Nutrient History in Bolton Lakes

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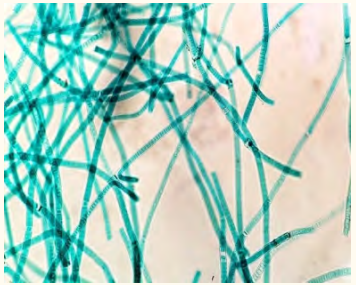
What has been going on?

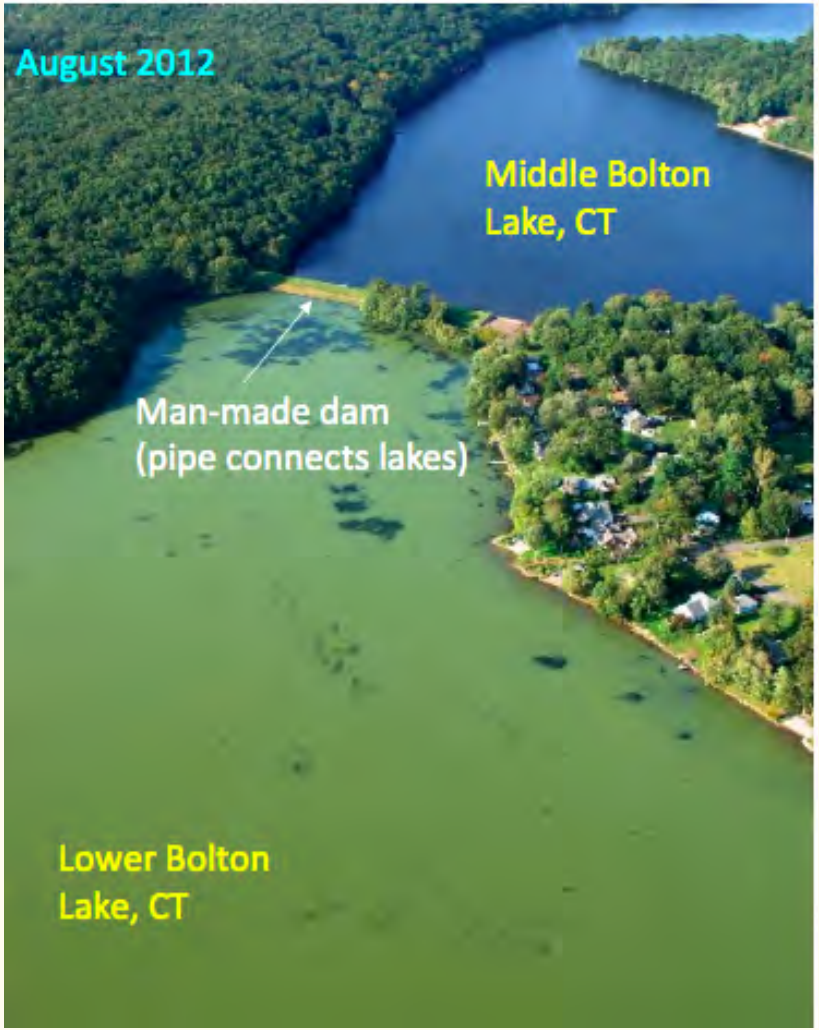
- In 2012, the Lower Bolton Lake experienced a very severe and prolonged blue-green algae bloom from mid August to September.

- Blue-green algae, also known as cyanobacteria, can cause cloudy waters, unpleasant odors, liver and neurotoxins, skin irritants, and loss of biodiversity in the lake

- The carbon (C) to nitrogen (N) ratio in lake organic matter reflects the dominant lake organisms during that time

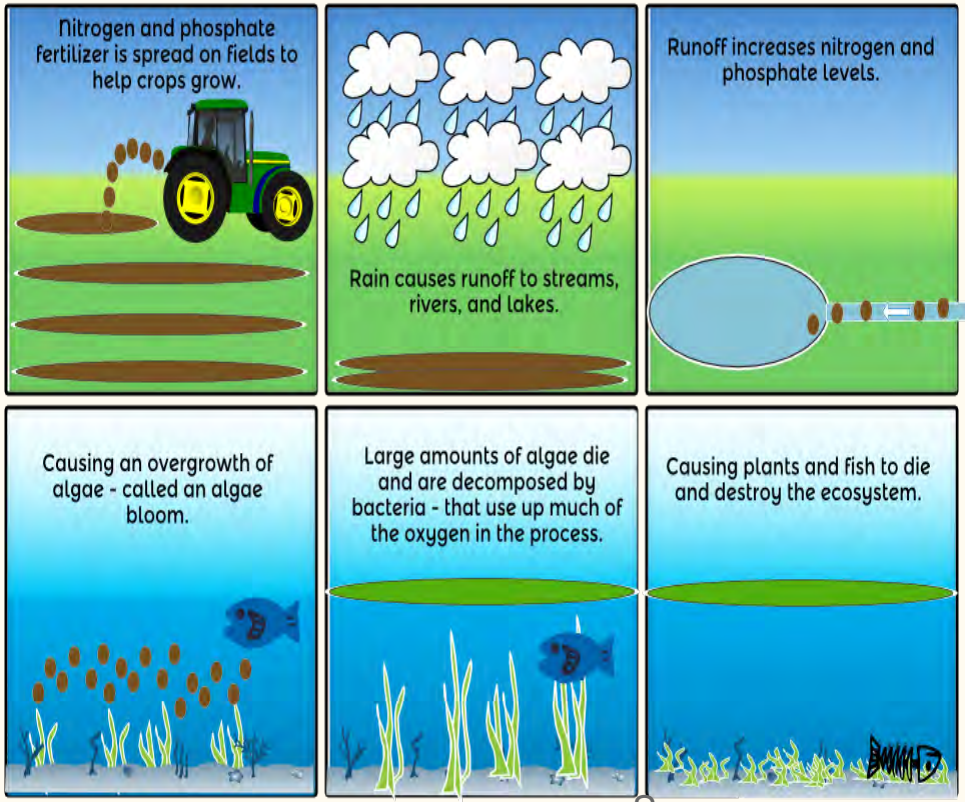


Source: WCVB-TV



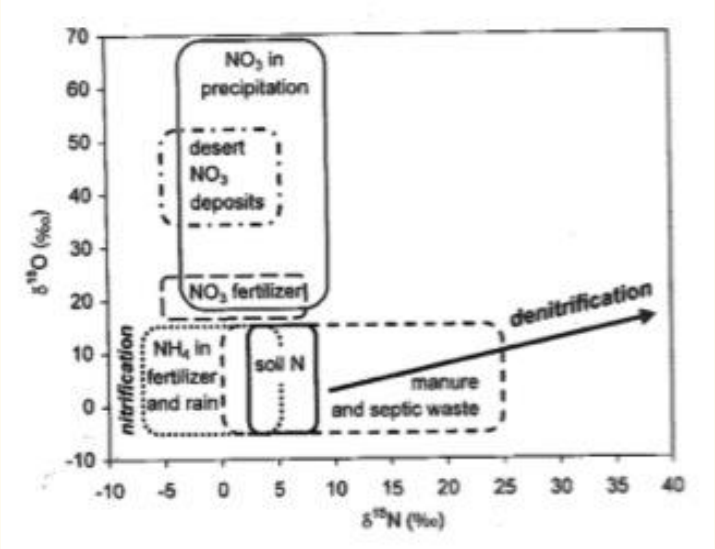
Possible causes of algal blooms

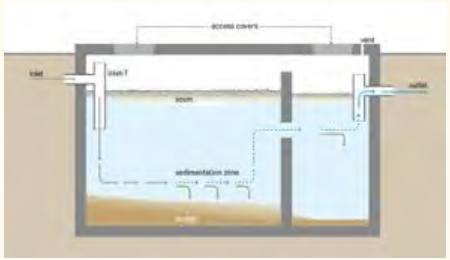
- Cultural eutrophication = where human activities increase nutrient input rates to aquatic ecosystems
- The two nutrients mainly responsible for cultural eutrophication are nitrogen (N) and phosphorus (P) because they are the main nutrients limiting algae in lakes
- Analyzing the stable nitrogen isotopes helps us to identify the sources of N



Source: emaze.com

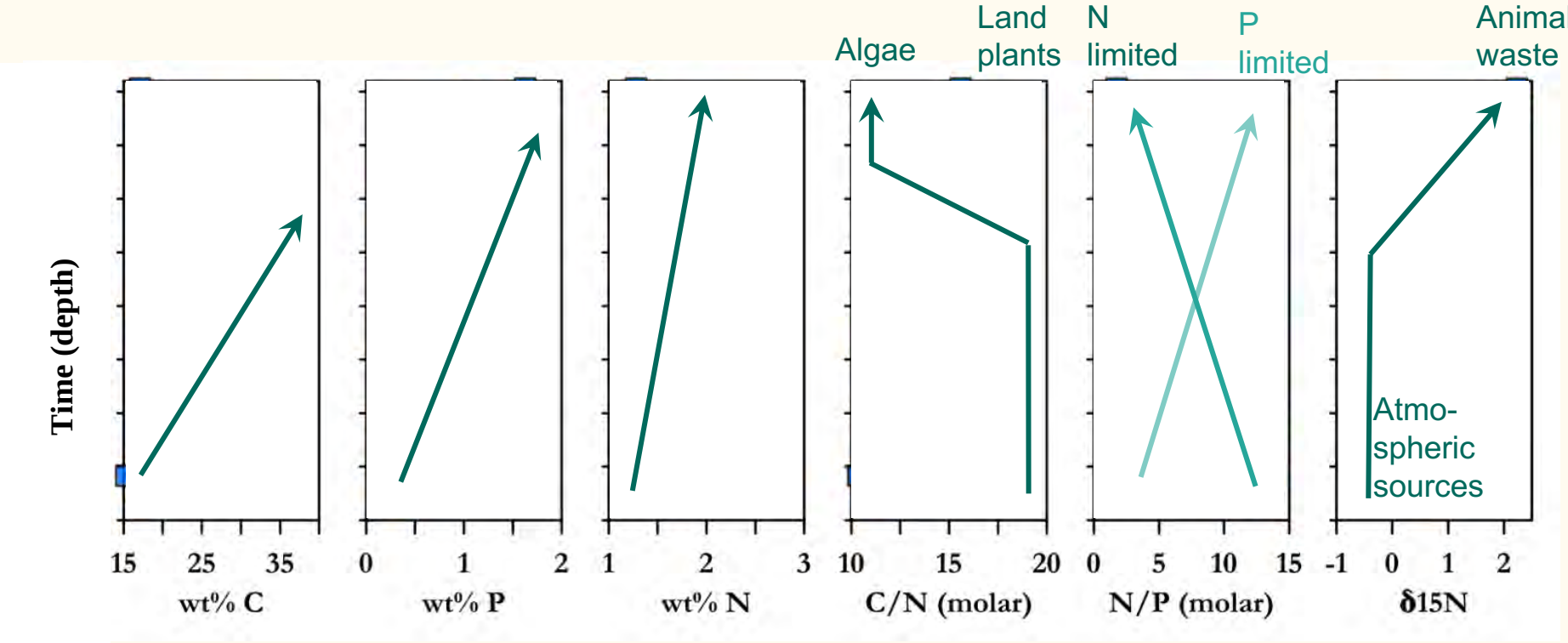
$\delta^{15}N$ - Implications in Determining Nutrient Sources





Productivity Indices from Leaf Chemistry, 2015

What might a history of eutrophication look like?

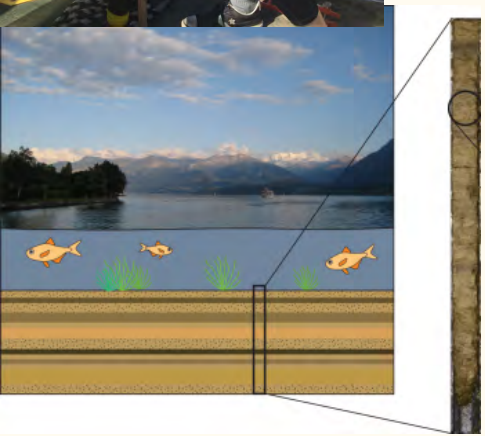


Goals

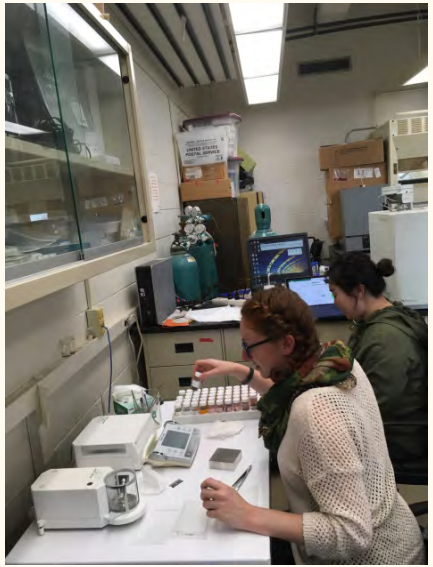
- We investigated how the concentration of nitrogen and phosphorous in the Lower and Middle Bolton Lakes have changed over time

- Hypothesis: Due to the recent intense algae bloom, we expect to see a lower ratio of carbon to nitrogen and a higher concentration of nitrogen and and phosphorous in the recent lake sediments of the lower lake compared to the older sediments and compared to the sediments in the middle lake.

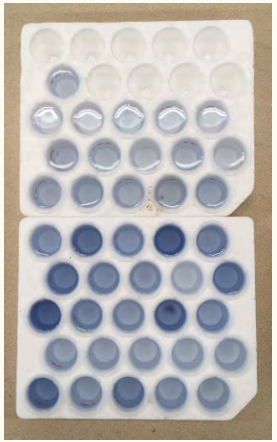
Methods



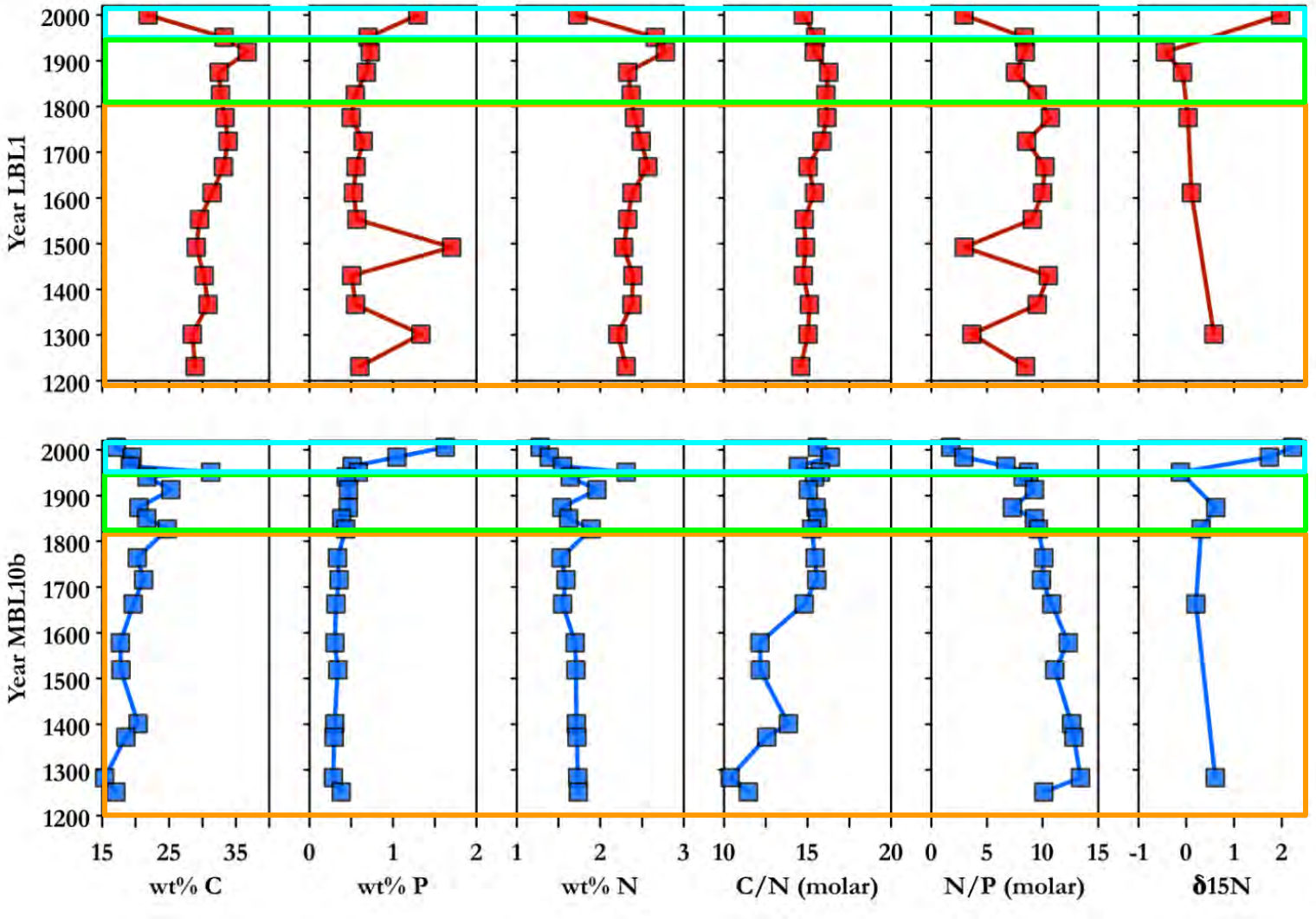
Sediment core



Elemental analyzer and
Isotope analysis



UV/Vis Spectrophotometry
(Method after Ruttenburg, 2002)

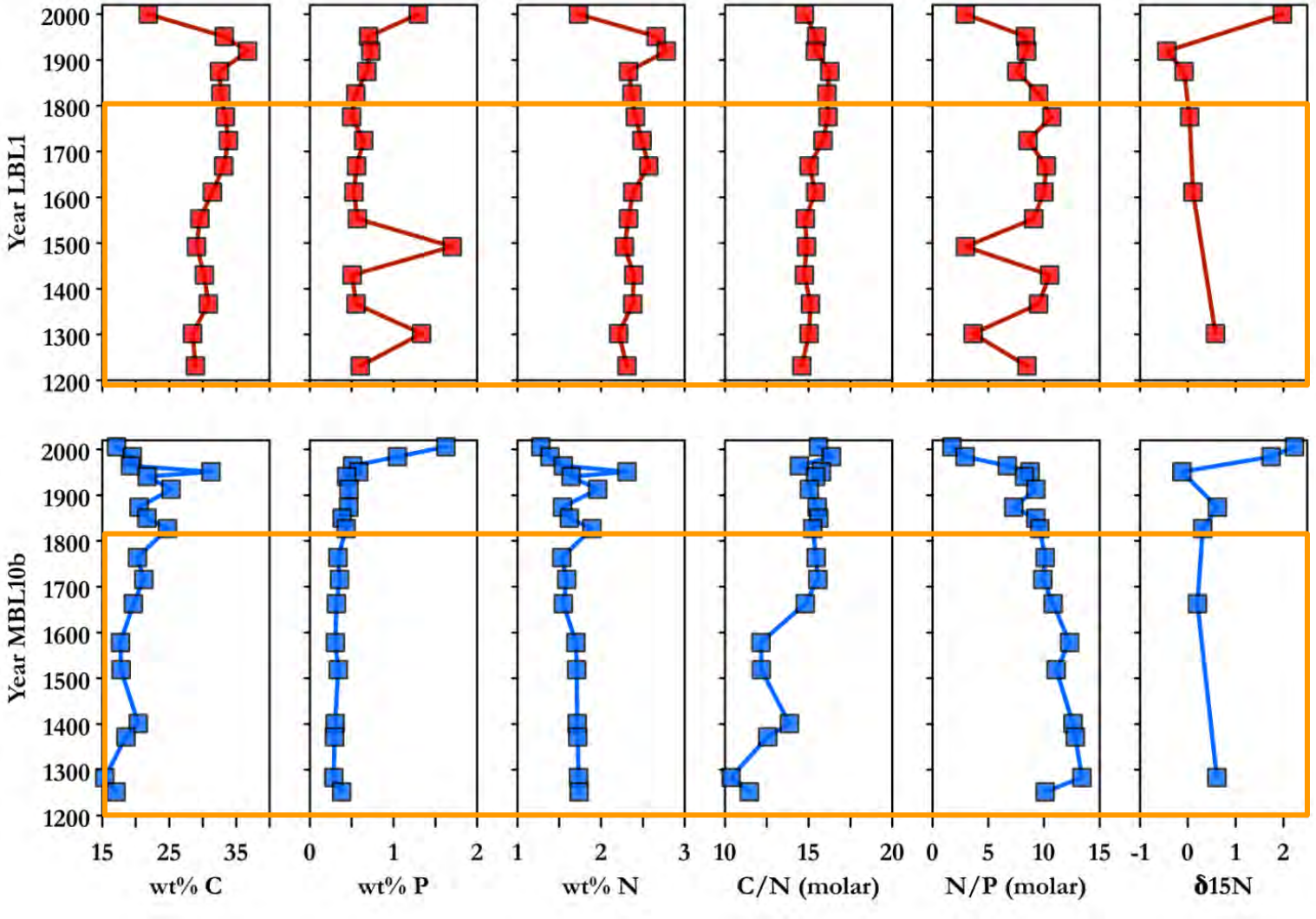


Present
Modern

Pristine

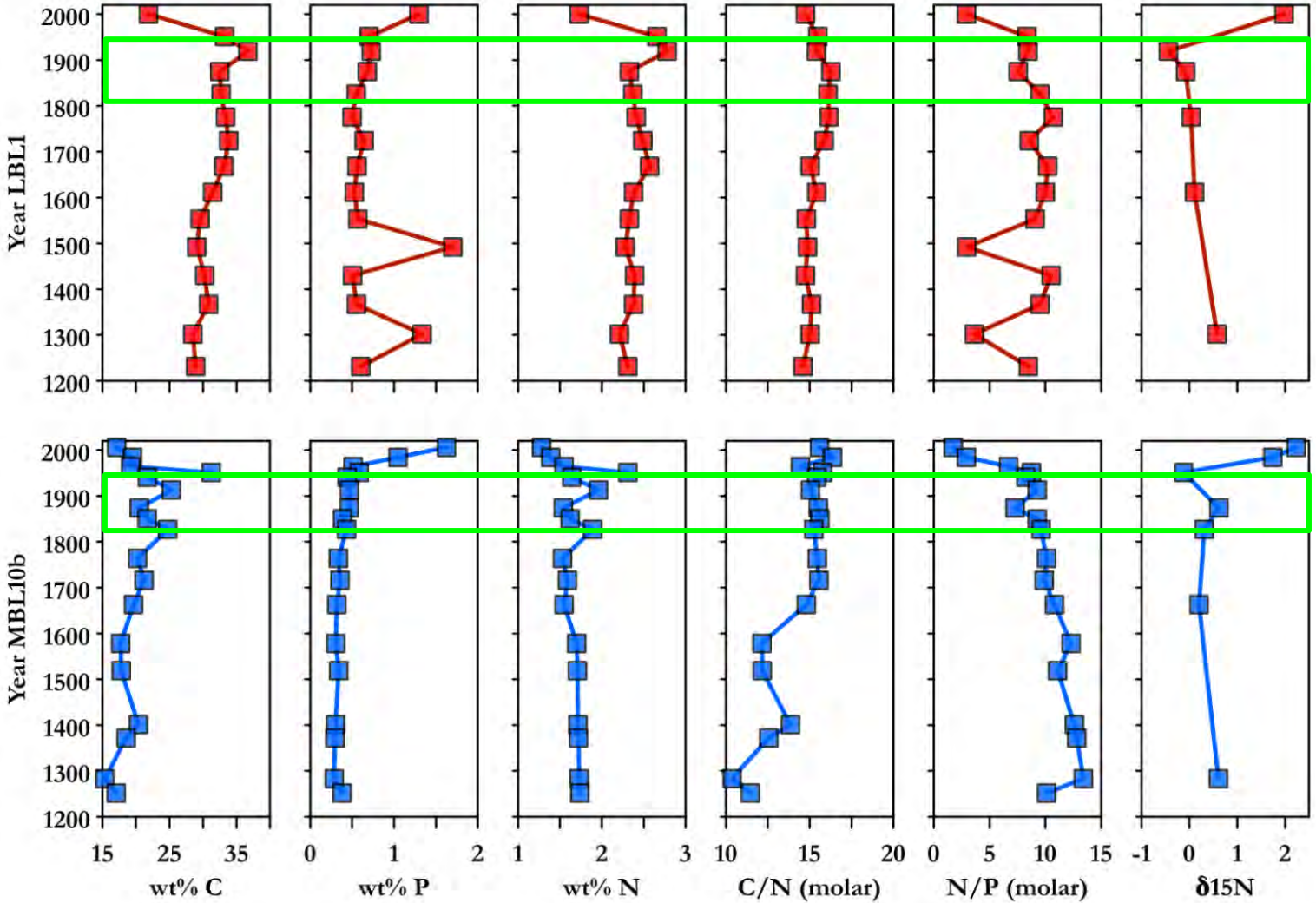
Present
Modern

Pristine



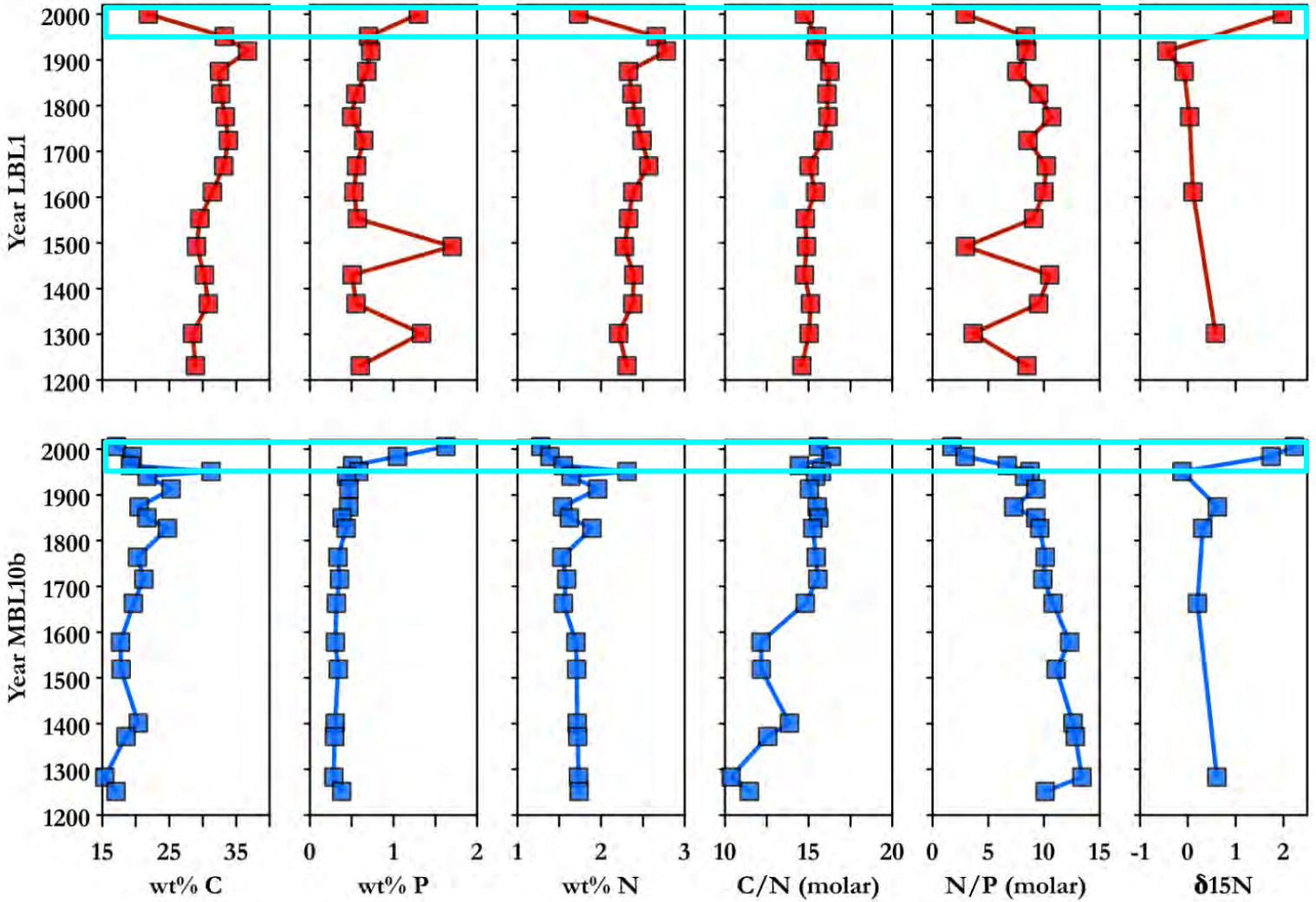
Pristine

- No cultural eutrophication
- Increase in organic matter
- More nitrogen than phosphorus
- Combination of algae and land plants



Modern

- Minor increases in nitrogen
- Faster increase in organic matter
- Change in nitrogen source



Present

- Major increase in phosphorus
- Shift toward nitrogen-limitation
- Nitrogen from animal waste or septic systems
- Dilution of organic matter

Conclusions

- Between 1800 - 1950 both lakes experienced minor increase in inputs of nitrogen.
- After 1950 both lakes experience an large increase in phosphorus input and a decrease in nitrogen input. Nitrogen isotope values for both lakes shift toward an increase in animal waste or wastewater input.
- Over time the carbon/nitrogen ratio stays constant at 15, suggesting that the lake was and continues to have a mixture of organic matter from algae and land plants

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References

Braig, E., Mayr, C., Kirchner, G., Hofmann, A., Raeder, U., and Melzer, A., 2013, Fifty years of eutrophication and lake restoration reflected in sedimentary carbon and nitrogen isotopes of a small, hardwater lake (south Germany): Journal of Limnology, v. 72, no. 2, p. 21.

Dean, W. E., 1999, The carbon cycle and biogeochemical dynamics in lake sediments: Journal of paleolimnology, v. 21, no. 4, p. 375-393.

Downing, J. A., and McCauley, E., 1992, The nitrogen: phosphorus relationship in lakes: Limnology and Oceanography, v. 37, no. 5, p. 936-945.

Eastern Connecticut Resource Conservation & Development Area Inc. 2014, Bolton Lakes Watershed, An Update: Eastern Connecticut Environmental Review Team Report.

Ekdahl, E. J., Teranes, J. L., Guilderson, T. P., Turton, C. L., McAndrews, J. H., Wittkop, C. A., and Stoermer, E. F., 2004, Prehistorical record of cultural eutrophication from Crawford Lake, Canada: Geology, v. 32, no. 9, p. 745-748.

EPA. 2012. Recreational Water Quality Criteria.

Hecky, R., Campbell, P., and Hendzel, L., 1993, The stoichiometry of carbon, nitrogen, and phosphorus in particulate matter of lakes and oceans: Limnology and Oceanography, v. 38, no. 4, p. 709-724.

Isles, P. D., Xu, Y., Stockwell, J. D., and Schroth, A. W., 2017, Climate-driven changes in energy and mass inputs systematically alter nutrient concentration and stoichiometry in deep and shallow regions of Lake Champlain: Biogeochemistry, v. 133, no. 2, p. 201-217.

Kolzau, S., Wiedner, C., Rücker, J., Köhler, J., Köhler, A., and Dolman, A. M., 2014, Seasonal patterns of nitrogen and phosphorus limitation in four German lakes and the predictability of limitation status from ambient nutrient concentrations: PloS one, v. 9, no. 4, p. e96065.

Meyer, R. E., and Meola, S. M., 1978, Morphological characteristics of leaves and stems of selected Texas woody plants, Department of Agriculture, Agricultural Research Service, v. 1564.

Northeast Aquatic Research, L., 2017, Lower Bolton Lake, Status Up-Date.

Peterson, B. J. , and B. Fry . 1987. Stable isotopes in ecosystem studies. Annual Review of Ecology and Systematics 18: 293–320.

Ruttenberg, K. C., 1992, Development of a sequential extraction method for different forms of phosphorus in marine sediments: Limnology and oceanography, v. 37, no. 7, p. 1460-1482.

Schindler, D. W., Hecky, R., Findlay, D., Stainton, M., Parker, B., Paterson, M., Beaty, K., Lyng, M., and Kasian, S., 2008, Eutrophication of lakes cannot be controlled by reducing nitrogen input: results of a 37-year whole-ecosystem experiment: Proceedings of the National Academy of Sciences, v. 105, no. 32, p. 11254-11258.

Wan, Z. and Bi, H., 2014. Comparing model scenarios of variable plankton N/P ratio versus the constant one for the application in the Baltic Sea. Ecological modelling, v. 272, p. 28-39.