Northern White Cedar Swamps-
Ecology, Restoration and Management

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Northern White-Cedar in Michigan

February 21-22, 1990

Ramada Inn
Sault Ste. Marie, Michigan

The Ecology of Northern White-Cedar

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Northern White-Cedar Ecology and Silviculture in the Northeastern United States and Southeastern Canada: A Synthesis of Knowledge

Philip V. Hofmeyer, Laura S. Kenefic, and Robert S. Seymour

NORTH. J. APPL. FOR. 26(1) 2009

Miller, R.O. 1992.
Ecology and management of northern white-cedar.
p 1-14. IN Regenerating conifer cover in deer yards. Proceedings of a workshop held is North Bay Ontario, December 4 & 5, 1990. B. Naylor and L. Thompson Editors. Central Ontario Forest Technology Development Unit Technical Report No. 28. October 1992. 117 pp.

Northern white-cedar

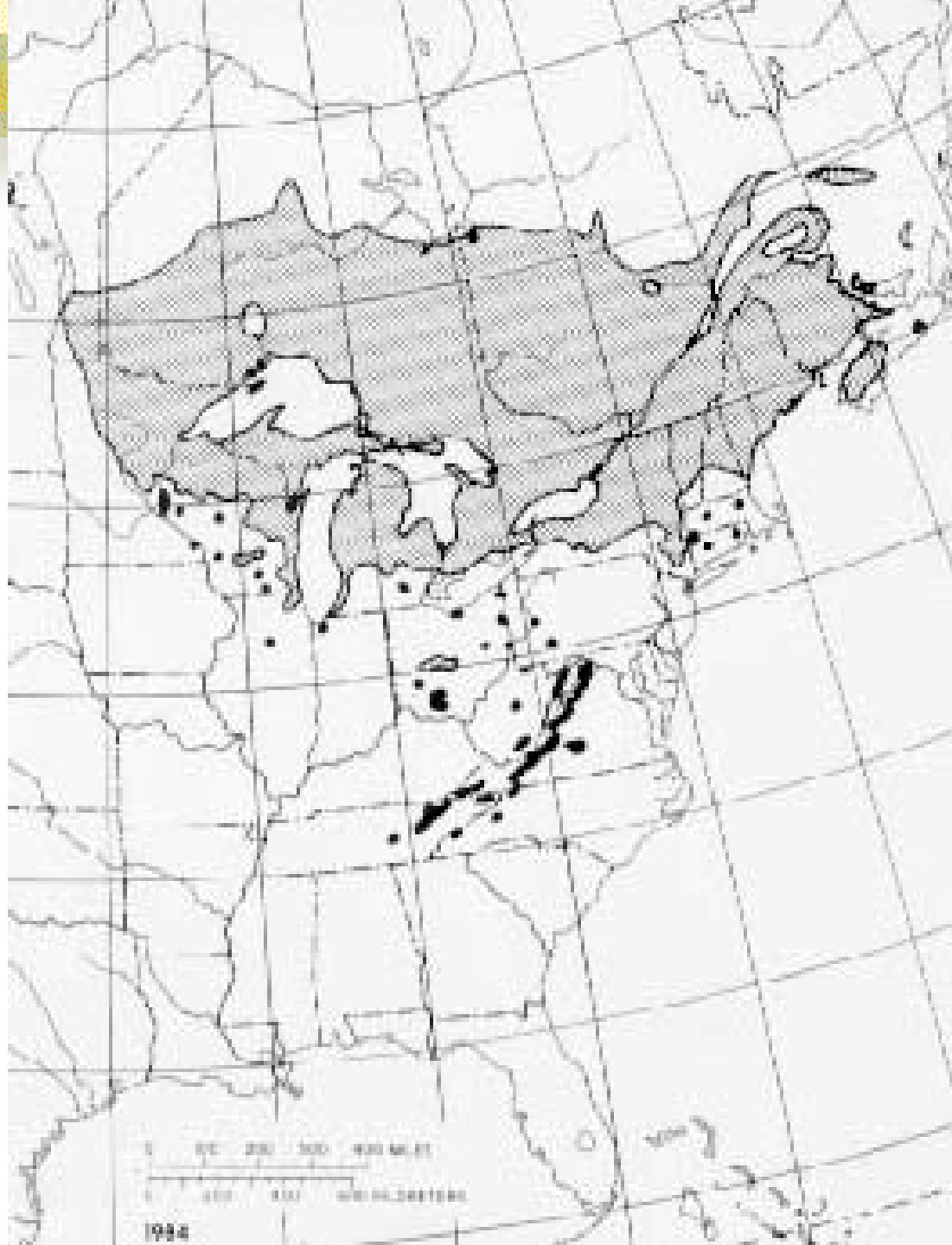
Cupressaceae (*Thuja occidentalis)* L.

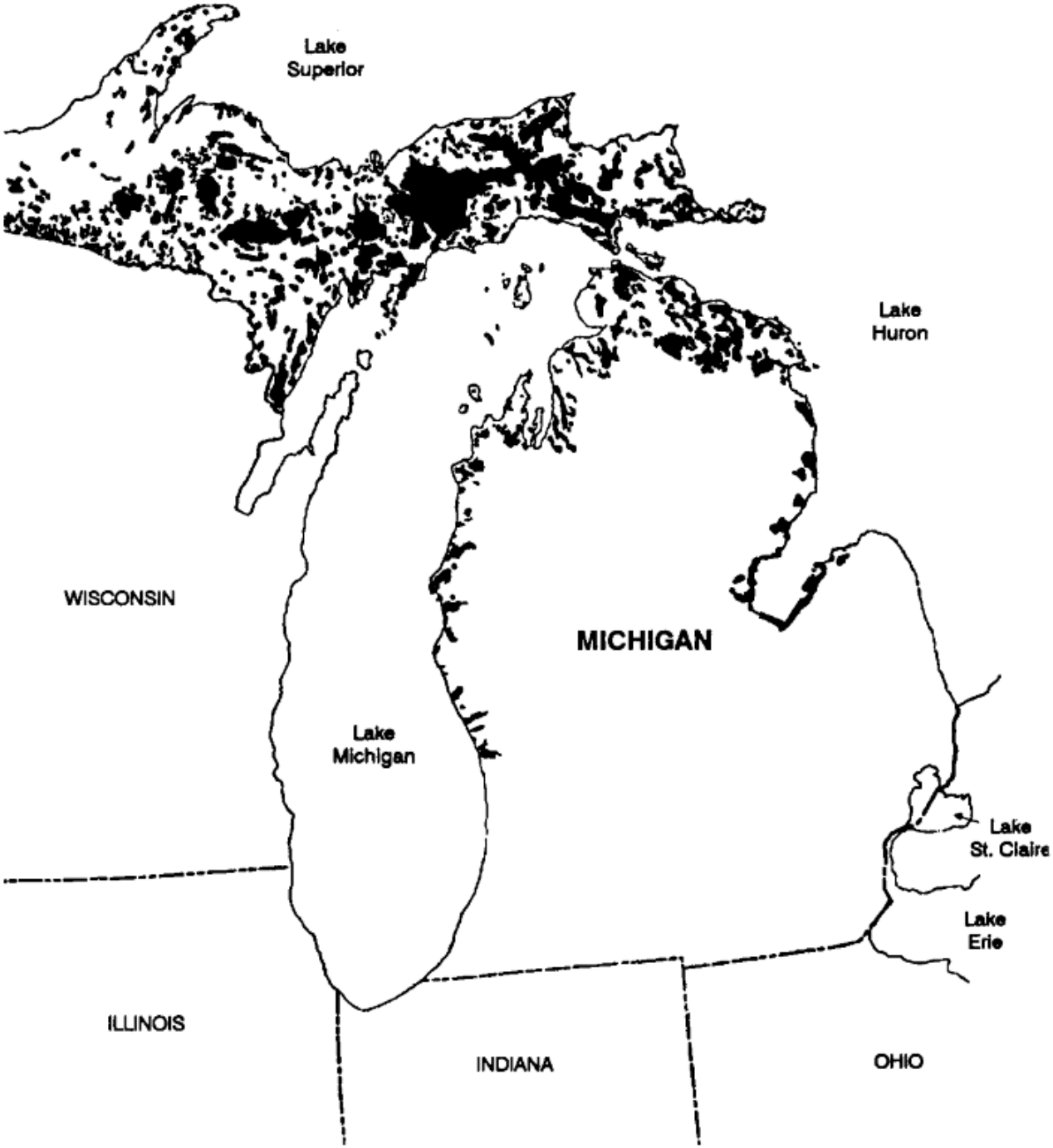
- The genus *Thuja* contains about 5 species world-wide native to North America [2] (*T. plicata* and *occidentalis*) and Asia [3] (Japan and China).
- Related to cypress, redwoods, sequoia, western red cedar, fitzroya, juniper, but not cedars (*Cedrus*).
- There are no recognized subspecies, varieties, or forms.
- Arborvitae "tree of life" A awful-tasting tea of cedar reportedly cured early European explorers of scurvy, perhaps, because of a high vitamin C content.

Area:

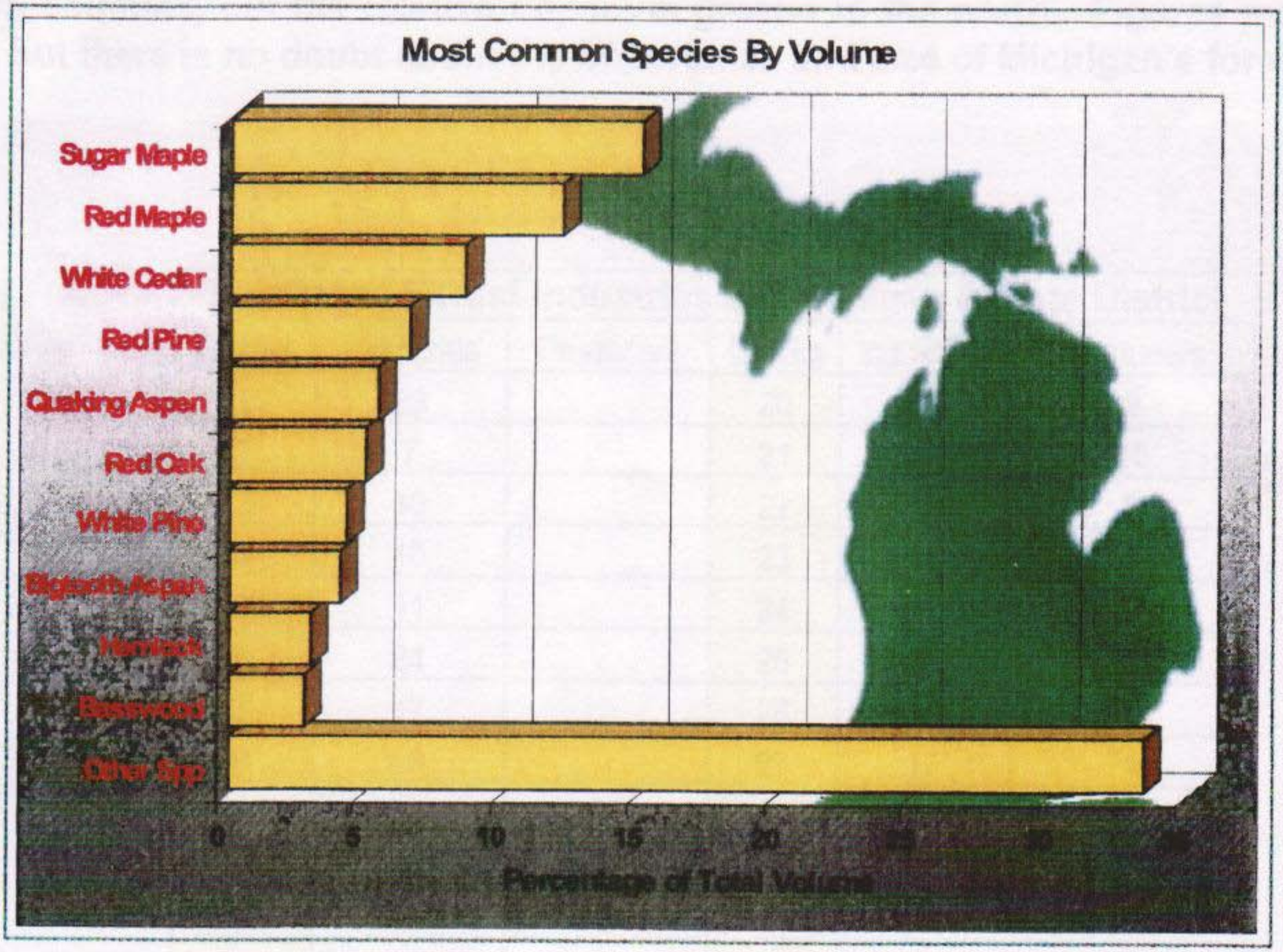
540,000 ha in MI (2,085 sq miles)

370,000 ha in UP (1,429 sq miles)

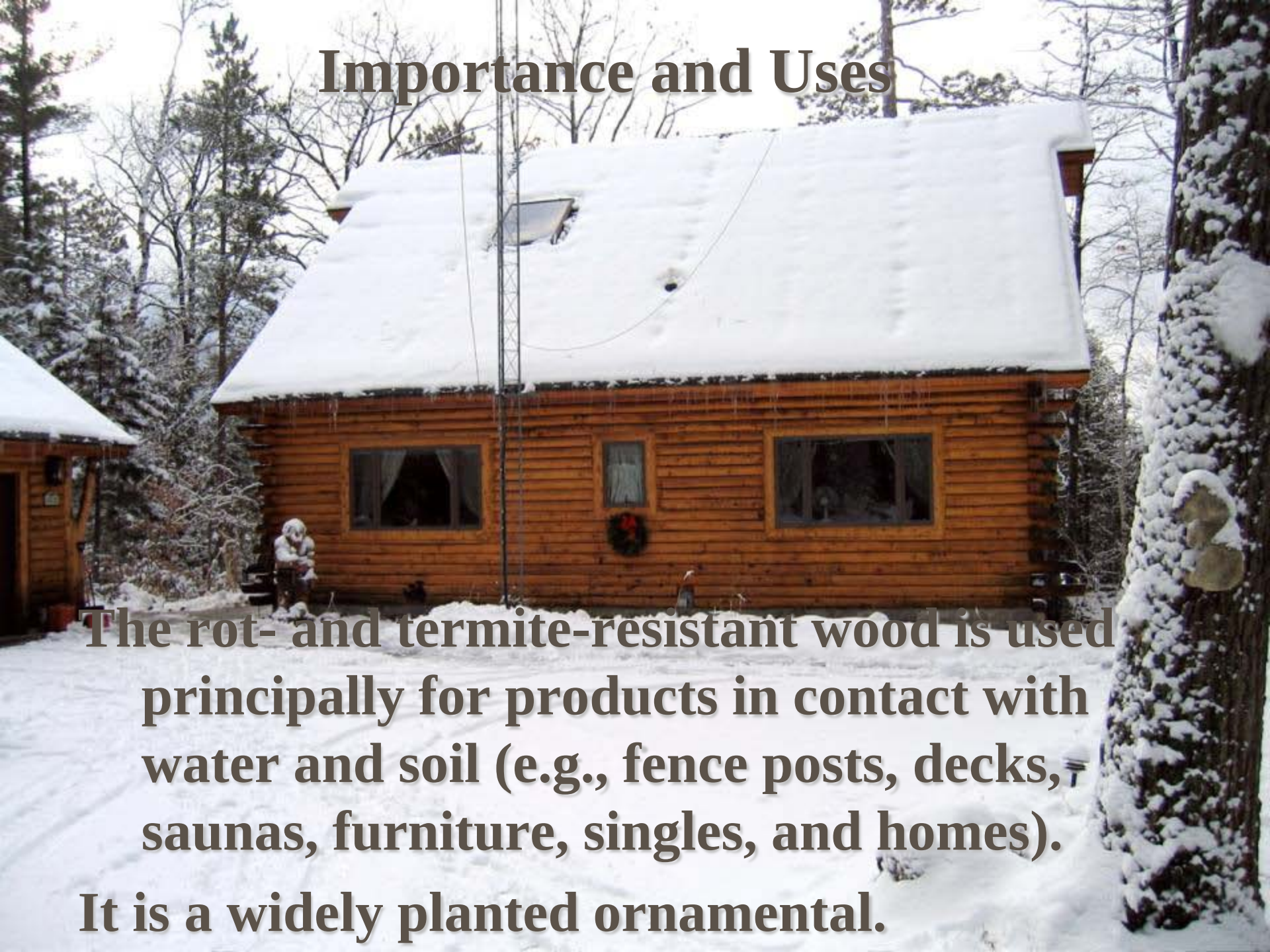




Forested wetlands in N. Michigan


Most Common Species By Volume
Sugar Maple
Red Maple
White Cedar
Red Pine
Quaking Aspen
Red Oak
White Pine
Bigtooth Aspen
Hemlock
Basswood
Other Spp
0
5
10
15
20
Percentage of Total Volume

Importance and Uses



The rot- and termite-resistant wood is used principally for products in contact with water and soil (e.g., fence posts, decks, saunas, furniture, singles, and homes).

It is a widely planted ornamental.

Importance

- Northern white-cedar is valuable for wildlife habitat, particularly for deeryards during severe winters for thermal cover and browse.
- White-cedar is also utilized by such mammals as the snowshoe hare, porcupine, and red squirrel. Its browse is generally rated as highly preferred by hares and is sometimes heavily utilized.
- Birds common in white-cedar stands during the summer include several warblers (northern parula, black-throated green, blackburnian, black-and-white, and magnolia), white-throated sparrows, and kinglets. The pileated woodpecker commonly excavates cavities in mature white-cedars to feed upon carpenter ants.

Habitat

- Northern white-cedar grows on both uplands and lowlands.
- The uplands are primarily seepage areas, old fields, and limestone cliffs and boulder fields.
- Northern white-cedar generally grows best on limestone-derived soils that are neutral or slightly alkaline and moist but well drained.

Habitat

- The lowland sites include swamps, streambanks, moist riparian and lakeshores.
- NWC is dominant in rich swamps that have a strong flow of mineral-rich groundwater (pH>7, Ca>20 ppm).
- Organic soils (peat) are usually moderately to well decomposed (sapric), 0.3 to 1.8 m (1 to 6 ft) thick, and often contains rotted wood (Carbondale and Tawas Mucks).

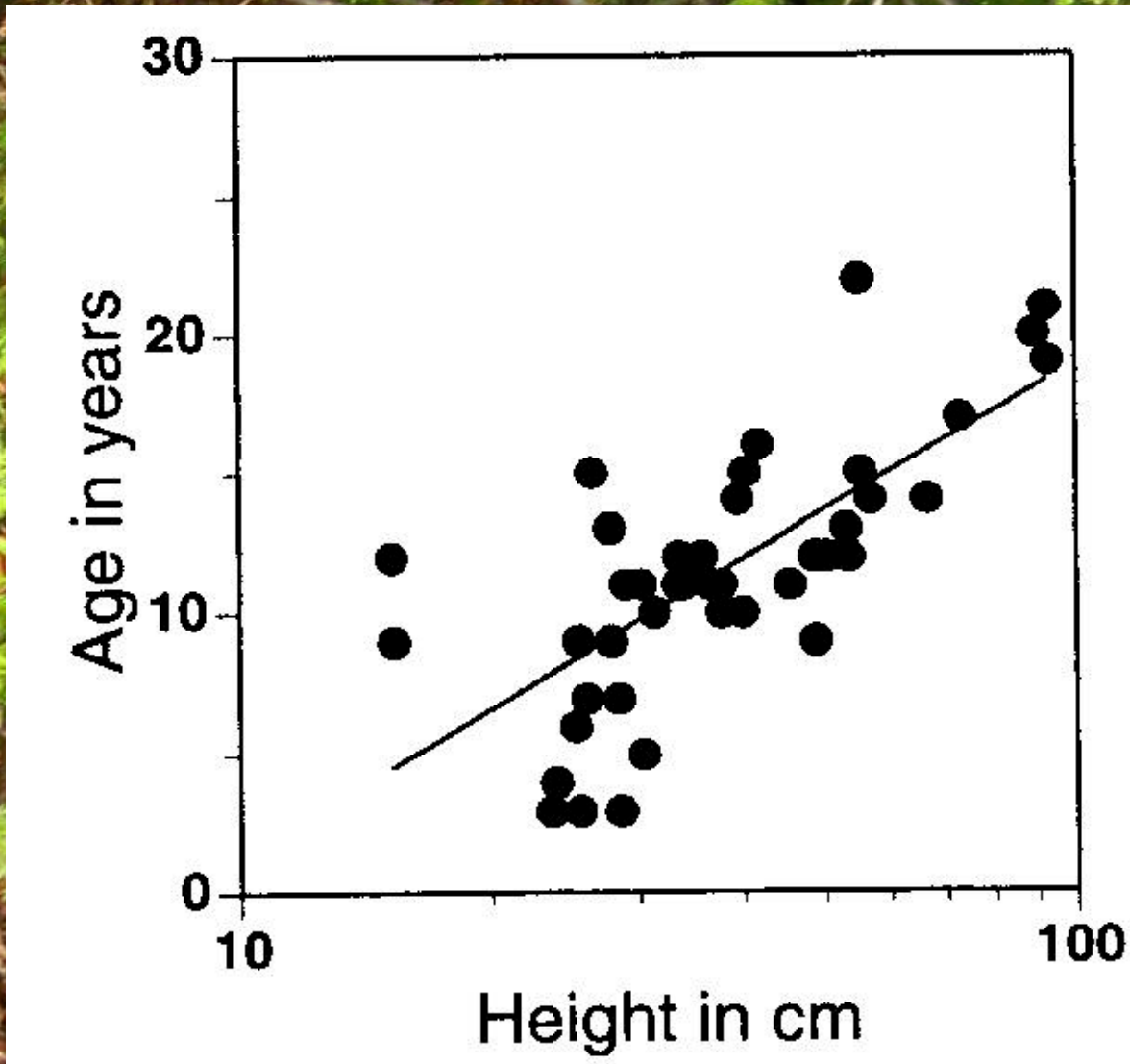
Size & Age

- Northern white-cedar is a medium-sized tree, commonly 12 to 15 m (40 to 50 ft) tall and 30 to 60 cm (12 to 24 in) in d.b.h. at maturity.
- Growth is often best on upland sites, especially on the limestone soils along Lake Michigan.
- The record tree in Michigan measures 175 cm (69 in) in d.b.h. and 34 m (113 ft) in height.
- Cedar can live to be several hundred years old, one of our longest-lived U.P. tree species. Oldest cedar found is over 1,200 years old.

Ecology

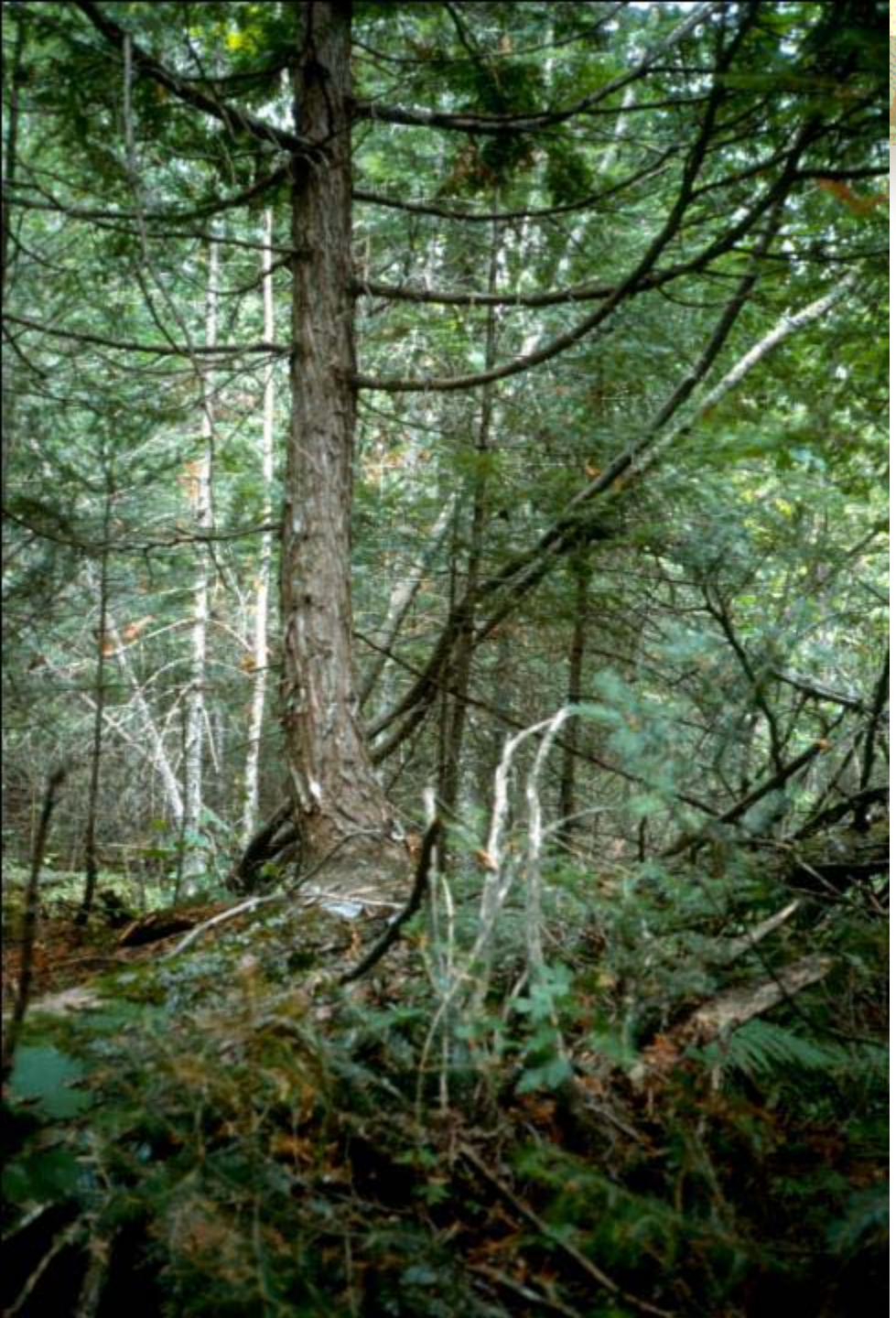
- Cedar are shade tolerant, slow growing and long-lived pioneer trees.
  - Do not fit traditional successional models
  - Can be pioneer and climax species!
  - Maybe better to think of them as stress-tolerant, not shade tolerant (xeric-hydric)

Slow growth rates



Seeds

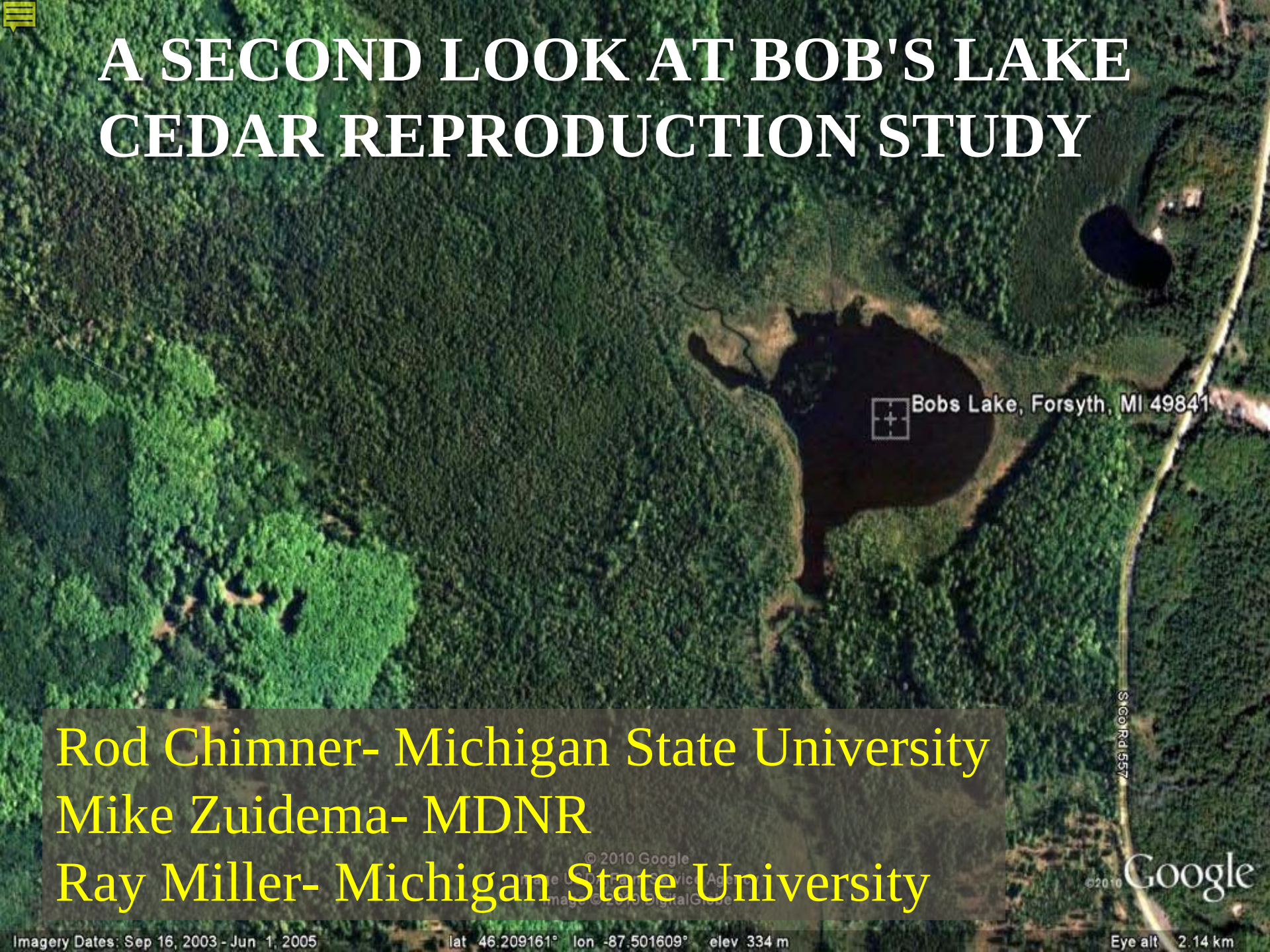
- Seed production starts ~30 years old and is best after 75 years (60,000 to 260,000 seeds).
- Seeds have only slight internal dormancy (winter).
- Viable in the forest floor~1 year.
- Nurselogs account for more than 70 percent of the seedlings.
- Can also germinate on decayed litter, peat or humus, and sphagnum moss.
- Seedling growth is slow. Annual height growth averages 3 inches (8 cm) in the first few years.



Vegetative Reproduction

- Northern white-cedar can send out roots from any part of a branch or stem if moisture conditions are favorable **(adventitious rooting).**
- Layering generally accounts for more than half the stems of white-cedar reproduction in northern Michigan swamps.
- Cedar also reproduce asexually by tree fall leaving a straight line of trees.

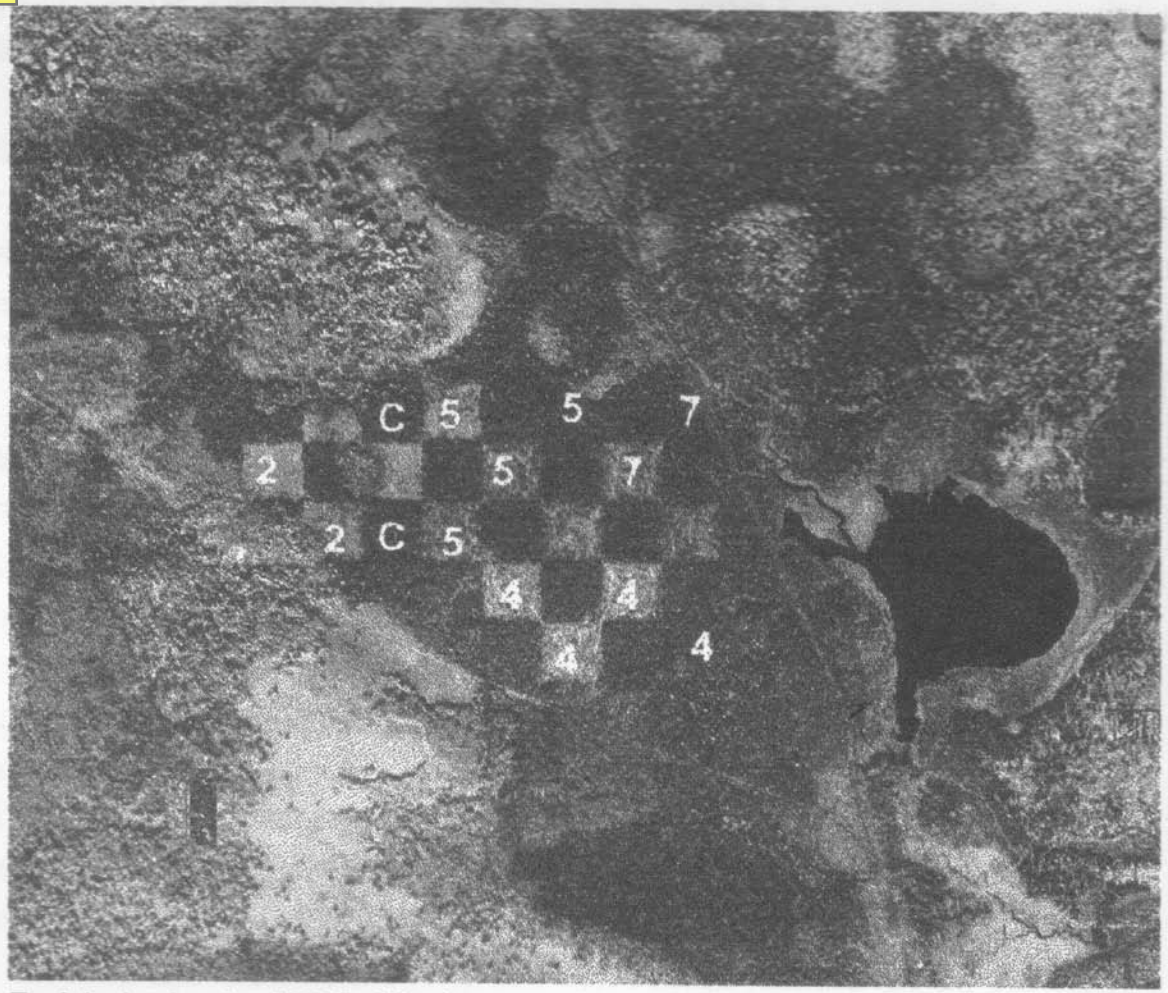
A SECOND LOOK AT BOB'S LAKE CEDAR REPRODUCTION STUDY



Rod Chimner- Michigan State University
Mike Zuidema- MDNR
Ray Miller- Michigan State University

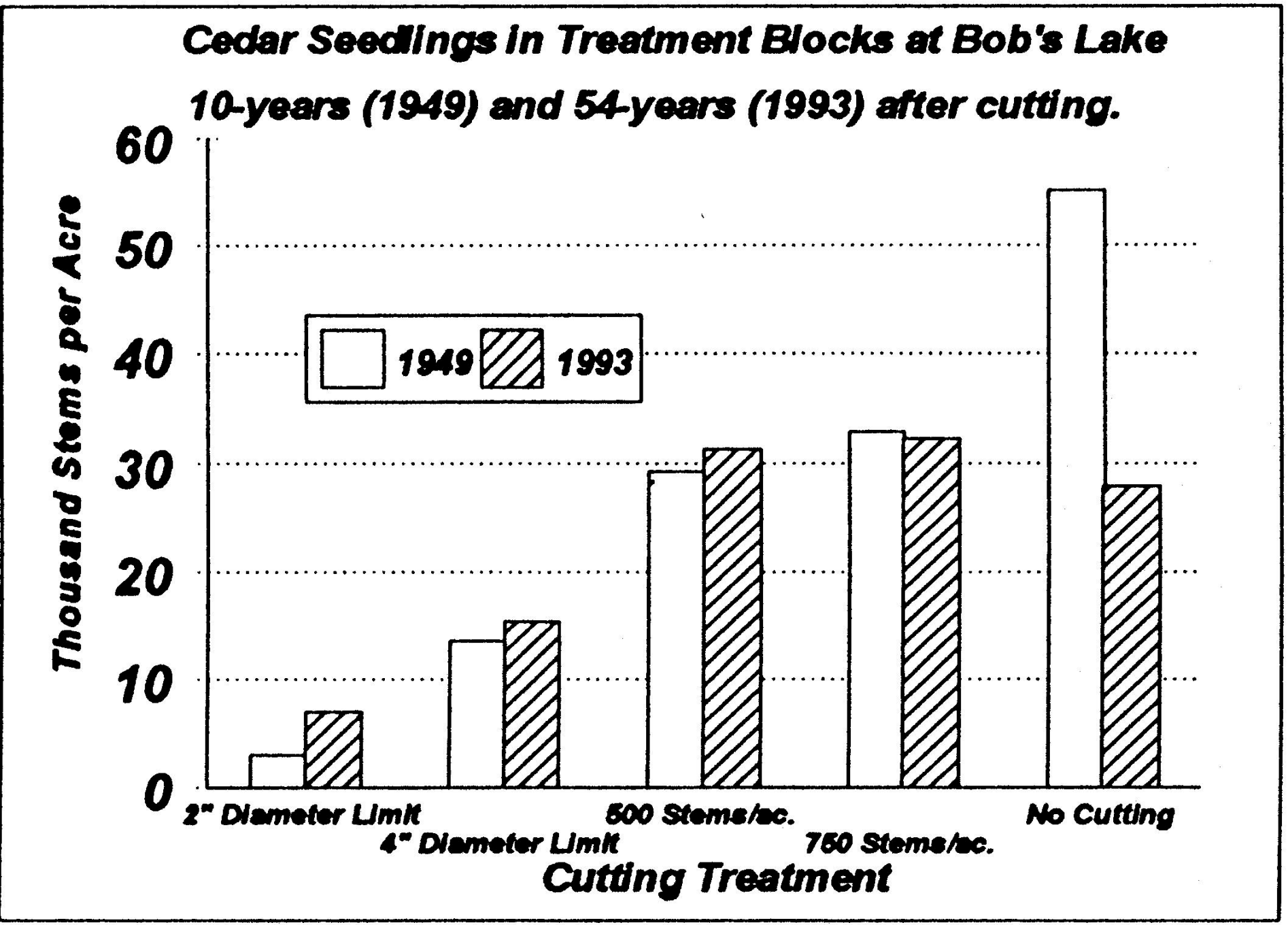
Table 1. Plots selected for regeneration study (Plot numbers).

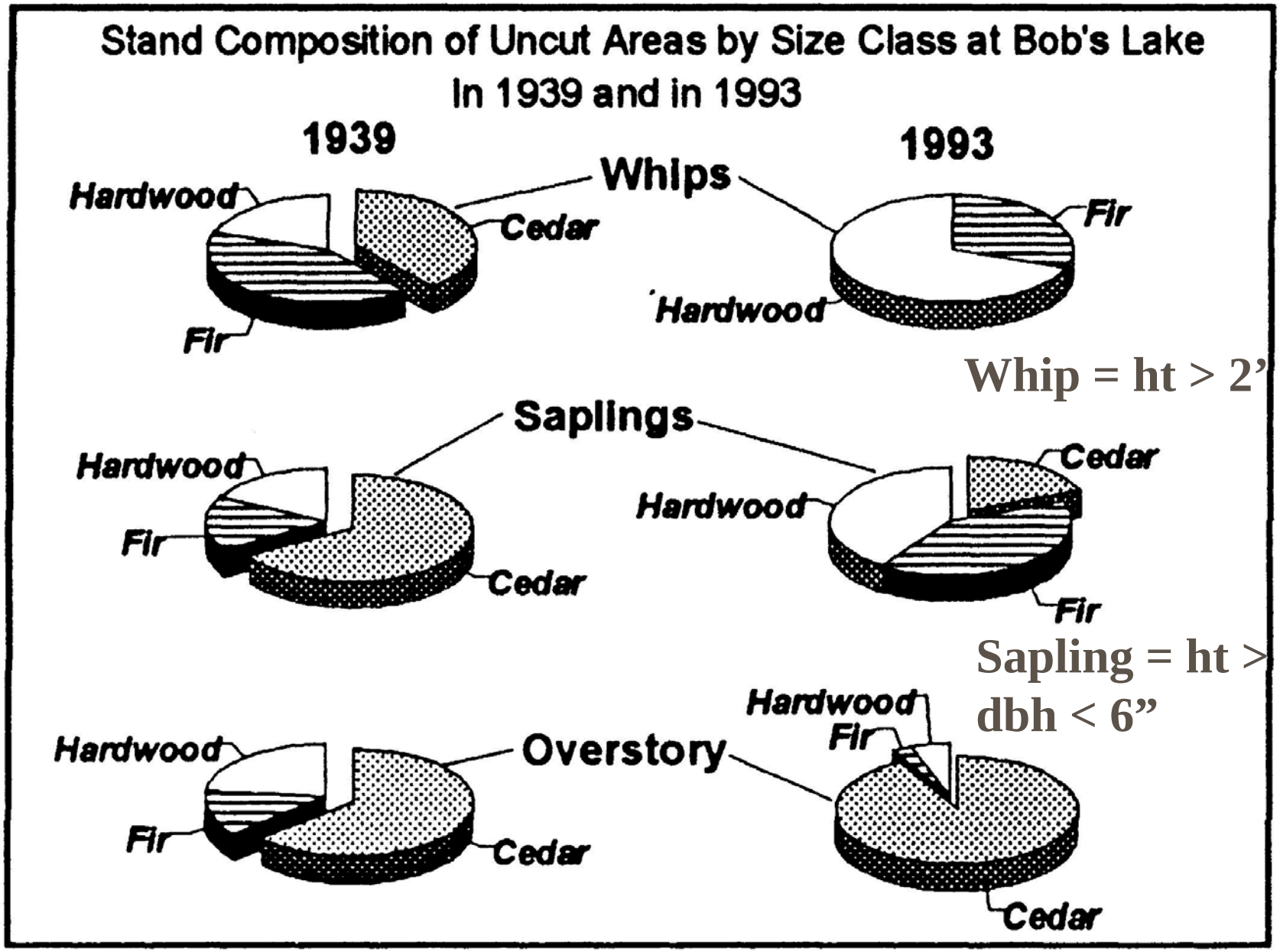
Cutting methods	Slash disposal methods		
	Pile and burn	No slash	Lop and scatter
Cut all material over 2" dbh			24,26
Cut all material over 4" dbh	34,40		36,38
Selective cut to 500 stems per acre	12,14		20,28
Selective cut to 750 stems per acre	16		18,32
Uncut check		11,27	



Bob's Lake in **1939** (during cutting). Note the regrowth on the ridge to the north-west and the absence of regrowth on the ridge in the south-west corner of the photo. Treatment blocks are identified as follows: C=no cutting, 2=2" diameter limit, 4=4" diameter limit, 5=500 stems per acre, 7=750 stems per acre. Three treatment blocks in the north-east and south-east corners had not yet been cut when this photo was taken.

Data from Miller and Chimner 1995





Whip = ht > 2’ & < 8’

Sapling = ht > 8’ with a dbh < 6”

Overstory = dbh > 6”

Table 2. Stand composition in the Bob's lake cutting at time of establishment and 1993 (In stems per acre).

Species	Stems 2-8 feet in height		Stems 6 inches dbh and over		Total stems over 2 feet in height	
	Time of establishment	1993[1]	Time of establishment	1993	Time of establishment	1993
N. White Cedar	189	0	158	275	1007	328
Black Spruce	2	7	58	20	109	36
Balsam Fir	200	520	33	4	400	679
Aspen	4	0	0	1	16	1
Red Maple	51	49	0	0	53	49
Tamarack	7	0	0	0	9	1
Alder	31	800[2]	0	0	138	1141
Other[3]	n/a	37	n/a	21	n/a	85
Total	484	1418	249	321	1732	2320

[1]Assumed 1 inch dbh to be equal to 2-8 feet in height for summer of 1993.
[2]Alder was not seperated into 1 inch dbh class, approximately equal to 800 alder/acre.
[3]Other species include:paper birch, black ash, aspen and dogwood (*Cornus* spp. Michx.).

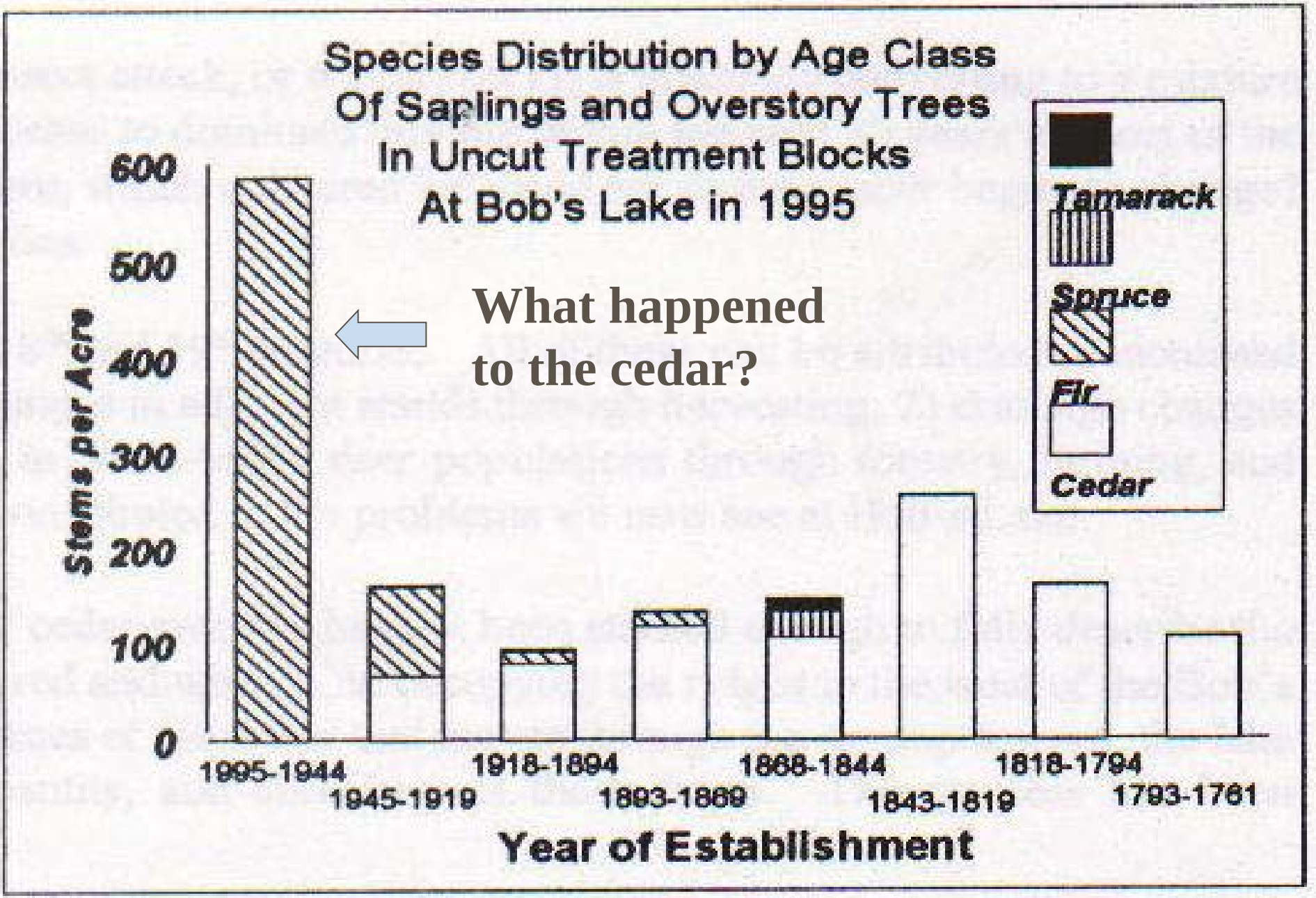
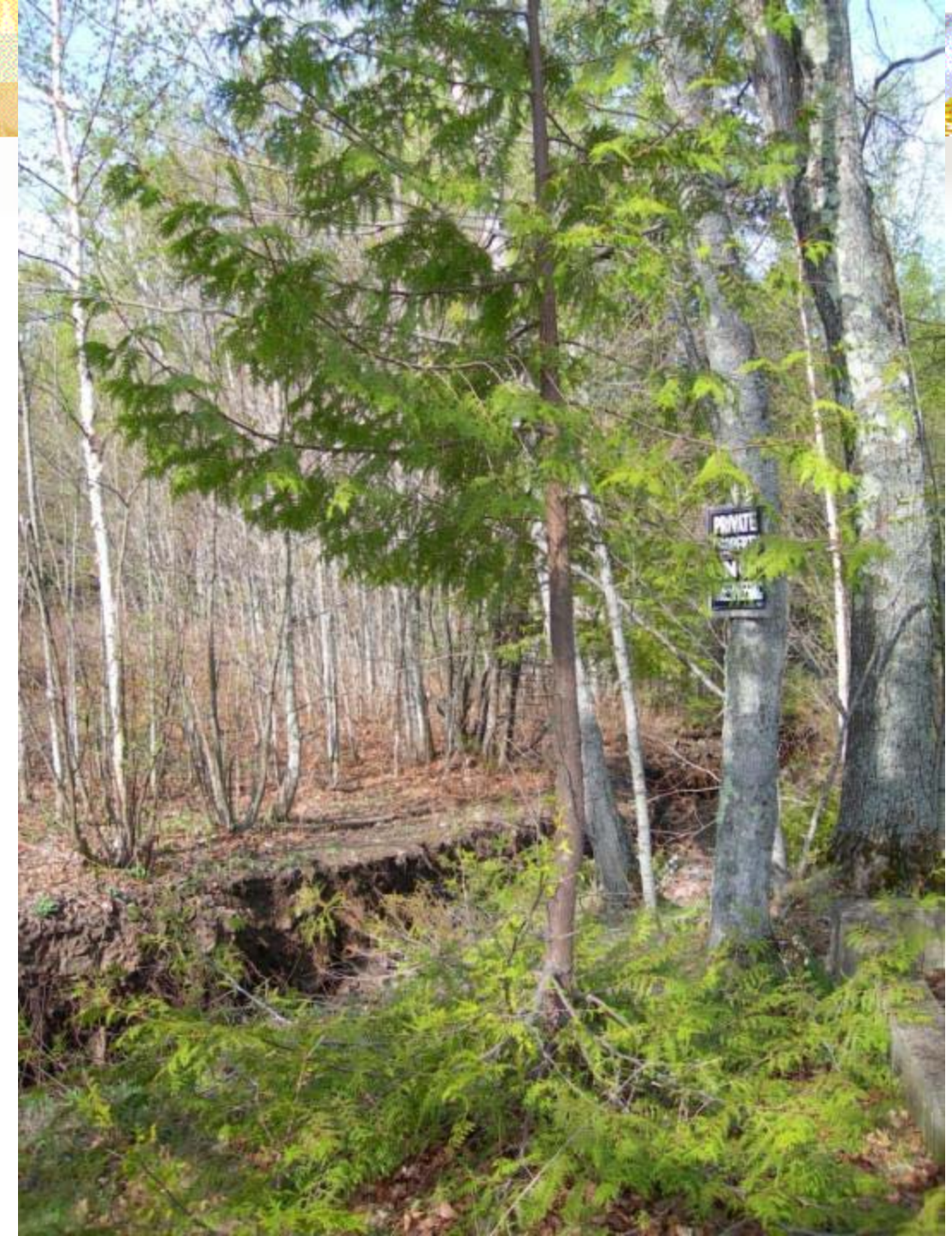
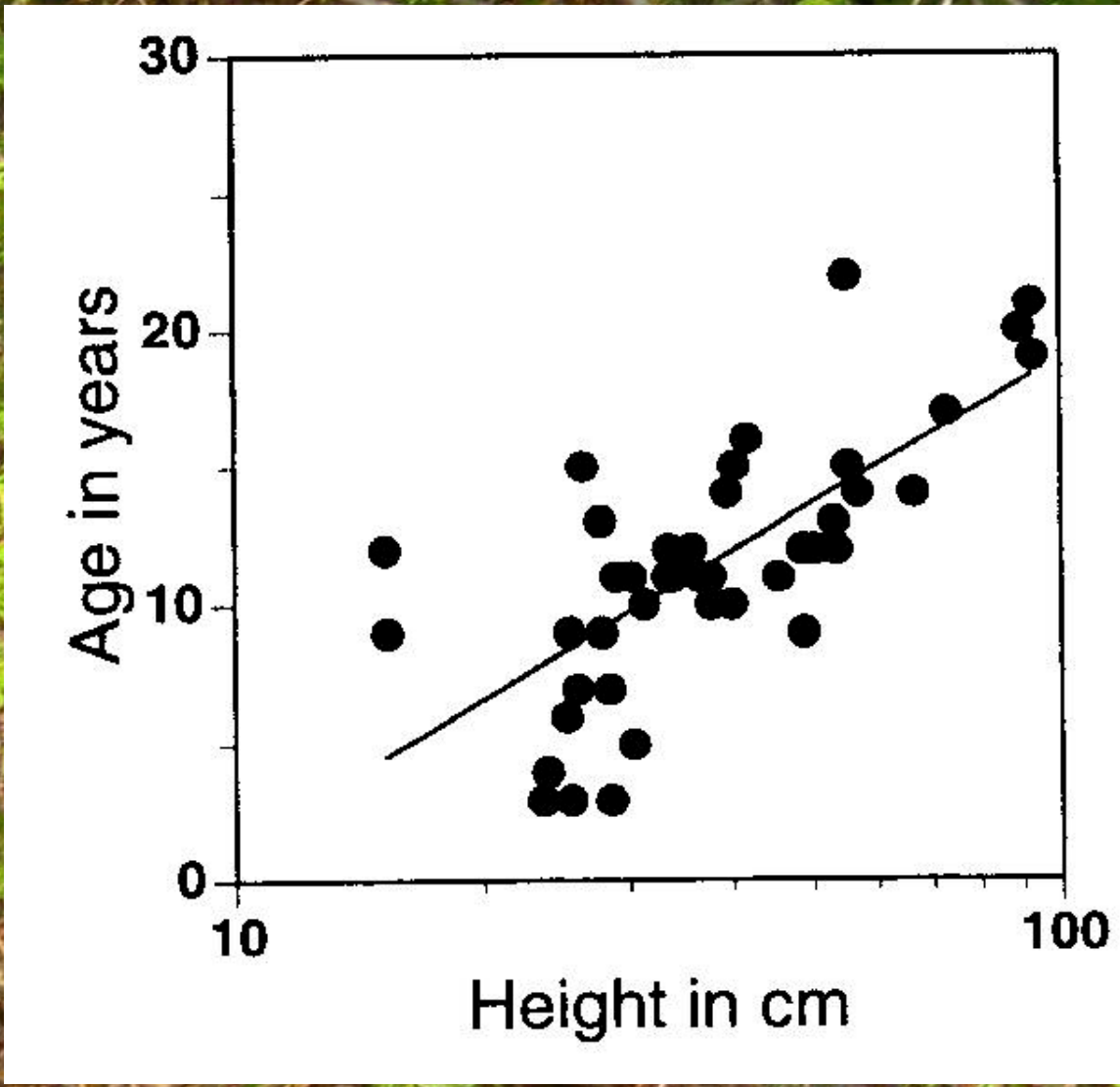


Figure 6

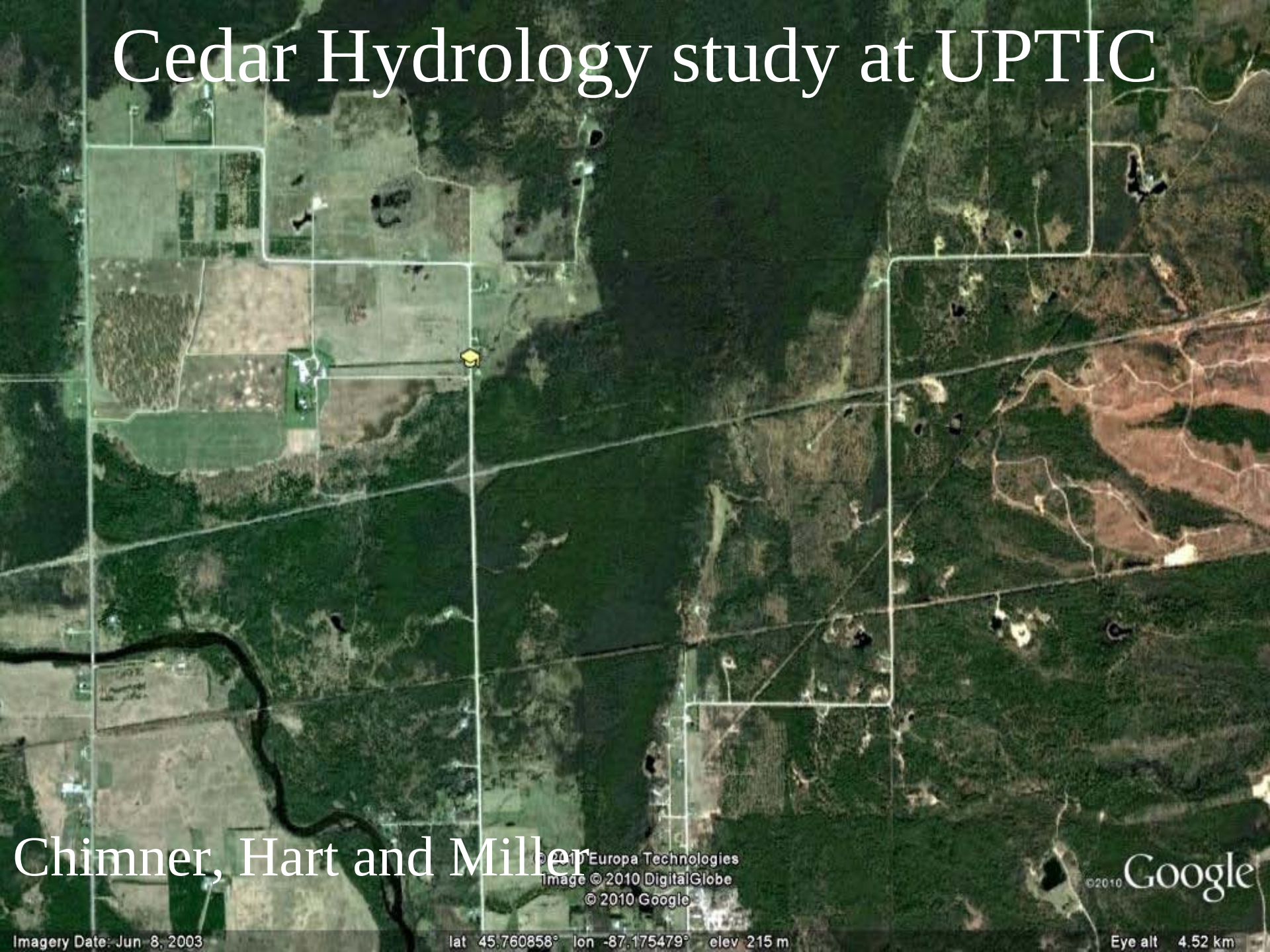
Data from Miller and Chimner 1995


PRIVATE

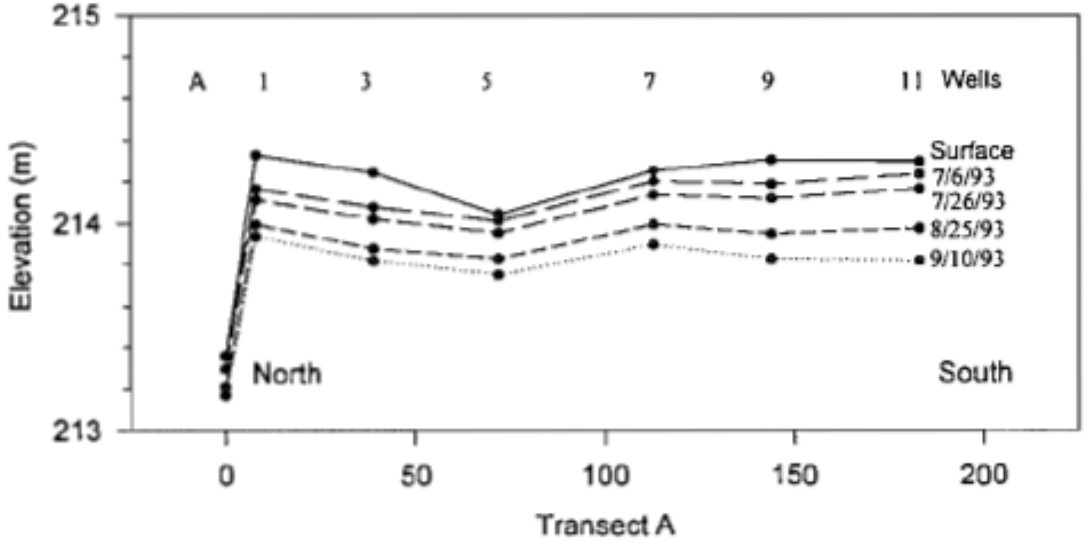
Slow growth rates

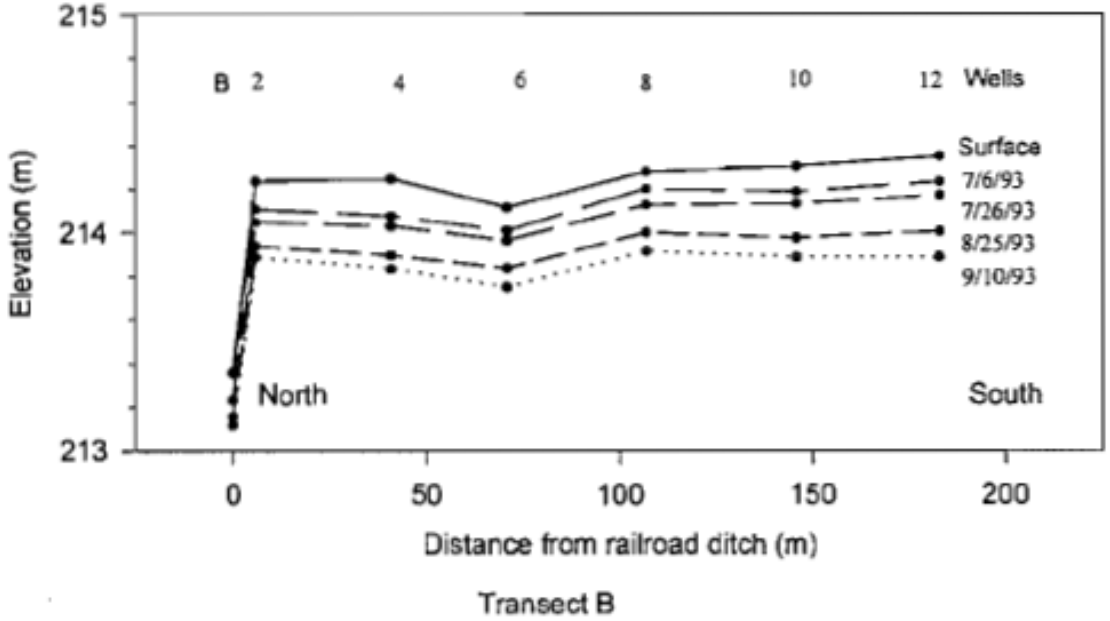


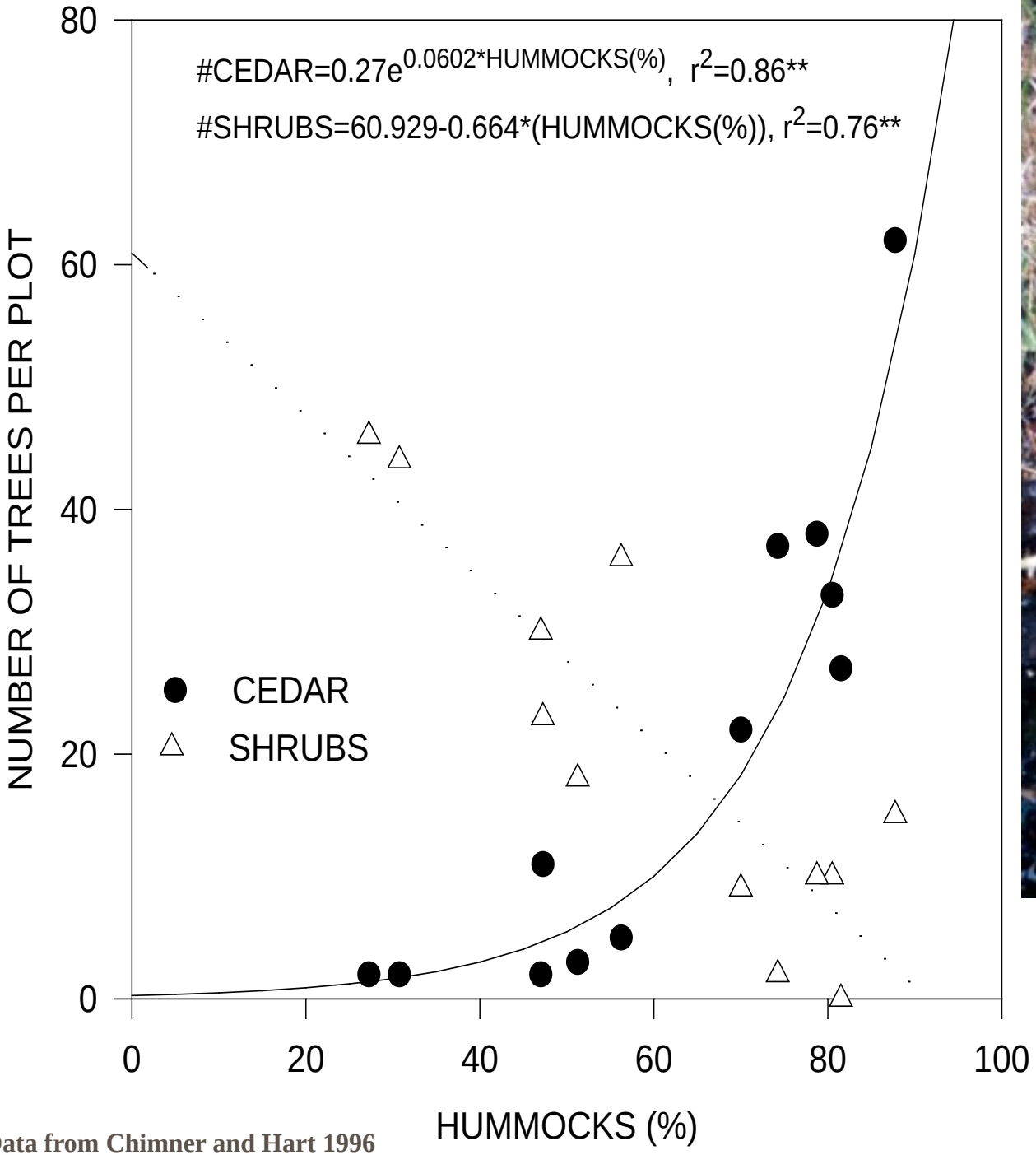
Cedar Hydrology study at UPTIC



Chimner, Hart and Miller


215
214
213
Elevation (m)
A
1
3
5
7
9
11
Wells
Surface
7/6/93
7/26/93
8/25/93
9/10/93
North
South
0
50
100
150
200
Transect A


215
214
213
Elevation (m)
B
2
4
6
8
10
12
Wells
Surface
7/6/93
7/26/93
8/25/93
9/10/93
North
South
0
50
100
150
200
Distance from railroad ditch (m)
Transect B



Data from Chimner and Hart 1996

Hydrology


117
2
© 2009 Europa Technologies
Image USDA Farm Service Agency
© 2009 Google
46°06'04.84" N 85°34'18.49" W elev 194 m
©2009 Google
Eye alt 2.70 km

MDOT Cedar Construction

MDOT Cedar Creation Project

Treatment 1 (herbivory effects)

Construct 6 exclosures and 6 controls per site

Exclosure size = 1/16 ha

Exclosures constructed out of 8’ woven wire

MDOT Cedar Creation Project

Treatment 2 (Microtopography effects)

Bucket mound exclosures with some areas left flat to create a hummock, pool and lawn features.

Hummock spacing ~ 100 per exclosure

Hummock ht = 30 cm

Pool depth = 30-50 cm

Plant 1-year-old cedar plugs (24” in height)

Plant on top of hummocks, in pools, and in lawns.

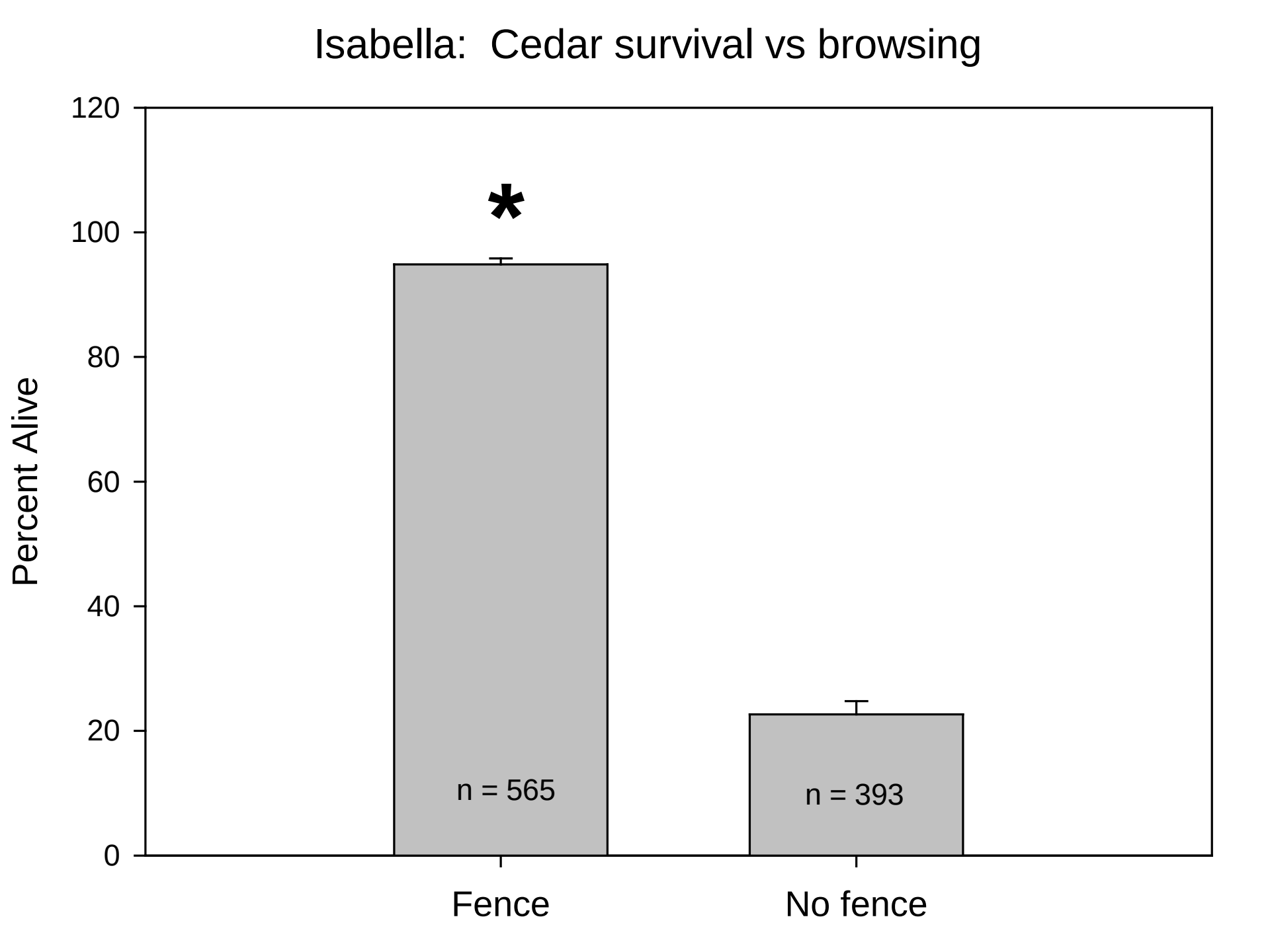
Planted at:120 trees per exclosure (778 trees/acre)

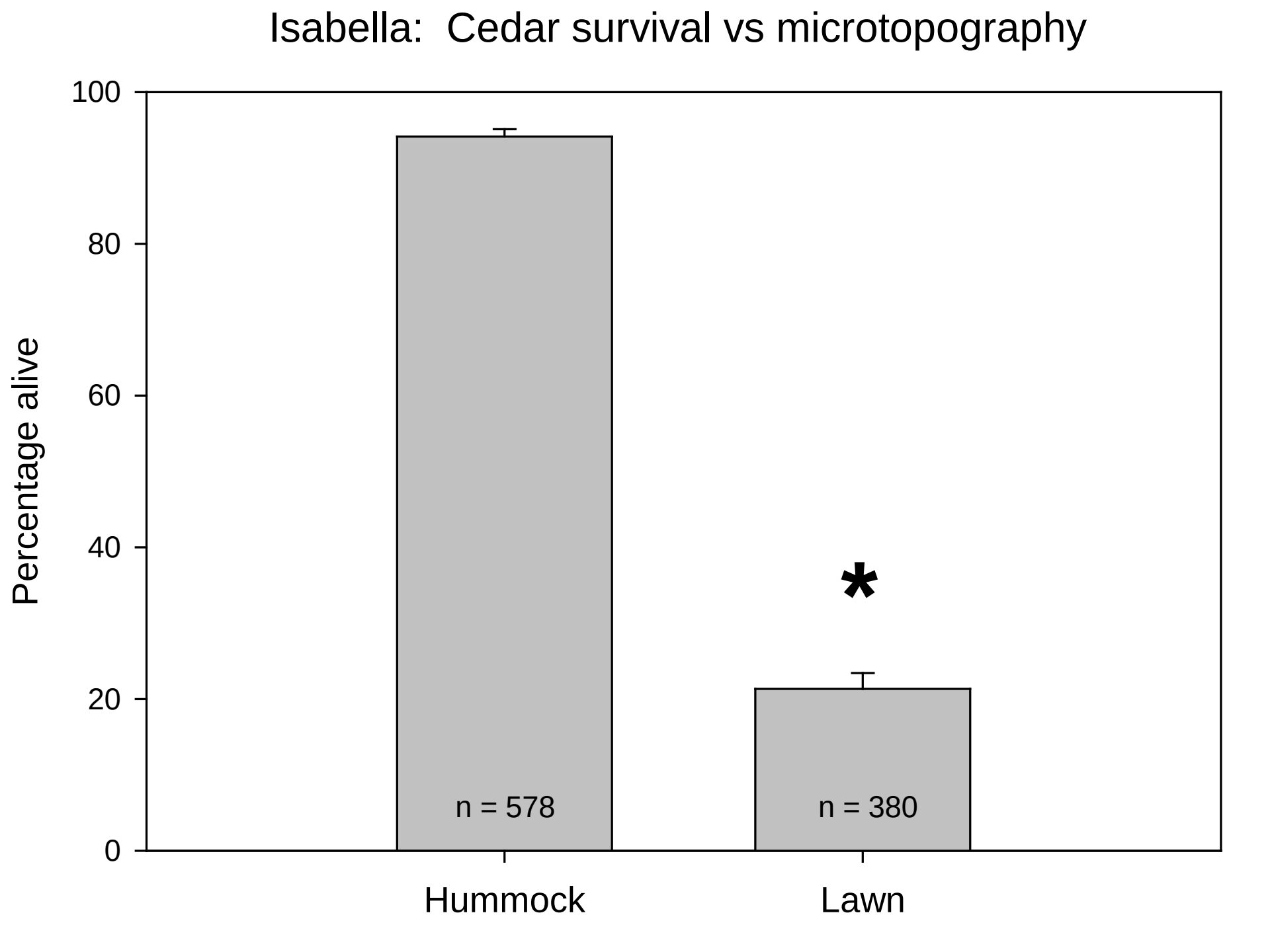
Blocked sites by area (hydrology effects).

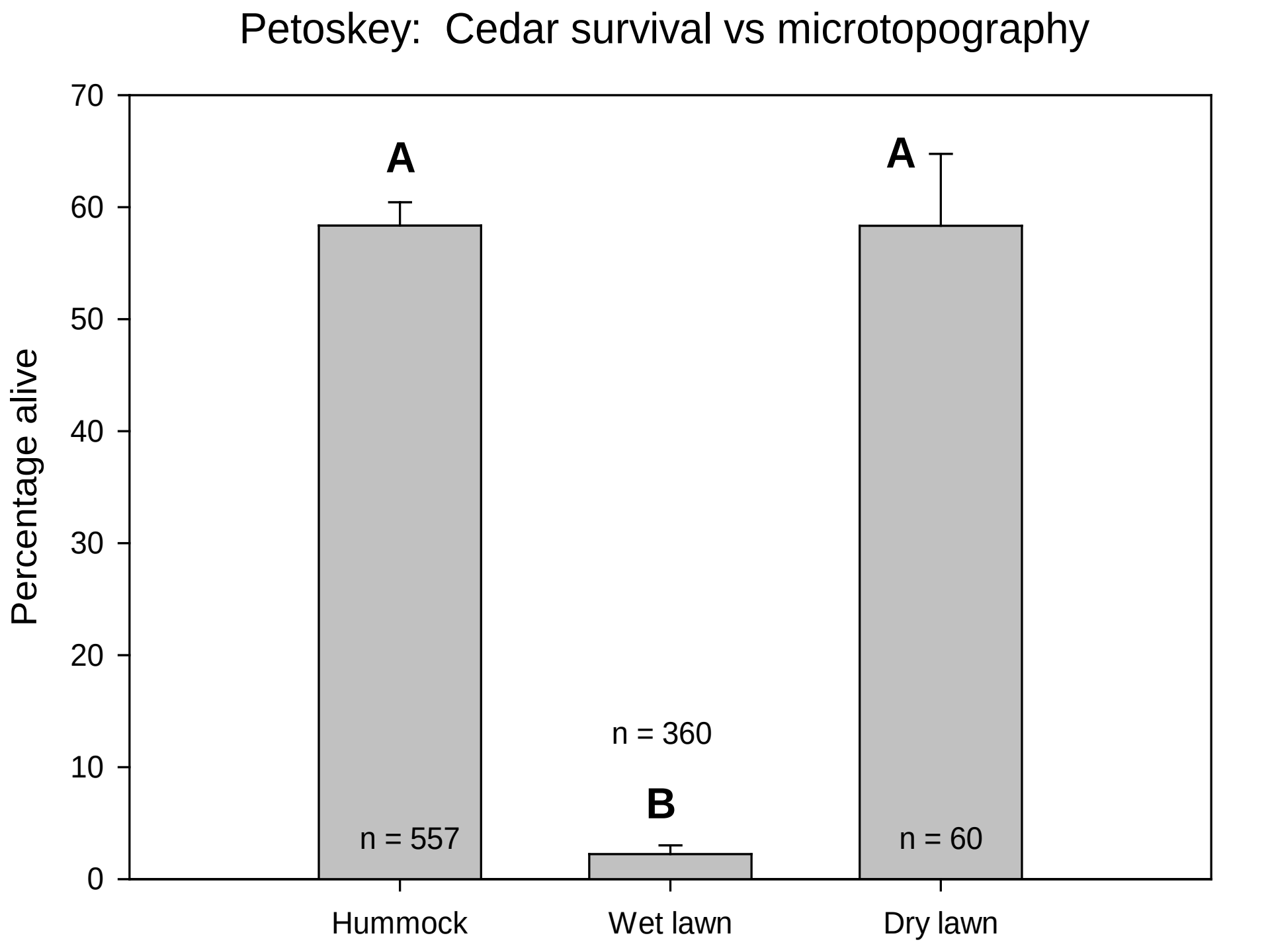
Wet to dry gradient

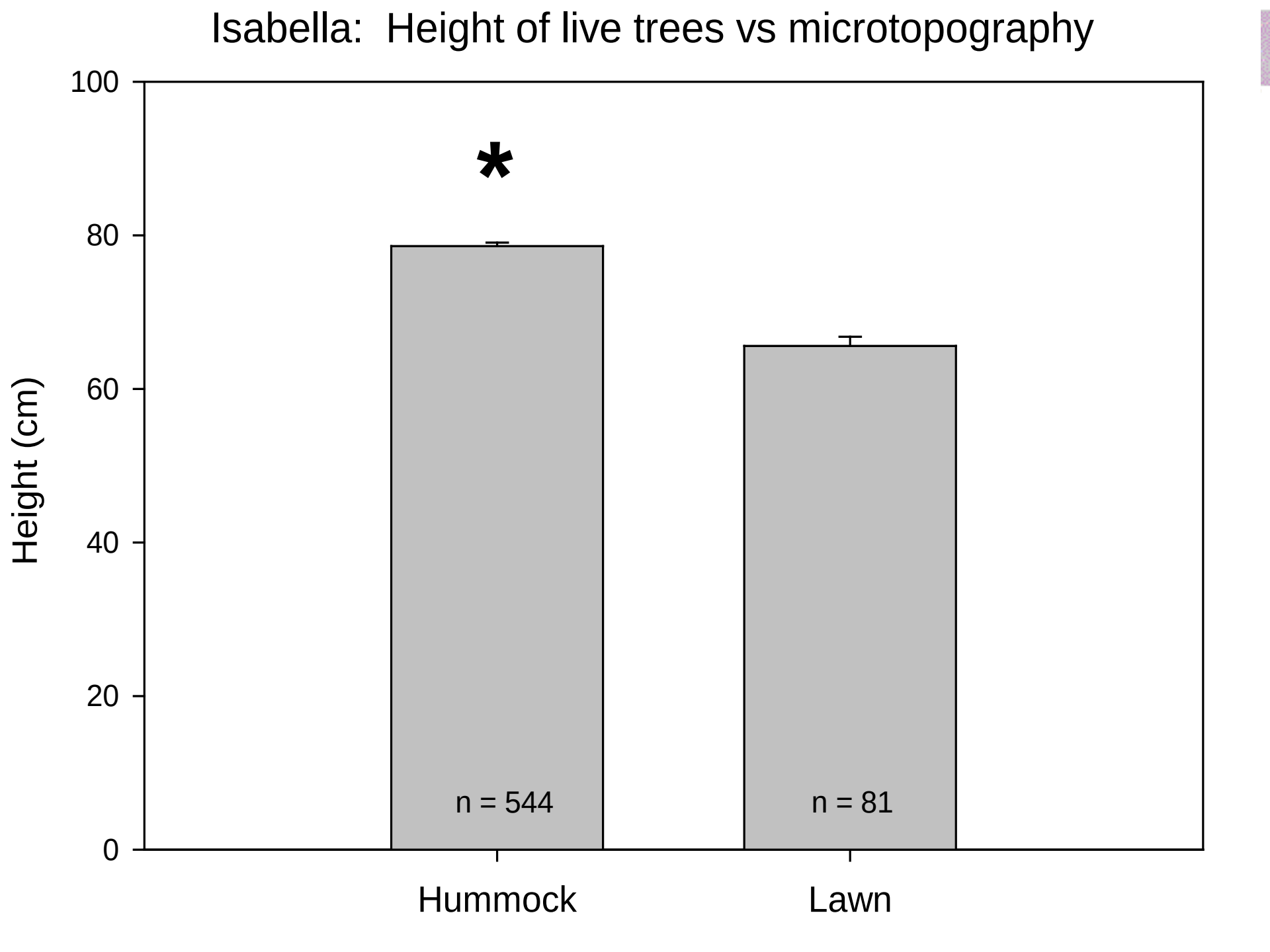

09/12/2007


09/12/2007

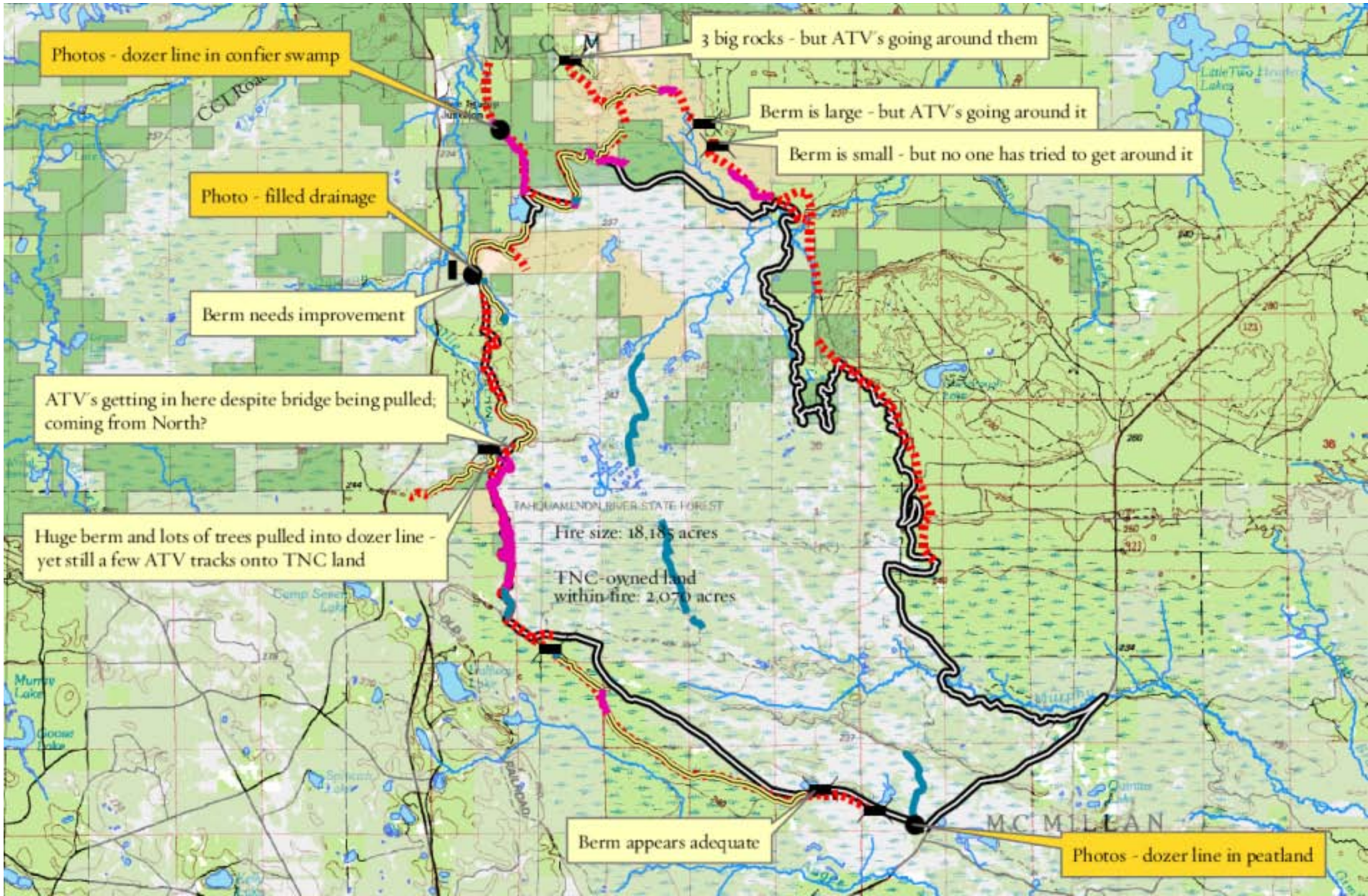

Isabella: Cedar survival vs browsing
120
100
80
60
40
20
0
Percent Alive
*
n = 565
n = 393
Fence
No fence


Isabella: Cedar survival vs microtopography
Percentage alive
100
80
60
40
20
0
*
n = 578
n = 380
Hummock
Lawn

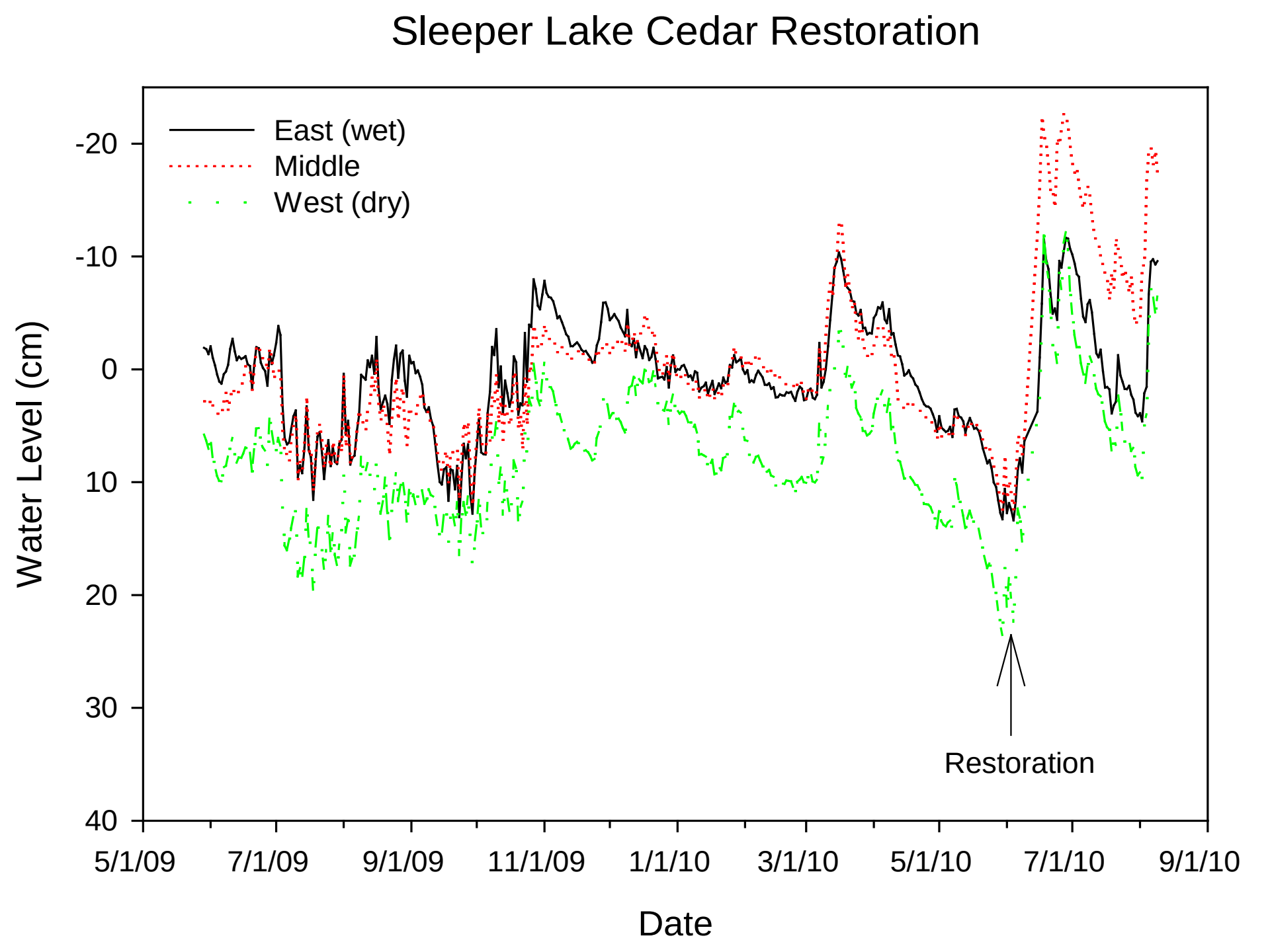

Petoskey: Cedar survival vs microtopography
Percentage alive
70
60
50
40
30
20
10
0
A
A
B
n = 557
n = 360
n = 60
Hummock
Wet lawn
Dry lawn


Isabella: Height of live trees vs microtopography
Height (cm)
100
80
60
40
20
0
*
n = 544
n = 81
Hummock
Lawn

Sleeper Lake Fire-2007




CASE
CX160B
CASE


Sleeper Lake Cedar Restoration
East (wet)
Middle
West (dry)
Restoration
Water Level (cm)
-20
-10
0
10
20
30
40
5/1/09
7/1/09
9/1/09
11/1/09
1/1/10
3/1/10
5/1/10
7/1/10
9/1/10
Date

Management Options

- Thinning: Hannah (2004) recommends:
  - Intermediate thinning
    - However, some studies have shown that cedar can respond to release (however, just barely!), while other indicate that they do not.
    - NWC is areas with greater groundwater flow responded more than in low flow areas.

Management Options

- Harvesting: Recommended treatments include:
  - Clearcutting
    - small blocks
    - narrow strips
    - rotating clear cuts
  - Uneven age selection methods
  - Partial cutting, group selection, and diameter limit cutting is discouraged in deer yards because they reduce available browse
  - Most argue that no silvicultural treatment can be recommended due to inconsistent results

Management Options

- Slash handling: Recommended treatments include:
  - Burning
  - Removal
  - Windrowing
  - Scattering

Confusion: slash is often principle food source for deer in cut area, luring deer away from seedlings and saplings. But slash inhibits initial seedling growth. However, dense slash provides protected refuge areas that may be the only areas to regenerate any cedar.

Management Options

- Site Preparations: Recommended treatments include:
  - Burning (reduce sphagnum, blacken soil, bare soil, pH)
  - Mechanical scarification (grind and mix soil)
  - Micro site modification (bedding, furrowing and mounding)
  - Drainage (increased aeration, but unlikely today)
  - pH and fertility adjustments

  Caveat: These methods have been poorly tested and outcomes are unknown.

Management Options

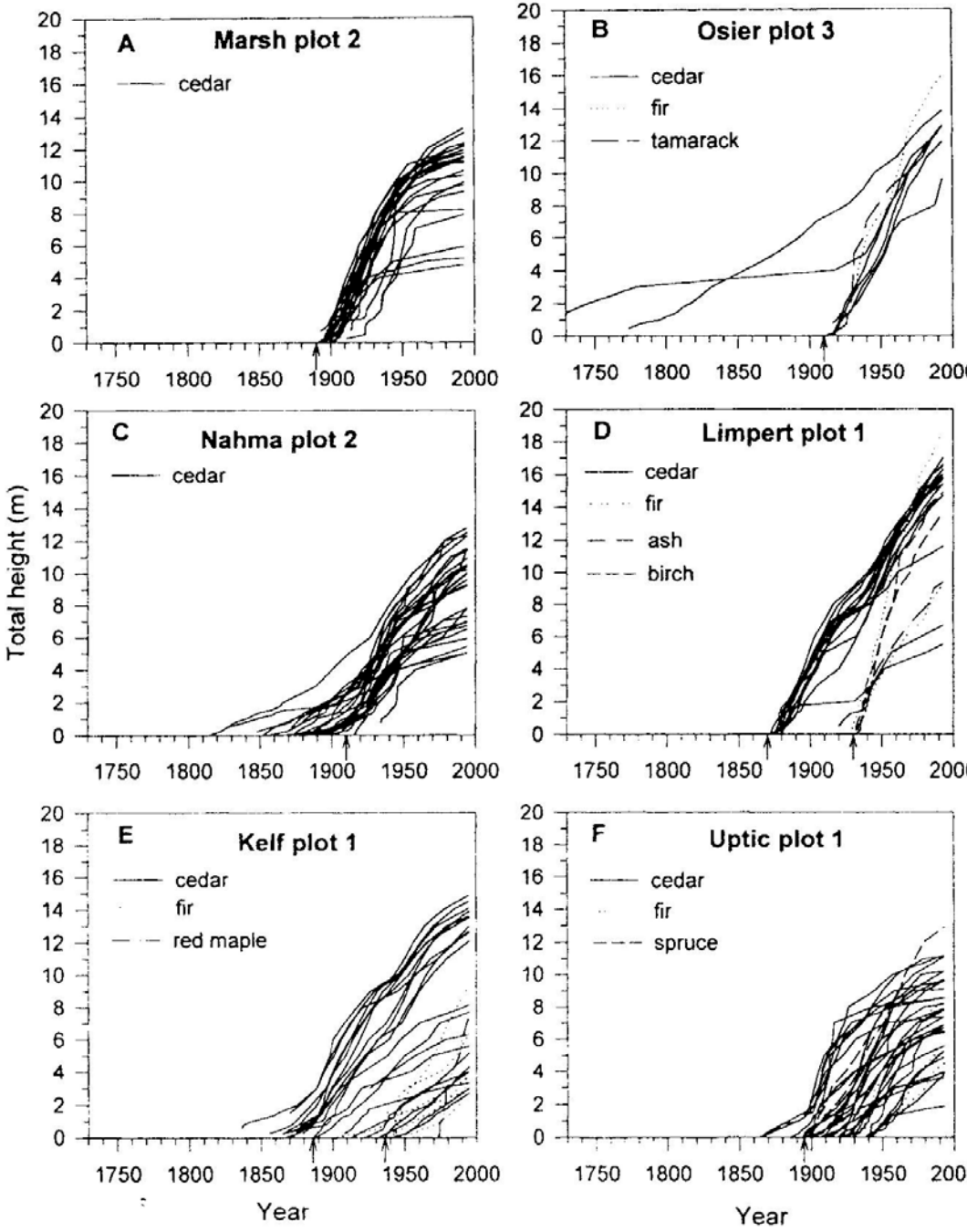
- Wildlife Control: Recommended treatments include:
  - Exclosures ($$)
  - Lure animals away by feeding
  - Reduce populations
  - Introduce predators
  - More snow??

Most of the current cedar came in after large disturbance events (logging) between 1870 and 1935. Only 3% of all cedar established after 1945.

Likely disturbance released existing seedlings/saplings

What was the pre-logging forest like?

Why haven't logging events regenerated cedar in the last 70 years?



Data from Heitzman et al. 1997

Management Options

- Regeneration Methods: Recommended treatments include:
  - From seed (limited dispersal distance)
  - Plantings (expensive and hard to find)
  - Layering (poor form)
  - Type conversion (allow balsam fir and alder)
  - Encourage advanced regeneration?

Other issues besides deer

- Available substrates (logs, mounds, ect.)
- Distance to road was found to correlate with cedar regeneration (close to roads had more browsing and altered hydrology).
- Altering hydrology with site prep

Habitat

Found along streams and drainageways; adjacent to inland lakes; in abandoned embayments and interdunal swales along the Great Lakes; and also in depressions in outwash plains, till plains, and lake plains, these forests are a defining feature of northern Michigan landscapes. Organic muck or peat soils are acid at the surface, but subsurface soil layers may be neutral or slightly alkaline in pH, especially where they overlie limestone or dolomitic bedrock (e.g., along the Lake Huron shore in the northeastern Lower Peninsula and throughout the eastern Upper Peninsula). Structure and composition of these forests are strongly influenced by a constant flow of cold, mineral-rich groundwater through the soil. Trees tend to be very shallow rooted because of saturated soils. Wind, therefore, is the major disturbance, typically creating an untidy tangle of uprooted and leaning trees. Fires are rare, occurring only after prolonged periods of drought. These swamps are one of the most floristically diverse forest communities in Michigan.

- GENERAL BOTANICAL CHARACTERISTICS : Northern white-cedar is a monoecious, native, evergreen tree with a narrow, almost columnar crown. Branches on open-grown trees extend to the ground. The trunk is often divided into two or more secondary trunks of equal size. Northern white-cedar has scalelike foliage and fibrous, sometimes shredding bark [25,26]. At maturity northern white-cedar is 40 to 50 feet (12-15 m) tall and 12 to 24 inches (30-60 cm) in d.b.h. Infrequently it reaches heights of 70 to 80 feet (21-24 m) and diameters of 48 to 60 inches (120-150 cm) [26]. This species is extremely slow growing; after 50 years, it might reach 40 feet (12 m) in height on good sites, but only 15 feet (4.6 m) or less on poor sites [27]. Northern white-cedar reaches ages in excess of 800 years [5,32]. Two trees on the Niagara Escarpment in southern Ontario were dated at 935 and 1,032 years [32]. Seedlings develop deep roots in well-drained soil and shallow roots in saturated soil. With age, northern white-cedar develops a widespreading root system which is well adapted to secure water and nutrients from cracks in rocks [26].

Data from Rooney et al. 2002

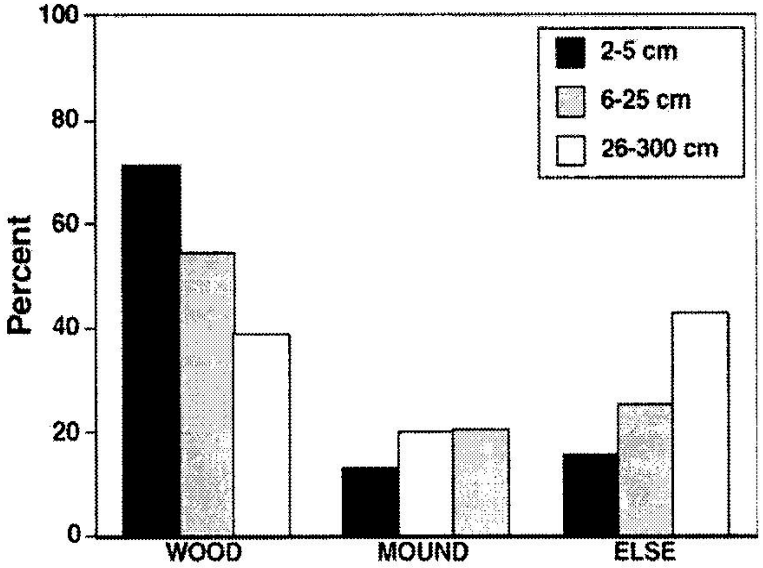


Fig. 4. The observed proportion of seedlings, small saplings, and large saplings growing on decaying wood (WOOD), raised mounds (MOUND), or other (ELSE) substrates during the 1990–1991 field season. Sample sizes were: $n = 3303$ (seedlings 2–5 cm), $n = 1448$ (small saplings 6–25 cm), and $n = 799$ (large saplings 26–300 cm).

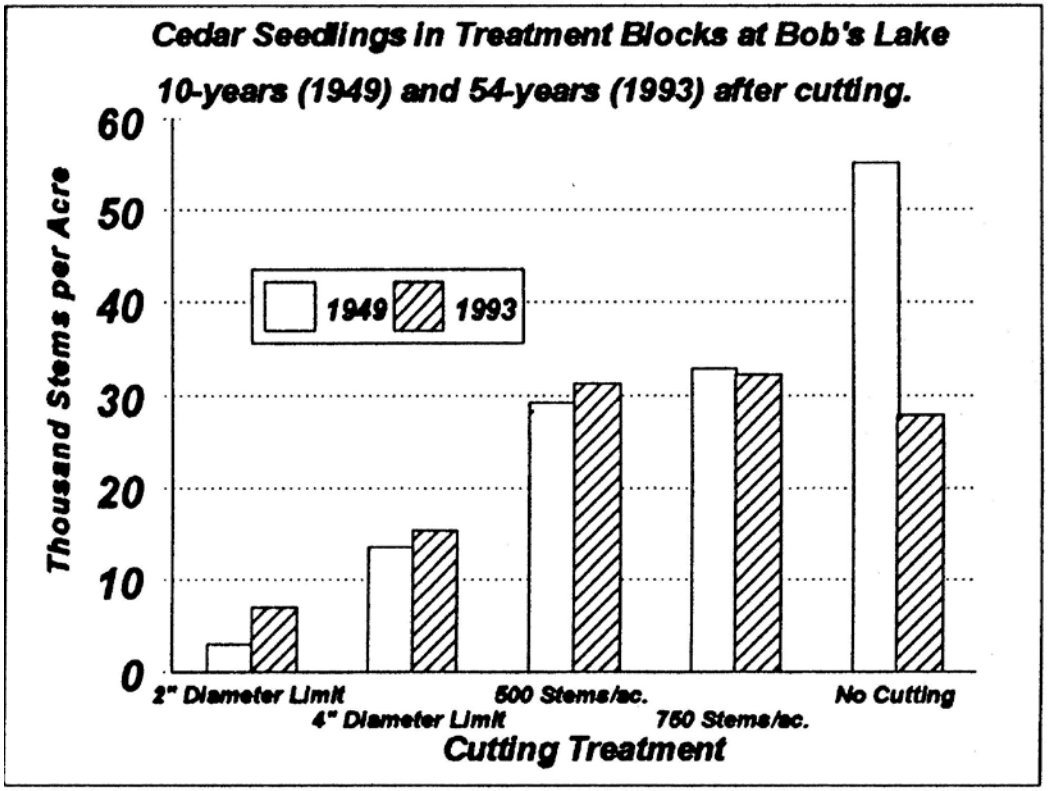


Figure 3

Data from Rooney et al. 2002

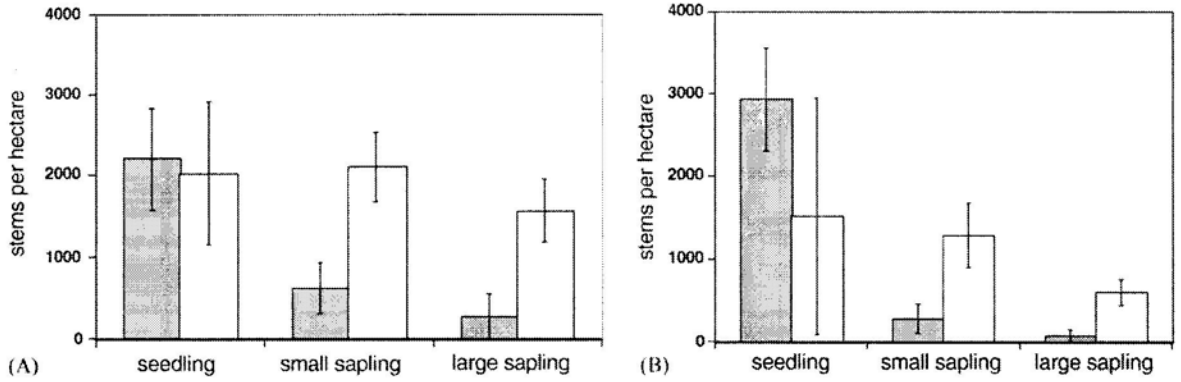
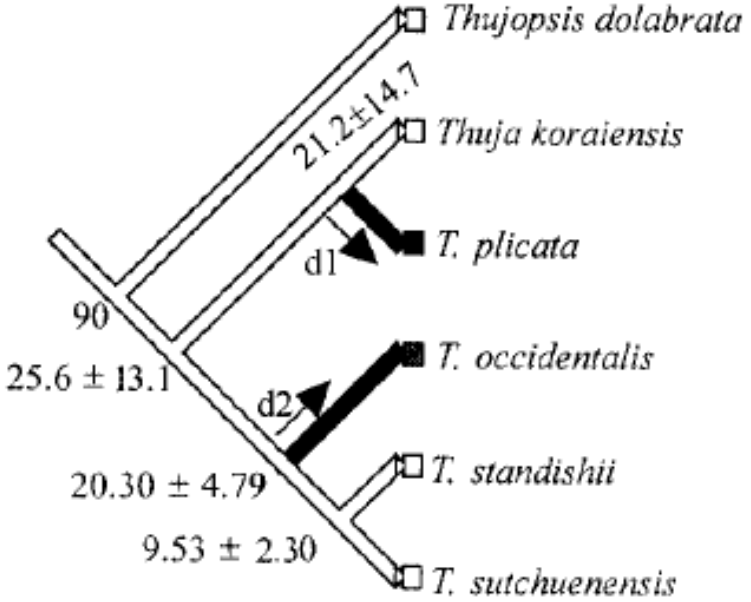


Fig. 5. The number of northern white cedar stems per hectare in the seedling (4–9 cm), small sapling (10–29 cm), and large sapling (30–300 cm) height class tallied in high deer density ownerships (shaded bars) and lower deer density ownerships (open bars) in (a) 1990–1991 and (b) 1996. Sample sizes for low deer were $n = 26$ in 1990–1991 and $n = 8$ in 1996, and for high deer $n = 51$ in 1990–1991 and $n = 41$ in 1996. Error bars represent 1 S.E., and an asterisk indicates a significant difference in stem densities of a given size class between high deer density and low deer density sites as determined by one-way ANOVA.

Data from Miller and Chimner 1995

northern white-cedar Cupressaceae (*Thuja occidentalis)* L.

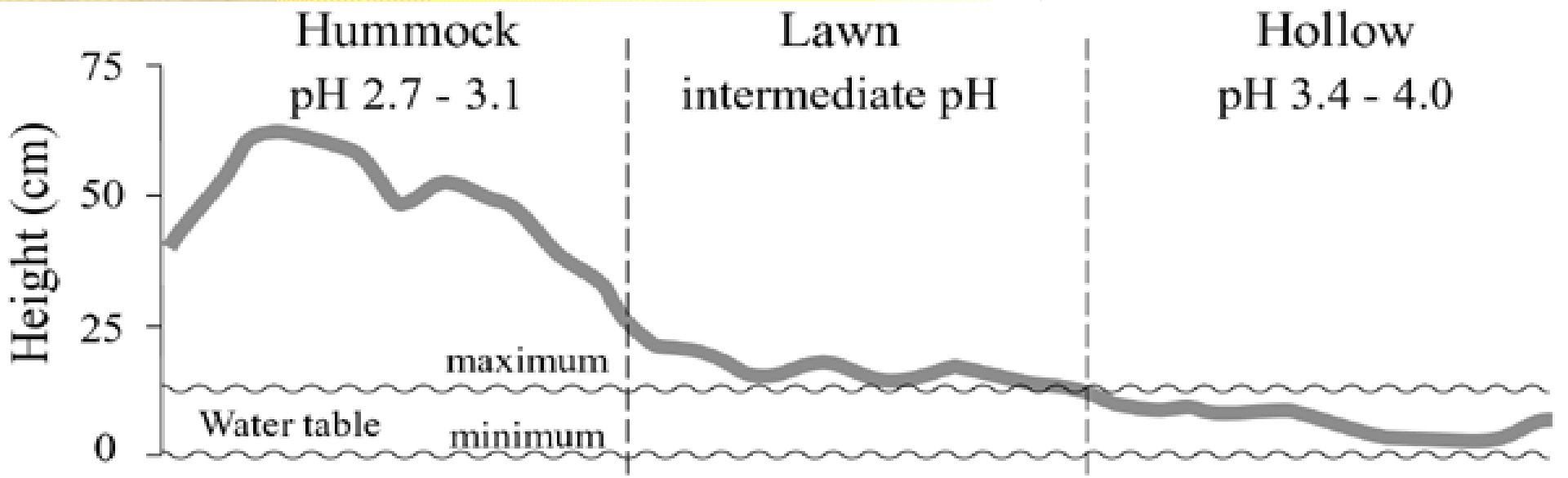
- *Thuja* is an E. Asia - N.A. disjunct species.
- *Thuja* is an old genus (~25 mya)
- *Thuja* originated in Asia and dispersed to NA twice.
  - 1st time 21 mya to Western NA
  - 2nd time 20 mya to Eastern NA



Northern white-cedar *Thuja occidentalis*

Leaf: Evergreen, overlapping scales, on main shoots, 1/4 inch long with long points.
Flower: Monoecious; solitary, females green with 4 to 6 scales; males are green tipped with brown and globose.
Fruit: A cone, 1/2 inch long, oblong, borne upright on the branches, scales are leathery, red-brown and rounded, with a small spine on the tip.

Bark: Fibrous, red-brown, weathering to gray; diamond-shaped patterns are usually apparent.
Scent: Very distinct scent



	Hummock pH 2.7 - 3.1	Lawn intermediate pH	Hollow pH 3.4 - 4.0
Mosses:	*Sphagnum fuscum*	*Sphagnum magellanicum*	*Sphagnum cuspidatum*
	Sphagnum capillifolium	*Sphagnum capillifolium*	*Sphagnum majus*
	Polytrichum strictum	*Sphagnum angustifolium*	*Sphagnum fallax*
	Aulacomnium palustre	*Sphagnum rubellum*	*Sphagnum angustifolium*
	Pleurozium schreberi	*Sphagnum papillosum*	*Sphagnum pulchrum*
	Dicranum undulatum		*Warnstorfia fluitans* var *fluitans*
	Pohlia nutans		*Cladopodiella fluitans*
Vascular plants:	*Rubus chamaemorus*	*Carex oligosperma*	*Carex limosa*
	Kalmia angustifolia	*Eriophorum angustifolium*	*Carex oligosperma*
	Ledum groenlandicum	*Eriophorum virginicum*	*Eriophorum virginicum*
		Scirpus cespitosus	*Rhynchospora alba*
		Andromeda glaucophylla	*Utricularia cornuta*
			Andromeda glaucophylla

Associated Forest Cover

- Northern white-cedar swamps commonly includes balsam fir *(Abies balsamea)* and tamarack *(Larix laricina)*, black spruce *(Picea mariana)*, white spruce *(P. glauca)*, black ash *(Fraxinus nigra)*, and red maple *(Acer rubrum)*.
- Yellow birch *(Betula alleghaniensis)*, paper birch *(B. papyrifera)*, quaking aspen *(Populus tremuloides)*, bigtooth aspen *(P. grandidentata)*, balsam poplar *(P. balsamifera)*, eastern hemlock *(Tsuga canadensis)*, and eastern white pine *(Pinus strobus)* are common on the better drained sites, especially uplands.

Understory

Tag alder *(Alnus rugosa)* is commonly the most important shrub on the better sites.

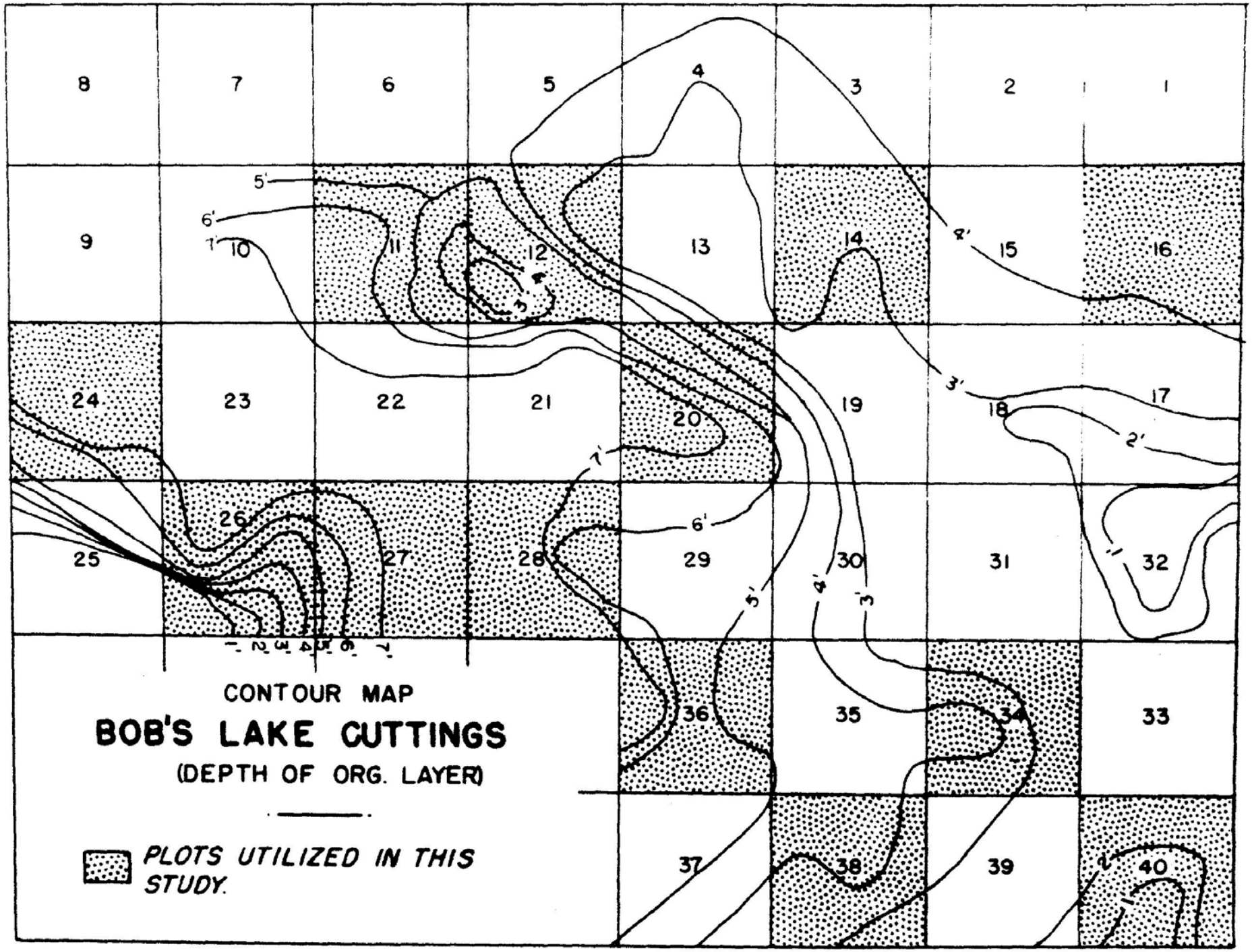
Other characteristic shrubs on the better sites (especially in swamps) include mountain maple *(Acer spicatum)*, red-osier dogwood *(Cornus stolonifera)*, and fly honeysuckle *(Lonicera canadensis).*

On poorer sites they include Labrador-tea *(Ledum groenlandicum)*, blueberries *(Vaccinium* spp.*)*, and wintergreen (teaberry) *(Gaultheria procumbens);* creeping snowberry *(G. hispidula) is* common on both kinds of sites.

Herbaceous Understory

- Characteristic herbs on the better sites (especially in swamps) include dwarf raspberry *(Rubus pubescens)*, false lily-of-the-valley *(Maianthemum canadense)*, woodfern *(Dryopteris* spp.*)*, and bunchberry *(Cornus canadensis).*
- On poorer sites they include false Solomons-seal *(Smilacina trifolia)* and pitcher plant *(Sarracenia purpurea).*
- Ground cover is usually a mosaic of sphagnum *(Sphagnum* spp.*)* and other mosses, liverworts, decaying logs, and litter.


Nurse logs


8
7
6
5
4
3
2
1
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19
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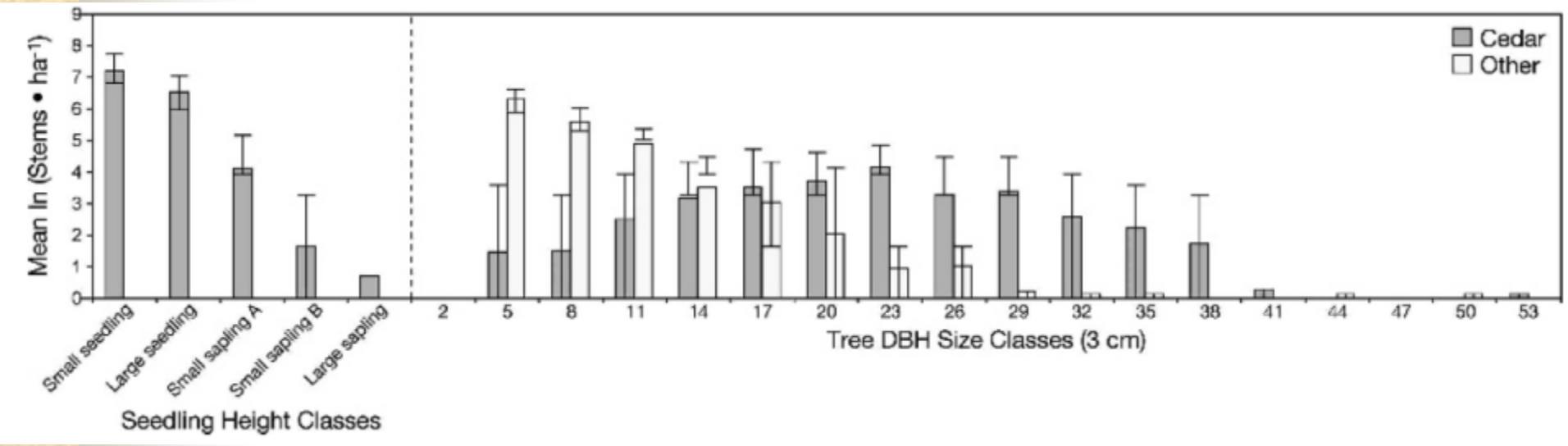
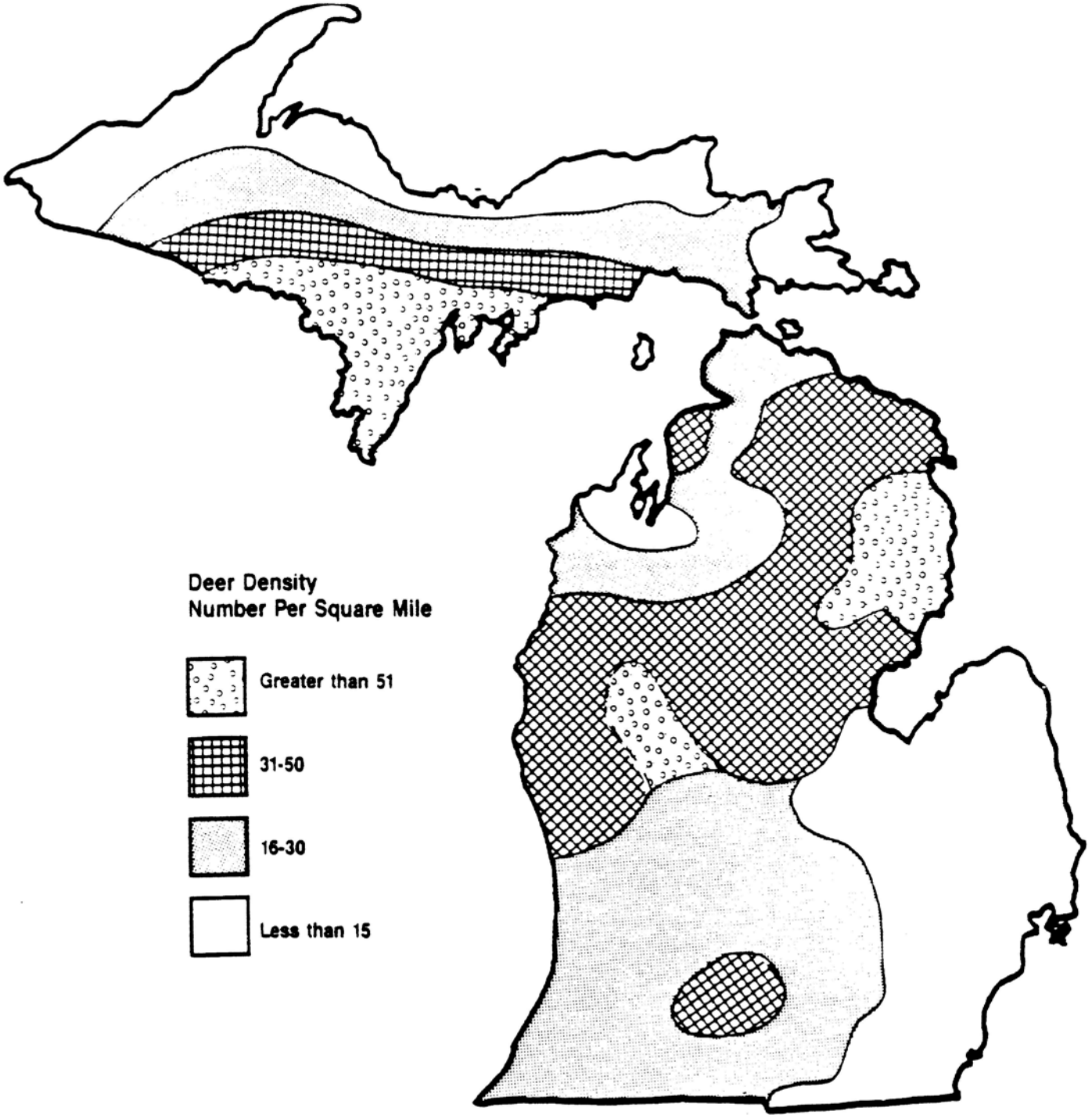
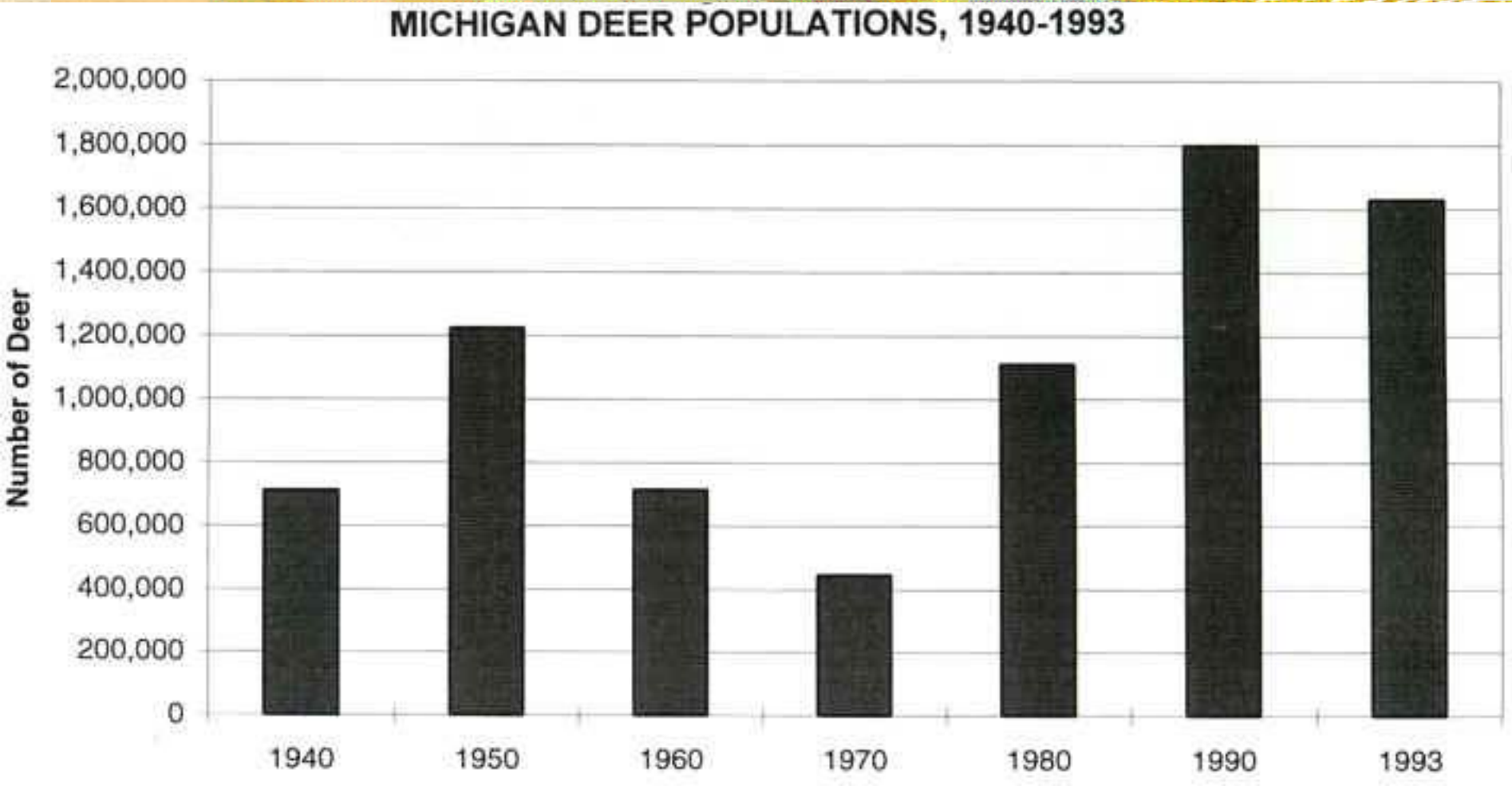
27
28
29
30
31
32
36
35
34
33
37
38
39
40
5'
6'
7'
8'
3'
2'
1'
6'
5'
4'
3'
CONTOUR MAP
BOB'S LAKE CUTTINGS
(DEPTH OF ORG. LAYER)
PLOTS UTILIZED IN THIS STUDY.

Cedar replacement




Deer Density
Number Per Square Mile
Greater than 51
31-50
16-30
Less than 15



a tenfold increase since the early 1900's

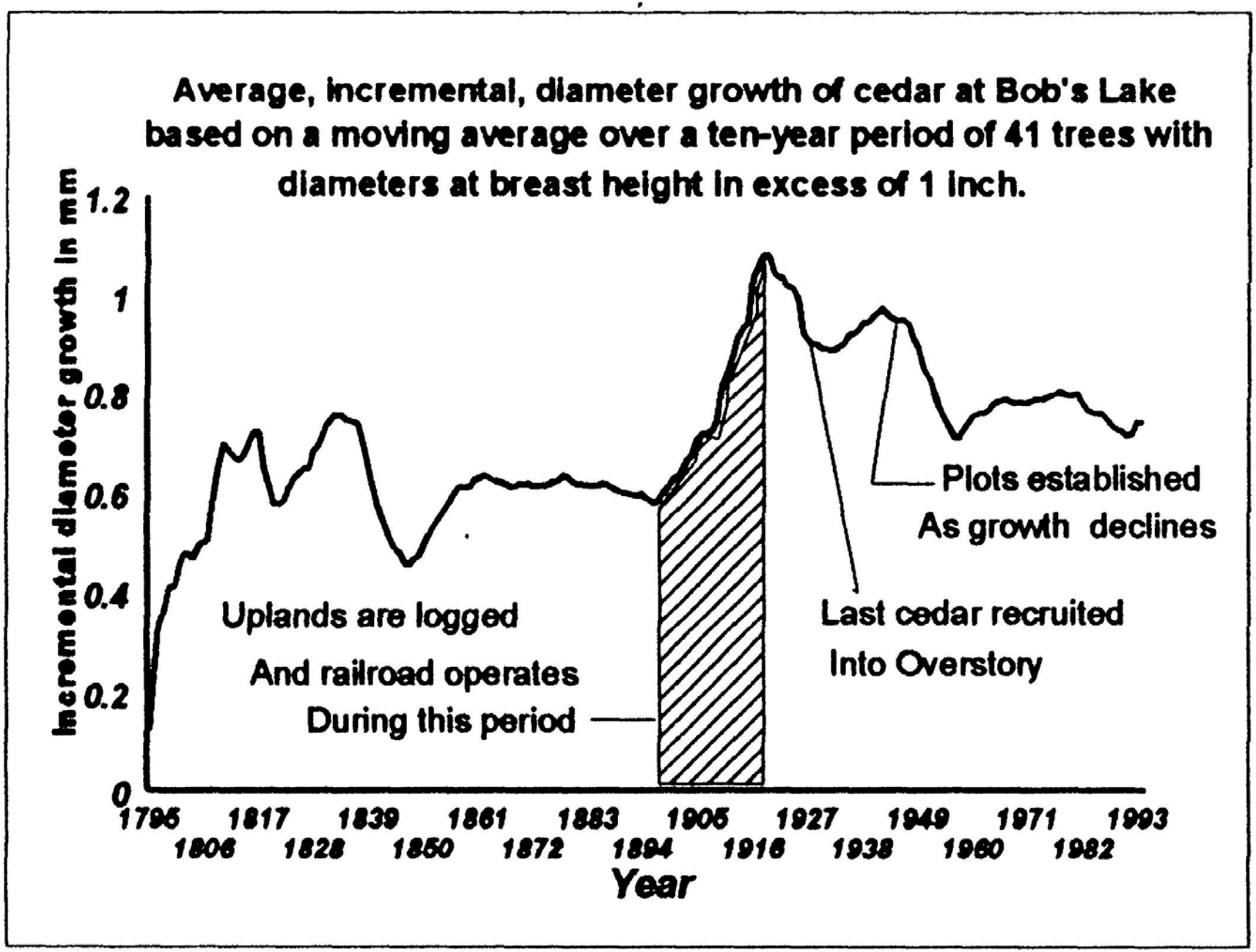
Issues

- There continues to be a demand for cedar products, but there has been a problem regenerating cedar for over 70 years.
- State and Federal “moratorium” on cutting on public lands over the last 30 years

Talk format

- General characteristics of cedar
- Bobs lake

- Management options
- Restoration


Average, incremental, diameter growth of cedar at Bob's Lake based on a moving average over a ten-year period of 41 trees with diameters at breast height in excess of 1 inch.
Incremental diameter growth in mm
1.2
1
0.8
0.6
0.4
0.2
0
Uplands are logged
And railroad operates
During this period
Plots established
As growth declines
Last cedar recruited
Into Overstory
1795
1806
1817
1828
1839
1850
1861
1872
1883
1894
1905
1916
1927
1938
1949
1960
1971
1982
1993
Year

Summary

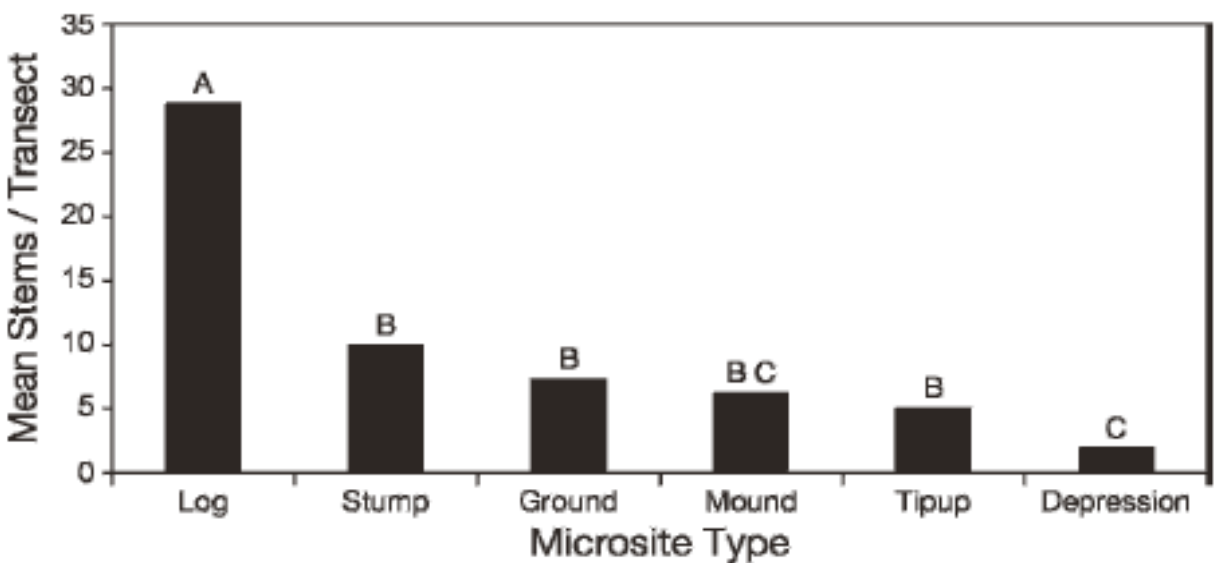
- Northern white-cedar occupies a large part of MI forests, it is the 4th most common type (8% of N. and UP of Michigan).
- Cedar occur in limestone uplands or rich/extremely rich fens, or along drainages.
- Cedar are shade tolerant, slow growing and long-lived pioneer trees.
- Cedar are important for deer and wood products.
- Although cedar have been regenerating in this area for a millennium, cedar have not regenerated in many areas for over 70 years.

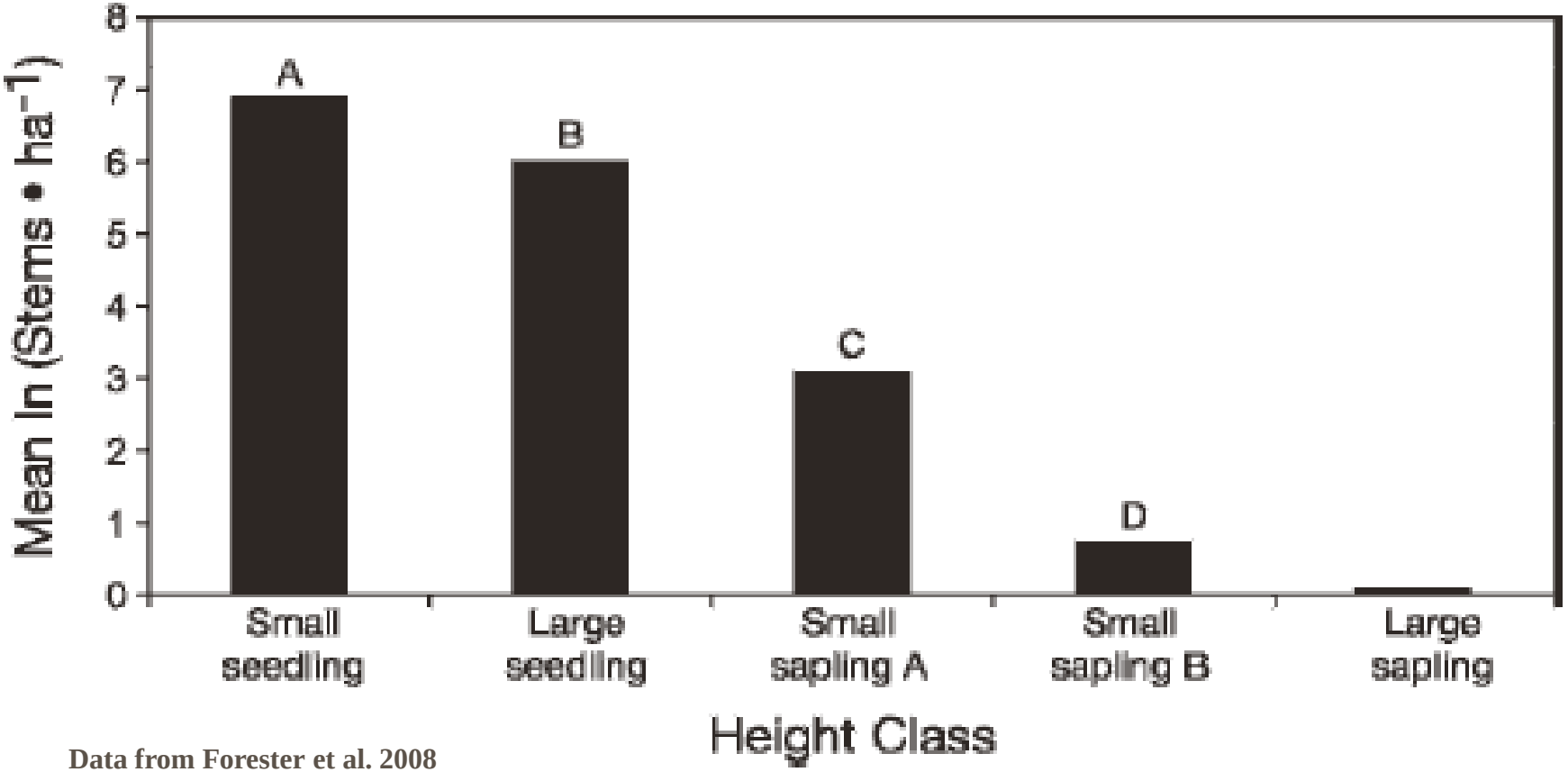
Summary

- Deer tend to eat all the new cedar before they can become part of the overstory, because they are so slow growing.
- Recruitment is limiting not establishment.
- Lack of regeneration has led to a state and federal moratorium on harvesting.
- Current harvesting occurs on private land with little management.
- Cedar harvesting typically results in stand replacement of tag alder and balsam fir.
- Little research done on cedar in last 50 years.

Regenerating Cedar

- Is ceder establishment limiting?
  - Seed sources
  - Proper substrate
  - Moisture
  - Microtopography
  - Harvest techniques
  - Proper site preparation





Data from Forester et al. 2008

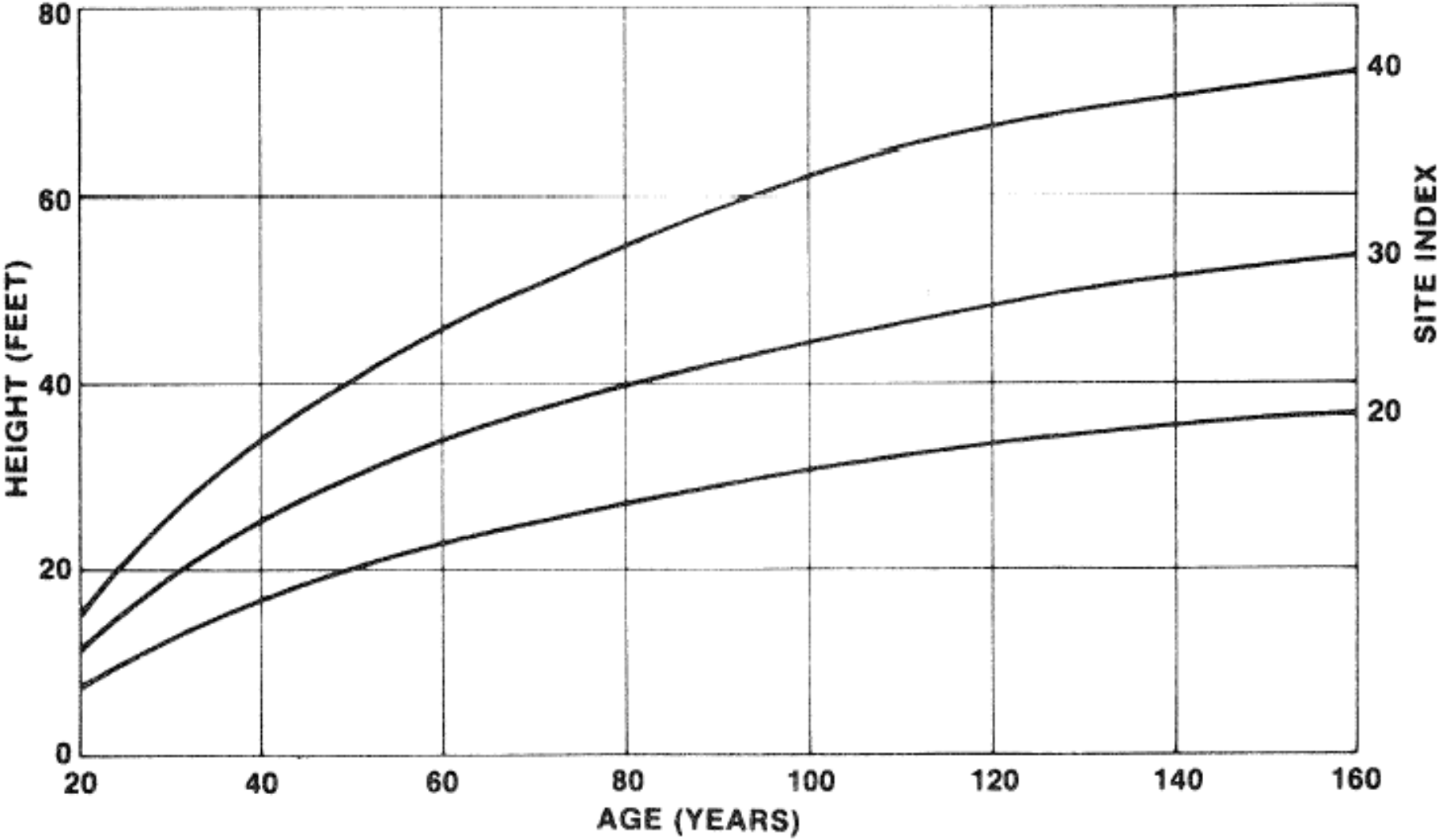
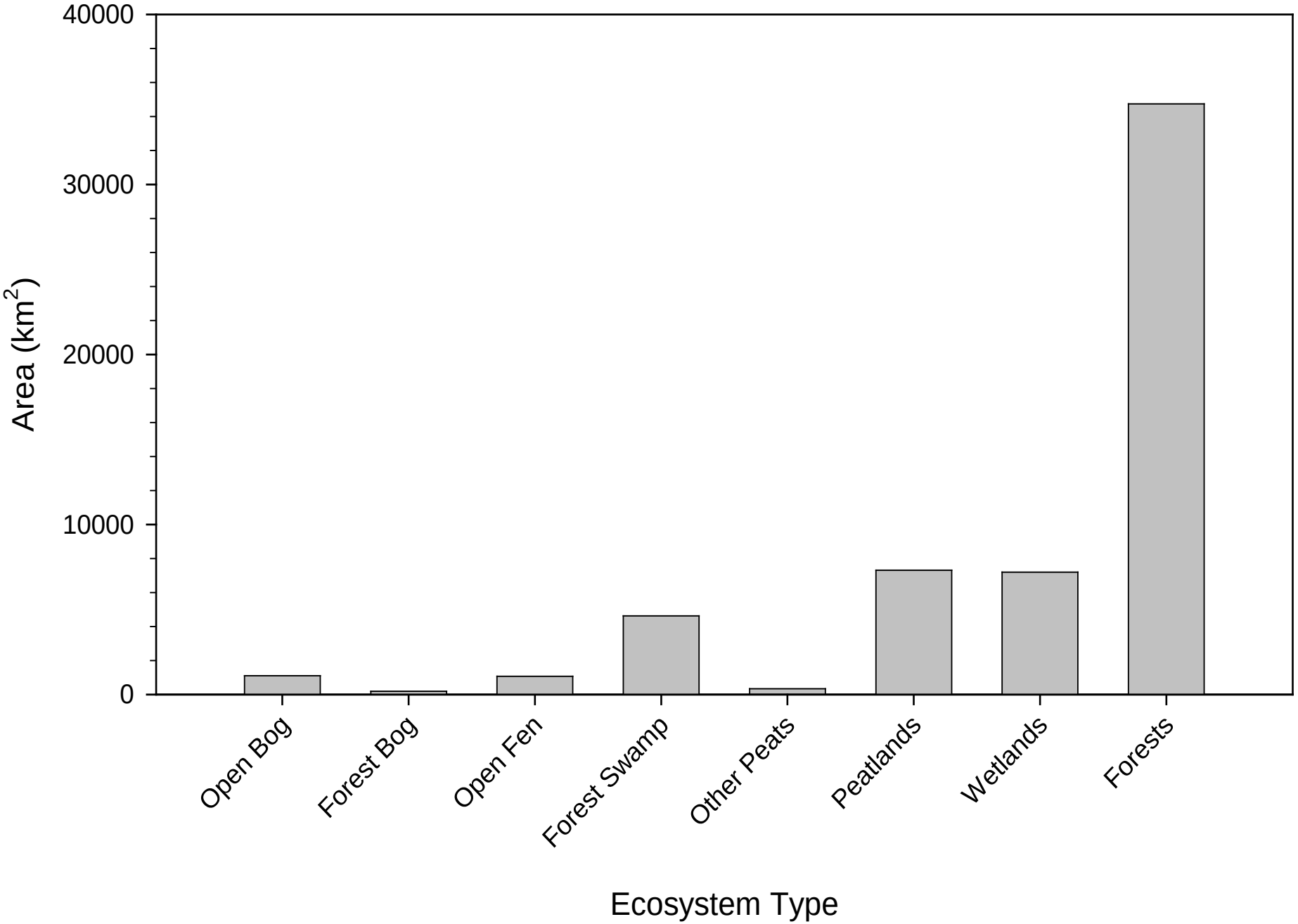


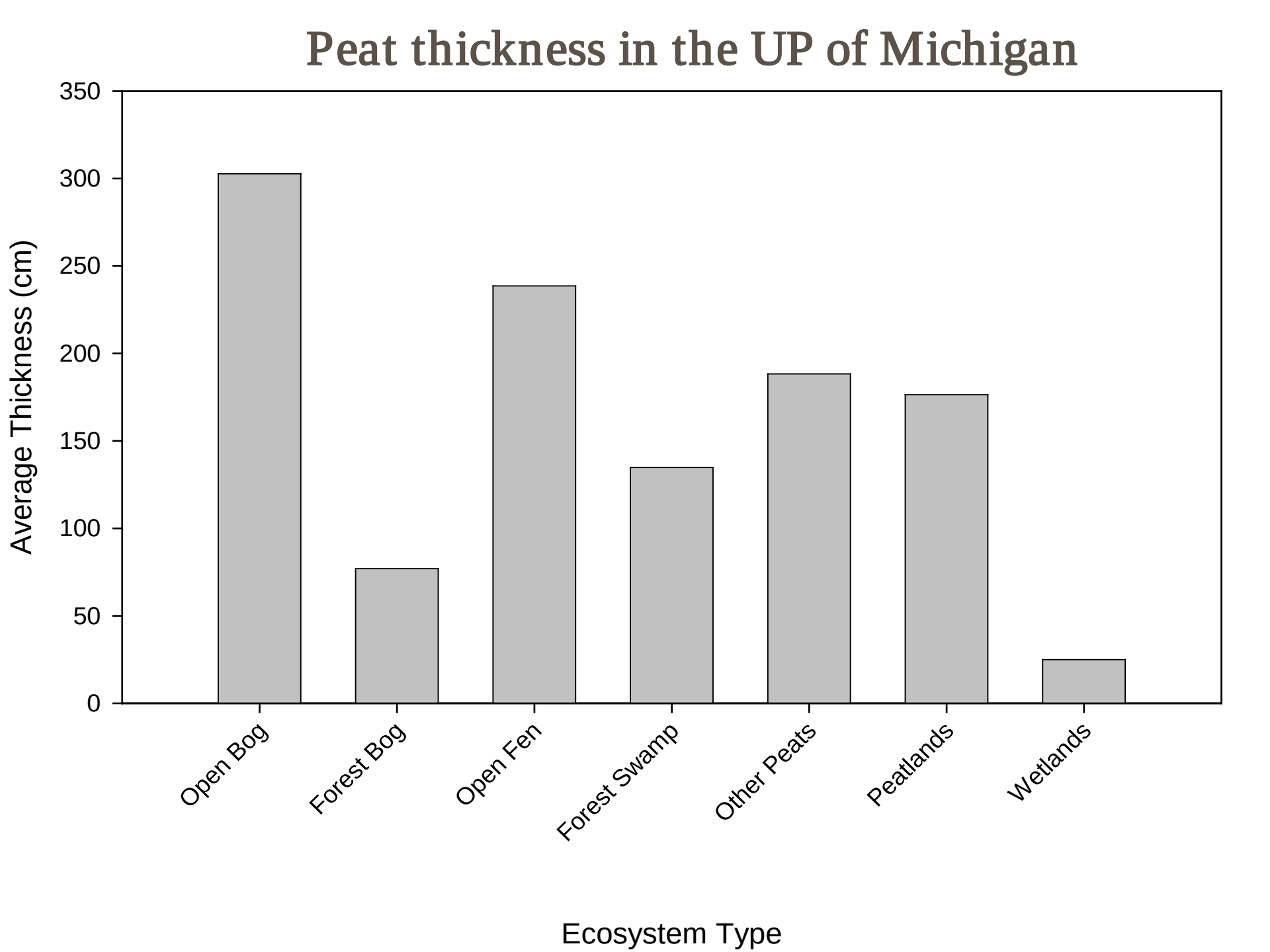
Figure 6. — *Site index curves for northern white-cedar stands. Adapted from Gevorkiantz and Duerr, 1939, "Volume and yield of northern white cedar in the Lake States", unpublished report on file at North Central Forest Experiment Station, St. Paul, Minn.*

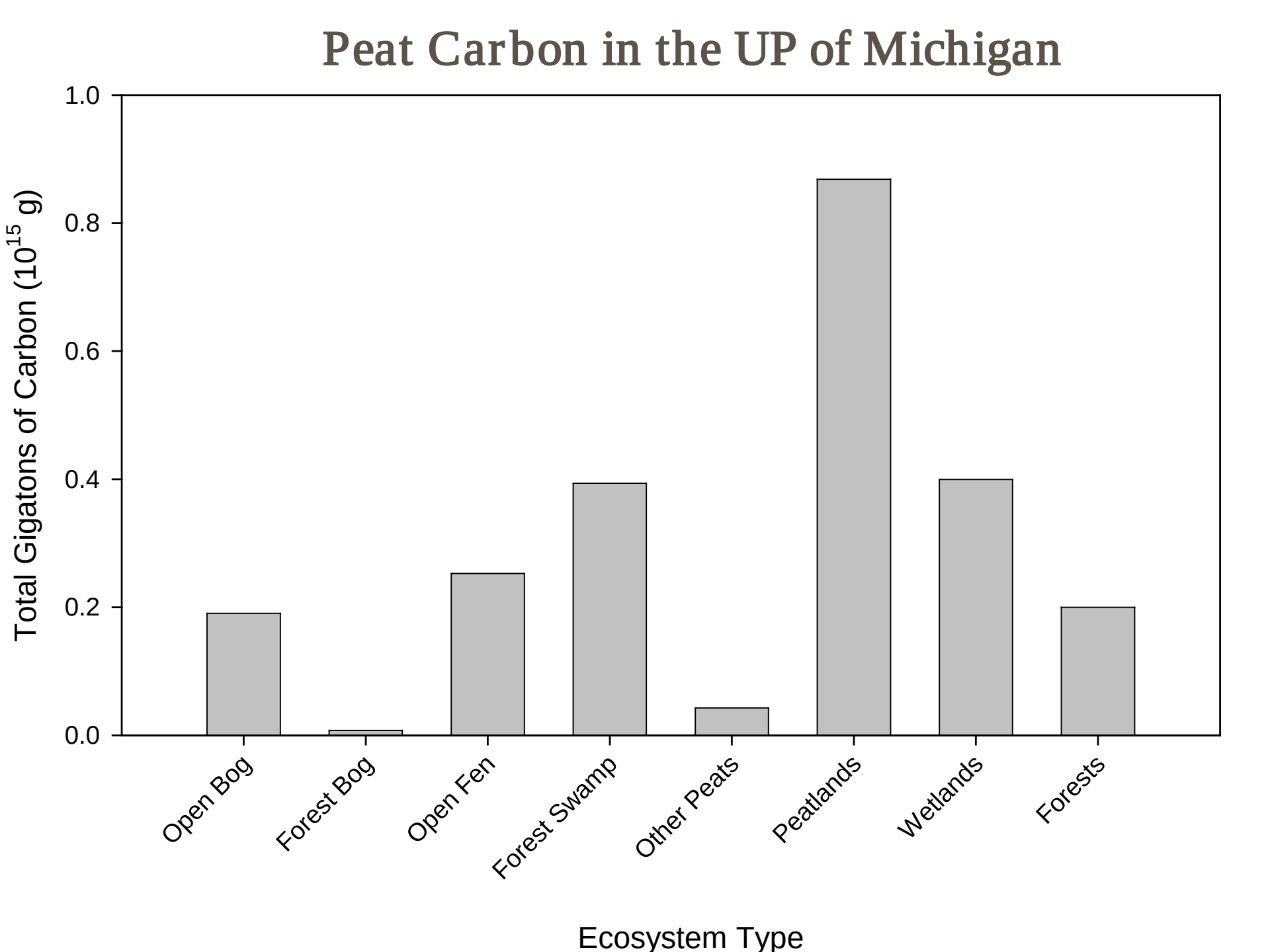
Table 9. Average calcium, specific conductivity and pH levels of the study site compared to Glaser et al. (1981, 1990) levels.

Peatland type	pH	Specific Cond (uS cm-1)	Calcium (mg/l)
Extremely Rich Fen	>6.8	>82	>20
Rich Fen	6.0-6.8	23-82	10-20
Poor Fen	4.3-6.0		3-10
Bog	<4.3	12-27	<3
Cedar site (Chimner 1994)	7.31	295	44.4

Peatland area in the UP of Michigan




Peat thickness in the UP of Michigan
Average Thickness (cm)
350
300
250
200
150
100
50
0
Open Bog
Forest Bog
Open Fen
Forest Swamp
Other Peats
Peatlands
Wetlands
Ecosystem Type


Peat Carbon in the UP of Michigan
Total Gigatons of Carbon (10^{15} g)
1.0
0.8
0.6
0.4
0.2
0.0
Open Bog
Forest Bog
Open Fen
Forest Swamp
Other Peats
Peatlands
Wetlands
Forests
Ecosystem Type