Quantifying the response rates of lake ecosystems to Holocene deglaciation through the use of stable isotopes

Presented by Joshua C. Galster

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Outline

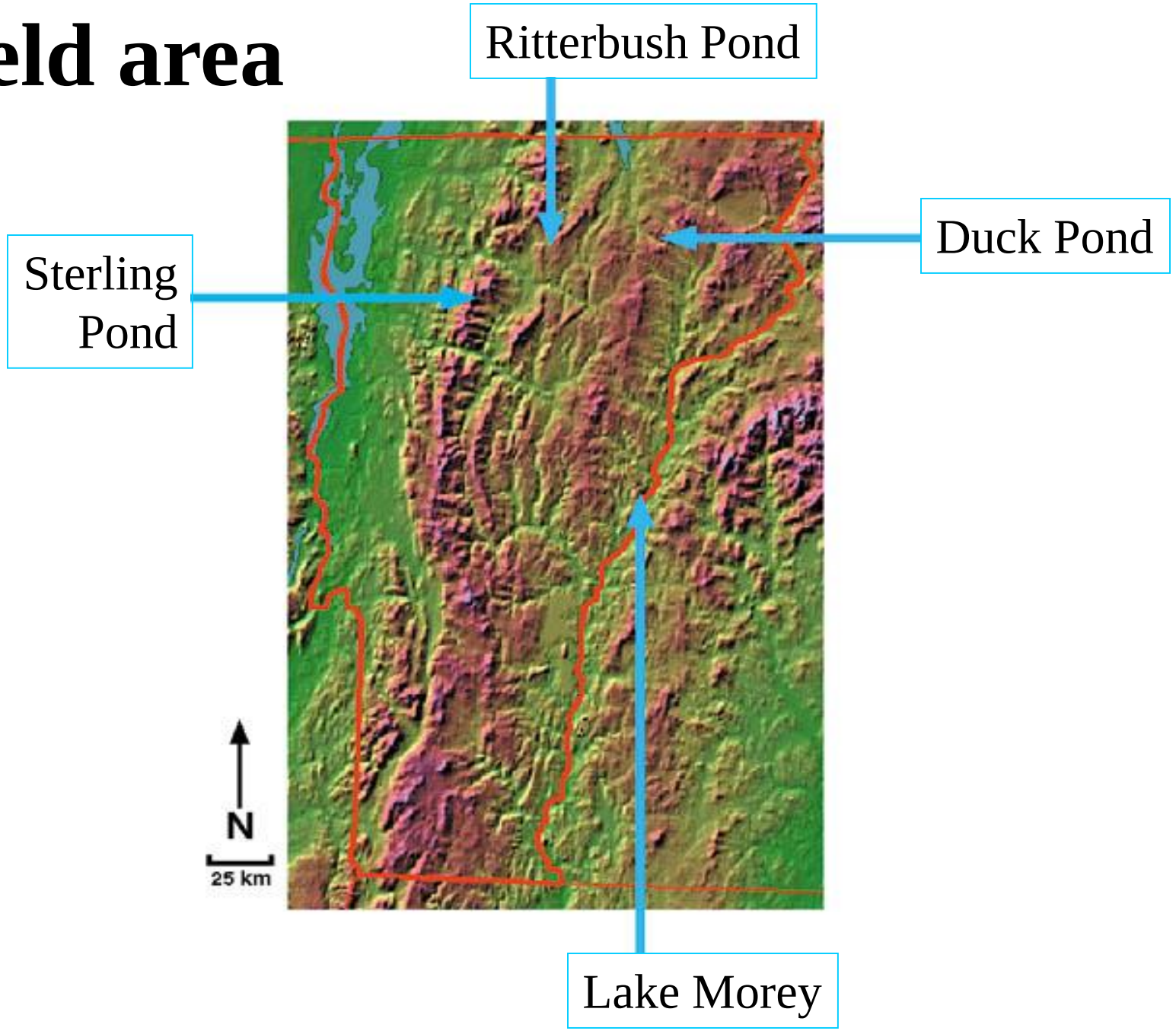
- Background
- Methods
- Results
- Summary and comparisons
- Interpretations and significance
- Future directions

Statement of Problem

- To determine the rate that the terrestrial and aquatic ecosystems established themselves following deglaciation.

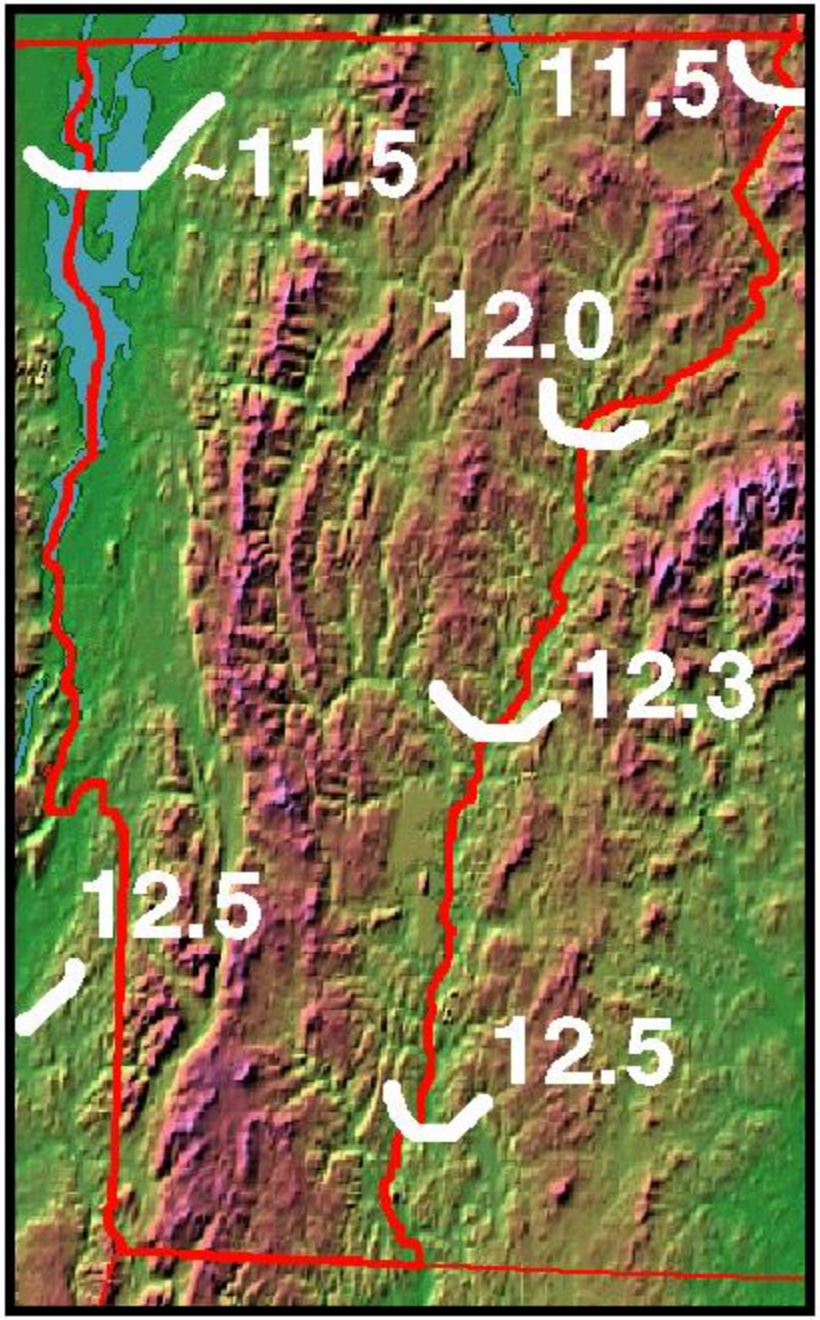
- To determine the factors that influence that establishment rate.

Field area



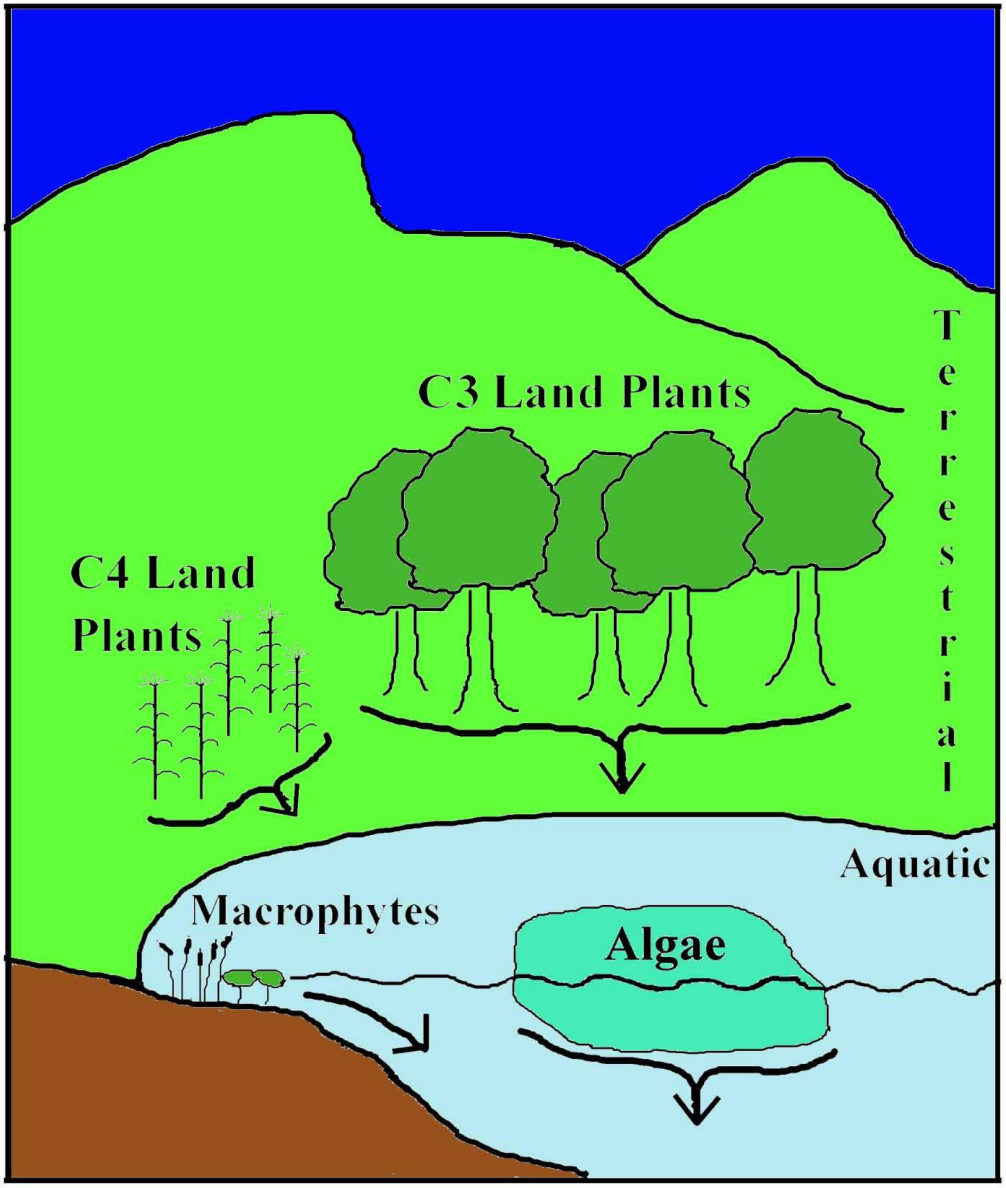
History of Deglaciation in Vermont

- White lines represent the glacial extent, in ^{14}C yBP (from Ridge et al., 1999).
- Dates mostly from Lake Hitchcock varves.
- Lack of ^{14}C dates and the mountainous topography complicate the deglaciation history in the central part of the state.



Sources of sedimentary organic matter

- Terrestrial sources
- Aquatic sources
- Aeolian sources minor (<5%)

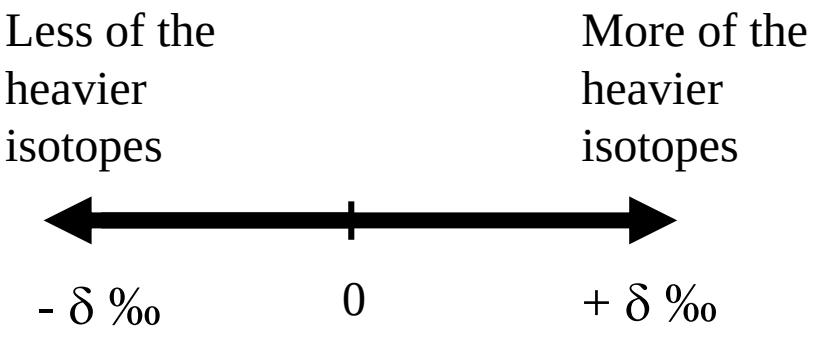


Stable isotopes

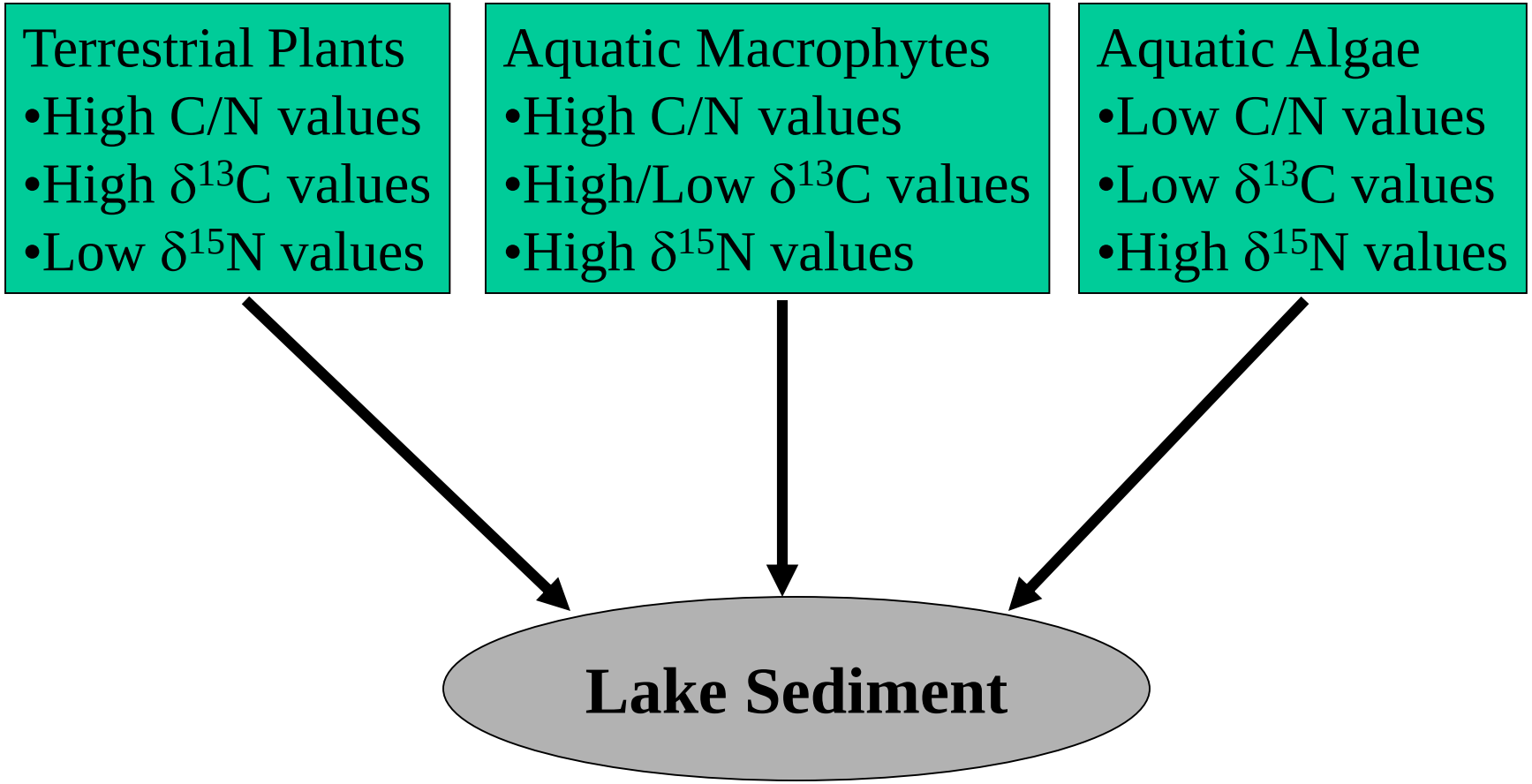
- Are naturally occurring
- Do not radioactively decay
- Reported using the ‘δ notation’

$$\delta‰ = [(R_{sample}/R_{standard}) - 1] \times 1000$$

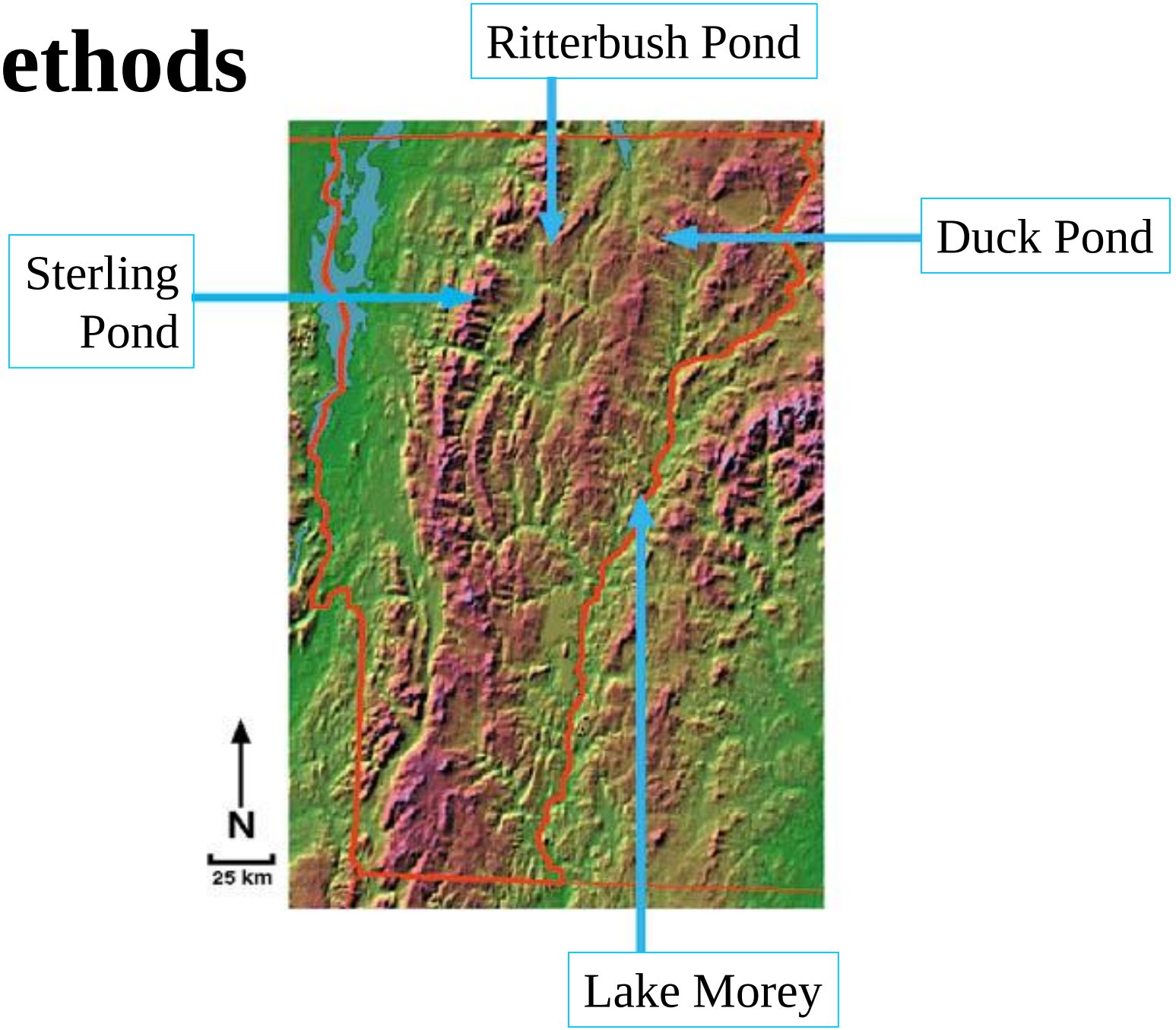
where ‘R’ is the ratio of heavy to light isotopes (e.g. $^{13}C/^{12}C$ and $^{15}N/^{14}N$)

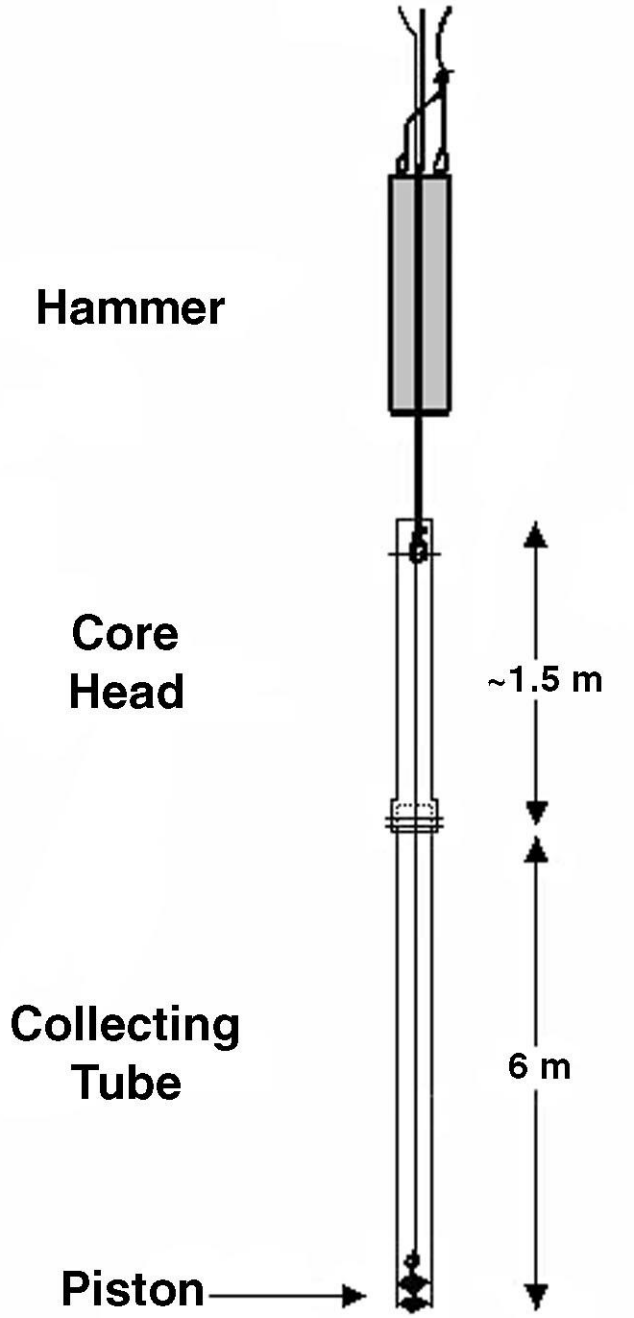


Composition of OM sources



Methods





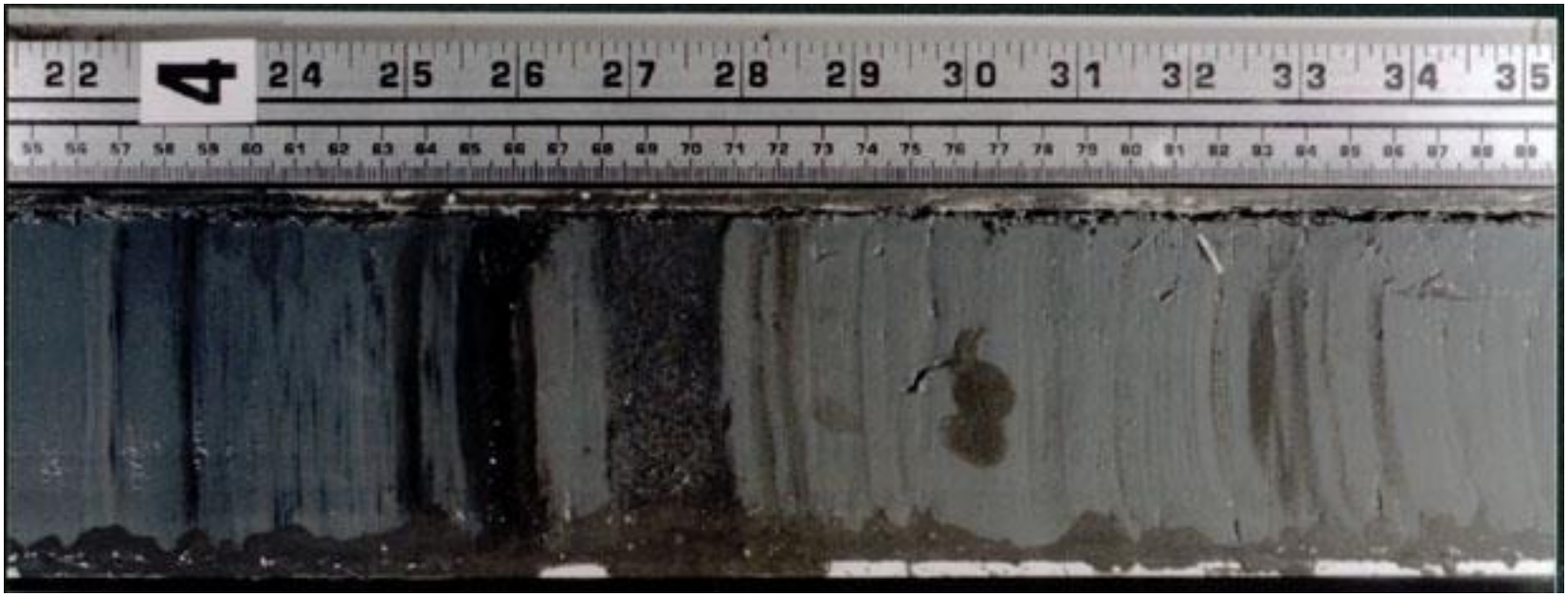
Modified Reasoner (1993) coring device

Collect Cores → X-RAY → Photograph → Visual Log

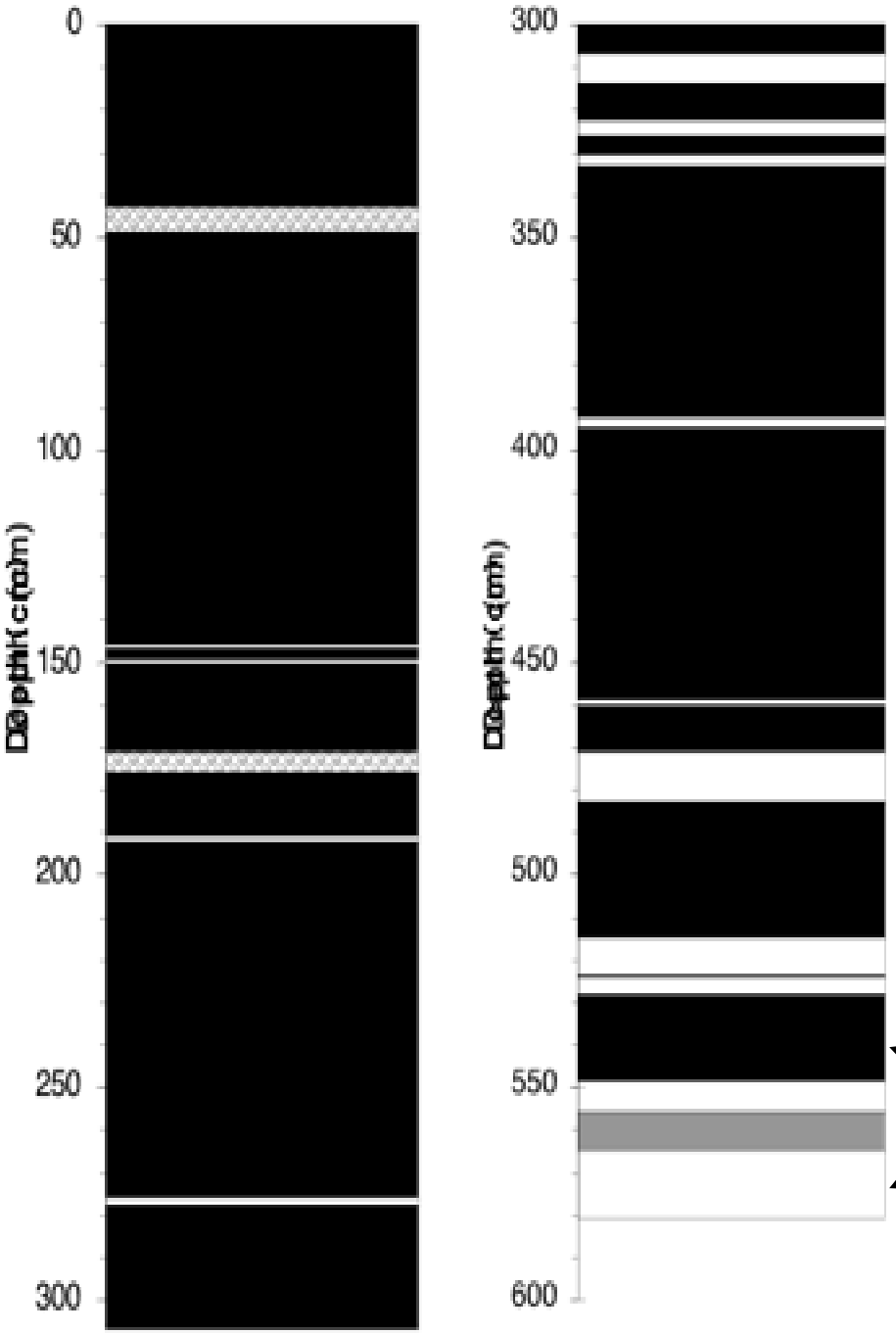
Visual Log → Sample at 1-cm resolution

Sample at 1-cm resolution → Acidify → Radiocarbon dating

Acidify → Freeze dry → C/N analyses → Isotope analyses

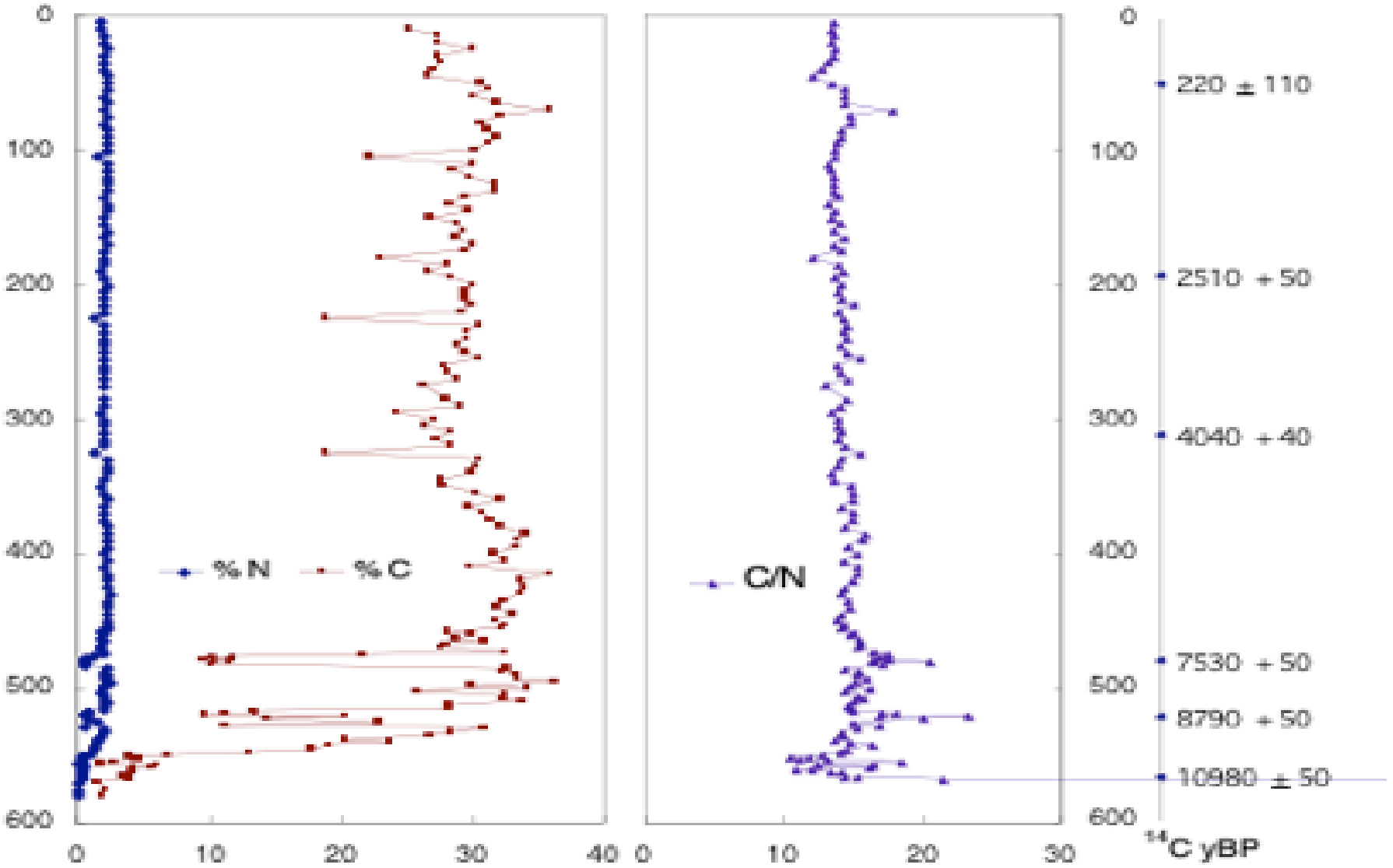


Duck Pond Lithology

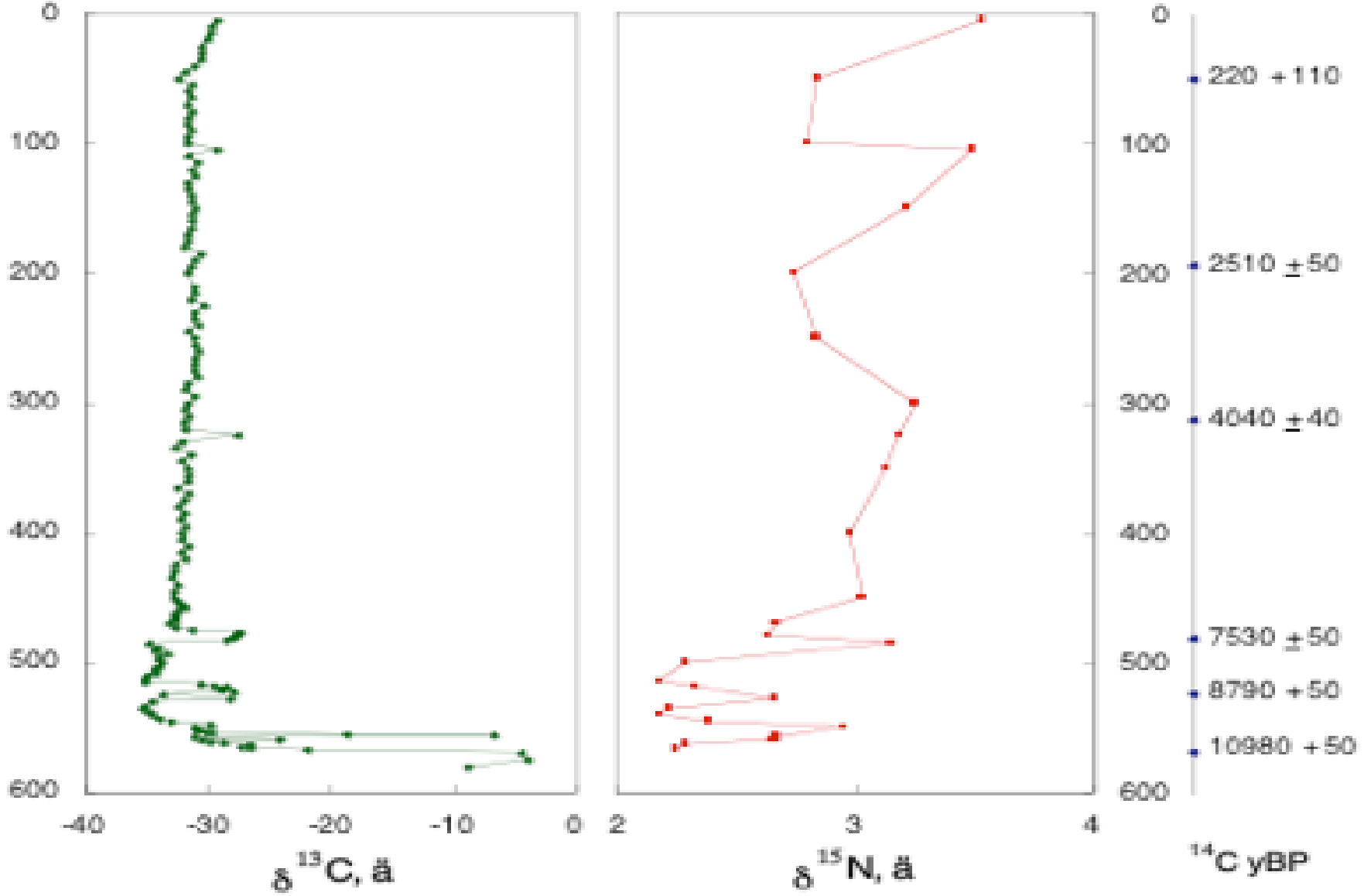


Bottom sediment transitions from coarse sand to gyttja.

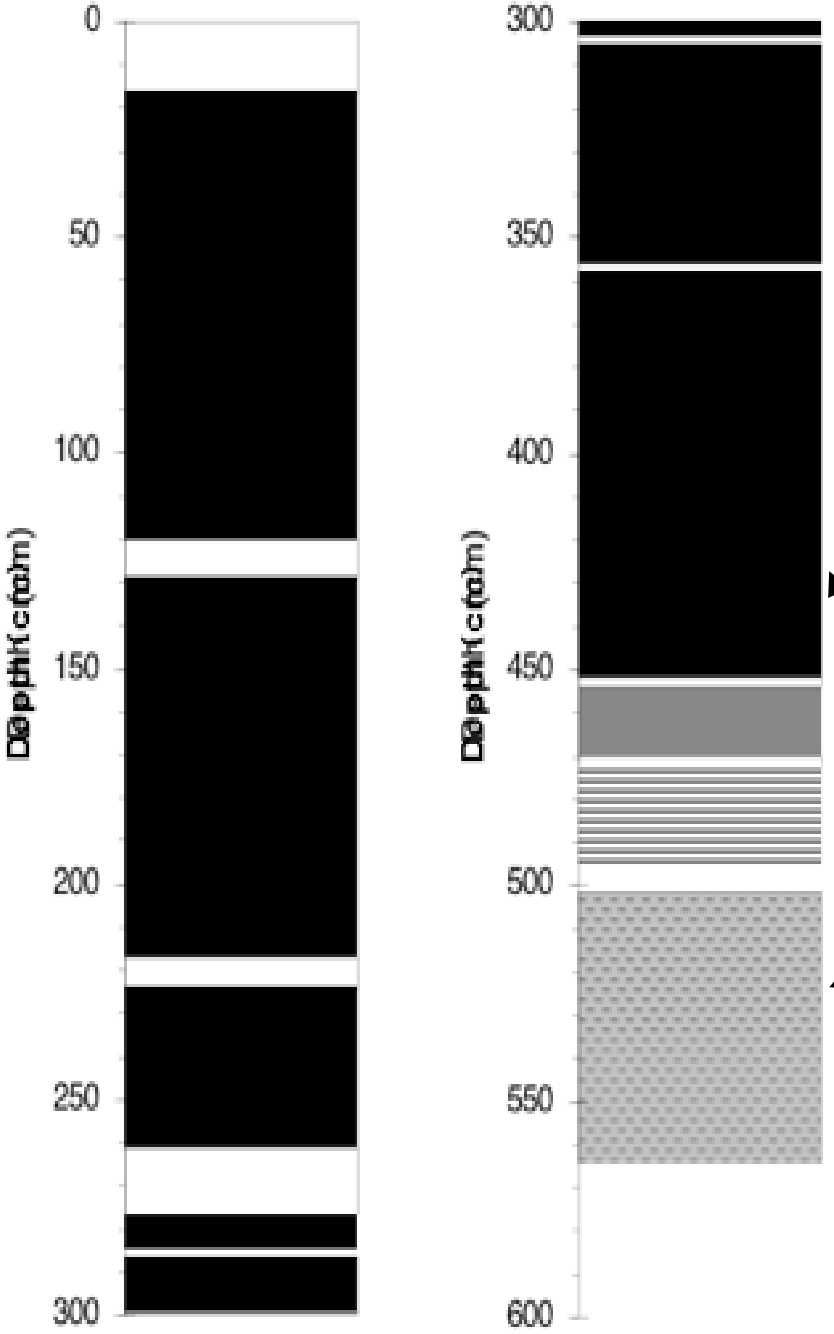
Duck Pond


0
100
200
300
400
500
600
% N
% C
0
10
20
30
40
C/N
0
10
20
30
220 ± 110
2510 + 50
4040 + 40
7530 + 50
8790 + 50
10980 ± 50
14C yBP

Duck Pond

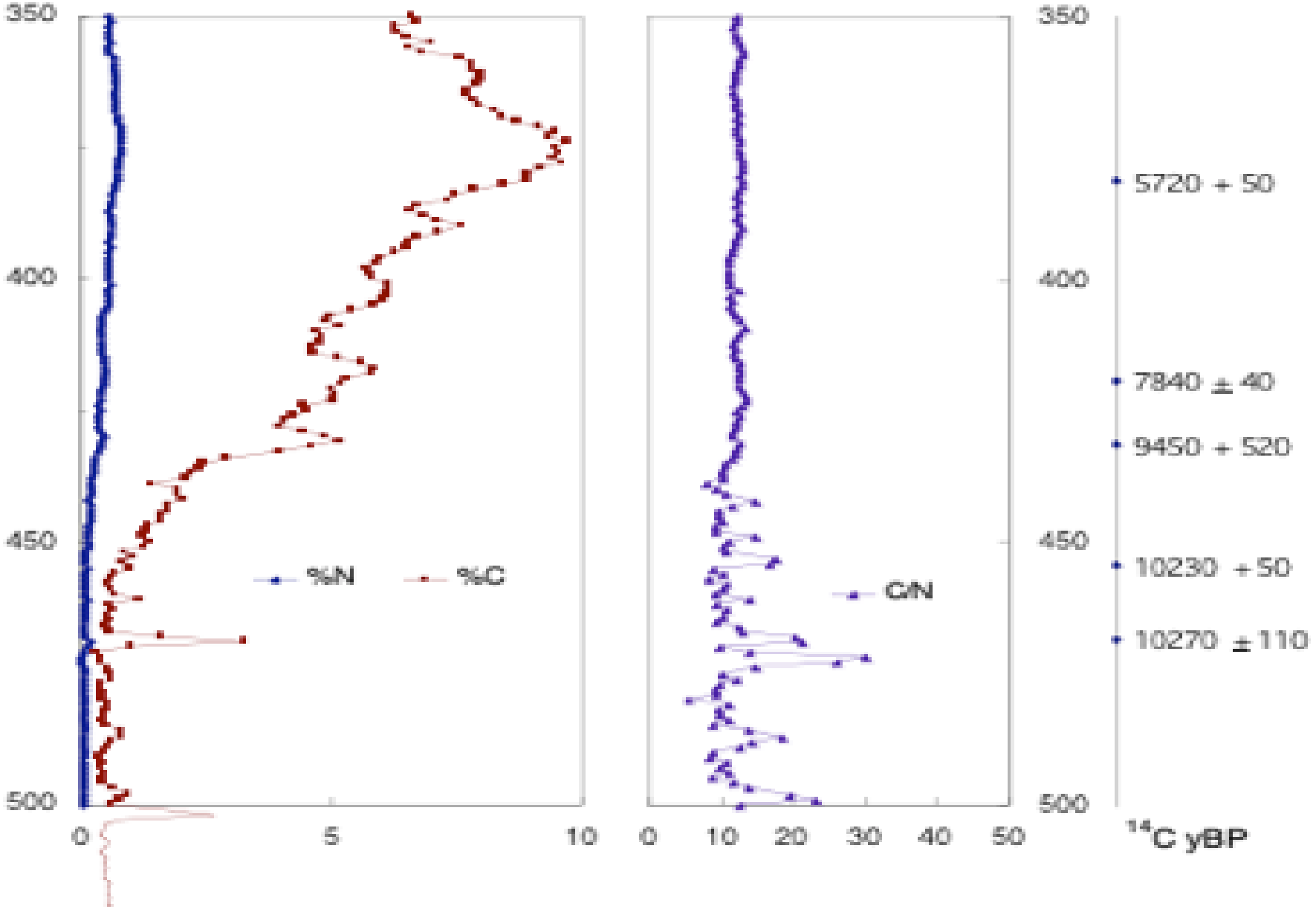

0
100
200
300
400
500
600
-40
-30
-20
-10
0
δ 13C, ä
2
3
4
δ 15N, ä
220 +110
2510 ±50
4040 ±40
7530 ±50
8790 +50
10980 +50
14C yBP

Lake Morey Lithology

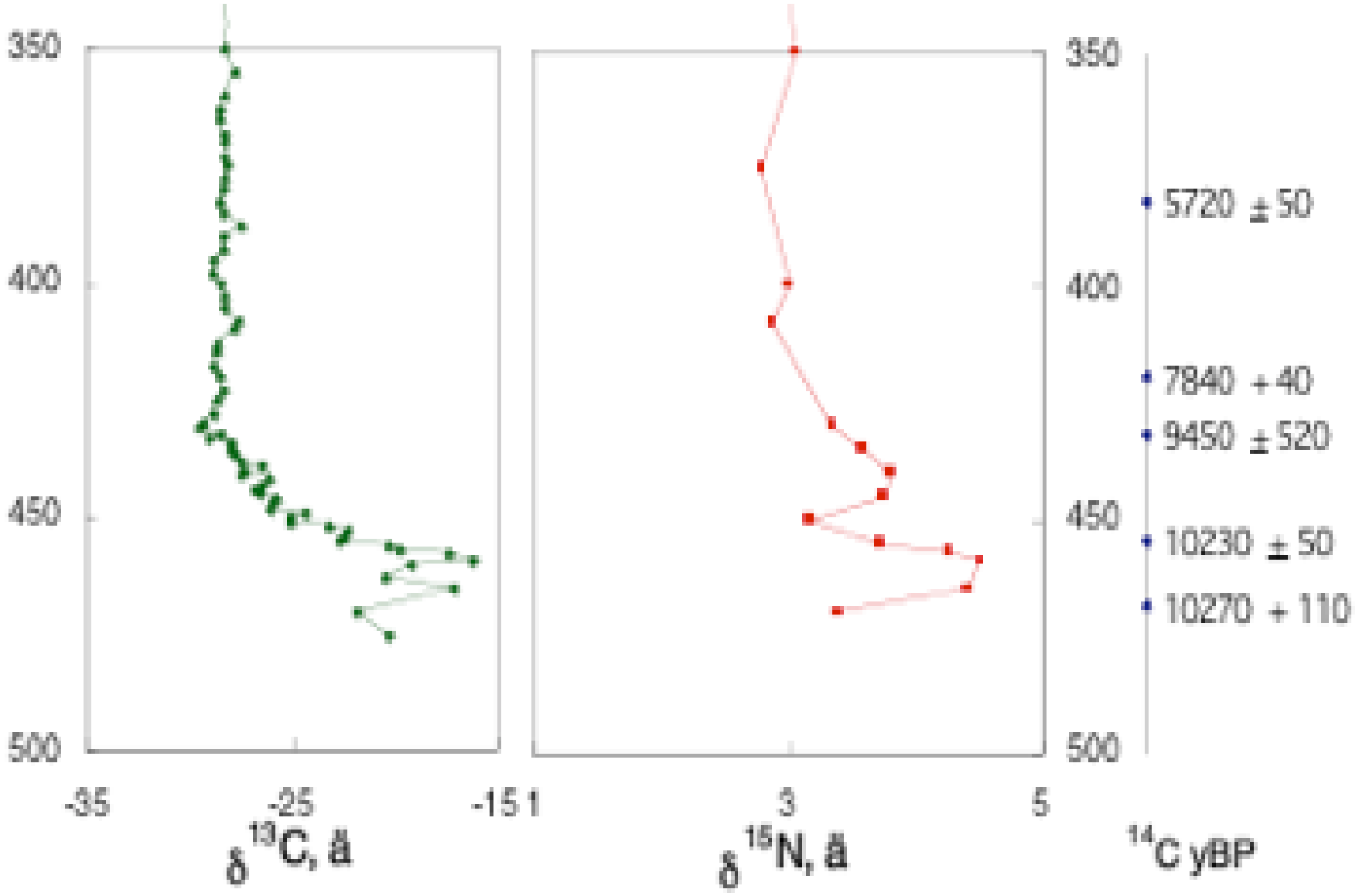


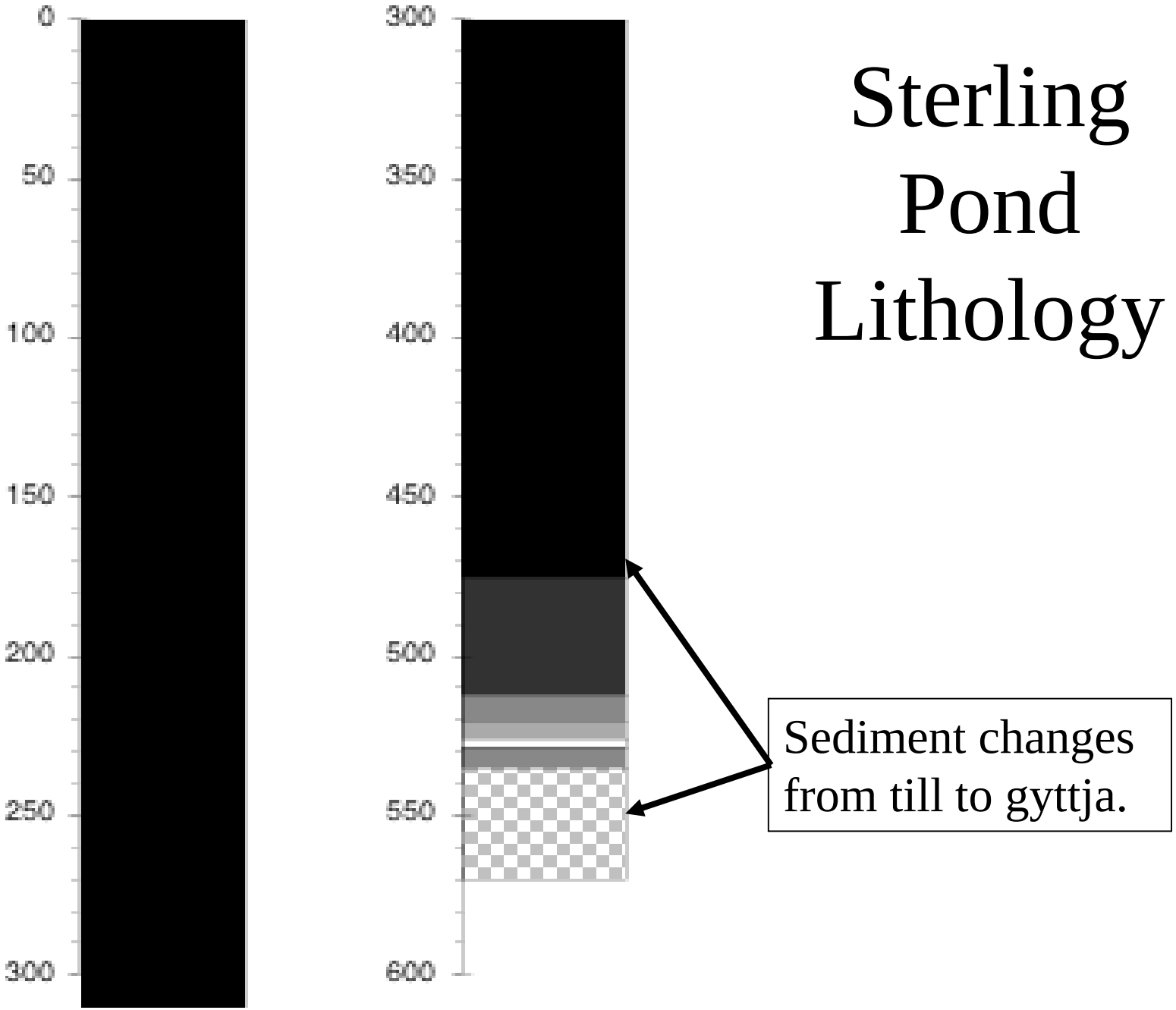
Sediment changes from varved silt to mostly gyttja.

Lake Morey

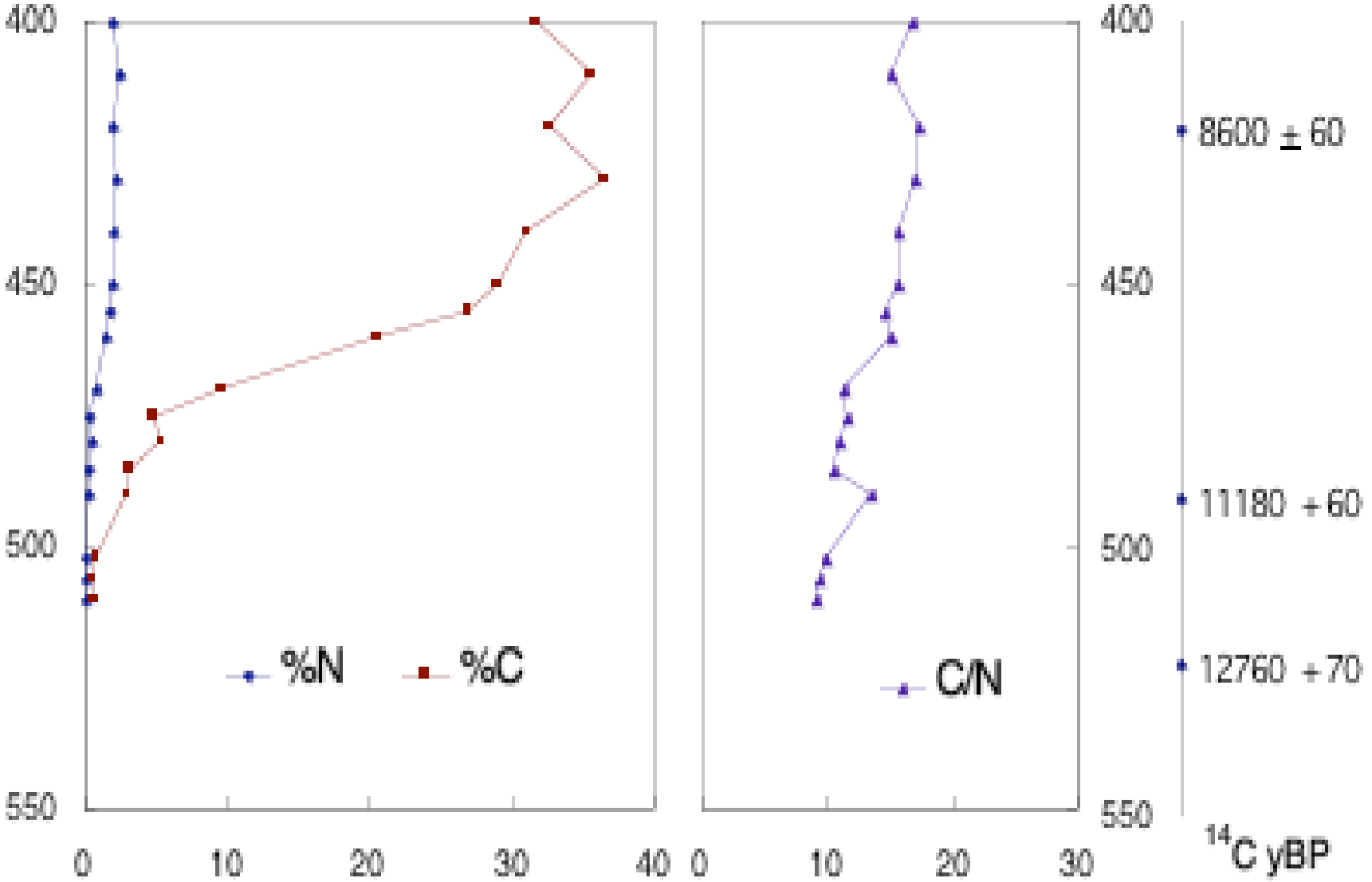

350
400
450
500
%N
%C
C/N
0
5
10
0
10
20
30
40
50
5720 ± 50
7840 ± 40
9450 ± 520
10230 ± 50
10270 ± 110
14C yBP

Lake Morey

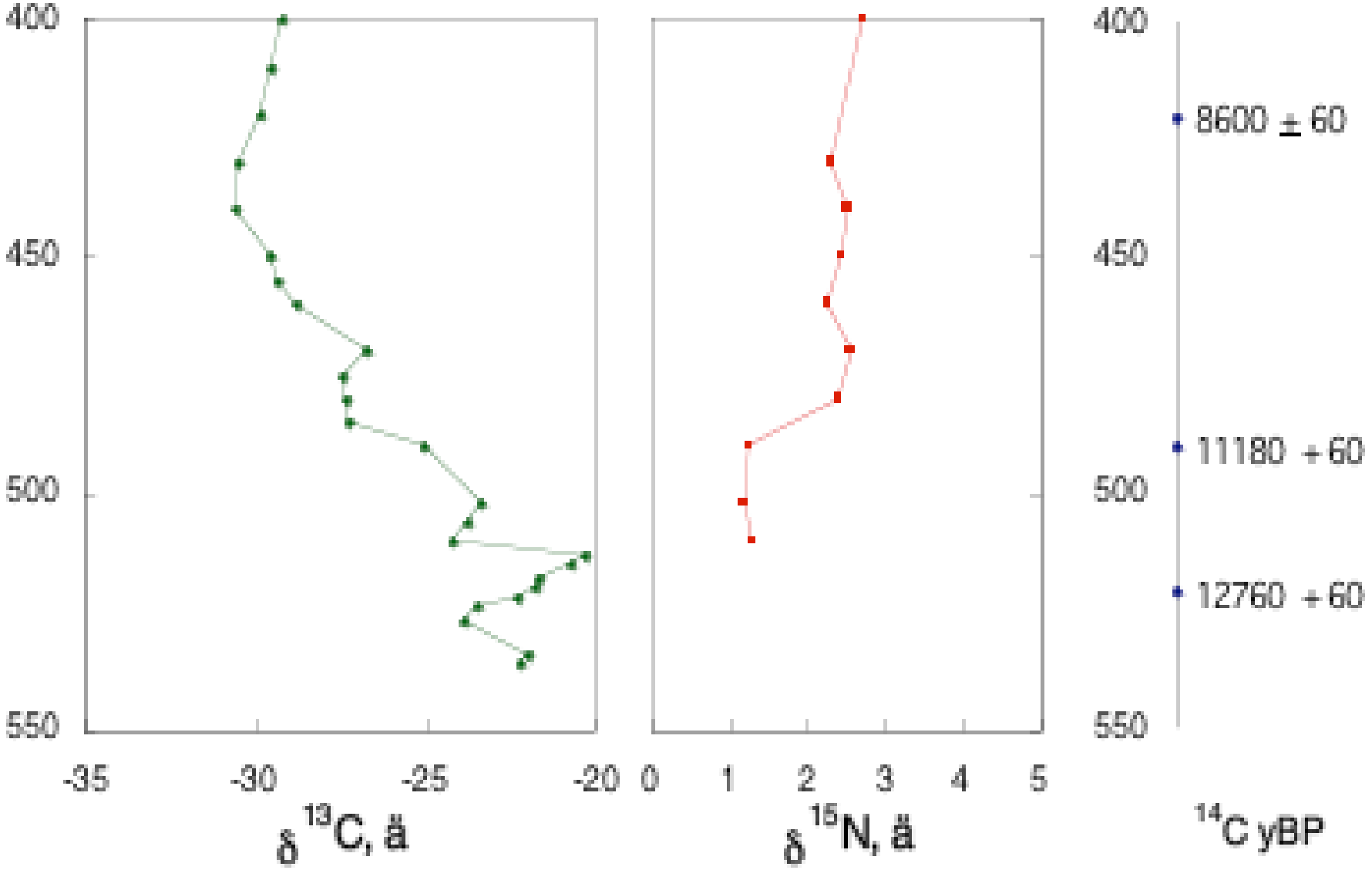

350
400
450
500
-35
-25
-15
δ 13C, ‰
3
5
δ 15N, ‰
5720 ± 50
7840 ± 40
9450 ± 520
10230 ± 50
10270 ± 110
14C yBP

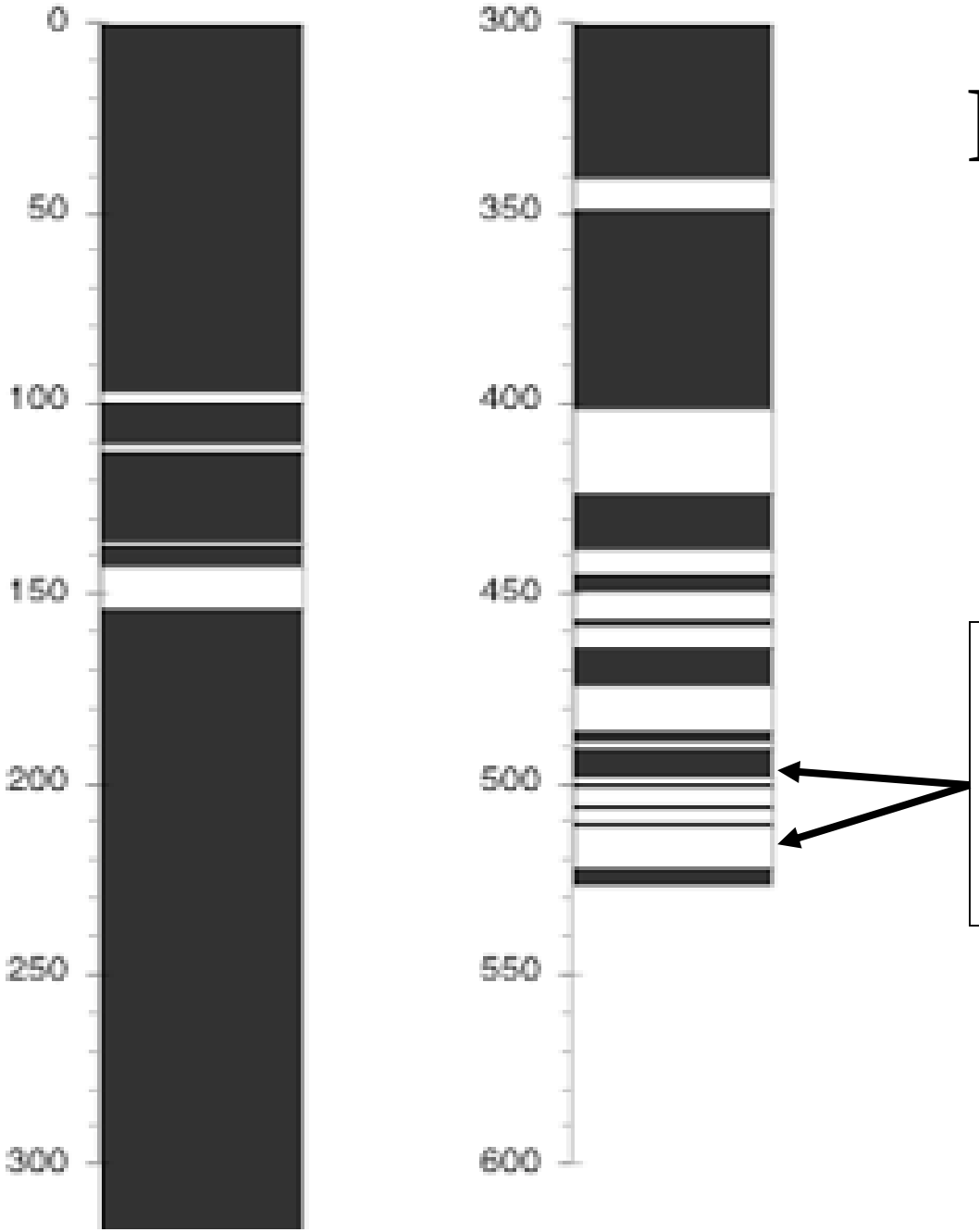

0
50
100
150
200
250
300
300
350
400
450
500
550
600
Sterling Pond Lithology
Sediment changes from till to gyttja.

Sterling Pond



Sterling Pond

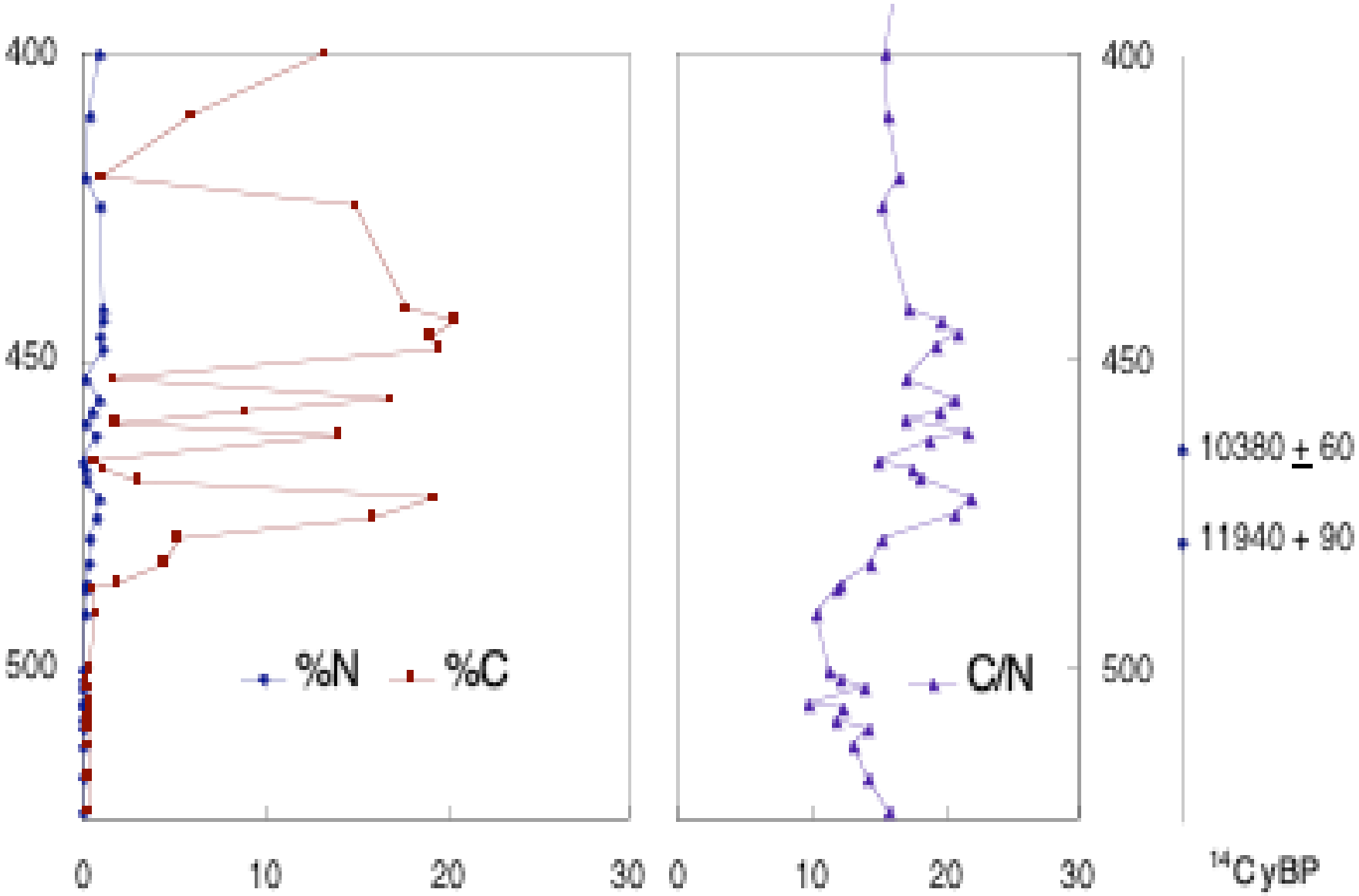




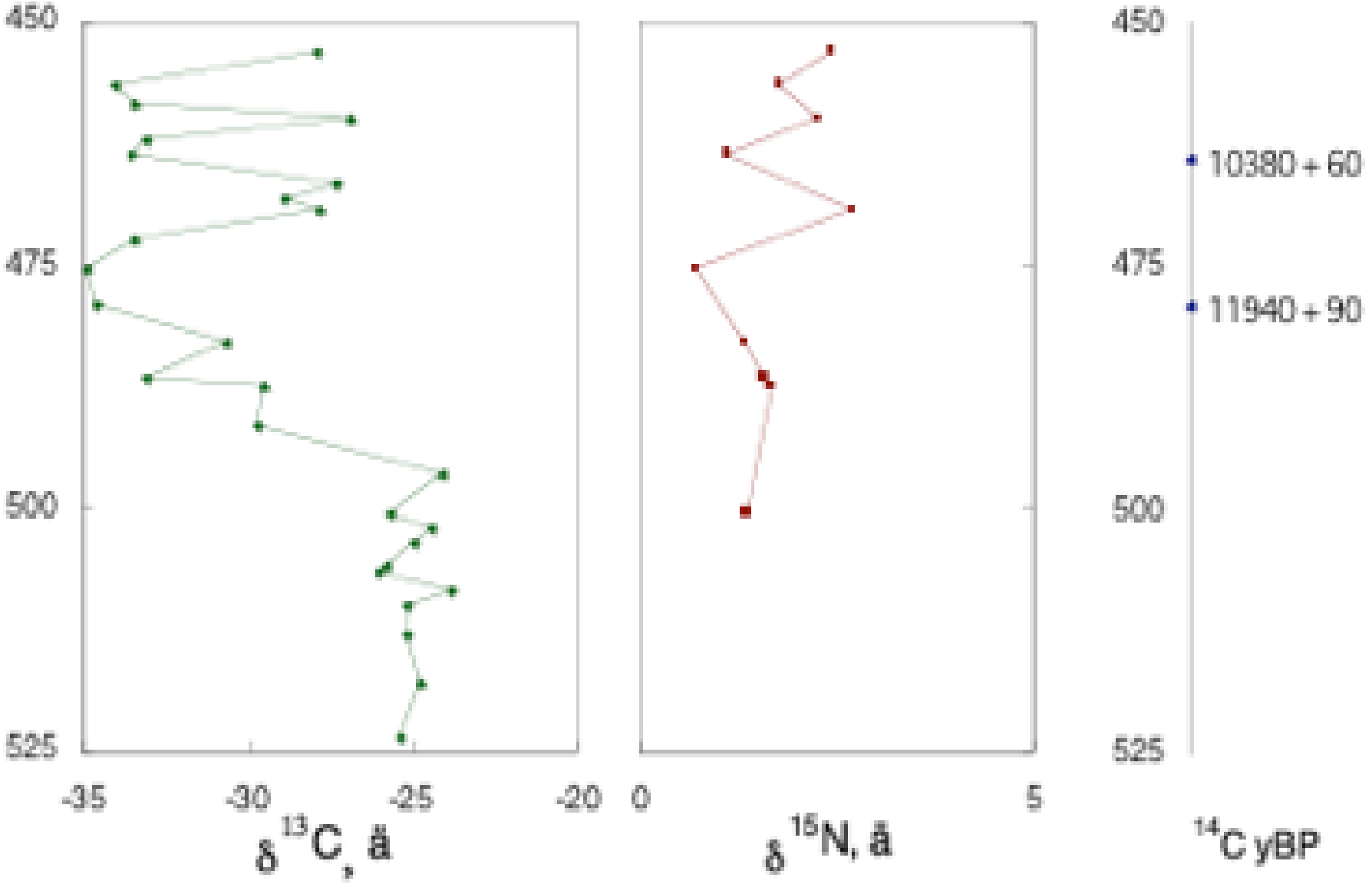
Ritterbush Pond Lithology

Sediment transitions from coarse sand to gyttja.

Ritterbush Pond



Ritterbush Pond



Summary of shift lengths

Lake	Start of %C shift (^{14}C yBP)	End of %C shift (^{14}C yBP)	Length of %C shift (^{14}C y)	Start of δ^{13}C shift (^{14}C yBP)	End of δ^{13}C shift (^{14}C yBP)	Length of δ^{13}C shift (^{14}C y)
Lake Morey	10200	5600	4600	10200	9500	700
Duck Pond	11000	8900	2100	11000	9200	1800
Sterling Pond	12400	9000	3400	12400	9300	3100
Ritterbush Pond	>12000	11300	>700	>12000	11600	>400

%C increase represents the establishment of the local ecosystems

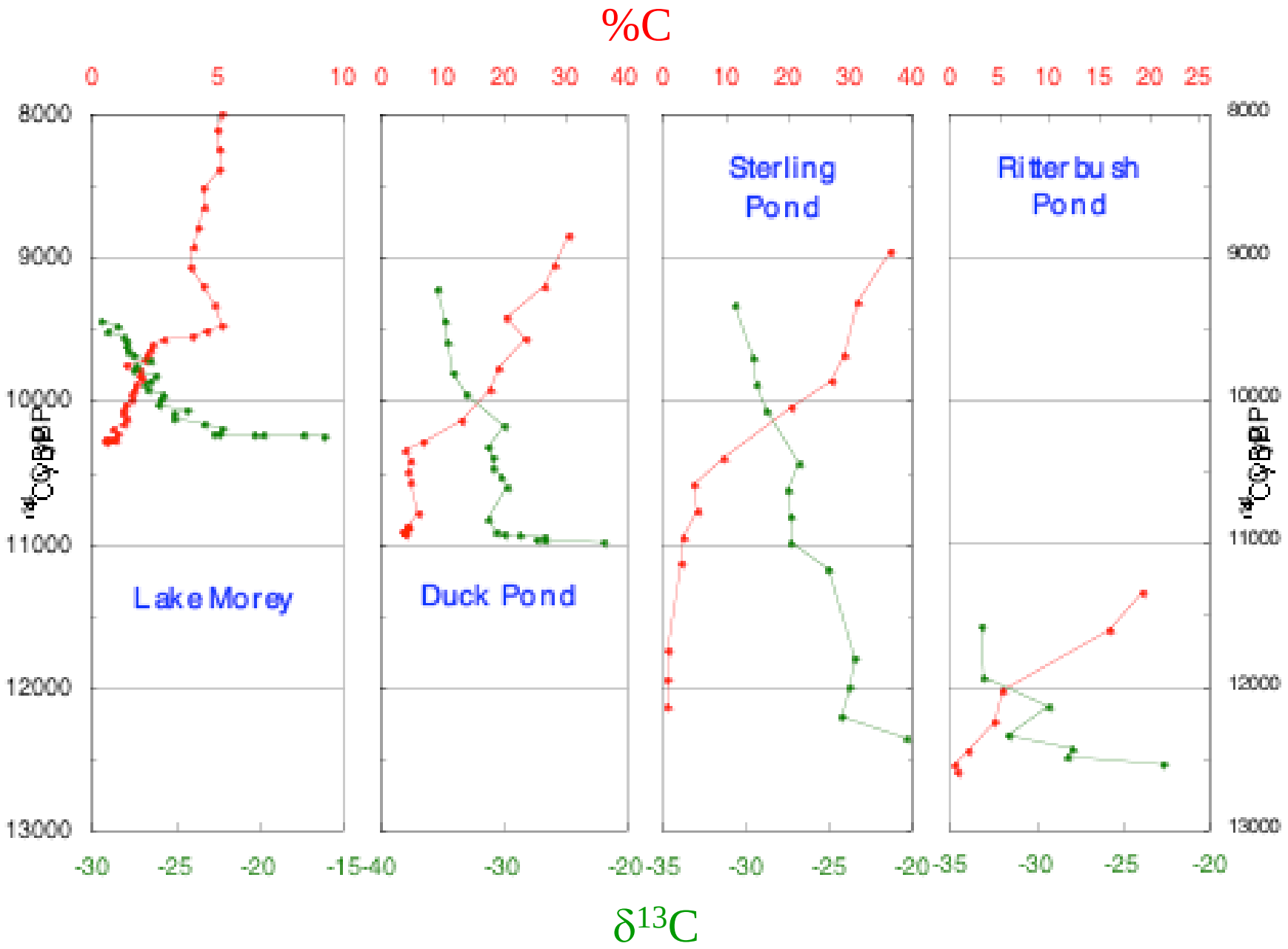
- The radiocarbon dates from three (Duck, Sterling, and Ritterbush) of the lakes put the beginning of the %C shift soon after deglaciation

- The date (10,200 ^{14}C yBP) of the %C increase in Lake Morey corresponds with the drainage of glacial Lake Hitchcock (10,300 ^{14}C yBP).

Three interpretations of the shift in $\delta^{13}C$ values

- Increase in pCO_2 caused the shift
- Shift from C_4 to C_3 vegetation
- A change in the source of the organic matter from relatively less terrestrial matter to more aquatic matter

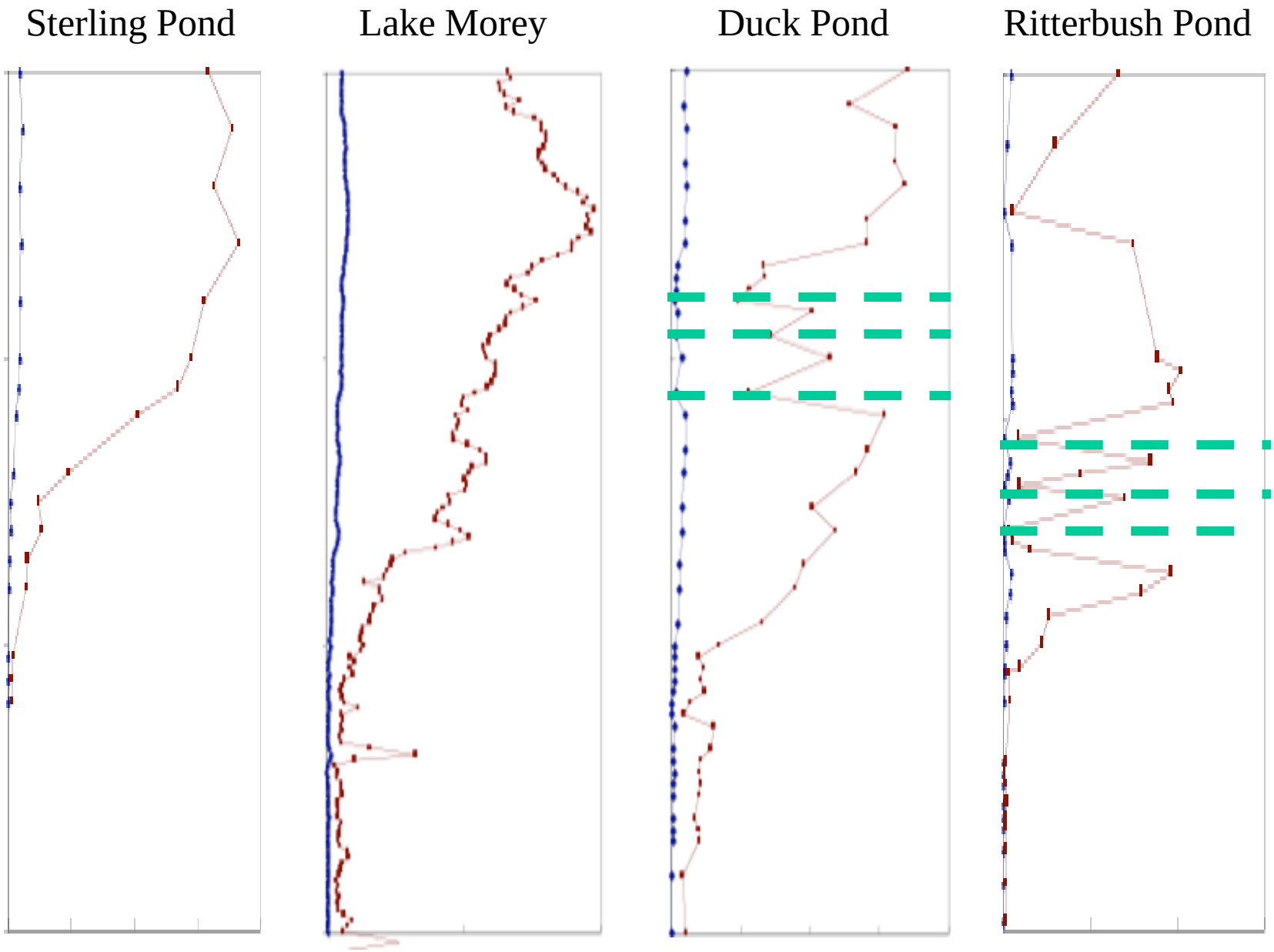
Timing of the shifts



Physiographic data

Lake Name	Surface area (km^2)	Maximum depth (m)	Elevation (m)	Drainage basin area (km^2)	Drainage basin relief (m)
Lake Morey	2.22	13	127	20.7	414
Duck Pond	0.03	14	520	0.7	290
Sterling Pond	0.03	9	917	0.3	40
Ritterbush Pond	0.05	14	317	2.2	293

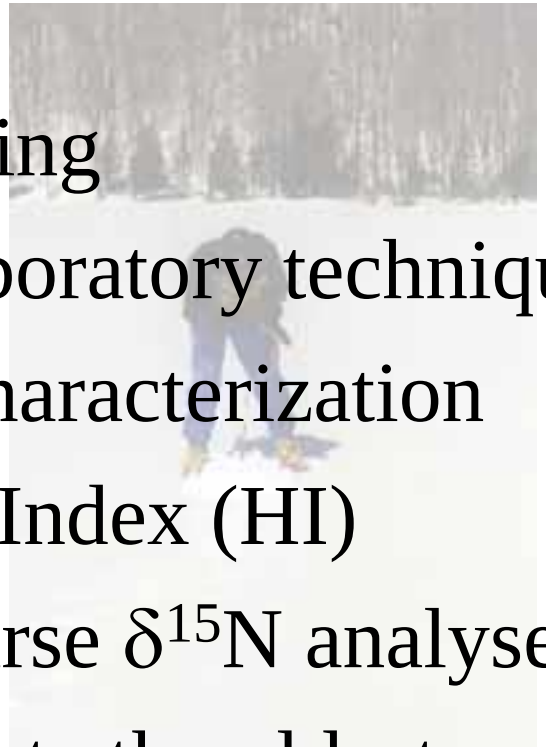
Amount of inorganic inputs



Conclusions

- %C increases represent the growing ecosystems.
- Decrease in $\delta^{13}C$ shows the aquatic ecosystem establishing itself after the terrestrial one.
- Establishment rate of ecosystems determined by elevation and input amount.
- Better comparisons between different limnological records.

Future directions



- Continue coring
- Expanded laboratory techniques
  - Pigment characterization
  - Hydrogen Index (HI)
- Continue coarse $\delta^{15}N$ analyses
- Accurately date the oldest sediment