An Adirondack "Heritage Lake"

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Abstract
The concept of Adirondack "heritage lakes" is introduced as a basis for identifying lakes that are as close to pristine as possible in a region where virtually all waters are more or less impacted by anthropogenic disturbances such as acidification, alien invasions, reclamation, stocking, liming, road salting, or eutrophication. Historical, paleo-ecological, and trap-netting investigations of Wolf Lake, located in the central Adirondacks, are presented to illustrate ways in which heritage status can be determined and documented. The identification and protection of heritage lakes can yield important benefits for lake management, scientific study, outdoor recreation, and wilderness preservation efforts.

The Adirondack Park covers 6 million acres in northern New York and encompasses approximately 3,000 lakes and ponds. While most of these waters have a wilderness-like appearance, virtually all of them have been more or less affected by various anthropogenic disturbances, including atmospheric pollution and acidification (Rhodes 1991; Charles et al. 1990; Cumming et al. 1994), liming, exotic species invasions, fish stocking, siltation, rotenone treatment, road salt contamination, and cultural eutrophication (Stager 1996; Stager et al., 1997).

The impacted nature of these waters has important consequences for the management of Adirondack lakes and their inhabitants. It can be argued, for example, that if a lake is already changed from its original state, then future manipulations may not be inherently objectionable intrusions upon a true wilderness ecosystem. In addition, wilderness lake management requires a clear sense of what true wilderness looks like, otherwise evaluating the effectiveness of attempts to restore or maintain a wild state amounts to mere guesswork. And the scarcity of pristine lakes can reduce the accuracy of scientific studies that require undisturbed "control" systems for comparison to those under investigation. For instance, one study of the long-term effects of fisheries management techniques on Adirondack waters involved treatment of several lakes with rotenone, restocking with trout, and comparison with lakes that were not manipulated during the study (Harig and Bain, 1985). However, one of the controls (Green Pond) had in fact been treated with rotenone and stocked prior to the study, invaded by non-native planktivorous fishes, and polluted by nutrient-rich runoff from shoreline development, thus compromising its value as a control system.

Finally, the aesthetic consequences of this situation are also potentially significant. Most visitors to the region assume that the lakes they encounter are truly wild. The lakes enhance the aesthetic experience of those who want to "get back to nature," and local tourism literature often markets that emotionally appealing image quite explicitly. In this context a truly pristine lake is inherently valuable, and the possible existence of real gems amid the costume jewelry should make the identification and protection of relatively undisturbed Adirondack lakes of special importance. Unfortunately, this has yet to be done in a rigorous, systematic fashion, nor has the possible existence of and threats to such lakes yet received wide attention.

The concept of "heritage lakes"
We use the term "heritage" here to describe a lake that displays unusually little impact from human activity. It derives from the concept of Adirondack brook trout "heritage strains" (Demong, 2001) which highlights the endemic, historically significant nature of the objects of study, but it expands the focus beyond game fish to encompass entire ecosystems. By our definition, a heritage lake should support the same kind of fish community that it had prior to human settlement in the region, but it should also have similar water chemistry.

![Disturbance Scale Diagram](image)

**Figure 1.** A qualitative model to illustrate the increasing abundance of lakes along a spectrum of increasing disturbance from pristine conditions. The most widespread disturbance is probably the invasion of exotic species; two thirds of all Adirondack lakes surveyed in the mid-1980's contained yellow perch or golden shiners (W. Kretzer, personal communication).
sedimentation regimes, and plankton communities whose background can be documented by historical or paleoecological methods.

Figure 1 presents one way of visualizing the relative abundance of Adirondack lakes along a spectrum of increasing displacement from pristine conditions. Heritage lakes occupy the narrow end of this wedge-shaped gradient, in theory encompassing the range of truly pristine waters but in fact lying slightly to the left of it due to the global distribution of human impacts via atmospheric pollution. In the absence of protective measures, the qualifying disturbance range and numbers of Adirondack heritage lakes will shrink farther to the right on this chart.

An important step in the documentation of heritage lake status is choosing a specific reference point in time to which one can compare present conditions. Lakes change from day to day, season to season, and year to year, and over longer periods of centuries to millennia the natural changes can be greater than those due to recent human activity. As a result, there is no single "original" state for any given lake, and after looking back through geologic time one might even suggest that the primal condition of the typical Adirondack lake is a pool of silty-laden meltwater surrounded by glacial sands and gravel. Clearly, this is not a realistic management goal, and instead we propose the use of 1800 A.D. as a more acceptable reference period for the evaluation of heritage status in the Adirondacks because it represents a time just prior to human settlement in the high country during which climatic conditions similar to those of today are likely to have prevailed. Adirondack climates have changed relatively little during most of the 20th century (Stager and Martin, 2002), but the centuries immediately preceding the 1800's were likely affected by the so-called Little Ice Age (ca. 1400-1800 A.D.) which may have affected regional hydrology and vegetation significantly.

One must also be able to document the undisturbed nature of the lake in question. In the Adirondacks, where no observational data predate the mid-19th century, it is only through paleoecological techniques that conditions relative to 1800 A.D. can be determined. Chief among these methods is the analysis of lake sediment cores which can yield information about plankton communities (fossil algae or zooplankton remains), sedimentation regimes (organic matter, isotopes, etc.), and other ecological features that can be dated by lead-210 and other radioisotopic means. Although continuous paleo records are preferable in this regard, a relatively rapid, inexpensive evaluation of heritage status can also be conducted through the analysis of top and bottom samples of cores that can be assumed to represent the last 200 years or so, as was done very effectively in an earlier study of Adirondack lake acidification (Cumming et al., 1992). The presence or absence of non-native fishes can be determined by simple, if labor-intensive, netting studies. While not perfect, such a multidisciplinary approach can potentially make the documentation of heritage lake status efficient, consistent, and scientifically sound.

In a setting where hundreds of lakes face a broad array of ecological problems, the identification of a few waters at the least disturbed end of the spectrum can help lake managers to direct attention and limited resources to sites that can return great value at minimal cost simply by shielding them from inappropriate management practices. Protective measures might include keeping the lake free of stocked game fish, constructing a barrier dam on an outlet to keep exotic species out, or simply promoting appreciation of the lake's unique nature among visitors.

Case Study: Wolf Lake

We now present a case study as a preliminary model for the documentation of heritage status in an Adirondack lake. The focus is Wolf Lake, located in a former private watershed within the Huntington Wildlife Forest (HWF) near Newcomb, Essex County (44 01'42" N, 74 13'16" W; Fig. 2). It is currently owned by the State University of New York which permits access only for educational and research purposes. In 1997, we investigated the fish community and sediment record of Wolf Lake at the invitation of HWF staff in order to determine the effects of past human activity, if any, on the lake and to compare its present state to that of the early 19th century.

Site description

Wolf Lake lies at ca. 600 m elevation, covers approximately 154 acres, and has a maximum depth of ca. 14 m in the southern basin. It has an inlet and outlet at the northern end, hills covered in hardwood forest rise sharply from the eastern and western shores, and a marsh occupies the southern shore. The unpaved Adjidaumo Road runs close to the southwestern shoreline for approximately 200-300 m, and a narrow side track provides vehicular access to a rustic log cabin on the south shore that was once used for storage and occasional lodging by students and researchers, but is now abandoned.

We examined unpublished reports housed in the Adirondack Ecological Center (Newcomb, N.Y.) in order to reconstruct as much of the ecological history of Wolf Lake and its surroundings as possible from direct documentation. The results are summarized here.

An "old wagon road" was present near the eastern shore of the lake on a map drawn in 1937, but is not in use today. At present, the only vehicular access is by way of the Adjidaumo Road, which was built in the late 1930's. A hurricane in 1950 caused extensive damage to Adirondack forests, but there was minimal impact in the vicinity of Wolf Lake. Small-scale selective logging occurred in the watershed between 1957 and 1991. Water chemistry data collected between 1950 and 1997 show that...
the waters were consistently clear, dilute, and circumneural; Secchi depths ranged between 5 and 8 m, conductivity was 20-38 umhos/cm, alkalinity was 60-78 ueq/L, and pH was generally between 6.5 and 7.0.

The earliest description of the fish community of Wolf Lake comes from a survey by state fisheries biologists in 1932 that reported yellow perch in the lake. However, no netting was done in that study, and no record of perch was ever filed after that date despite repeated subsequent netting studies. We therefore believe that the 1932 report of perch may be inaccurate. The first trap-net study (Dence, 1937) was conducted in 1933 and yielded common shiner, common sucker, black-nosed dace, red-bellied sunfish, and lake trout. Trap-netting in 1957 (Bernhardt, 1957) yielded the same species as well as horned dace, cutlips minnow, northern sculpin, and brown bullhead. In 1966, the rare dwarf white sucker (Catostomus commerson sonni utahwana) was identified in Wolf Lake (Cross, 1971), and a 1980 fisheries study (Zuckerman, 1980) reported white sucker, slimy sculpin, and brook trout. The lack of non-native fishes in Wolf Lake in 1980 is particularly notable because nearby lakes in the HFW contained yellow perch well before that time (Bernhardt, 1957).

Materials and methods

In October, 1997, a trap net was set in the shallows at the south end of the lake, and the catch was examined the following morning. The aim of this study was simply to test for the presence or absence of yellow perch, golden shiners, northern pike, or bass, which are the most common invasive fishes in the Adirondacks. As a result of this simple approach, many of the fish that did not belong to those taxa were not identified to the species level and no species counts were done. We recommend that more thorough taxonomic work be undertaken in future investigations of this nature.

A 31 cm long sediment core was collected from the south basin of Wolf Lake with a gravity corer (Fig. 2). The core was extruded vertically in the field at 1 cm increments and the sediments were stored in vials under refrigeration prior to analysis. Subsamples for $^{210}$Pb dating were oven dried and powdered for analysis by MyCore Scientific, Deep River, Ontario, and their ages were calculated using the constant rate of supply model (Binforder, 1990). Lead-210 dating assumes a zero age for the top sediments; if the top sediments are missing, then the dates calculated will be too young. Corroboration of such dates can, in theory, be obtained through $^{137}$Cs dating but, due to insufficient funds, this option was not available in our study.

Percent weight loss on ignition (LOI), which provides an estimate of the organic content of sediments, was calculated after overnight ignition of core sediments at 500°C. Higher LOI often indicates anoxia and/or higher productivity in a lake; lower LOI may indicate the opposite conditions as well as increased inputs of inorganic materials such as silt. Subsamples for microfossil analysis were digested in hydrogen peroxide and mounted on glass slides with Permount. Siliceous algal remains were identified at 1000X under oil immersion and identified by reference to Patrick and Reimer (1966, 1975) and Camburn et al. (1984-1986).

Results

Large numbers of white suckers, creek chubs, and various small minnow species were present in the trap net after 24 hours, along with smaller numbers of brown bullhead, red-bellied sunfish, and brook trout. No yellow perch, golden shiners, pike, or bass were found. The fish community observed in this study resembles that found in the previous studies, indicating that a diverse native fish community persisted in Wolf Lake as recently as 1997.

The 31-30 cm sediments yielded a $^{210}$Pb date of 1792 A.D. The sediment LOI values in the lower half of the core remained close to 60% but they dropped abruptly ca. 1940 A.D. and remained close to 40-50% thereafter (Fig. 3).

Diatom valves were numerous, diverse, and well preserved throughout the core (Fig. 4). The most common species was the planktonic diatom Cyclotella stelligera, followed in abundance by planktonic Aulacoseira subarctica and a combined taxonomic group ("misc. Pennales") consisting of genera typically associated with littoral habitats (including Gomphonema, Eunotia, Staurosonea, Cymbella, etc.). The most pronounced changes in the diatom assemblages occurred ca. 1910, when percentages of C. stelligera increased at the expense of A. subarctica and miscellaneous Pennales. The abundances of chrysophyte remains relative to those of diatoms decreased and chrysophyte scales became more common relative to cysts after the early 1900's (Fig. 3).
Discussion

The reduction of sediment organic contents (LOI; Fig. 3) that began ca. 1940 A.D. probably reflects the presence of the Adjidaumo Road, which might increase the delivery of inorganic sediments to the south basin via runoff. The lowest LOI values after 1940 might reflect logging within the watershed ca. 1957-1991, and the LOI increase above the 5 cm level in the core may reflect the cessation of logging. Overall, the most notable changes that are readily identifiable in this sediment record are the moderately reduced organic content of today’s south basin and the slightly higher percentages of *C. stelligera* relative to *S. subarctica* and Pennales which might indicate a slight decrease in productivity or some other unidentified ecological change since the early 19th century.

Is Wolf Lake truly pristine? By the strictest definition of the term, no, because its sediments are now less organic than they were, its diatom and chrysophyte communities are slightly different, and because, like every other lake in northeastern North America, it is exposed to a chronic rain of atmospheric pollutants. However, the lake is not acidified, the changes recorded in the sediments are relatively minor, and the basic structures of its algal and fish communities appear to be intact. In spite of

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**Figure 3.** Stratigraphy of the Wolf Lake core, showing relative abundances of diatoms and chrysophyte algal remains and organic content as estimated by weight loss on ignition at 500°C (LOI). The dotted line represents the approximate location of the 1800 A.D. reference period in the core.

**Figure 4.** Stratigraphy of the Wolf Lake core, showing percentages of major diatom taxa. The dotted line represents the approximate location of the 1800 A.D. reference period in the core.
the moderate differences mentioned above, Wolf Lake seems to be very much like it was ca. 1800 A.D., and we therefore feel that it qualifies for heritage status.

As a heritage lake, Wolf Lake is a potentially valuable point of reference for future studies of Adirondack waters of similar elevation, morphometry, and chemistry. First, it provides a real-world model of baseline ecological conditions to which one can compare the effects of anthropogenic disturbances in other Adirondack lakes. For instance, the lack of major environmental changes at Wolf Lake in the 1950's suggests that weather and other regional-scale factors did not significantly change the lake ecosystem then, which in turn supports earlier conclusions that water quality declines in Upper Saranac Lake (Stager, et al., 1997) and Black Pond (Stager, 2001) in the mid-1950's were due to cultural eutrophication and fisheries manipulations rather than to atmospheric pollution or regional weather.

This study identifies Wolf Lake as being worthy of special protection from invasion by non-native species through the outlet stream, through stocking programs, or via anglers. To date, the HWF staff and their predecessors have successfully shielded Wolf Lake from such threats by strictly limiting public access. However, we also recommend that a barrier dam be placed on the shallow outlet stream to prevent invasion by non-native fishes from other lakes downstream.

In hindsight, several improvements can be suggested for future studies of this nature. If possible, 210Pb chronologies should be corroborated with 137Cs or other dating methods. Additional information about past biotic communities might be obtained through the analysis of zooplankton remains, pollen, algal pigments, and other paleo proxies, and greater taxonomic precision in the study of fish communities would also be of value. We and our colleagues at the Adirondack Watershed Institute, Paul Smith's College, invite suggestions for further refinement of the concept of heritage lakes, for improving our methods of documentation, protection, and outreach, and for sites to be included in what we hope will be a growing and long-lived list of relatively undisturbed Adirondack waters.

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