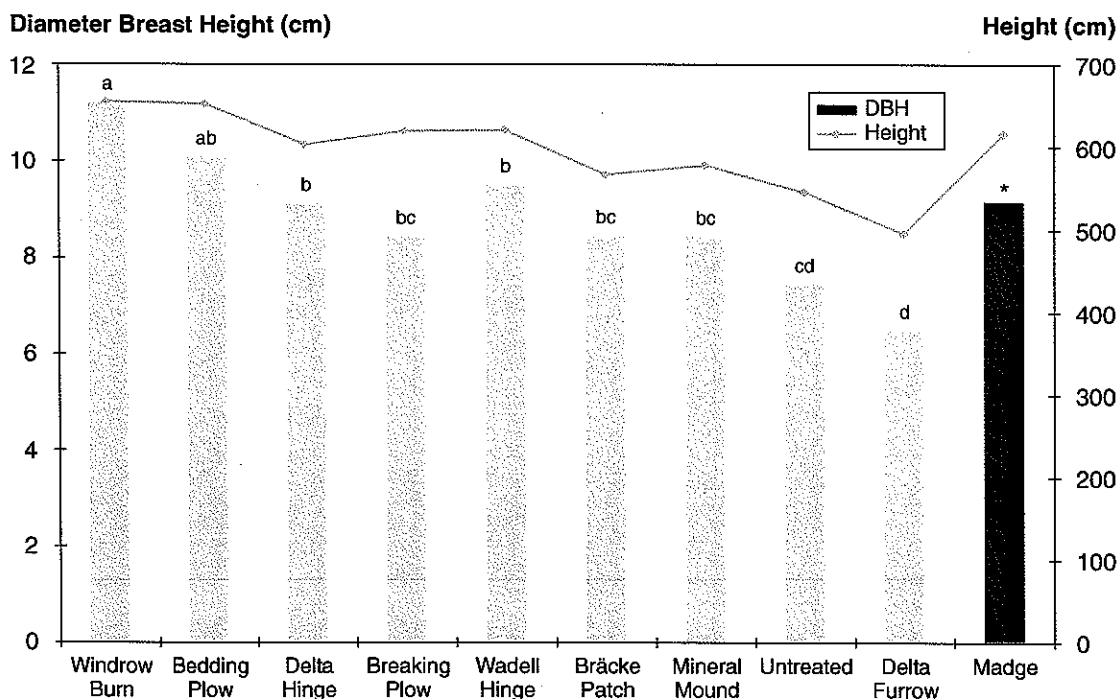


Bednesti: Seedling Competition Index 1988–1997
(Vegetation cover × height)/tree height



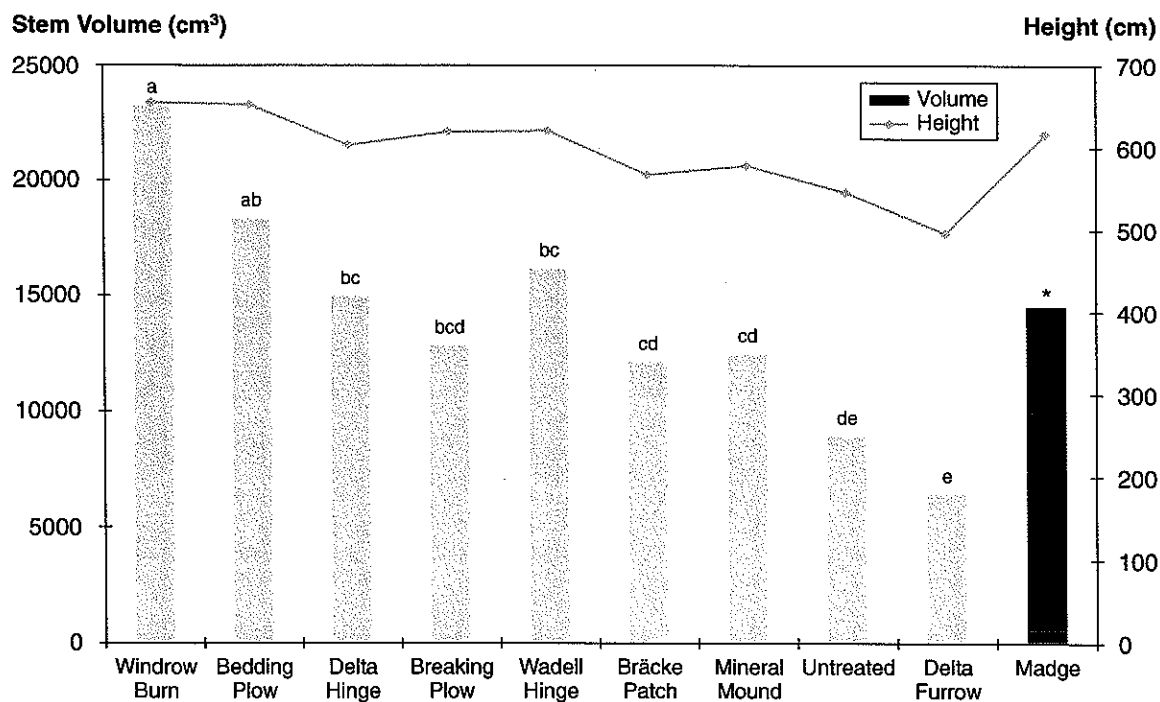
15-year Results - Mixing

15-year Diameter (Fall 2002)



* 14th-year (2001) data for Madge. 15th-year (2002) data not available.

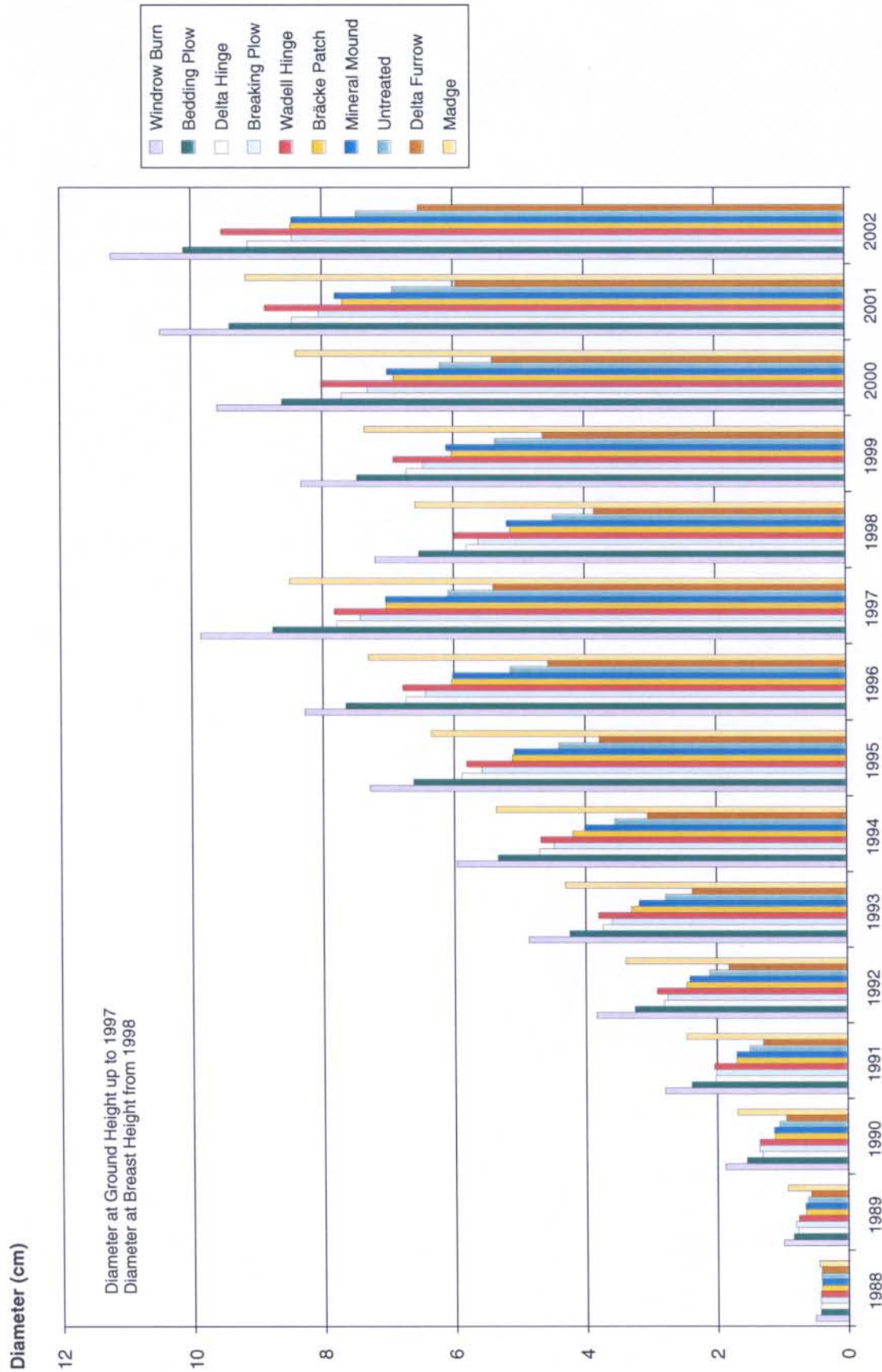
15-year Volume calculated from DBH (Fall 2002)



* 14th-year (2001) data for Madge. 15th-year (2002) data not available.

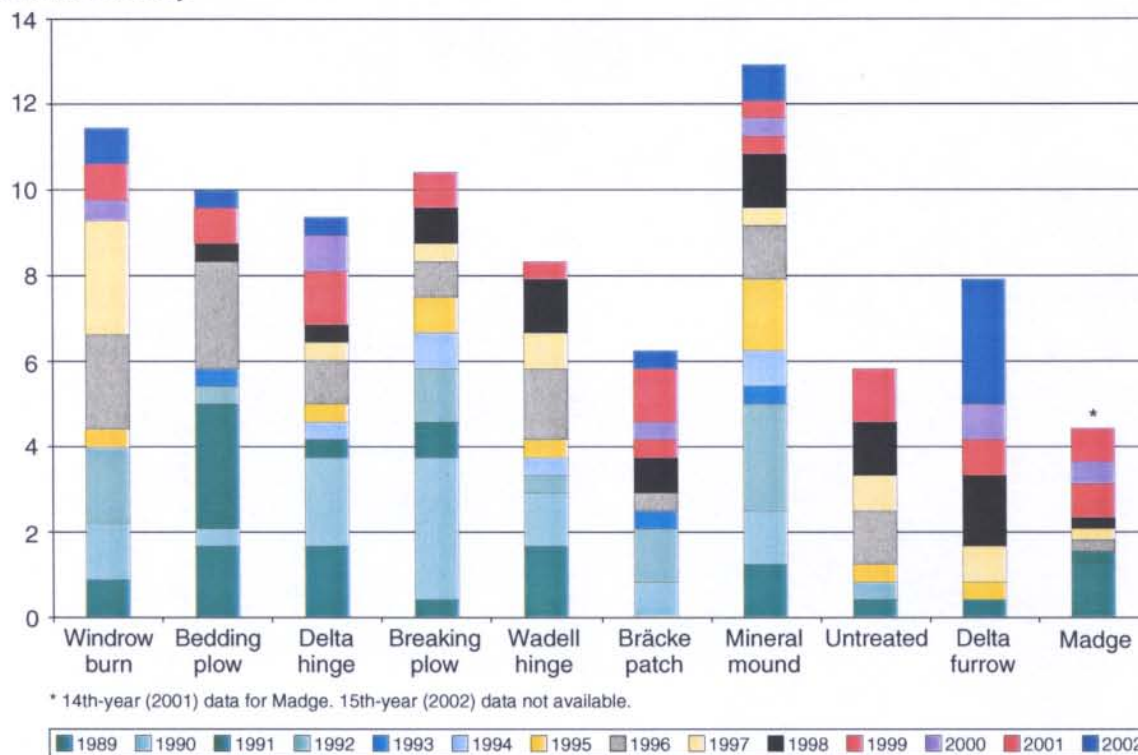
MORTALITY DATA FOR BEDNESTI NORTH

Diameter Trend Over Fifteen Years



Change in Mortality over 15 Years - Bednesti (North Side)

Percent mortality



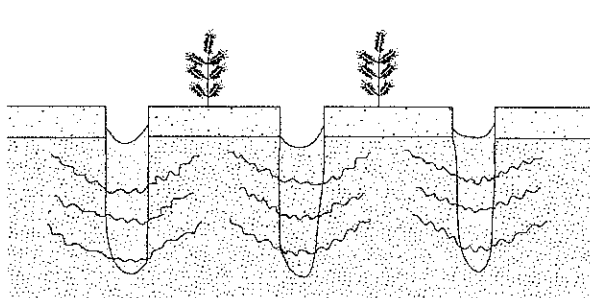
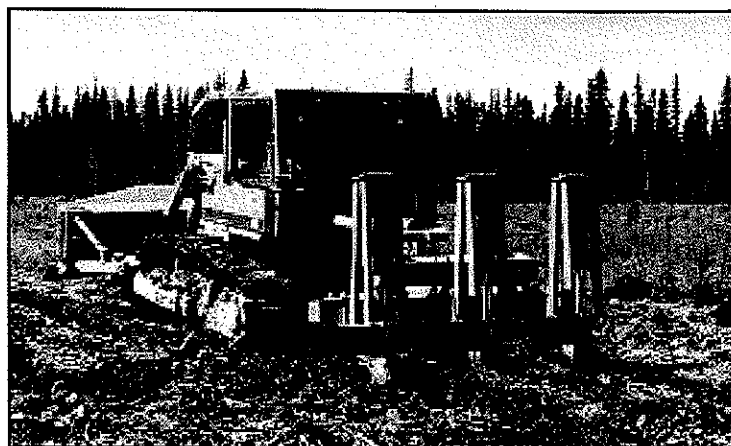
Notes:

SUBSOILING DEMONSTRATION SITE

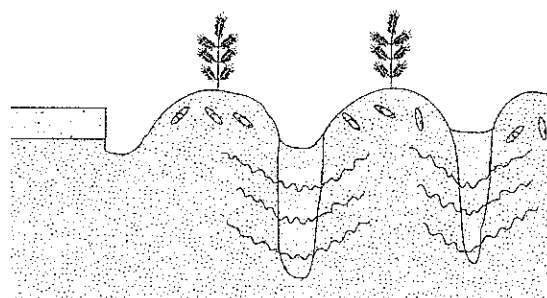
Subsoiling With and Without Bedding

Theme: Ripping a Compacted Soil Layer to Improve Site Productivity

This is a wetter area with a subhygric-hygric moisture regime. Subsoiling was used to break up the compacted subsurface layer of basal till. The soil was ripped to a depth of 50 cm. Alternating strips were subsequently bedded with the Eden relief bedding plow.



Ripped



Ripped and bedded

Operational Details – Subsoiling

Equipment: D7 crawler tractor with 3 winged ripper shanks

Operator: John Tereshuk, Prince George

Treatment date/conditions: July, 1988; as dry as possible during a rainy summer

Operability: soils a bit wet; debris tended to accumulate behind ripper shanks

Typical costs on similar sites: group discussion

Planting: planted April 24/25, 1989 with Pl 1+0 PSB211 stock. Boot screef required to get through duff in ripped only plots. Ground uneven.

Objectives of subsoiling were:

- to improve soil drainage by allowing water to percolate through the compacted layer (this should also increase soil temperature).
- to improve soil aeration and porosity.
- to increase the available rooting depth for tree seedlings.
- to improve site productivity and overall tree growth.

Bedding was carried out in addition to ripping to provide a superior microsite for newly planted seedlings:

- to provide a raised planting spot (better aeration, higher soil temperatures).
- to provide a mixed mineral soil/organic matter seedbed (improved nutrient availability, frost protection).

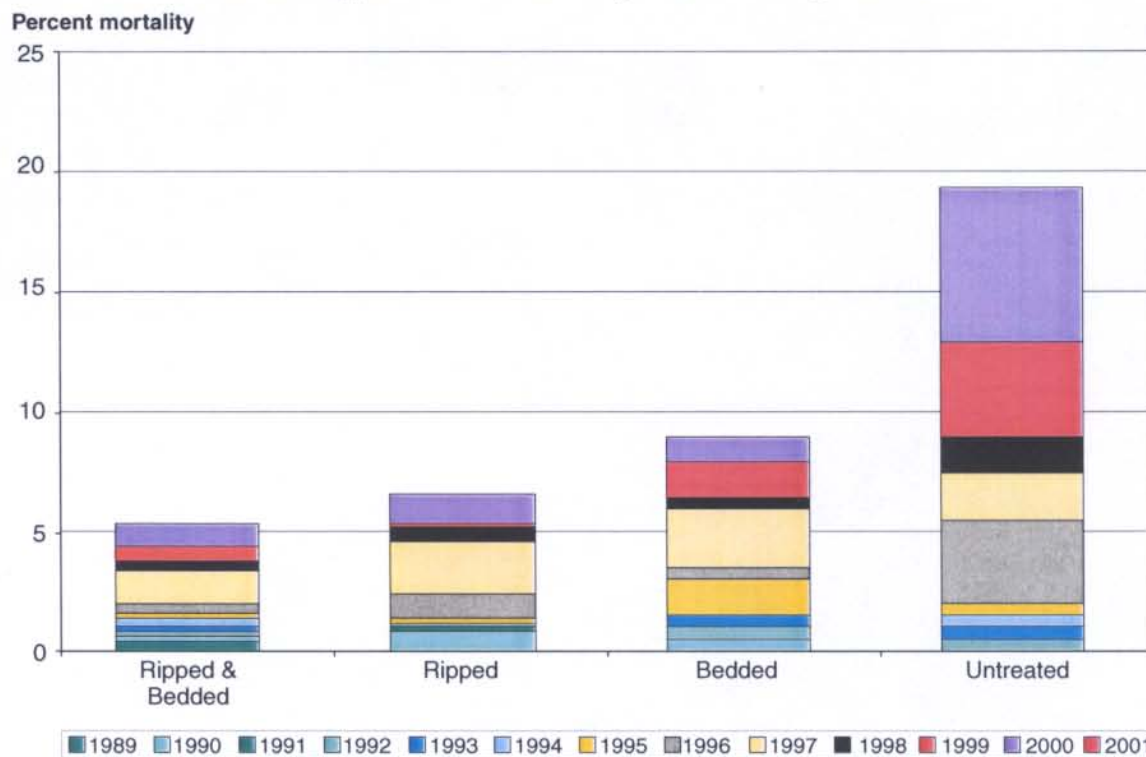
Note that the bedding plow produced better beds here than in the unripped soil.

Early Results – Subsoiling

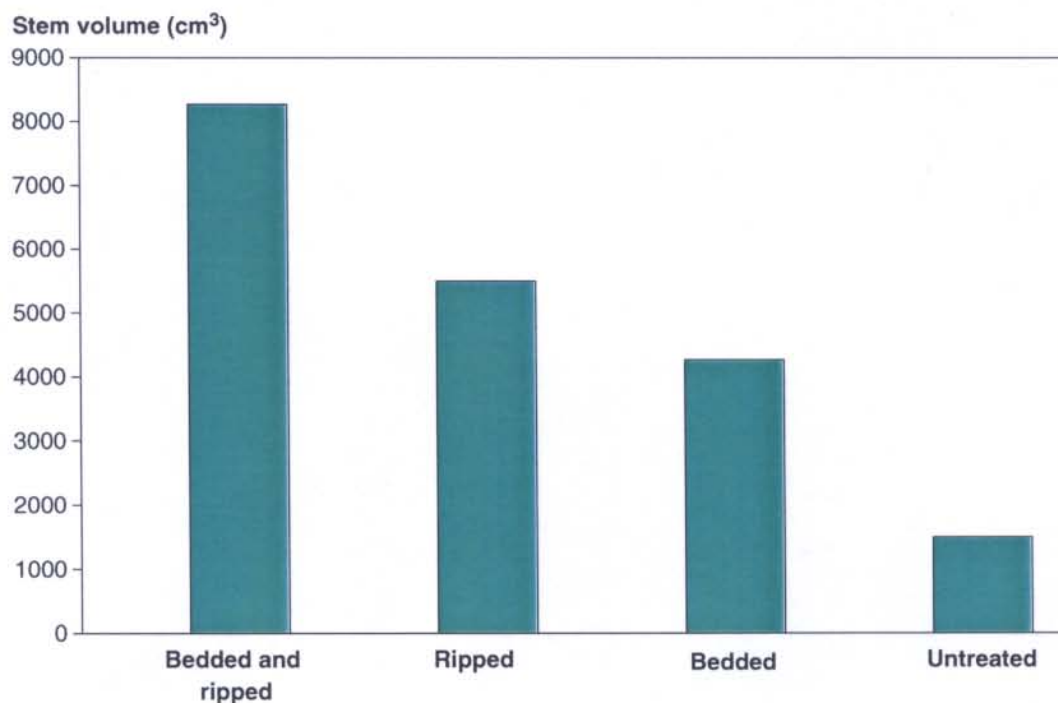
Ripping alone had little effect on soil density, but ripped+bedded soils were considerably less dense. Soils in both treatments were drier than in the untreated area, but, owing to frequent rainfall during the summer of 1988, the drying effect was not dramatic. Bulk density samples taken in the summer of 1998, 10 years after treatment.

Treatment	Depth (cm)	Soil Moisture (kg/m ³)
Untreated	10	825
Ripped	10	1133
Ripped + bedded	10	794
Bedded	10	732
Untreated	20	1527
Ripped	20	1464
Ripped + bedded	20	1054
Bedded	20	1150
Untreated	30	1582
Ripped	30	1513
Ripped + bedded	30	1371
Bedded	30	1452

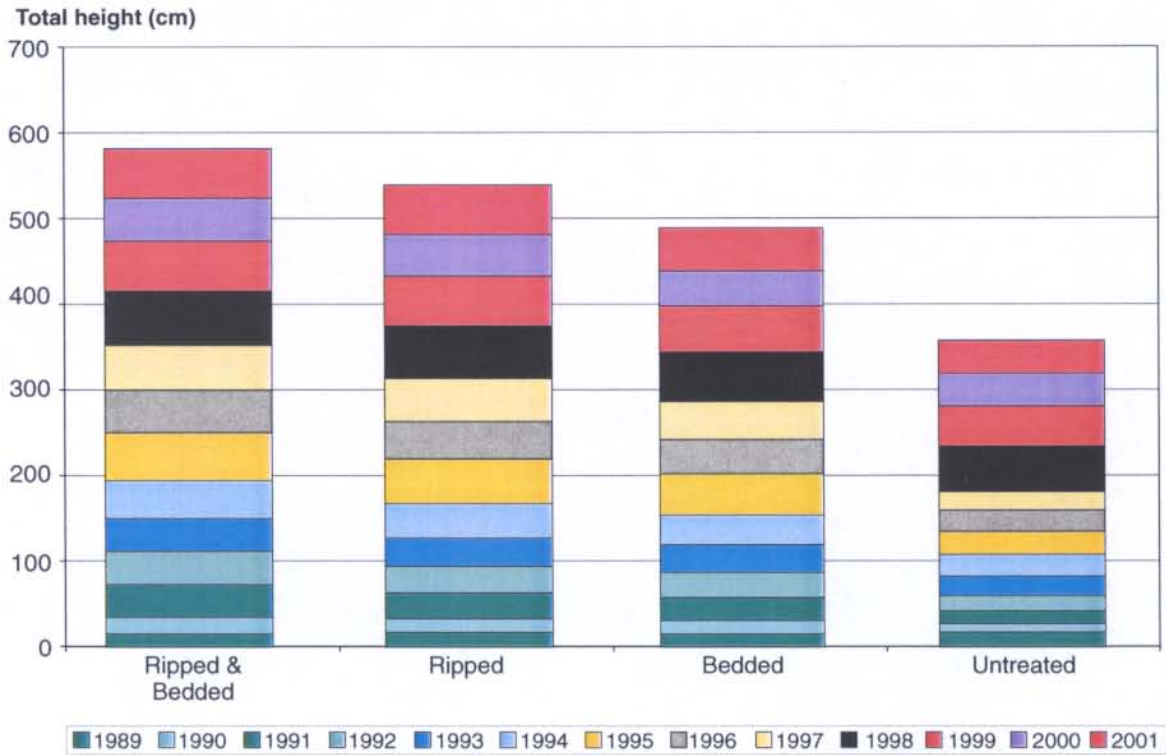
Bednesti Ripped Plots: Total Mortality Over 13 Growing Seasons*



Bednesti Ripped Plots: Total Volume After 10 Growing Seasons



Bednesti Ripped Plots: Total Height Growth Over 13 Growing Seasons



Bednesti Ripped Plots: Total Diameter Over 10 Growing Seasons

