Adirondack Forest Communities and Climate Change

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The hundreds of lakes stud-
ding the Adirondack landscape are
valued for their scenic beauty, their
populations of game fish, and their
recreational potential. Another
value, overlooked by most people,
is that the lakes contain environ-
mental archives in their sediments.
The lakes are like video cameras,
embedded in the landscape, pas-
sively recording changes in vege-
tation and environment over thou-
sands of years. The records pre-
served in the lakes can provide
insights for management of the
Adirondack landscape in the face
of ongoing and future environ-
mental changes, both natural and
human-caused.

Each spring, Adirondack
residents and visitors endure the
flower-dust storms rolling through
the air. As the sneezing subsides,
yellow films of pollen can be seen
floating on lakes and pools. Swimm-
ers and boaters cut channels
through the pollen and through the
floating debris of needles, seeds,
and other plant organs washed by
rivulets or blown by breezes onto
lakes from nearby forests. Much
of the pollen and plant debris sinks
to become entombed in the mud at
lake bottoms. As the decades and
centuries and millenia pass, the
mud accumulates, storing the
annual crops of pollen and litter.
Temperatures rise and fall, trees
live and die, species come and go.
The mud stays, archiving these
changes.

The vertical sequence of
mud at a lake bottom is like a
videotape, with images of chang-
ing vegetation recorded in the form
of body parts of trees and corpses
of pollen grains preserved in the
mud. Converting the magnetic
information on a videotape into
visible images requires sophisti-
cated electronic equipment. Ex-
tracting images of the past from
lake mud requires first that we
obtain a vertical core of the mud
and inventory the sequence of
changes in pollen and plant macro-
fossils (identifiable debris) from
bottom (oldest) to top (youngest)
(1). Decoding the information also
requires that we understand just
what the images represent. A vide-
otape of an actual event is subject
to distortions and biases imposed
by film, lens, distance, and choices
of where to focus and how to frame
the image. Pollen and macrofossil
sequences are similarly character-
ized by distortions and biases.
Studies of modern pollen and
macrofossil assemblages guide us
in interpreting the records from
lake sediments(2-5).

Because pollen grains are
small and readily carried long
distances in the atmosphere, pol-
len sequences provide a poorly
focused record of vegetational
changes integrated over a broad
area. My recent work comparing
modern pollen samples from Adi-
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rondack lakes with modern vegetation patterns indicates that most of the pollen grains come from trees growing within a 10-20 km radius of the lakes; fine-grained forest patterns are largely blurred by widespread pollen dispersal (6,7). In contrast, plant macrofossils, being large and heavy, do not travel far except by surface water, and hence all derive from trees growing within the watershed of a lake (4). Thus, macrofossils are sensitive to finer-scale patterns of vegetation. Together, pollen and macrofossil sequences provide contrasting but complementary images of vegetation change at different spatial scales (8).

I have studied post-glacial plant macrofossil sequences from six lakes in the High Peaks region of the central Adirondacks (4). Donald Whitehead and I have also studied pollen sequences from those lakes, which range in elevation from 660 m, Heart Lake, to 1320 m, Lake Tear of the Clouds (9). Forest composition in the High Peaks changes substantially with increasing elevation, and a key objective of my research has been to understand how forest patterns along the elevational gradient have changed during the past 10,000 years. Today the landscape at elevations between 500 and 800 m is occupied by forests of white pine, hemlock, yellow birch, sugar maple, and beech. These forests grade upward into subalpine forests dominated by red spruce and balsam fir. Red spruce drops out above 1200 m, while balsam fir persists all the way to timberline at 1400-1500 m.

Although these vegetation patterns may appear to be permanently engraved on the landscape (barring human disturbance), the pollen and macrofossil records lead to a more dynamic, and perhaps unsettling, perception of the vegetation (8). The pollen records at our sites indicate nearly continual change in regional forest composition during the past 10,000 years (9). Mid-elevation forests dominated by spruce, fir, and paper birch were invaded by white pine 9000 years ago. Forests of white pine and paper birch were replaced by hemlock-dominated forests about 7000 years ago. Sugar maple, beech, and yellow birch also appeared as important forest constituents between 8000 and 6000 years ago. Hemlock populations declined abruptly and drastically 4800 years ago, evidently owing to a widespread pest outbreak; similar declines are recorded at the same time throughout hemlock’s range in eastern North America (10). Beech, sugar maple, striped maple, and yellow birch all increased regionally after the hemlock decline. Around 3000 years ago, hemlock underwent a recovery that was cut short by a large regional increase in spruce (probably red spruce).

The macrofossil sequences from high-elevation sites indicate that mid-elevation trees such as white pine, hemlock, and yellow birch grew in forests 200 to 300 m above their modern elevational range limits between 8000 and 4000 years ago (4). The upper range boundaries of these trees are determined primarily by climate, with temperature and growing-season length most important. The macrofossils provide clear evidence for substantial climate change in the region during the past 10,000 years, with conditions warmer (1-2°C) than today during much of the period. Paleoecological studies by Margaret Davis, Pierre Richard, Denise Gaudreau and others in regions bordering the Adirondacks indicate similar climatic changes (11-15).

Although the macrofossil record indicates that ranges of individual tree taxa shifted up and down the mountain slopes as the climate changed, the patterns of forest zonation were not conserved (4,8). Forest zones didn’t move up and down slope. Rather, zones would emerge, persist for a while, and then dissolve to be replaced by new zonal patterns. The characteristic zonation patterns on the landscape today didn’t exist before 3,000 years ago. Where today we see hemlock-hardwoods forests.
grading upward into spruce-fir, 4,000 years ago we would have seen hardwoods (with a little hemlock) bordering fir-dominated forests. Eight thousand years ago the pattern consisted of white pine and paper birch grading upward into fir and paper birch. Until 2,000-3,000 years ago, no spruce-fir forests intervened between mid-elevation forests and subalpine fir forests (8).

The complexity of vegetational changes in the Adirondacks—the periodic transfiguration of vegetation patterns and forest communities—is linked to the complexity of climatic changes the region has experienced (8). Climate at any particular place on the landscape is a composite of many different factors (temperature, precipitation, solar radiation, etc.). Plants respond not only to the “averages” of those factors at a site but also to the extremes, and to the averages and extremes encountered at different times of the year. Thus, the vegetation patterns on the landscape at a given time are governed in part by the particular seasonal occurrences of the means and extremes of a large number of factors. A key insight from paleoclimatic studies during the past two decades has been that long-term climate change involves what amount to recombinations of these factors and their seasonal distributions (16-18). Averages may stay the same, while extremes increase in magnitude. Annual temperature may remain constant while seasonal contrast in temperature may increase or decrease. New combinations of growing-season temperature and precipitation may arise. If particular climatic regimes take form and then vanish through time, we should not be surprised to see vegetation patterns and community types do the same (19,20).

What do these paleoecological and paleoclimatic studies indicate about how forest patterns in the Adirondacks might respond to future climate change (for instance, global “warming” brought about by increasing atmospheric carbon dioxide)? I believe we can say confidently that the response will not simply consist of an upward shift in the current vegetation zones owing to increasing temperatures. Climate change will not be that simple, nor will the vegetational response to it. Current climate simulation models lack sufficient precision and spatial resolution to indicate just how the regional climate of the Adirondacks might change over the next few decades (21), and our mechanistic knowledge of the effects of climatic and other factors on plant species and vegetation is insufficient to predict precise responses to specified changes. Climate change will likely be complex, involving changes not only in a variety of atmospheric conditions (21-23), but also in magnitude and frequency of disturbances (fire, blowdown, canopy-gap initiation), which will themselves mediate vegetational responses (24-26). Direct physiological responses of plants to increasing atmospheric CO2 will add to the complexity (27), as will feedbacks and interactions involving soil chemistry, soil microorganisms, plants, and herbivores (28-30).

Because the structure and composition of biological communities are contingent on the prevailing environmental complex, attempts to preserve characteristic Adirondack community types may be unsuccessful in the face of climate change (31). However, the Adirondack region may play a critical role in preserving eastern North American biodiversity during the next century by virtue of its extensive undeveloped lands and diversity of habitats. By ensuring that those lands remain undeveloped—i.e., by preserving extensive, diverse, and connected habitats—we may be able to provide routes and destinations for plant and animal species that will need to adjust their geographic and habitat distributions to form new communities under the changing environmental regime (31-34).

We should be prepared for unprecedented and unexpected environmental changes during the next century. The ancient mud at the bottom of Adirondack lakes may be among the few things we can count on to stay the same.

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REFERENCES


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Wild Island in a Civilized Sea
by Michael G. DeNunzio

Created in 1892, the Adirondack Park was the first “countryside” park in the world. Its founders specifically incorporated a complex pattern of public and private lands, including thriving communities, within its boundary. It contains 6 million acres, covers one-fifth of New York State, and is equal in size to neighboring Vermont.

Some 58 percent of the Adirondack Park is private land, devoted principally to forestry, agriculture, and open-space recreation. The park is home to 130,000 permanent and 210,000 seasonal residents, and hosts an estimated 9 million visitors annually.

The remaining 42 percent of the Adirondack Park is publicly owned Forest Preserve, protected as “forever wild” by the State Constitution since 1894. One million acres of these public lands, representing one-sixth of the entire park, are designated as Wilderness, where a wide range of recreational activities may be enjoyed in an incomparable natural setting. Sixteen separate wilderness units, ranging in size from about 7,000 to over 220,000 acres, are scattered throughout the park. Motorized vehicles and equipment are banned from wilderness areas to preserve quiet and solitude, to protect sensitive wildlife, and to help prevent overuse. The majority of public land (more than 1.3 million acres) is classified as Wild Forest, in which motorized uses are permitted on designated waters, roads, and trails.

Plants and wildlife abound in the Adirondack Park, including many found nowhere else in New York State. Uncut ancient forests cover tens of thousands of acres. Ironically, much of the park is more wild and natural today than it was a century ago, when irresponsible logging practices and forest fires ravaged much of the region. Someday, all native wildlife, including those species totally eliminated from the Adirondacks during the last century, such as the wolf, lynx, and moose, may live and breed in the park once more.

The western and southern Adirondacks are a gentle landscape of hills, lakes, ponds, and streams. In the northeast are the High Peaks, 46 of them 4,000 feet or higher, 11 with alpine summits that rise above timberline.

The Adirondacks include the headwaters of five major drainage systems: the Hudson, Black, St. Lawrence, and Mohawk rivers, and the New York portion of the Lake Champlain basin. Within the park are 2,800 lakes and ponds and more than 1,500 miles of rivers fed by an estimated 30,000 miles of brooks and streams.