LDEO

Goddard Institute for Space Studies
New York, N.Y.

Dating the Last Ice Age Retreat in the New York Area - A Significant Controversy

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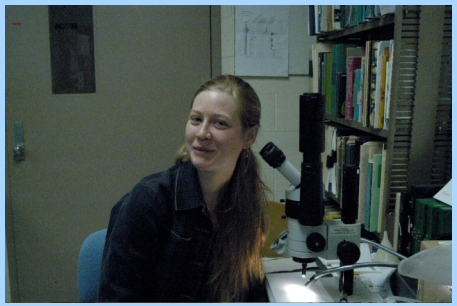
Comer Foundation
GISS lunchtime talk
Nov. 18, 2009

What time did ice melt at southeastern margin of Laurentide ice sheet?

What was the nature of the environment?

**Do basal lake dates in clays represent the timing of deglaciation or the beginning of organic sedimentation?

Thanks to hard workers!



Maia Beh, Miriam Jones, Jennifer Levy, Argie Miller, Tamika Tannis, Calder Orr,

Sanpisa Sritrairat

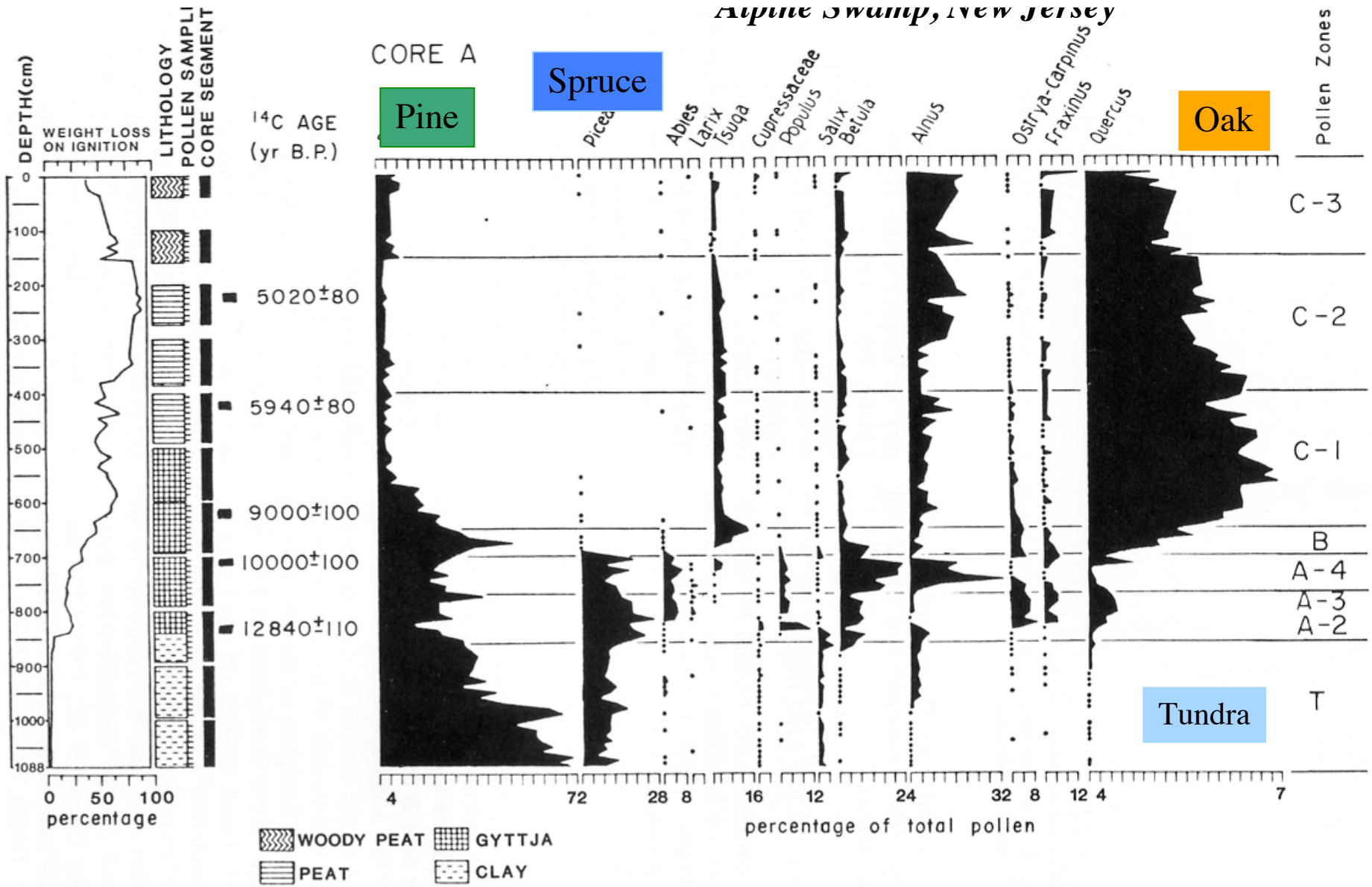


FIG. 2. Simplified pollen-percentage diagram from Core A, Alpine Swamp, New Jersey. Increases in percentage of boreal trees during the A-4 pollen zone suggest a climatic cooling. Conventional ^{14}C dates on bulk organic samples indicate that the cooling occurred sometime after 12,000 yr B.P. and before 10,000 yr B.P.

Peteet et al., 1990

Previous Chronological Control

•Bulk lake basal dates (Sirkin,1977, 1986; Davis et al. 1983; Cotter et al. 1986)
--extrapolation below to 18-22,000 C-14

-used for Glacial Maps (Stone et al., 2005)

•AMS lake basal dates (Peteet et al., 1990,1993)

12,500 C-14 (14,700 calendar = Bolling)

•Varve floating chronology (Ridge, 2000, 2004)

(28-23,000 correlated with Greenland oxygen isotopes in ice cores)

•Cosmogenic-nuclide ages 10Be (Balco et al., 2002; Balco et al., 2006; Schaefer et al., 2006)

» Revised by Balco et al. 2009

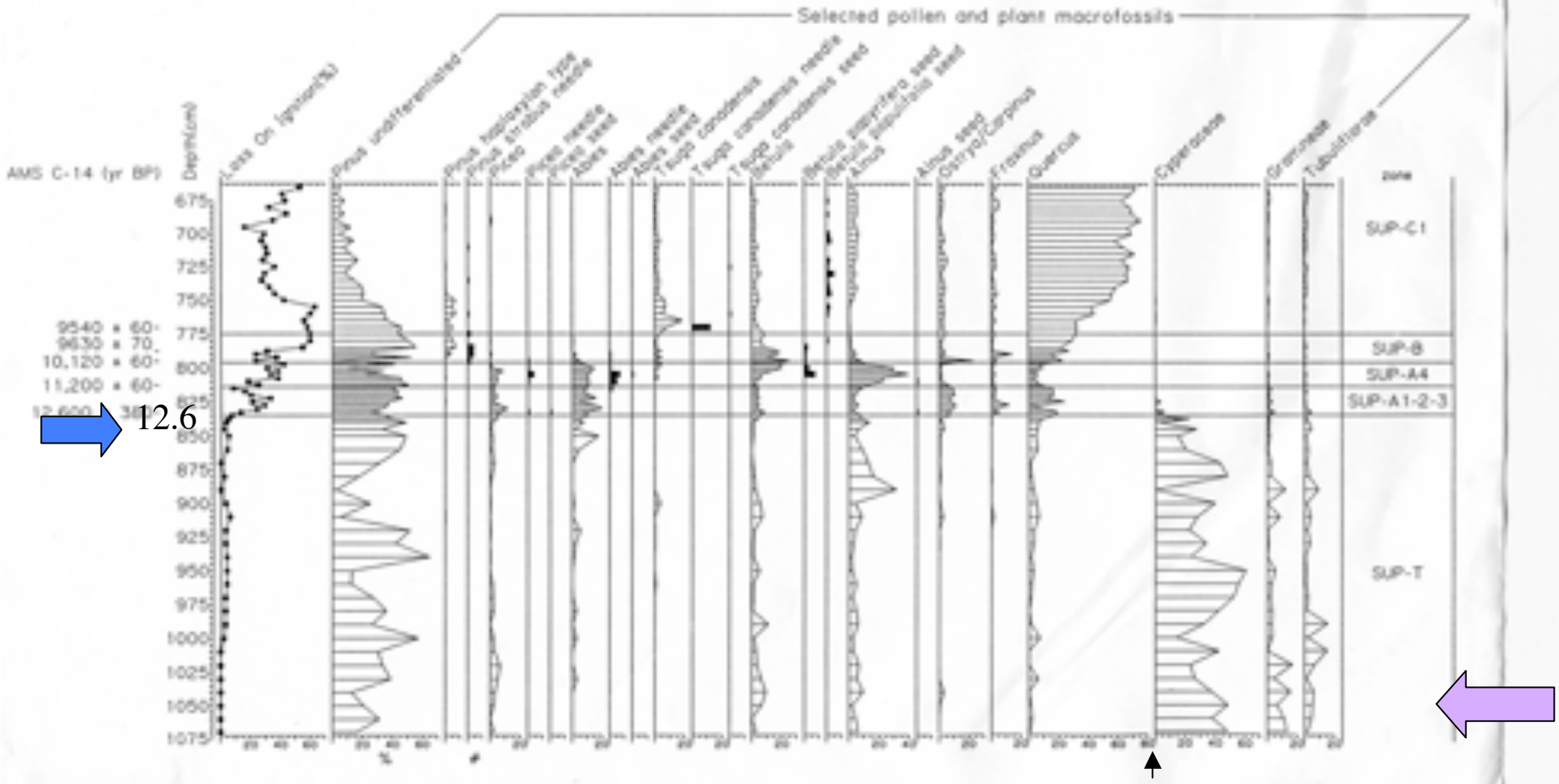
Martha's Vineyard 23,200 +500	24,000?
Buzzard's Bay 18,800 +400	21,000
Ledyard-Old Saybrook 19,000	20,200 - 20,300
Hudson Valley 18-19,000	20,000?

Fig. 4

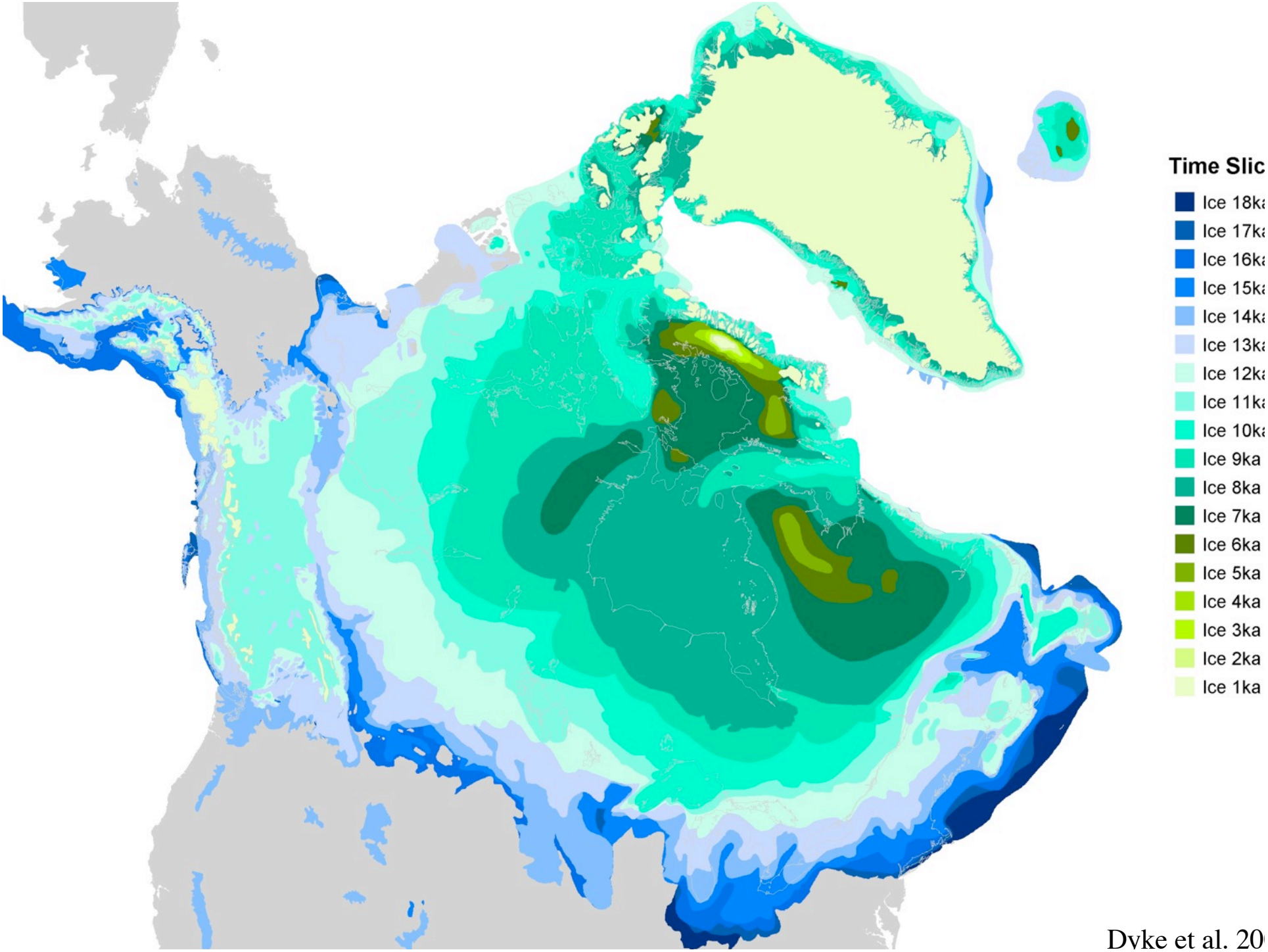
Sutherland Pond

Sutherland Pond, NY

Black Rock Forest



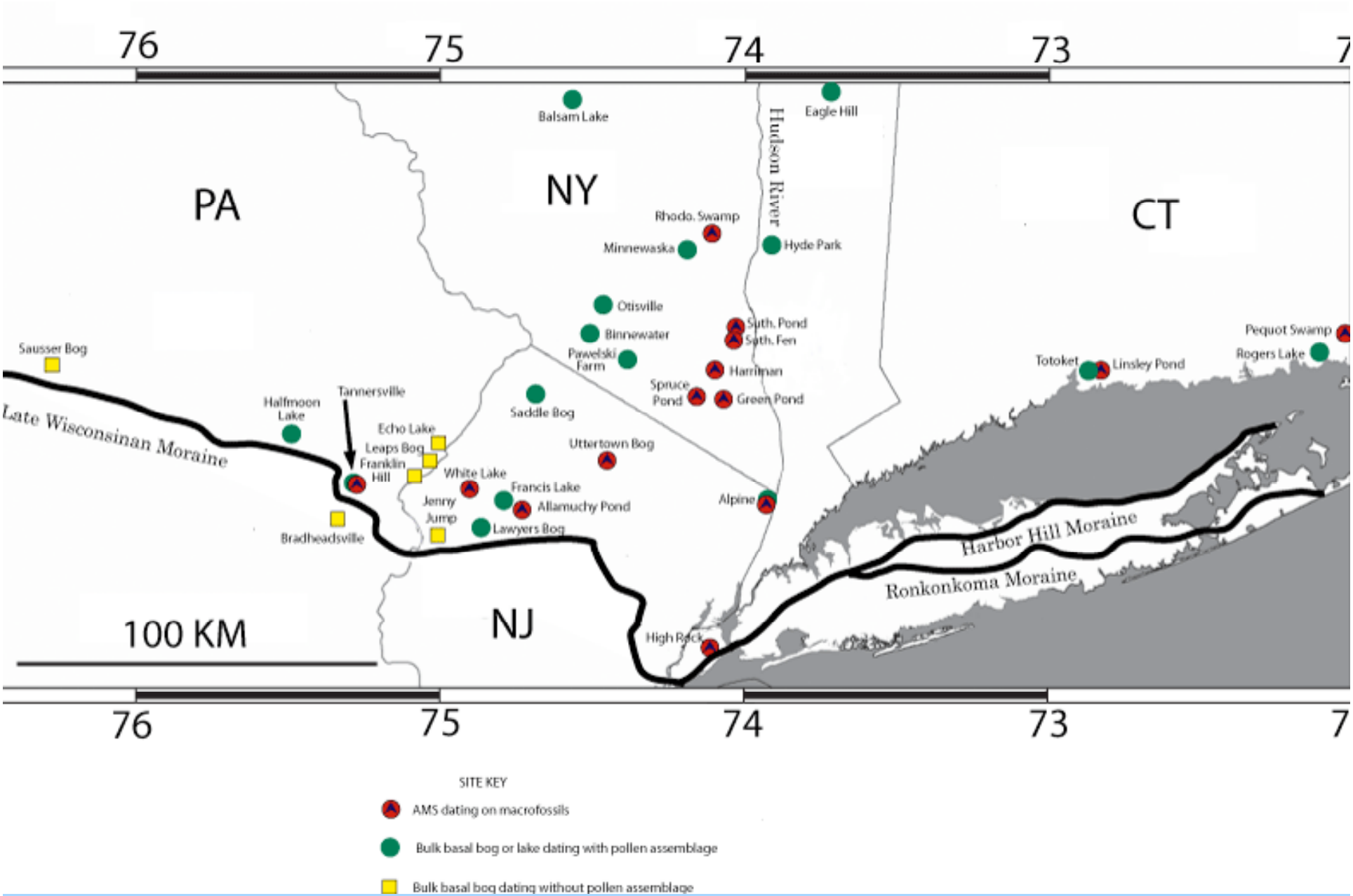
Maenza-Gmelch, 1997

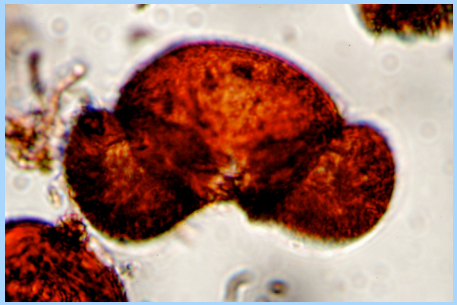

Time Slic
Ice 18ka
Ice 17ka
Ice 16ka
Ice 15ka
Ice 14ka
Ice 13ka
Ice 12ka
Ice 11ka
Ice 10ka
Ice 9ka
Ice 8ka
Ice 7ka
Ice 6ka
Ice 5ka
Ice 4ka
Ice 3ka
Ice 2ka
Ice 1ka

Dyke et al. 20

17 ^{14}C ka BP

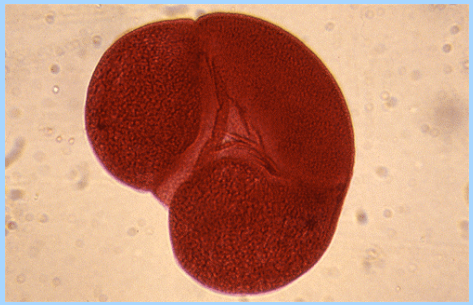
14 ¹¹C ka BP


76
75
74
73
7
PA
NY
CT
NJ
Balsam Lake
Eagle Hill
Hudson River
Rhodo. Swamp
Minnewaska
Hyde Park
Otisville
Binnewater
Sath. Pond
Sath. Fen
Pawelski Farm
Harriman
Spruce Pond
Green Pond
Saddle Bog
Uttertown Bog
Sausser Bog
Halfmoon Lake
Tannersville
Late Wisconsinan Moraine
Echo Lake
Leaps Bog
Franklin Hill
White Lake
Francis Lake
Jenny Jump
Allamuchy Pond
Lawyers Bog
Bradheadsville
Alpine
High Rock
Totoket
Linsley Pond
Pequot Swamp
Rogers Lake
Harbor Hill Moraine
Ronkonkoma Moraine
100 KM
SITE KEY
AMS dating on macrofossils
Bulk basal bog or lake dating with pollen assemblage
Bulk basal bog dating without pollen assemblage



Pinus (pine)

Methods



Picea (spruce)

Pollen and spores

Macrofossil and charcoal analysis

Species ID, local presence

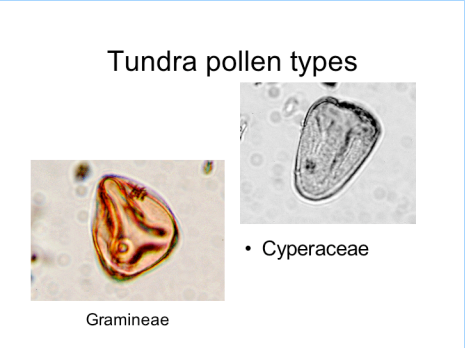
Sediment lithology and LOI

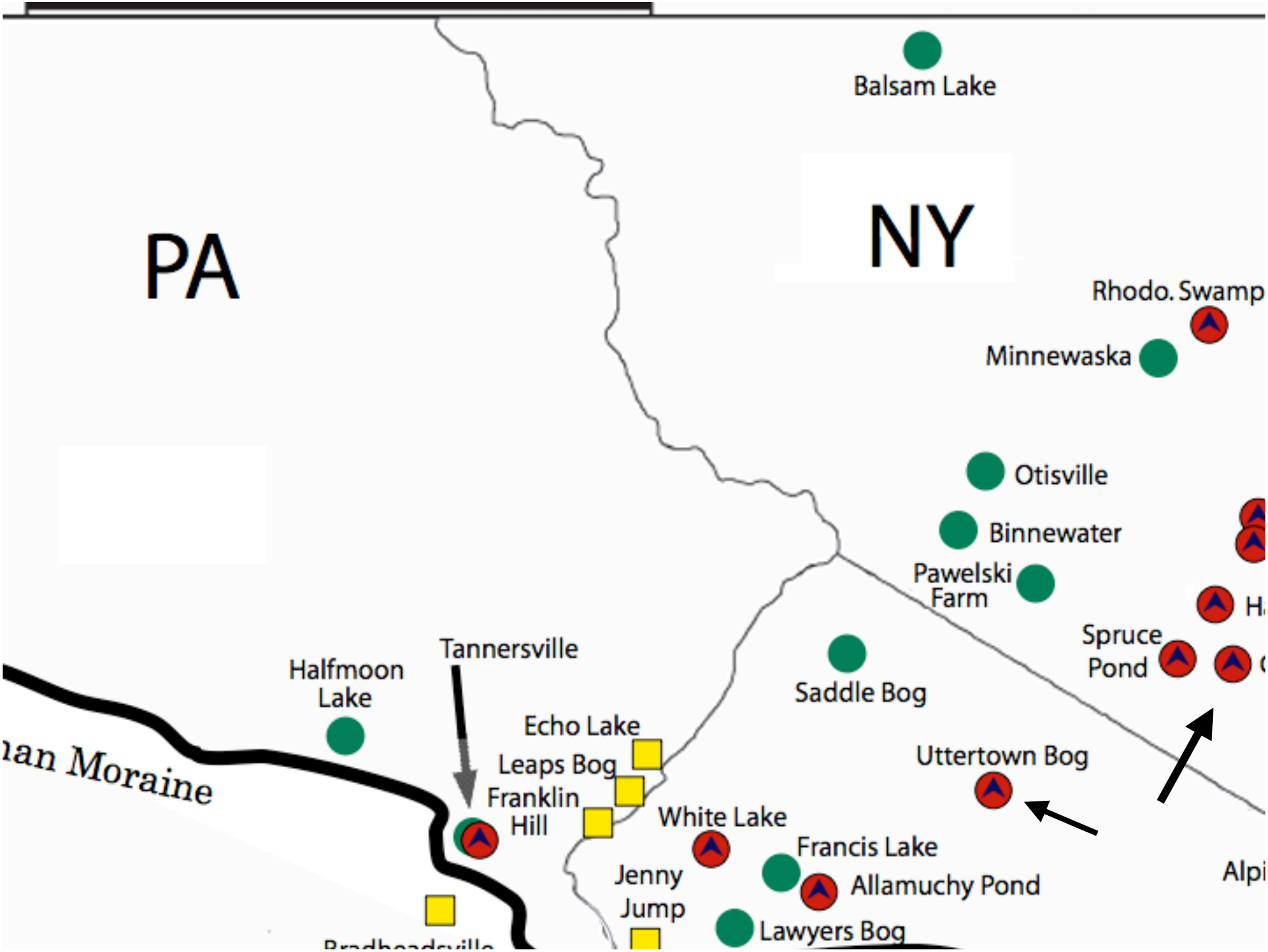
Lake/bog productivity and landscape stability

AMS C-14 dating on identified macrofossils

Betula

Dryas




PA
NY
Balsam Lake
Rhodo. Swamp
Minnewaska
Otisville
Binnewater
Pawelski Farm
Spruce Pond
Saddle Bog
Uttertown Bog
Halfmoon Lake
Tannersville
Echo Lake
Leaps Bog
Franklin Hill
White Lake
Francis Lake
Allamuchy Pond
Jenny Jump
Lawyers Bog
Alpi
an Moraine

TANNERSVILLE BOG, Pennsylvania

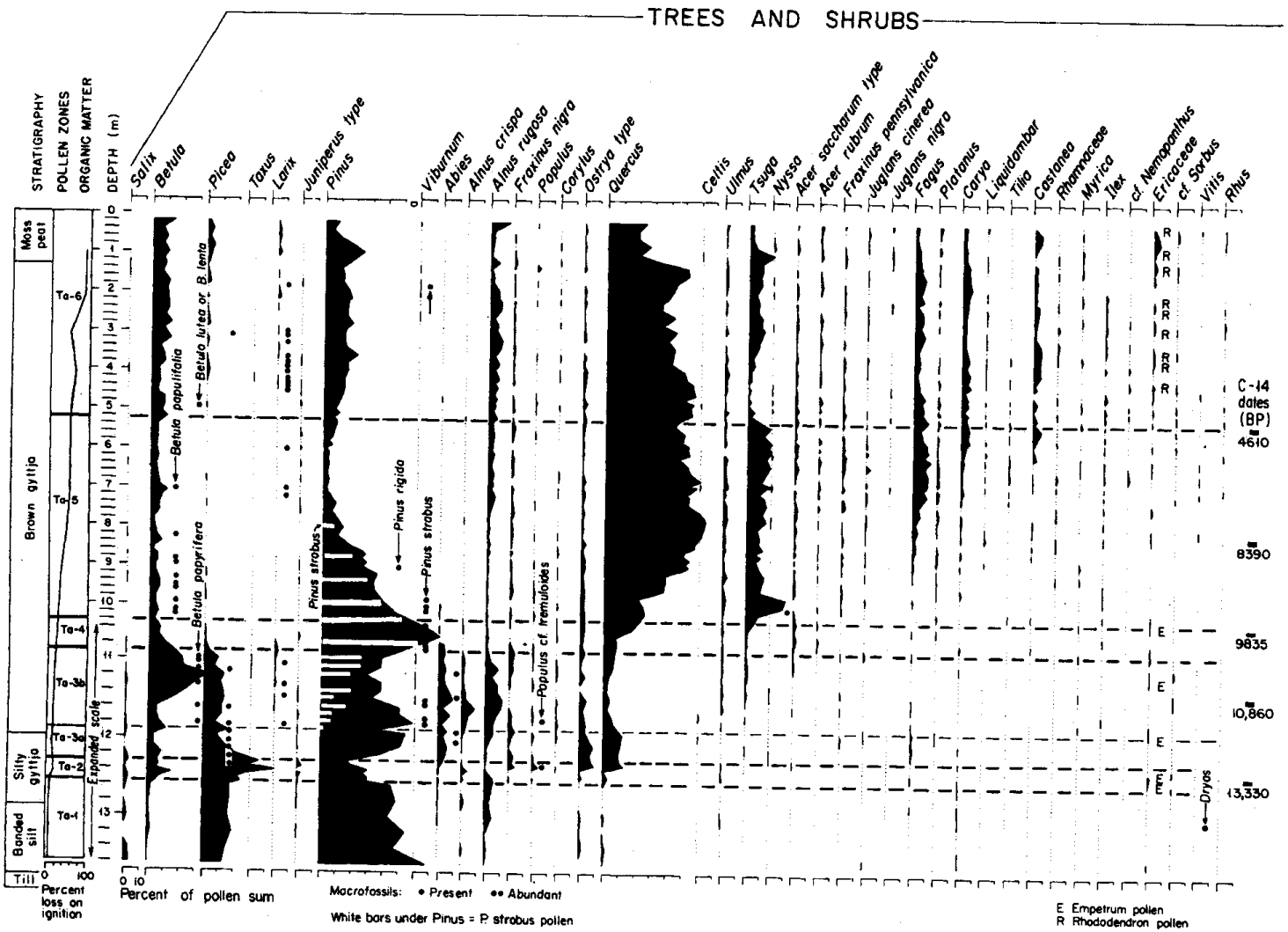
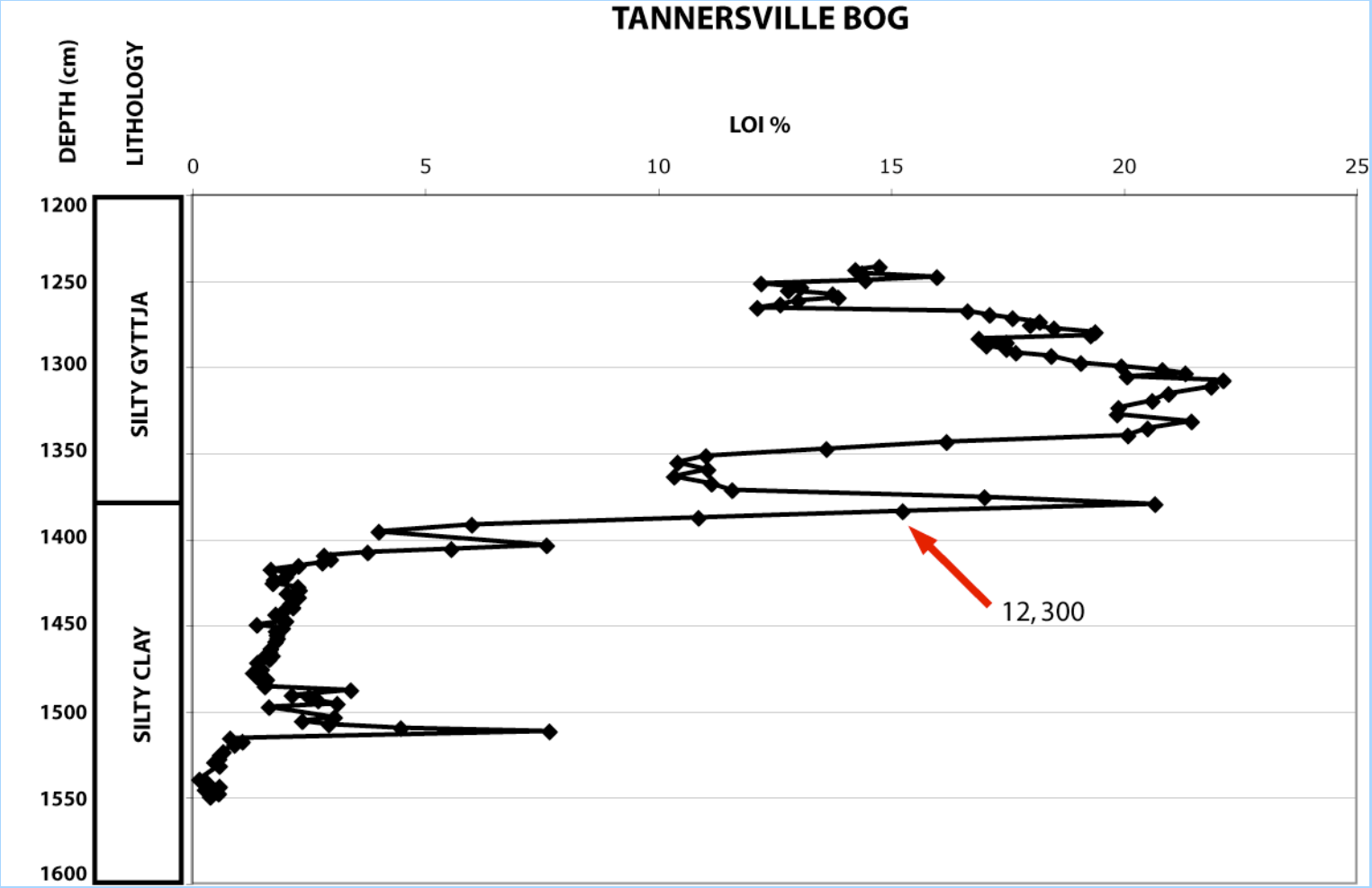
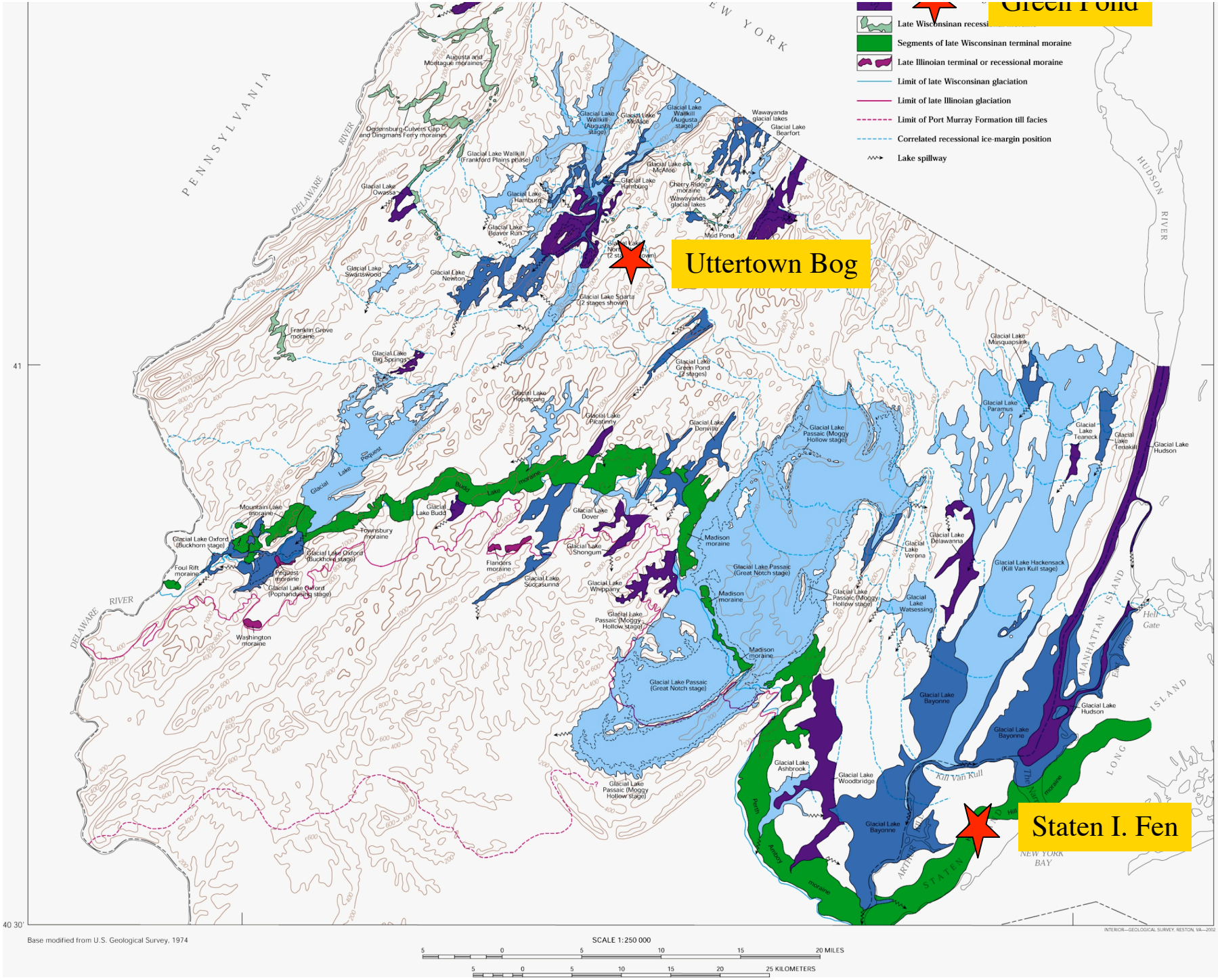


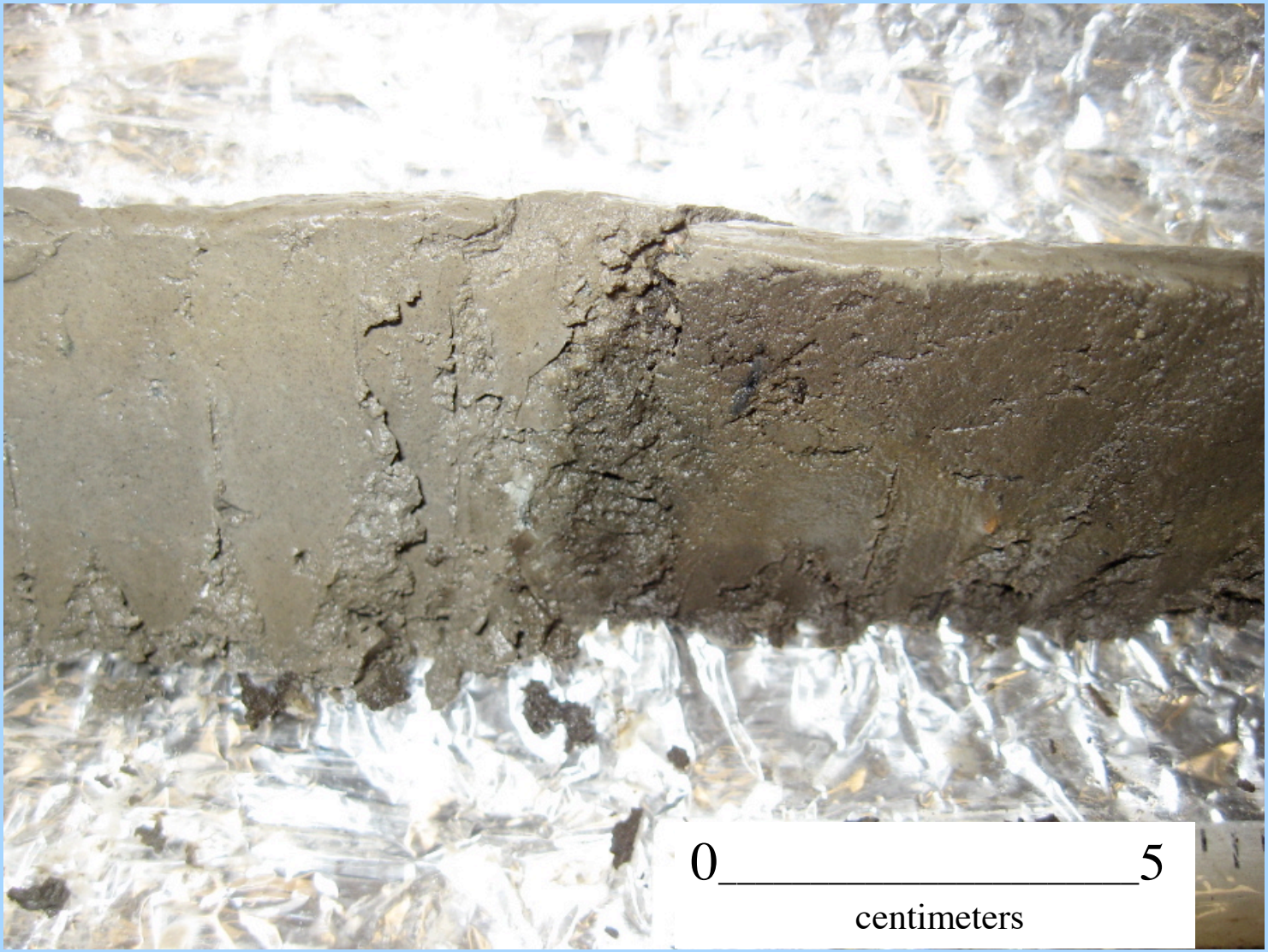
FIG. 8. Pollen diagram for Tannersville Bog, northeastern Pennsylvania.


TANNERSVILLE BOG
DEPTH (cm)
LITHOLOGY
LOI %
0
5
10
15
20
25
1200
1250
1300
1350
1400
1450
1500
1550
1600
SILTY GYTTJA
SILTY CLAY
12,300

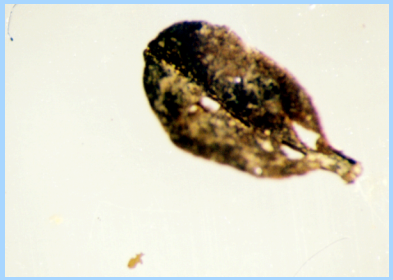
Site Name	Location	Depth (m) of dated material	AMS Lab No.	C-14 Age	Calibrated Age Ranges	Calibrated Age (BP): Midpoint ± 2σ range	Material Dated	P zone	Lithology	Reference
Allamuchy Pond, NJ	*40° 54' N 74° 48' W*	*9.0-9.10*	*RIDDL-1238*	*12,260± 220*	*13,726-15,000*	*14,363± 637*	Picea *needle*	*A-2/T*	*Clay/gyttja*	*Peteet* et al., *1993*
Alpine, NJ	*40° 58' N 73° 55' W*	*8.25-8.332*	*WIS-1482*	*12,840± 110*	*14,798-15,571*	*15,185± 387*	*Bulk*	*A-2*	*Clay/gyttja*	*Peteet* et al., *1990*
Alpine, NJ	*40° 58' N 73° 55' W*	*9.90-9.95*	*RIDDL-1136*	*12,290± 440*	*13,291-15,540*	*14,416± 1125*	Picea *needle*	*A-2*	*Clay*	*Peteet* et al., *l990*
Balsam Lake, NY	*42° 2' N 74° 37' W*	*7.5*		*12,600± 700*	*13,150-16,647*	*14899± 1749*	*Bulk*	*BL-5*	*Peaty clay*	*Ibe, 1985*
Binnewater Pond, NY	*41° 24'36" N 74° 33'07" W*	*11.05-11.06*	*AA45686*	*12,526± 94*	*14,202-15,038*	*14,620± 418*	*Bulk*	*A-2/ A-3*	*Gyttja*	*Robinson* et al., *2005*
Binnewater Pond, NY	*41° 24'36" N 74° 33'07" W*	*11.25-11.26*	*B157492*	*13,210± 90*	*15,254-16,074*	*15,664± 410*	*Bulk*	*A-3*	*Humic clay*	*Robinson* et al., *2005*
Binnewater Pond, NY	*41° 24'36" N 74° 33'07" W*	*12.55-12.56*	*B153148*	*22,870± 90*	*NA*		*Bulk*	*A-3?*	*Silty clay*	*Robinson* et al., *2005*
Francis Lake, NJ	*40° 58' N 74° 51' W*	*7.49*	*SI-5300*	*13,510± 135*	*15,567-16,583*	*16,075± 508*	*Bulk*	*A-2/T*	*Clay/ organic clay*	*Cotter* et al., *1984*
Francis Lake, NJ	*40° 58' N 74° 51' W*	*8.28*	*SI-5724*	*16,480± 430*	*18,880-20,460*	*19,670± 790*	*Bulk*	*T*	*Clay*	*Cotter* et al., *1984*
Green Pond, NY	*41° 14' N 74° 08' W*	*8.62-8.64*	*132151*	*12,185± 50*	*13,896-14,175*	*14,036± 140*	*Wood piece*	*GP-2*	*Clay/gyttja*	*This paper.*
Green Pond, NY	*41° 14' N 74° 08' W*	*9.10-9.12*	*132150*	*12,250± 60*	*13,924-14,420*	*14,172± 248*	Sambucus pubens *seed*	*GP-1*	*Clay*	*This paper.*
Halfmoon Lake, PA	*41° 04' N 75° 27' W*	*2.78-2.96*	*SI-5302*	*12,530± 125*	*14,158-15,089*	*14,624± 466*	*Bulk*	*A-2*	*Organic clay*	*Cotter* et al., *l984*
Harriman, NY	*41° 18' N 74° 08' W*	*2.77-2.82*	*CAMS 127227*	*13,095± 40*	*15,191-15,813*	*15,502± 311*	*AMS*			
High Rock, Staten Island	*40° 35'08" N 74° 07'25" W*	*3.58-3.60*	*CAMS 132153*	*12,540± 80*	*14,238-15,041*	*14,640± 402*	Picea *seed,* Rubus *seed,* Picea *needle*	*HR-2*	*Clay/Peat*	*This paper.*
High Rock, Staten Island	*40° 35'08" N 74° 07'25" W*	*4.07-4.10*	*CAMS 127226*	*12,465± 35*	*14,228-14,884*	*14,556± 328*	*AMS*	*HR-1*	*Rocky clay*	*This paper.*
Hyde Park, NY	*41° 46'48" N 73° 53'38" W*	*.345-.355*	*AA46613*	*13,280± 75*	*15,364-16,161*	*15,763± 399*	*Bulk*	*A-2*	*Silty clay*	*Robinson* et al., *2005*

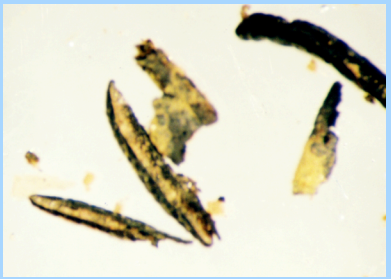
Minne-a, NY	41° 43' N 74° 14' W	1.4		14,500± 50	17,011-17,843	17,427± 416	Bulk	A-2?	Clay	Menking, unpub.
ers Bog,		5.2-5.4	SI-4922	11,520± 70	13,231-13,542	13,387± 156	Bulk	A-2	Clay	Cotter et al., 1984
ey Pond-	41° 19' N 72° 47' W	11.95-12	RIDDL 1140	12,590± 430	13,637-15,984	14,811± 1174	Picea needle	A-2	Silty clay	Peteet et al., 1993
ey Pond-	41° 19' N 72° 47' W	13.46-13.50	CAMS 132149	12,670± 220	14,095-15,517	14,806± 711	Picea needles and Betula bract	LP-2	Silty clay	This paper
ey Pond-	41° 19' N 72° 47' W	13.08-14.10	CAMS 127228	13,225± 40	15,338-16,026	15,682± 344	Salix twigs	LP-1	Clay	This paper
low Bog,		1.54-1.56	GX22773 -AMS	15,160± 70	18,452-18,748	18,600± 148 (81%)	Bulk	?	Organic-rich silty clay	Russell and Stanford, 2000
low Bog,		1.74-1.76	GX22028 -AMS	13,580± 80	15,759-16,595	16,177 418	Bulk	?	Organic-rich silty clay	Russell and Stanford, 2000
ille, NY	41° 28'23" N 74° 31'10" W	4.61-5.01	B153148	14,300± 50	16,684-17,488	17,086± 402	Bulk	T	Gravel	Robinson et al., 2005
lski Farm,	41° 20' 02" N 74° 25'45" W	1.54-1.55	AA45689	13,083± 86	15,128-15,859	15,494± 366	Bulk	A-2	Clayey peat	Robinson et al., 2005
ot Swamp,	41° 24' N 71° 58' W	3.22	OxA/ C13-9	12,420± 110	14, 076-14,944	14,510± 434	Twig and dwarf birch seed		Coarse sand interbedded with organic lenses	McWeeney, 1994
odendron np, onk, NY	41° 47' N 74° 08' W	2.82	CAMS 87258	12,510± 40	14,272-14,960	14,616± 344	Rubus seed	A-2	Organic silt	Peteet, unpub.
odendron np, NY	41° 47' N 74° 08' W	3.78	CAMS 87260	12,245± 50	13,941-14,286	14,114± 173	Picea twig	A-2	Organic silt	Peteet, unpub.
rs Lake,	41° 22' N 72° 7' W	11.5	NA	NA	NA	14,300	Bulk		Silt	Davis, 1969
le Bog, NJ		5.5-6?	NA	12,300	NA	NA	Bulk	A-2	Organic silt	Sirkin and Minard, l972
ce Pond,	41° 14'22" N 74° 12'15" W	8.5	CAMS 13423	12,410± 70	14,127-14,863	14,495± 368	AMS	A-2	Clayey gytjja	Maenza-Gmelch, 1997b
rland Fen,	41° 23' N 74° 02' W			12,350± 120	13, 983-14, 900	14,442± 459				
rland l, NY	41° 23'29" N 74° 02'16" W	8.3-8.5	CAMS 8392	12,600± 380	13,742-15,851	14,797± 1055	Picea needle & seed	A-2	Clay/gyttja	Maenza-Gmelch, 1997a
ersville PA	41° 02' N 75° 16' W	12.50	NA	13,330	NA	NA	Bulk		Silty gyttja	Watts, 1979
ersville PA	41° 02' N 75° 16' W	13.84	CAMS 132152	12,300± 40	14,016-14,495	14,256± 240	Wood			This paper

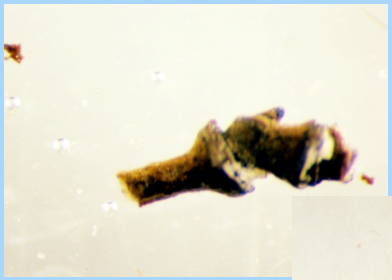

Green Pond
Uttertown Bog
Staten I. Fen
Late Wisconsinan recessi
Segments of late Wisconsinan terminal moraine
Late Illinoian terminal or recessional moraine
Limit of late Wisconsinan glaciation
Limit of late Illinoian glaciation
Limit of Port Murray Formation till facies
Correlated recessional ice-margin position
Lake spillway
PENNSYLVANIA
NEW YORK
DELAWARE RIVER
HUDSON RIVER
Augusta and Montague moraines
Ordensburg-Culvers Gap and Dingmans Ferry moraines
Glacial Lake Owassa
Glacial Lake Swartswood
Franklin Grove moraine
Glacial Lake Big Springs
Glacial Lake Wallkill (Augusta stage)
Glacial Lake Wallkill (Frankford Plains phase)
Glacial Lake McAfee
Glacial Lake Hamburg
Glacial Lake Beaver Run
Glacial Lake Newton
Glacial Lake Sparta (2 stages shown)
Wawayanda glacial lakes
Glacial Lake Bearfort
Cherry Ridge moraine
Mud Pond
Glacial Lake Hopatcong
Glacial Lake Picatinny
Glacial Lake Green Pond (2 stages)
Glacial Lake Denville
Glacial Lake Passaic (Moggy Hollow stage)
Glacial Lake Musquapsink
Glacial Lake Paramus
Glacial Lake Teaneck
Glacial Lake Tenakill
Glacial Lake Hudson
Glacial Lake Pequest
Mountain Lake moraine
Glacial Lake Oxford (Buckhorn stage)
Foul Rift moraine
Pequest moraine
Glacial Lake Oxford (Pophandusing stage)
Washington moraine
Townsbury moraine
Glacial Lake Budd
Budd Lake moraine
Flanders moraine
Glacial Lake Succasunna
Glacial Lake Dover
Glacial Lake Shongum
Glacial Lake Whippany
Madison moraine
Glacial Lake Passaic (Great Notch stage)
Glacial Lake Delawanna
Glacial Lake Verona
Glacial Lake Hackensack (Kill Van Kull stage)
Glacial Lake Watessing
Glacial Lake Bayonne
Glacial Lake Ashbrook
Glacial Lake Woodbridge
Kill Van Kull
Perth Amboy moraine
Hill moraine
MANHATTAN ISLAND
LONG ISLAND
STATEN ISLAND
ARTHUR KILL
NEW YORK BAY
Hell Gate
40 30'
41
Base modified from U.S. Geological Survey, 1974
SCALE 1:250 000
5 0 5 10 15 20 MILES
5 0 5 10 15 20 25 KILOMETERS
INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—2002



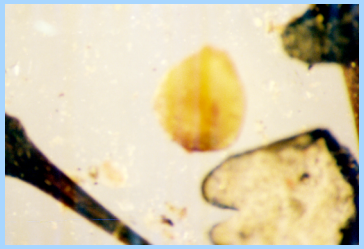
Green Pond, 8-9 m core depth

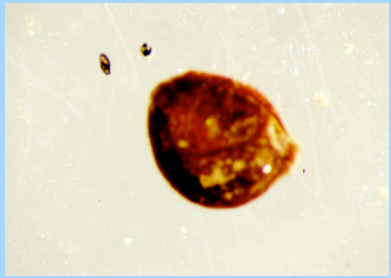


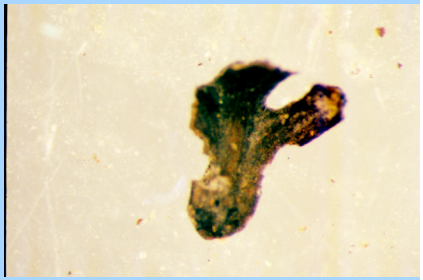




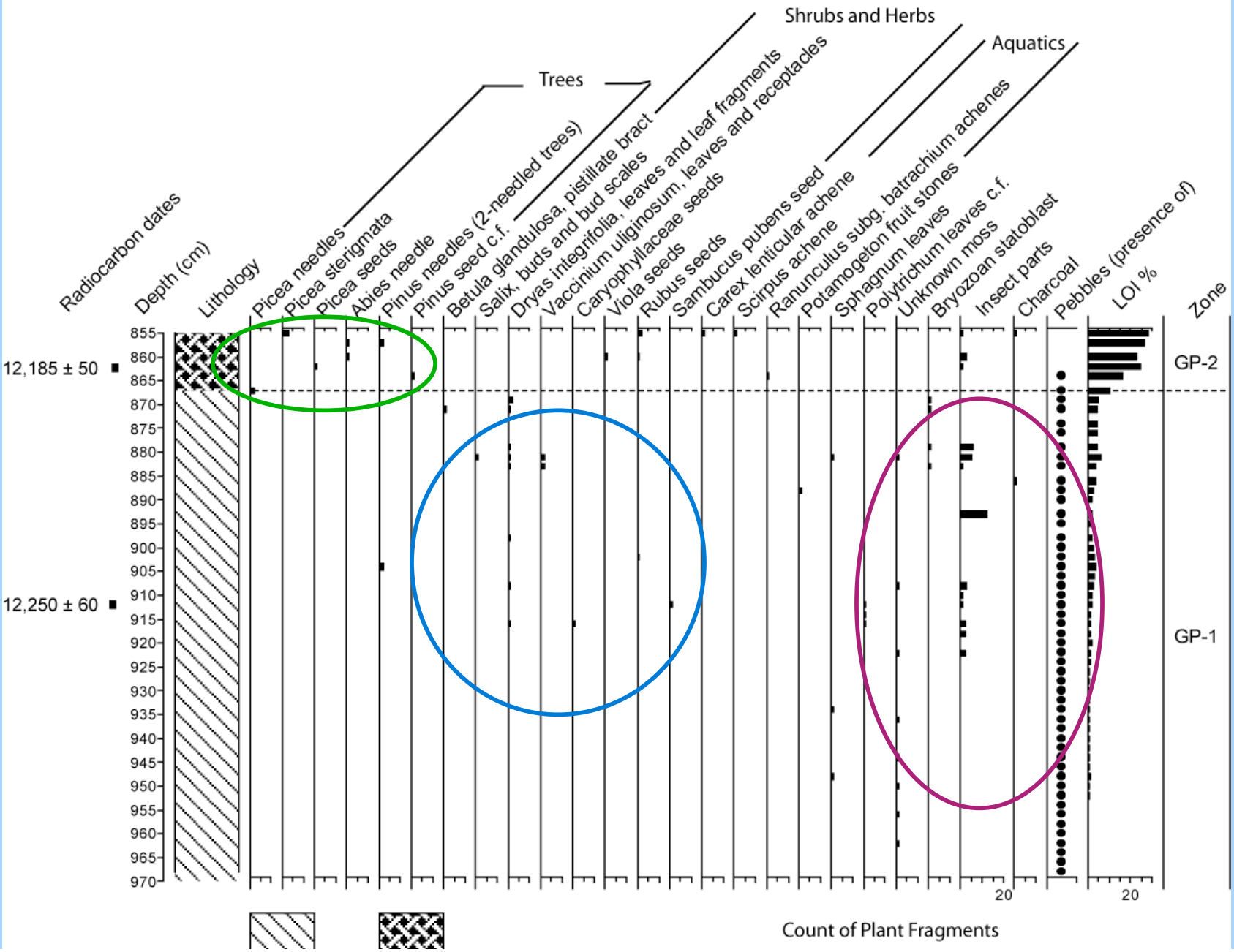
Plant Macrofossils in Glacial Clays

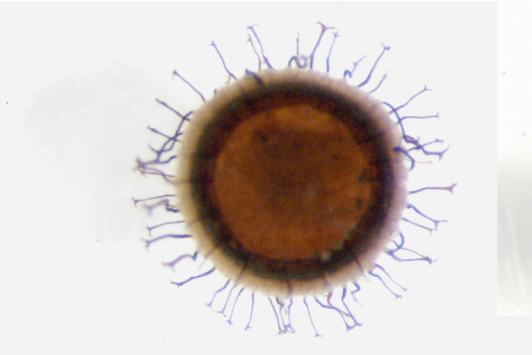






GREEN POND MACROFOSSILS

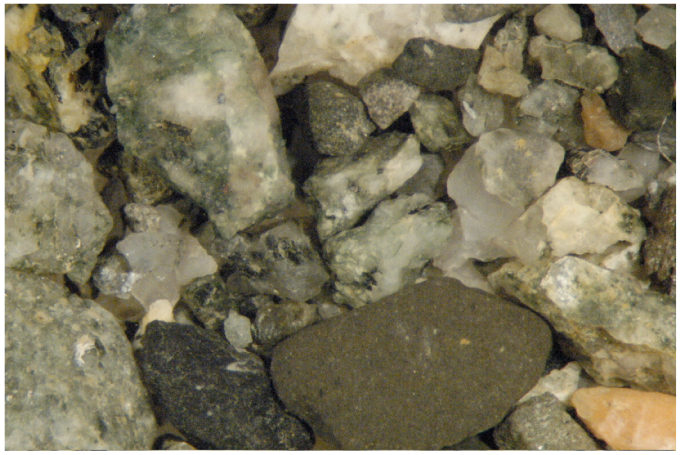




Bryozoan statoblast

Daphnia epipphia

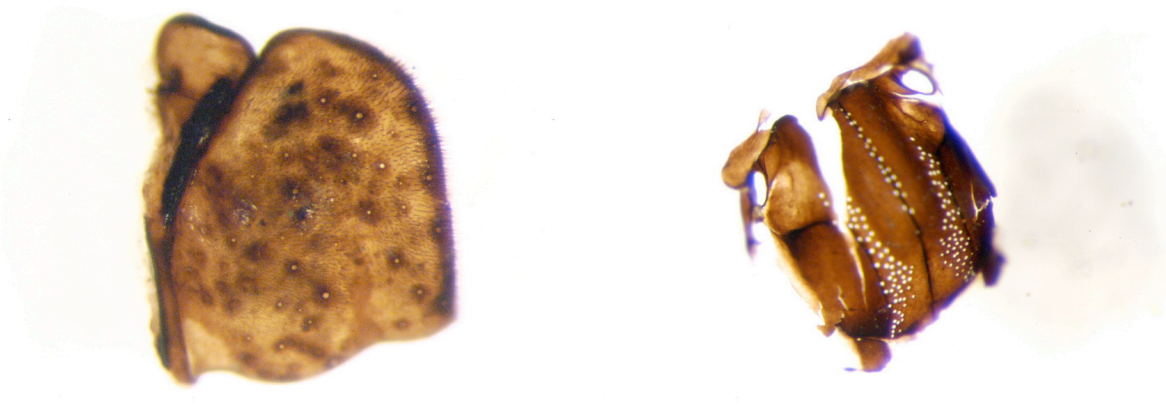
Moss parts

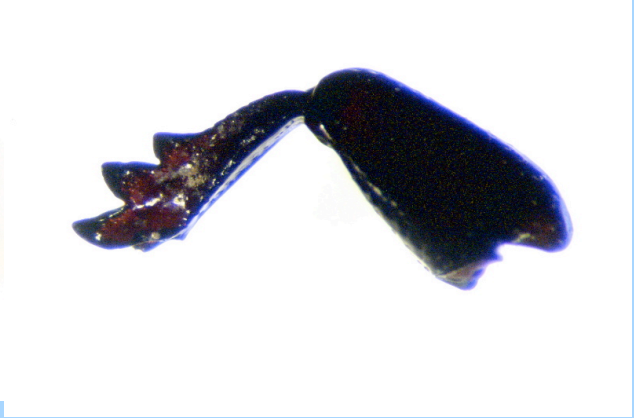


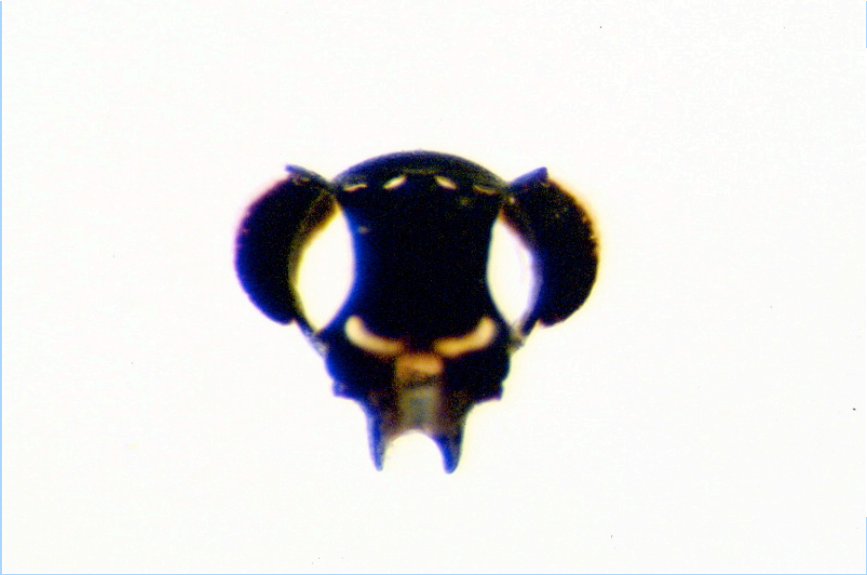
Rocks, Green Pond

Earliest macrofossils in glacial clays (less than 5% organic)

Insect macrofossils







Dryas fossil leaf

Dryas integrifolia

scaa.usask.ca/.../ [redacted].php?image=31

www.geobotany.uaf.edu/. ../dspevrgrn.html

Subarctic Tundra

Betula glandulosa

oregonstate.edu/ dept/ldplants/begl2.htm

www.botany.utoronto.ca/. ../307F1tundra.html

Fossil Betula cone scale

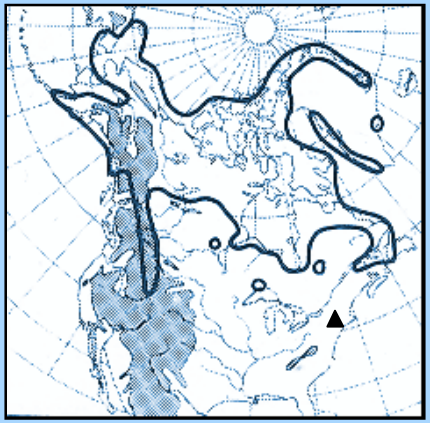
Vaccinium uliginosum

edu.ouka.fi/~maalto/ kasvit/juolukka .html

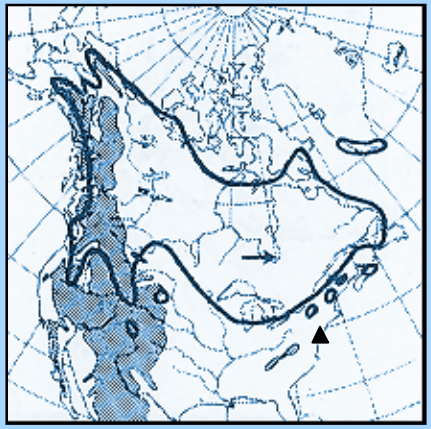
www.odezia-atrata .be/ Flora/Ericaceae/Vacciniu ..

Vaccinium fossil leaf

Subarctic
Tundra

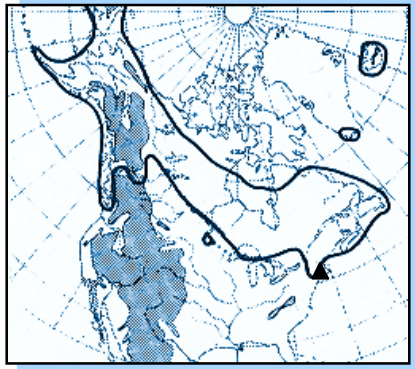


Dryas integrifolia leaf



Betula glandulosa cone bract

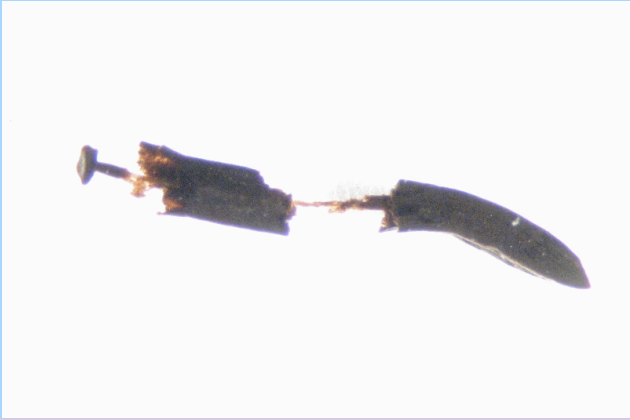
TUNDRA MACROFOSSILS FROM SOUTHERN NEW ENGLAND AND THEIR CURRENT DISTRIBUTION MAPS.



Vaccinium uliginosum leaf

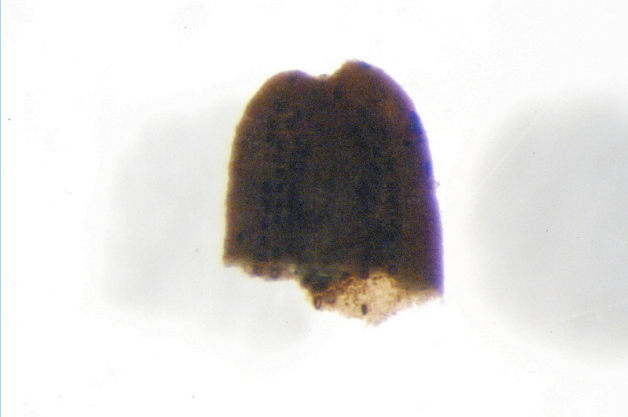
Salix bud

Boreal Trees & Shrubs



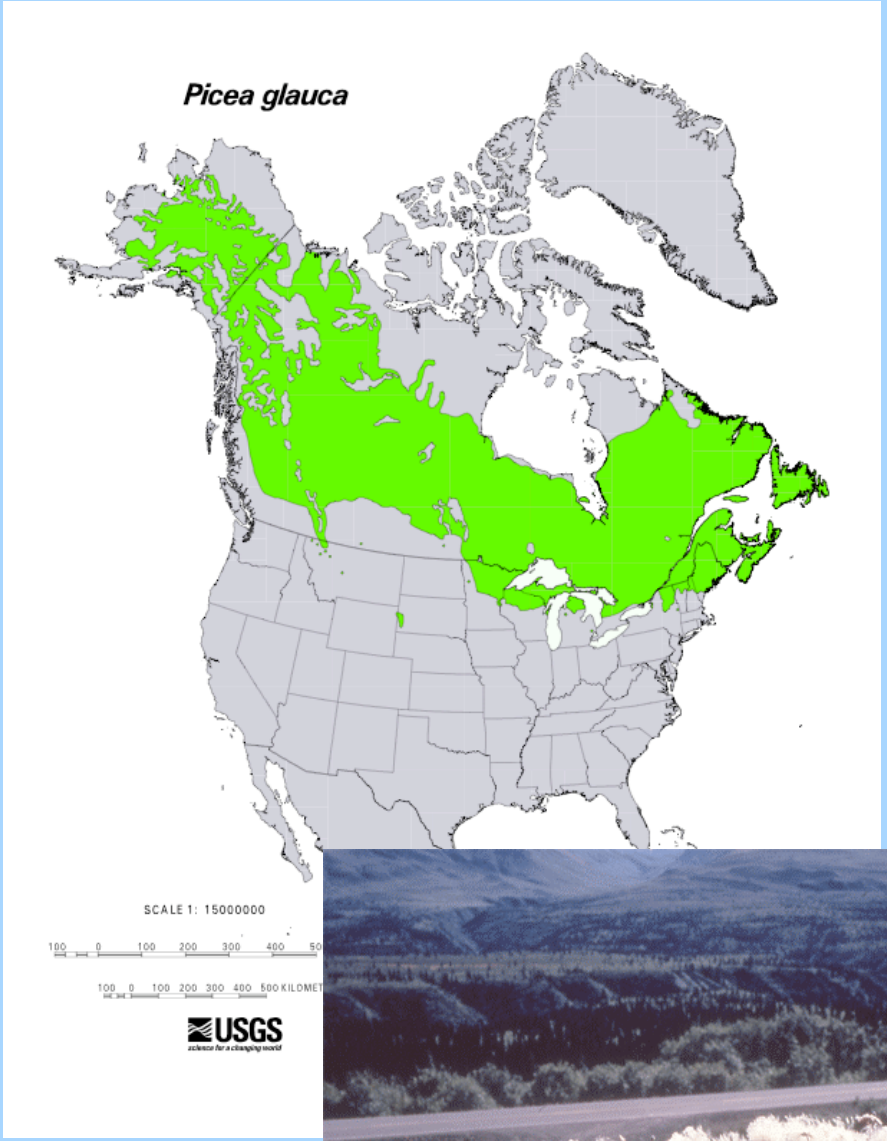
Picea glauca
fossil needle

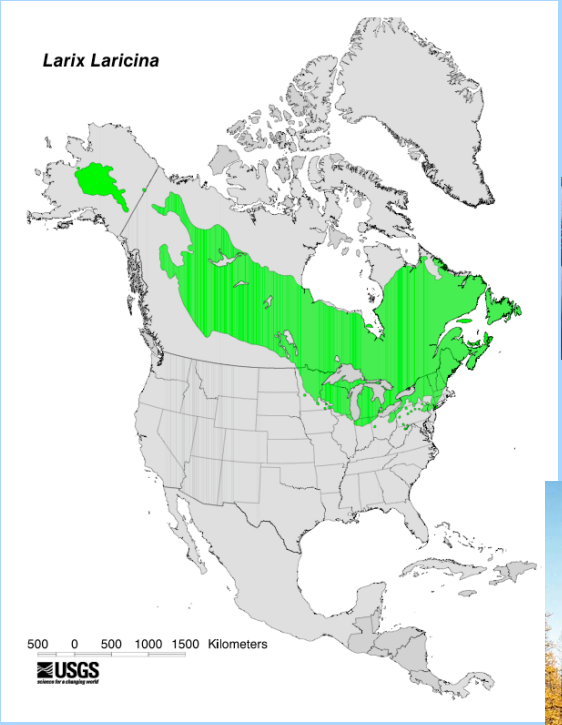
Picea fossil seed



Abies fossil needle tip

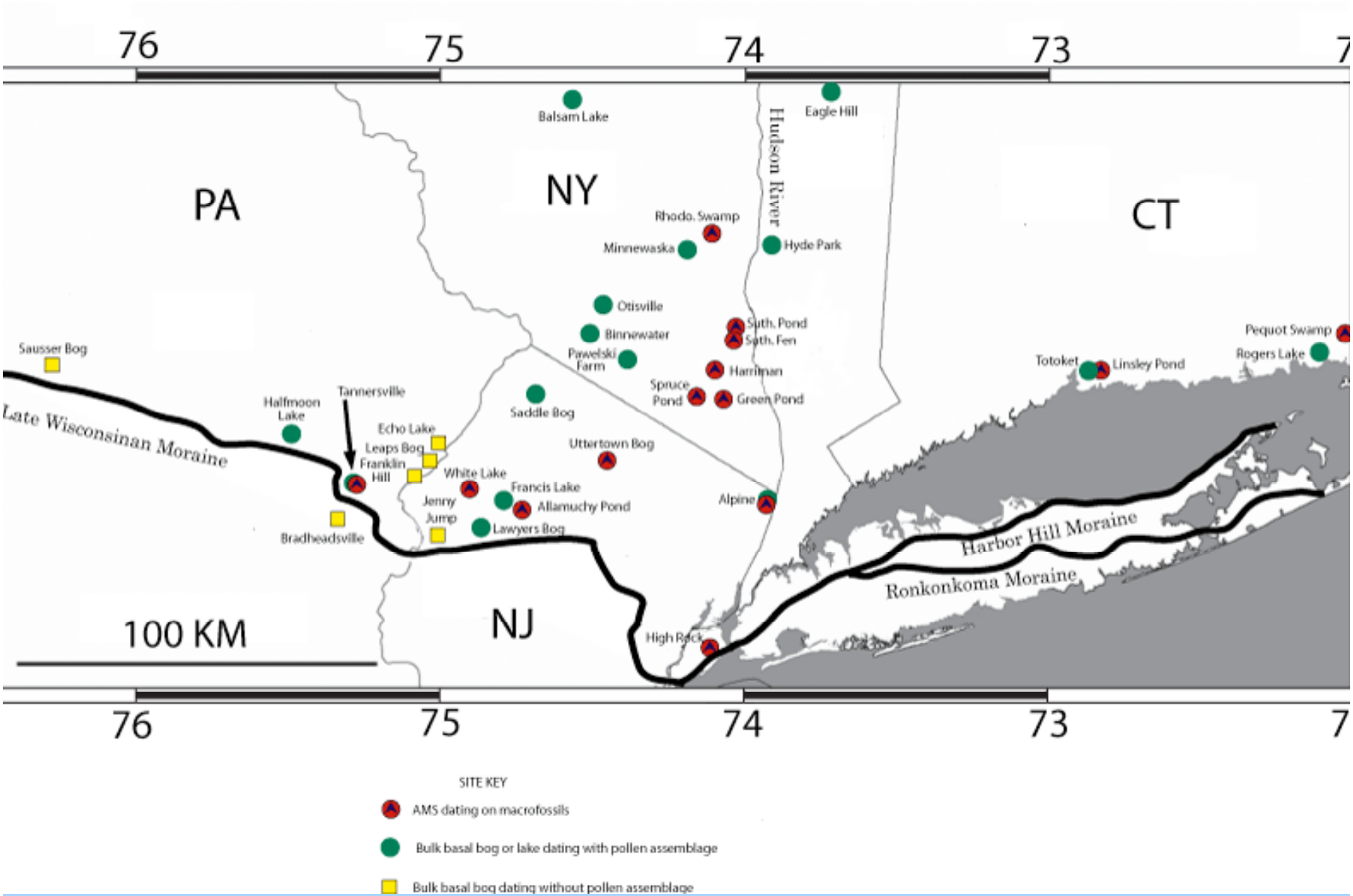
Alnus
fossil seed


Picea glauca
SCALE 1: 15000000
100 0 100 200 300 400 500
100 0 100 200 300 400 500 KILOMET
USGS
science for a changing world

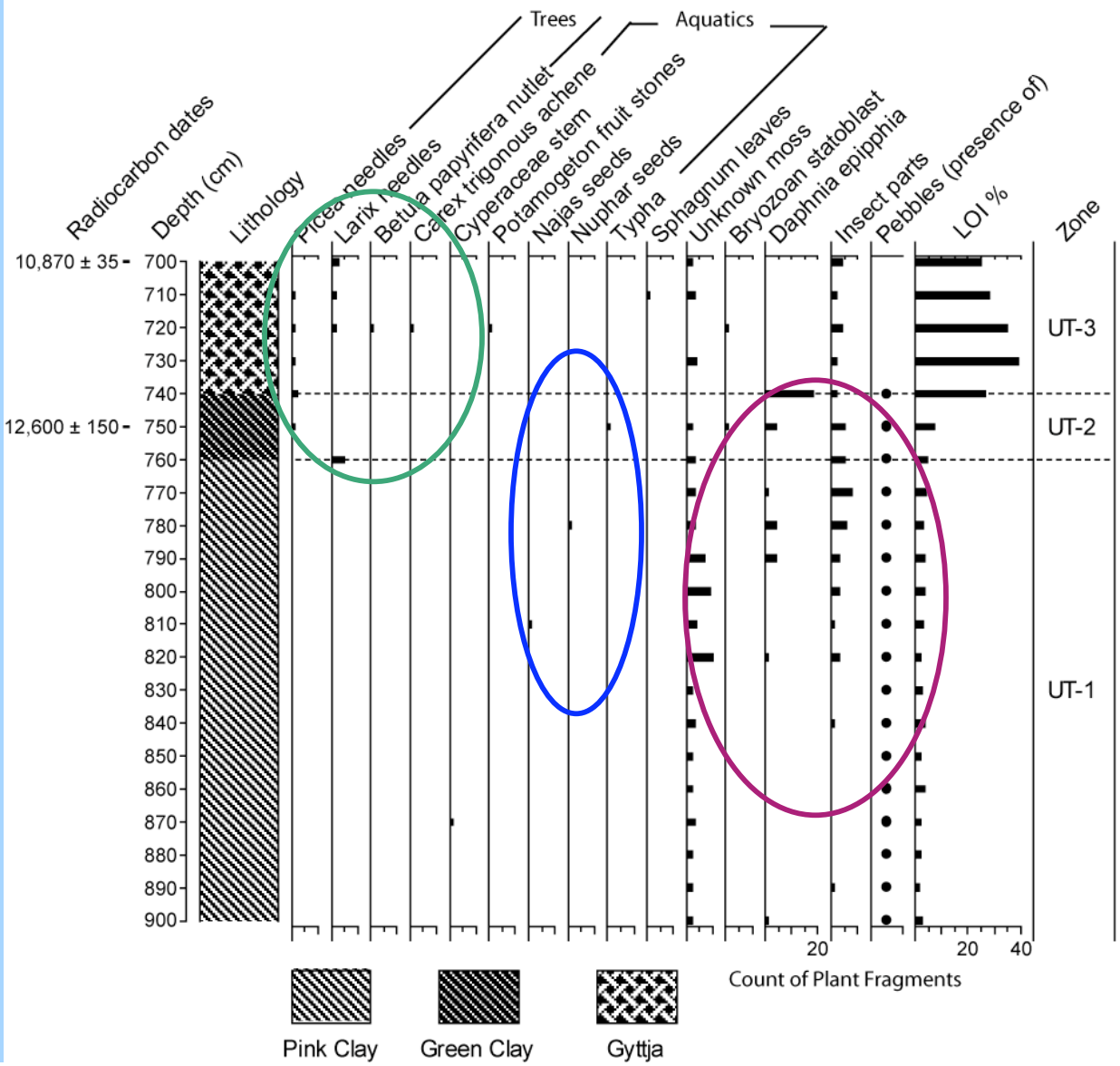

Larix Laricina
500 0 500 1000 1500 Kilometers
USGS
science for a changing world

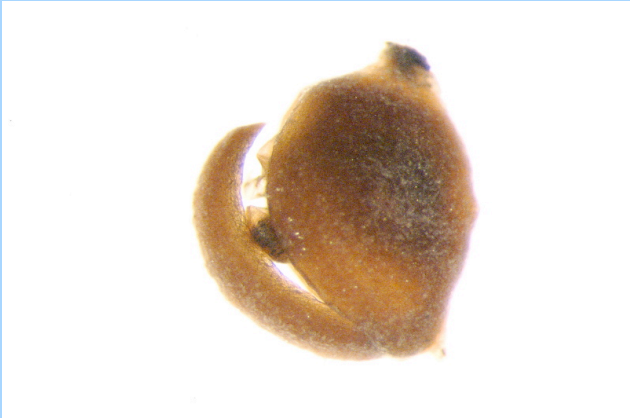
(C) 2001, Gary Fewless

Abies balsamea
500 0 500 1000 1500 Kilometers
USGS
science for a changing world


76
75
74
73
7
PA
NY
CT
NJ
Balsam Lake
Eagle Hill
Hudson River
Rhodo. Swamp
Minnewaska
Hyde Park
Otisville
Binnewater
Sath. Pond
Sath. Fen
Pawelski Farm
Harriman
Spruce Pond
Green Pond
Saddle Bog
Uttertown Bog
Sausser Bog
Halfmoon Lake
Tannersville
Late Wisconsinan Moraine
Echo Lake
Leaps Bog
Franklin Hill
White Lake
Francis Lake
Jenny Jump
Allamuchy Pond
Lawyers Bog
Bradheadsville
Alpine
High Rock
Totoket
Linsley Pond
Pequot Swamp
Rogers Lake
Harbor Hill Moraine
Ronkonkoma Moraine
100 KM
SITE KEY
AMS dating on macrofossils
Bulk basal bog or lake dating with pollen assemblage
Bulk basal bog dating without pollen assemblage

UTTERTOWN BOG MACROFOSSILS

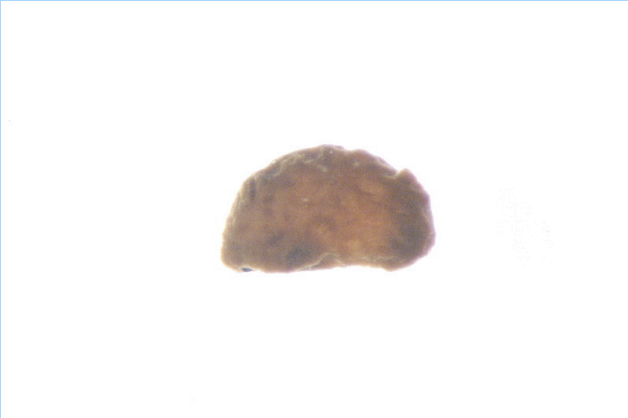




Potamogeton seed

Najas seed

Caryophyllaceae seed

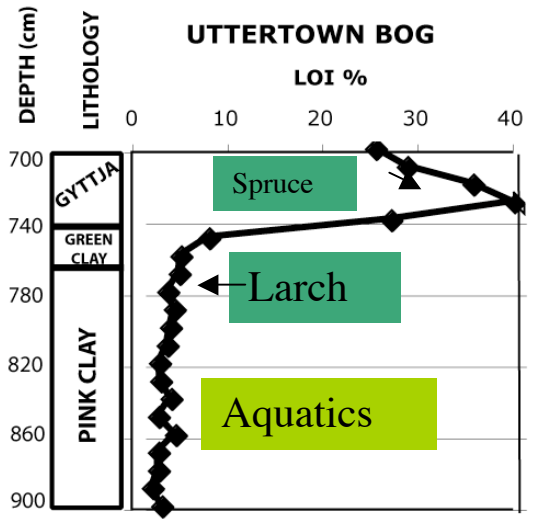


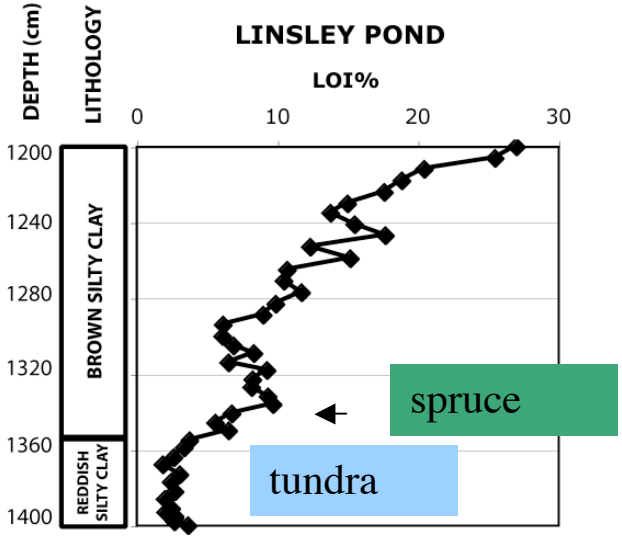
Rubus seed

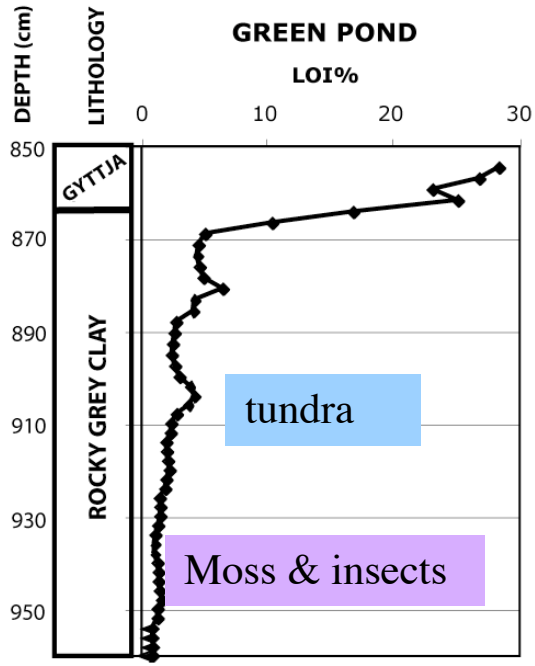
Harriman Swamp, NY
2006

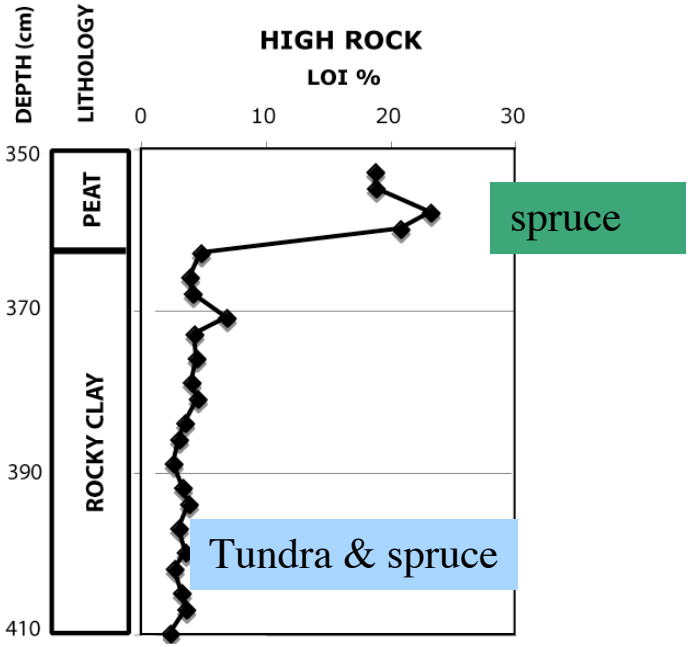
Basal grey clay topped by carbonate sediments

LOI % BY DEPTH

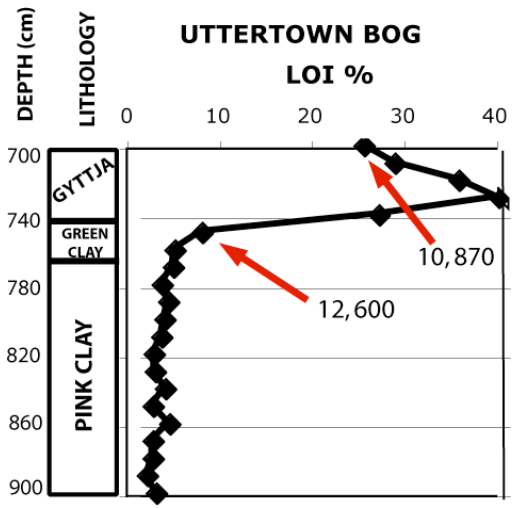

UTTERTOWN BOG
LOI %
DEPTH (cm)
LITHOLOGY
0
10
20
30
40
700
740
780
820
860
900
GYTTJA
GREEN CLAY
PINK CLAY
Spruce
Larch
Aquatics

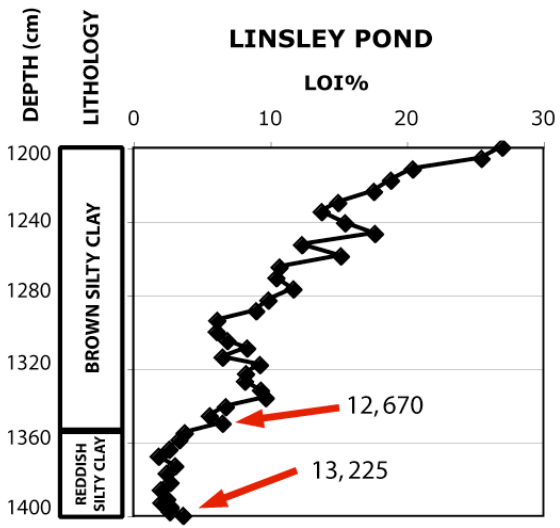

LINSLEY POND
LOI%
DEPTH (cm)
LITHOLOGY
0
10
20
30
1200
1240
1280
1320
1360
1400
BROWN SILTY CLAY
REDDISH SILTY CLAY
spruce
tundra

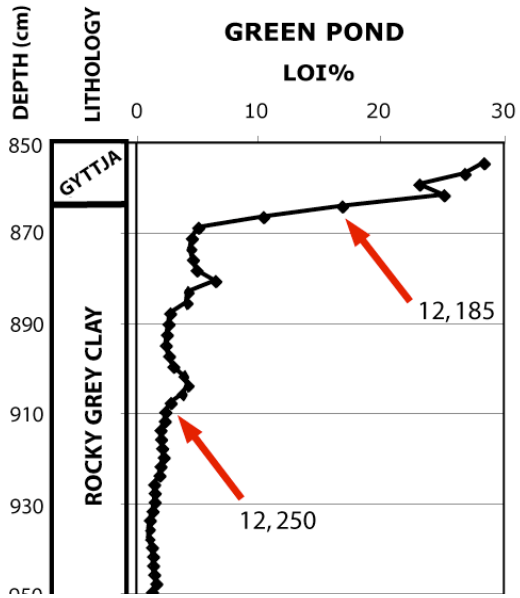

GREEN POND
LOI%
DEPTH (cm)
LITHOLOGY
0
10
20
30
850
870
890
910
930
950
GYTTJA
ROCKY GREY CLAY
tundra
Moss & insects

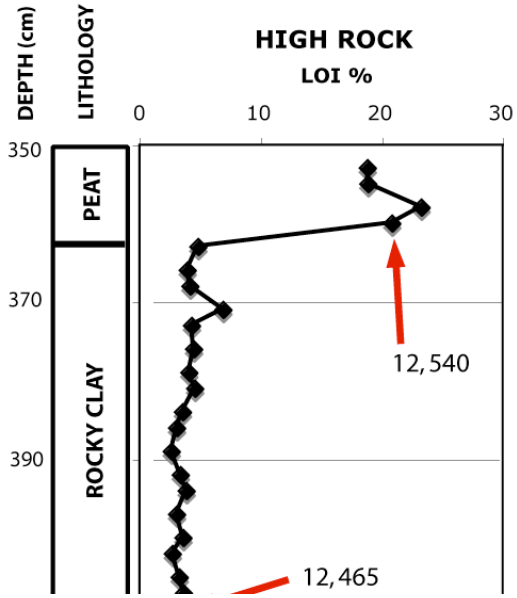

HIGH ROCK
LOI %
DEPTH (cm)
LITHOLOGY
0
10
20
30
350
370
390
410
PEAT
ROCKY CLAY
spruce
Tundra & spruce

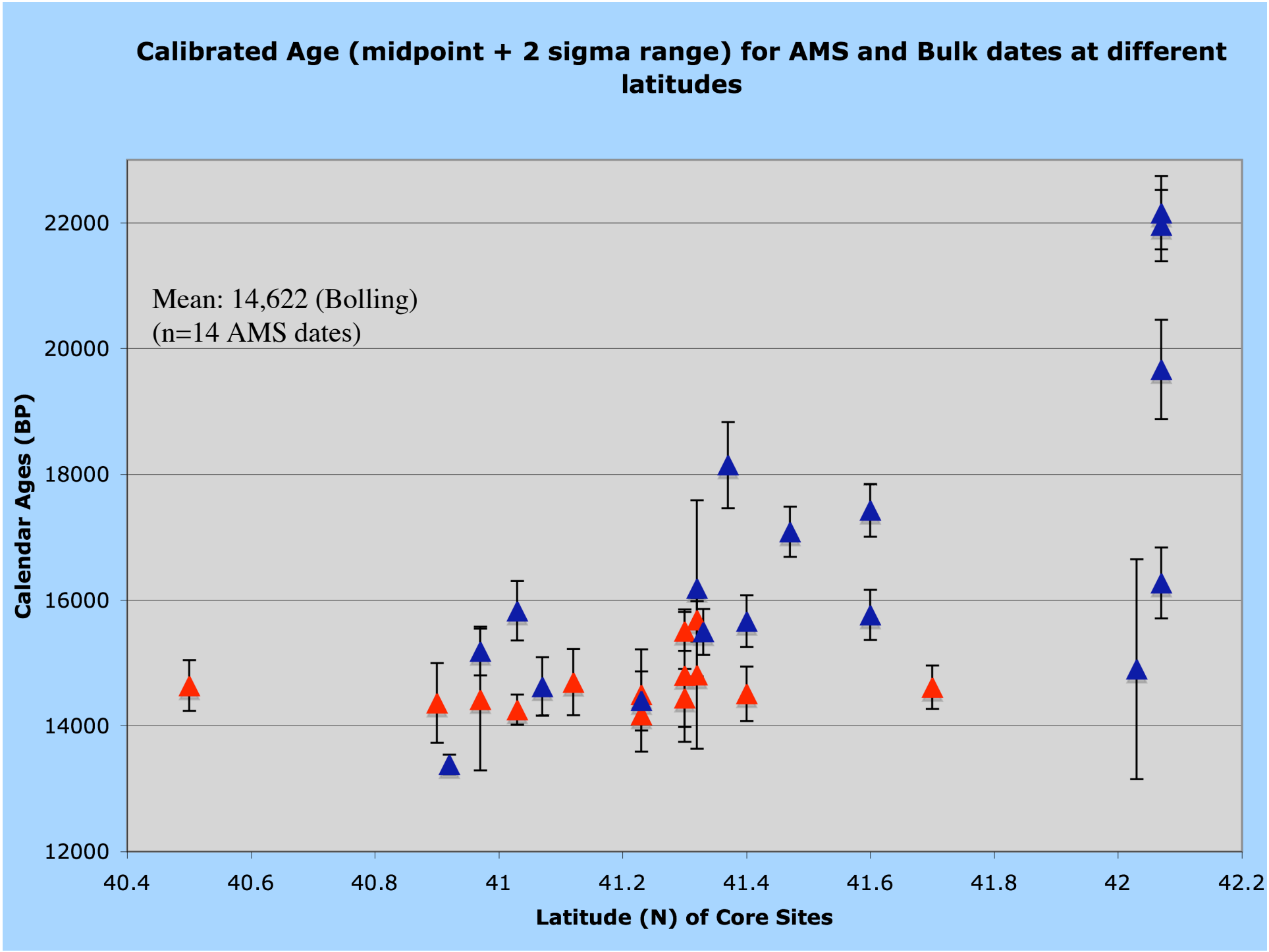
RADIOCARBON AGES



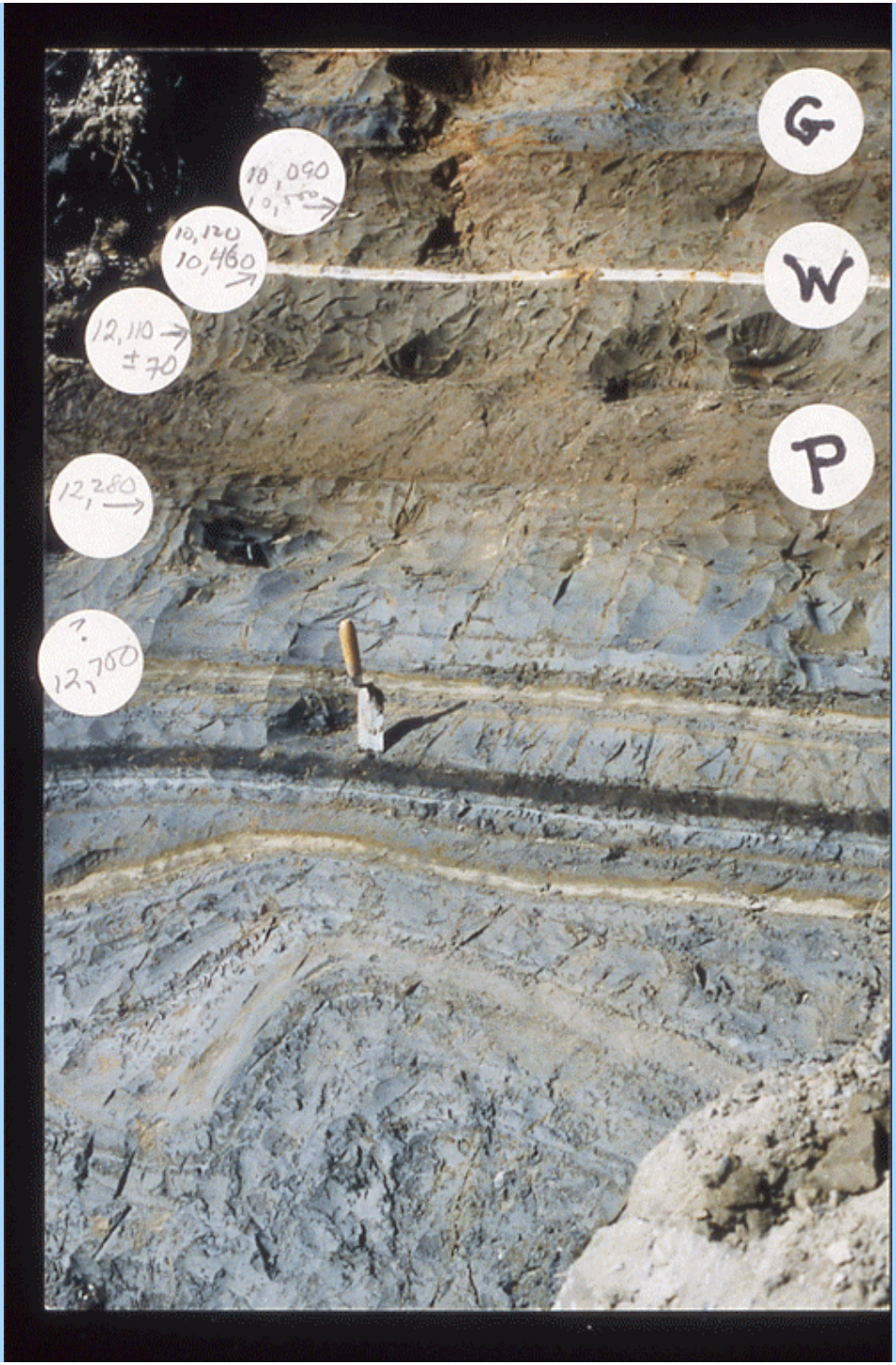







Calibrated Age (midpoint + 2 sigma range) for AMS and Bulk dates at different latitudes
Mean: 14,622 (Bolling)
(n=14 AMS dates)
Calendar Ages (BP)
22000
20000
18000
16000
14000
12000
40.4
40.6
40.8
41
41.2
41.4
41.6
41.8
42
42.2
Latitude (N) of Core Sites

Why are many bulk dates too old?



Kodiak Island, AK

Peteet et al., 1994

Why are lakes and bogs so young?

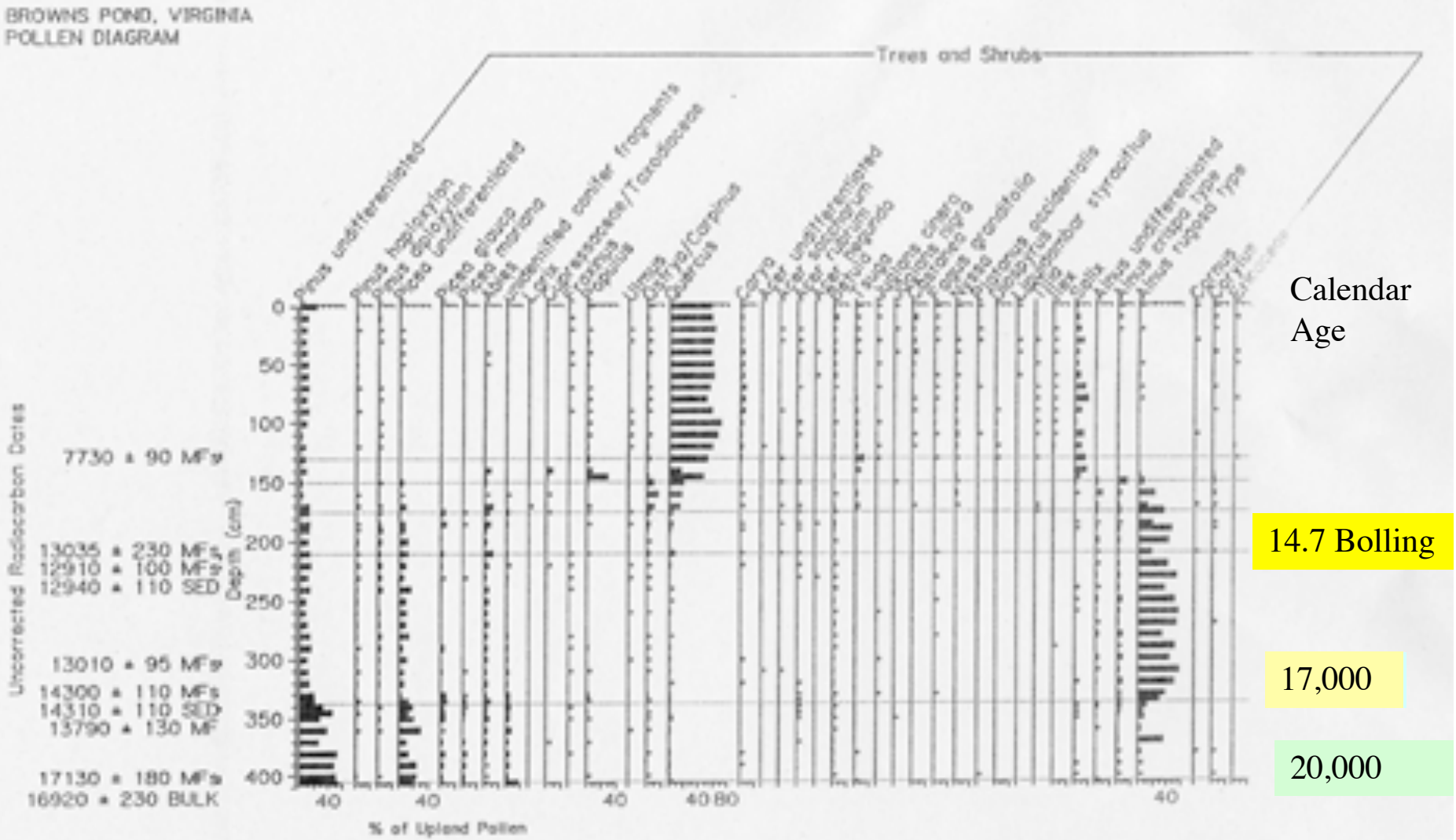

BROWNS POND, VIRGINIA
POLLEN DIAGRAM
Trees and Shrubs
Pinus undifferentiated
Pinus haploxylon
Pinus diploxylon
Picea undifferentiated
Picea glauca
Picea mariana
Abies
Tsuga canadensis
Larix
Juniperus
Cupressaceae/Taxodiaceae
Ulmus
Ostrya/Carpinus
Quercus
Carya
Acer undifferentiated
Acer saccharum
Acer rubrum
Betula nigra
Betula lenta
Fraxinus
Juglans cinerea
Juglans nigra
Salix
Nyssa sylvatica
Liquidambar styraciflua
Liriodendron tulipifera
Ilex
Celtis
Alnus undifferentiated
Alnus crispa type
Alnus rugosa type
Cornus
Corylus
Uncorrected Radiocarbon Dates
7730 ± 90 MFy
13035 ± 230 MFs
12910 ± 100 MFs
12940 ± 110 SED
13010 ± 95 MFy
14300 ± 110 MFs
14310 ± 110 SED
13790 ± 130 MF
17130 ± 180 MFs
16920 ± 230 BULK
Depth (cm)
0
50
100
150
200
250
300
350
400
40
40
40
40 80
40
% of Upland Pollen
Calendar Age
14.7 Bolling
17,000
20,000

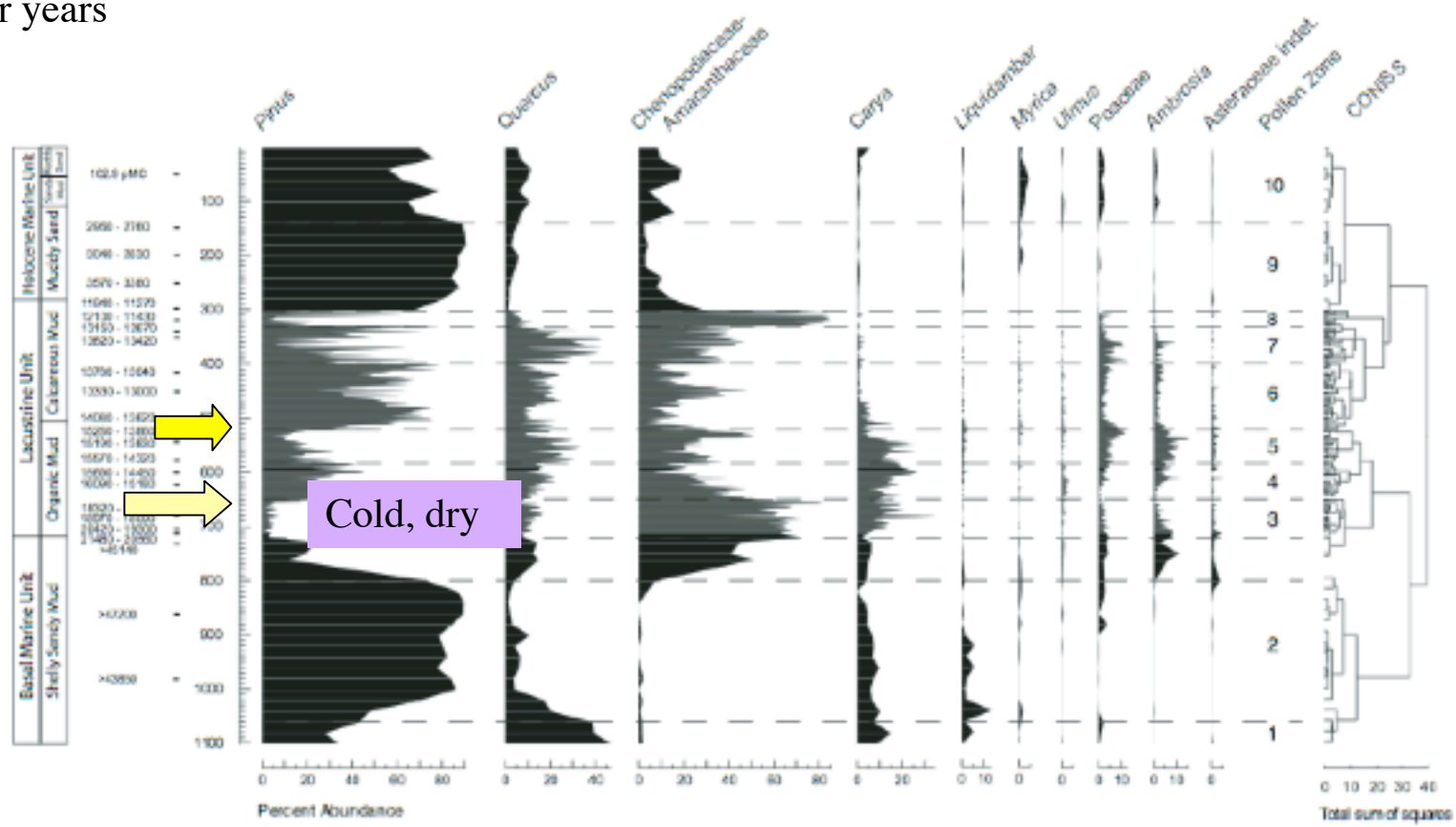
Figure 5.1

Tampa Bay, Florida Pollen & Spores

Calendar years

Bolling 14.7

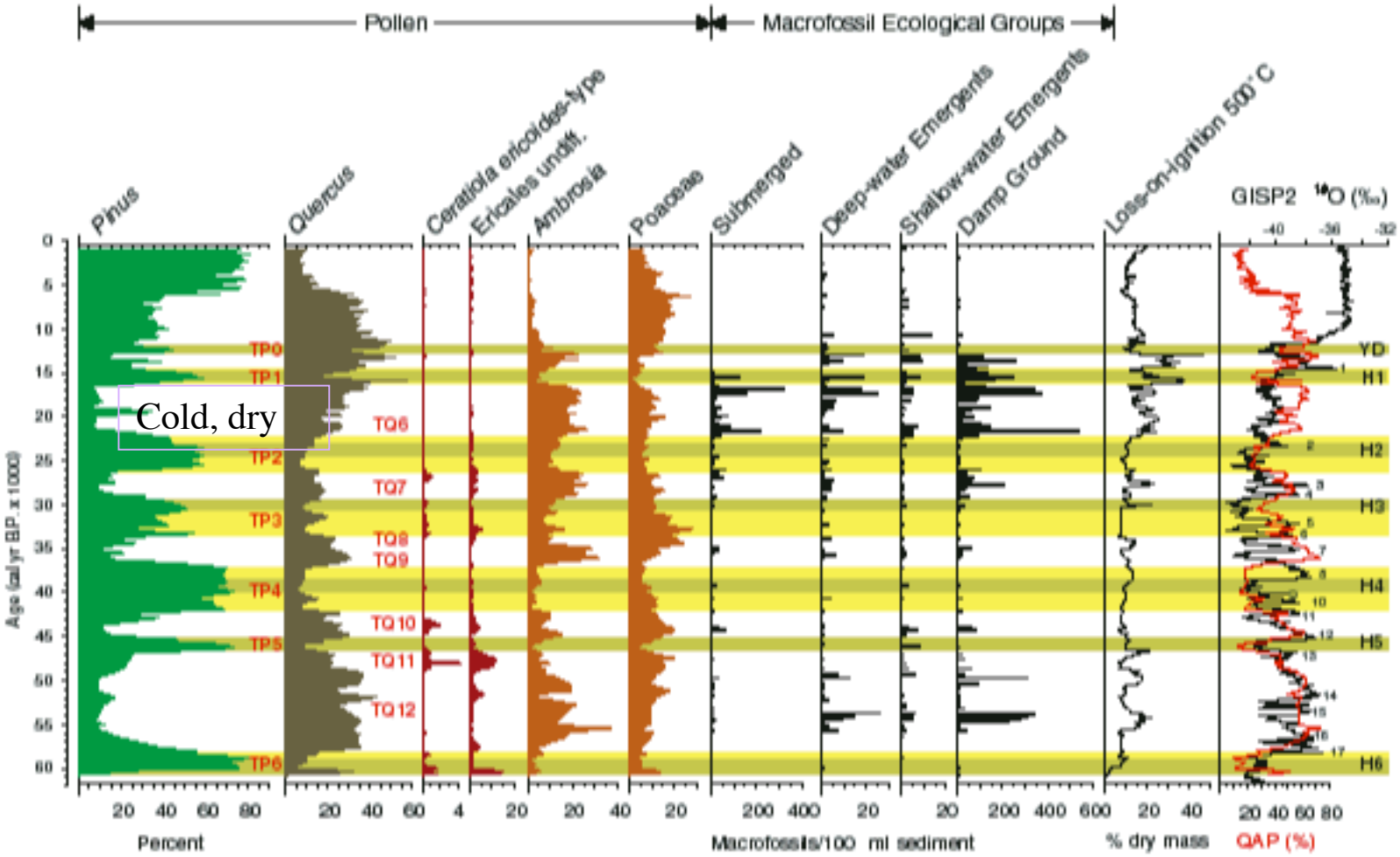
17.2



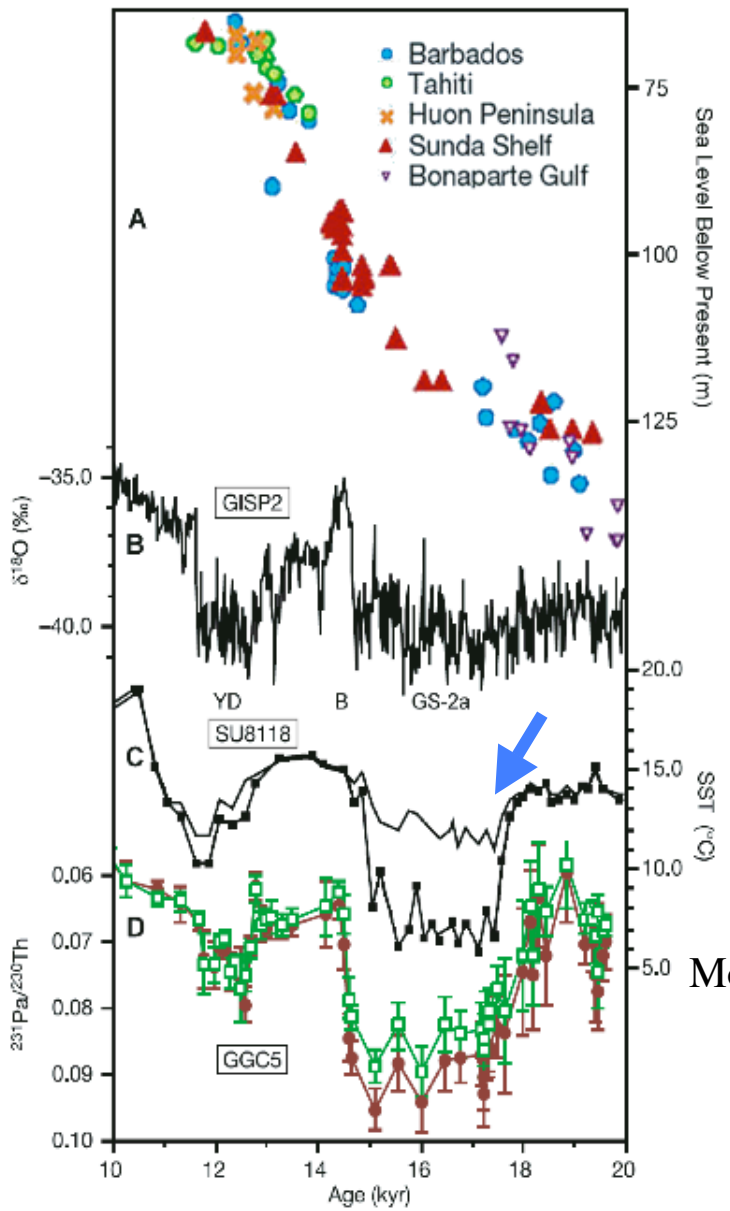
Willard et al., in press,

Lake Tulane, Florida

Pollen and spores, LOI, GISP2



Grimm et al., QSR, 2006



Bard et al. 2000
SST drop off Portugal

Modified from Denton et al. 2005

FIGURE 8

Conclusions and Questions

- Ice was present until 14,700 calendar years as indicated by pebbles, lack of organics on landscape
- Fourteen wetland sites record landscape stability & loss of tundra after 14.7, as recorded by pollen influx, LOI, macrofossils, and AMS ages (Bolling Warming).
- Basal dates indicate 1st plants on landscape with ice are tundra…not organic sedimentation
- Organic sedimentation started within 500 years of ice melt - Linsley Pond
- Was landscape so unstable for 2300-5000 years (if we accept Be ages? …ice, wind, erosion, temperature?
- Sites in Virginia and Florida show warming at 17k, followed by further warming at 14.7…cold and dry prior to that time
- Agrees with Bard et al. 2000 meltwater pulse off Portugal, and McManus diminished NADW overturning due to colder N. Atlantic.

Why do AMS 14C ages differ from 10Be on erratics and varve ages (but agree elsewhere)?

10Be -production rate calculations erroneous?, inheritance?

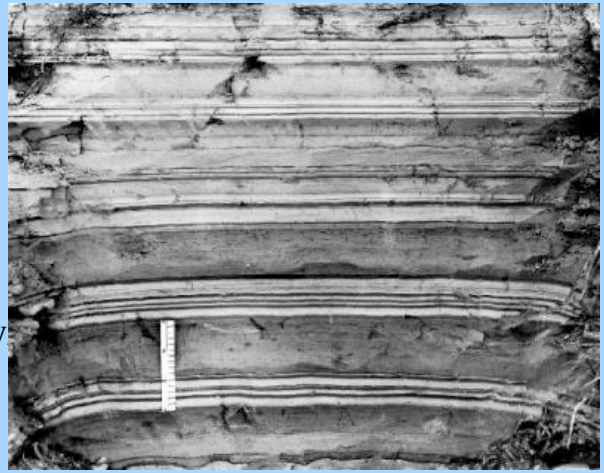
14C -minimum ages, ice blocks? inhospitable landscape?….

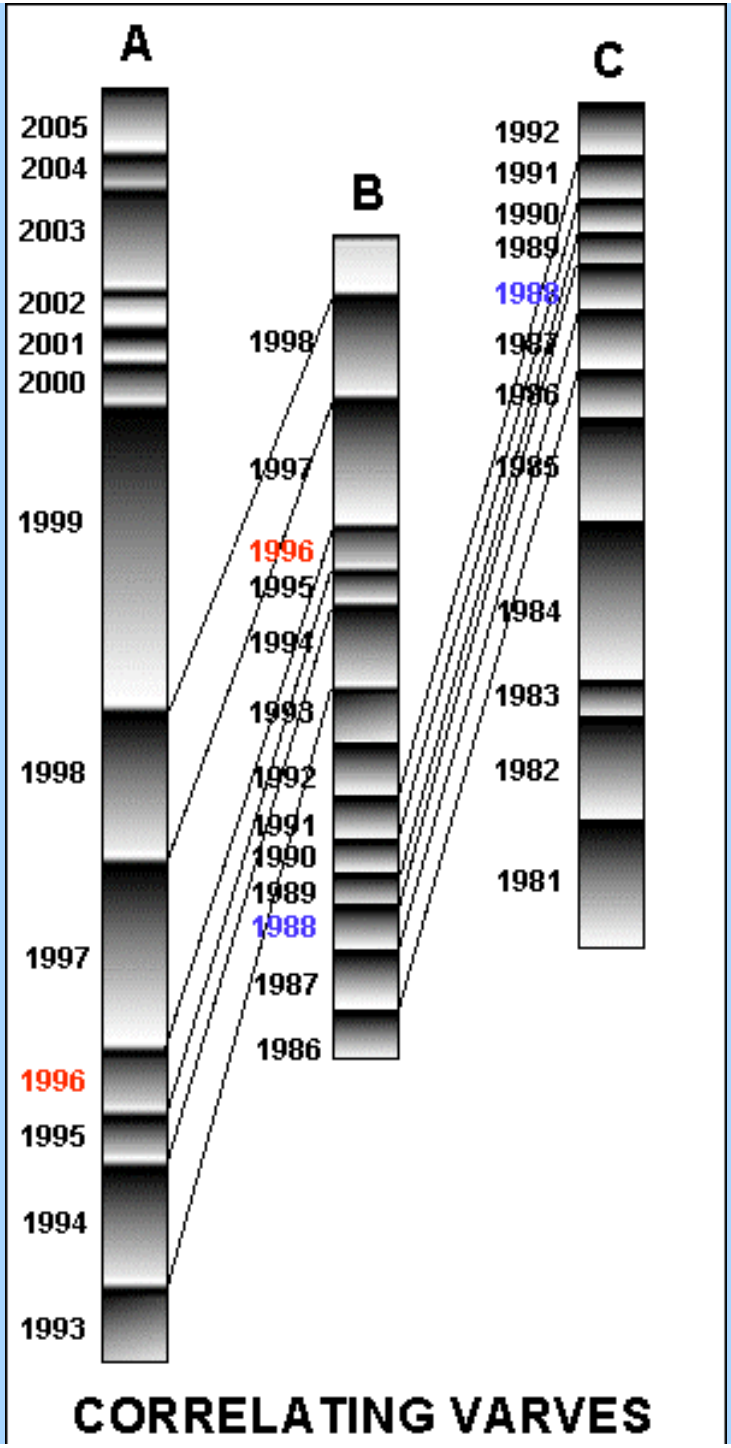
Real age matters for understanding ocean-atmosphere dynamics

Varve

- Sedimentary layer set deposited within a single year (glacial or non-glacial)
- *Glacial* -Spring - coarse-grained melt
- *Glacia*l -Winter -fine clay when frozen
- *Non-glacial* -Calcareous, ferrogenic, clastic, organic

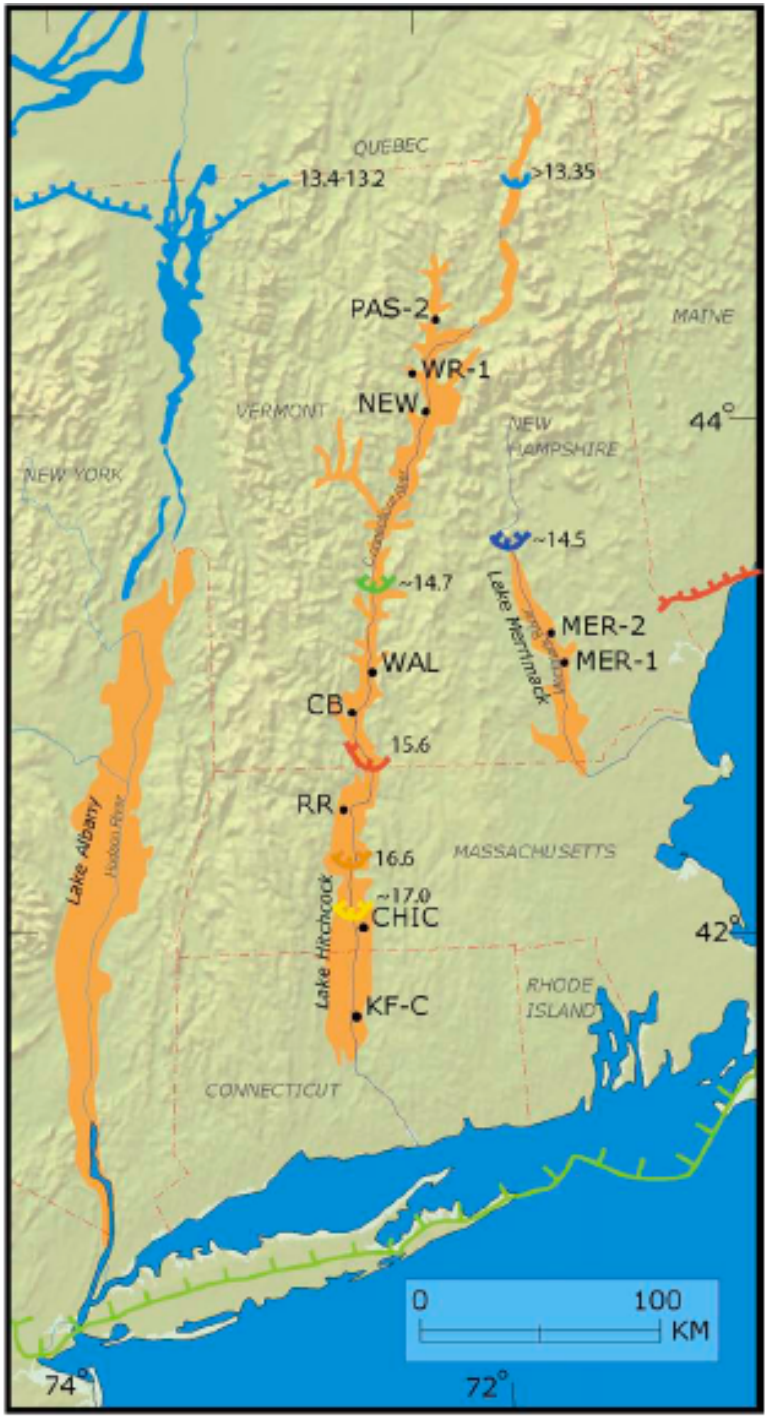
- http://ase.tufts.edu/geology





CORRELATING VARVES

Problem: Age discrepancy… ..Are varves present when uplands are ice-covered?



New England river valleys with glacial varve sequences

Benner et al, 2008

28-23,000 kyr