Improving the accuracy of radiocarbon chronologies from lake-sediment cores: Testing for the $^{14}$C reservoir effect in aquatic macrophytes

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Project Abstract
Obtaining accurate radiocarbon ($^{14}$C) chronologies for lake-sediment cores are crucial for improving reconstructions of past climate and landscape changes. These chronologies have documented the timing for changes in aquatic and terrestrial systems in response to regional and hemispheric climate events, such as the Medieval Warm Period (950-750 yr BP) and Little Ice Age (500-100 yr BP). Such research has identified both synchronized as well as time-transgressive patterns in the responses of terrestrial and aquatic systems to these climate perturbations, data useful for predicting rates of future responses of these systems to 21st century global warming. These paleoenvironmental studies have also reconstructed “baseline” conditions of aquatic and terrestrial systems, the natural state, which is often the goal of current and, presumably, future efforts to restore ecosystem health.

Despite the ability to obtain higher resolution $^{14}$C chronologies for lake-sediment cores in recent years by using the Accelerator Mass Spectrometry (AMS) method, this methodology is still limited. Particularly, terrestrial plant macrofossils (seeds and other remains) are irregularly present and often absent in sediment cores collected from lakes. In contrast, seeds of aquatic macrophytes are better represented, but they are suspected of providing erroneously older ages, because of a “reservoir effect,” the incorporation of ancient carbon in their tissues while alive. Our project will test for the first time if these aquatic macrophyte seeds do indeed provide spurious results. We will obtain a series of 12 matched sets, each set comprised of a $^{14}$C date obtained from aquatic plant seeds and an age for terrestrial plant macrofossils for the same stratigraphic level of a lake-sediment core, and compare the results of each set using a T-test. Radiocarbon dates have already been obtained for the terrestrial macrofossils, so funding is requested to date samples of aquatic macrophyte seeds. A well-known $^{14}$C-dating expert, Dr. Thomas Stafford of the University of Wisconsin-Madison, agreed to collaborate with us on this project.

If the $^{14}$C age of the aquatic plant seeds is statistically identical (insignificant at the 10% level) to the date obtained from terrestrial plant remains, then we will know that macrophyte seeds provide reliable ages. Furthermore, if aquatic plant seeds could be dated for the brief time interval when the $^{210}$Pb/$^{137}$Cs dating method overlaps with the $^{14}$C method, from 250 to 200 yr BP, then this would substantially improve reconstructions of the timing of events associated with the transition from Native American to Euro-American land use.

Alternatively, if the paired sets of dates provide results that differ at the 10% level of significance then we will prove that aquatic plant macrofossils provide erroneous dates. The outcome of this project, regardless of the result, will aid the PIs through the development of more effective $^{14}$C-dating protocols. This would make the proposals of the PIs submitted to government agencies more competitive, considering the expense of $^{14}$C-dating multiple samples. Our published results would also be of great interest to a large audience of paleolimnologists, geochemists and paleoecologists, thus furthering the reputation of the CWS for excellence in water-related studies.