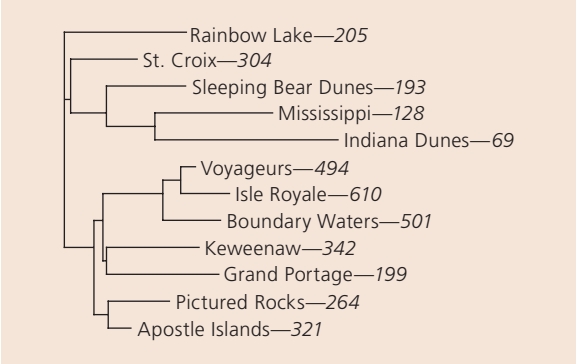
Twenty-four years of Great Lakes lichen studies provide park biomonitoring baselines

By James P. Bennett

FOR THE PAST 24 YEARS, BIOLOGISTS HAVE studied lichens in the Great Lakes national park units in considerable detail (see map), including floras and chemical element surveys, for biodiversity and air quality assessments. They have studied lichens because they are sentinel species indicating ecosystem health, and because they are excellent biomonitoring and bio-indicator species of air quality. These studies have been funded by individual parks, the NPS Air Resources Division, and the U.S. Geological Survey.

It is well-known that lichen diversity increases with latitude in this region, and this is seen in the numbers of species in the parks (see dendrogram). The five areas in the top group are located south of 46°N latitude, are either associated with rivers or have very little rock substrate (which is usually rich in lichens), and average 180 species per park. The seven areas in the bottom group (five are in the Lake Superior basin) are north of 46°N and average 390 species per park, more than twice as many as in the other group.

A species that grows exclusively on rocks, the elegant sunburst lichen (*Xanthoria elegans*) is found in 56 U.S. national parks. In the Great Lakes area it has been documented at Apostle Islands, Isle Royale, Keweenaw, Saint Croix, and Voyageurs as part of ongoing lichen studies.

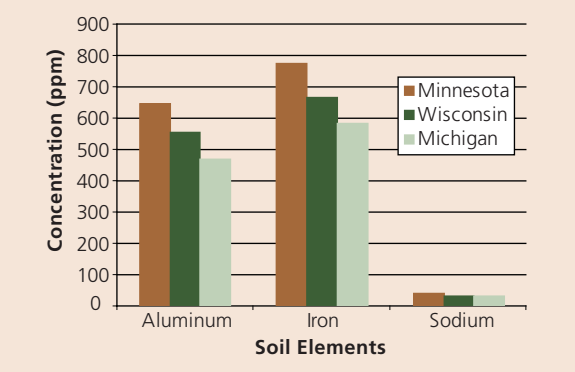


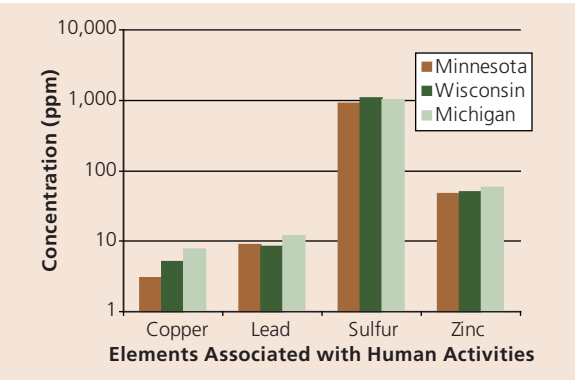
The dendrogram shows the relationships among the park/forest areas based on the diversity of lichen species present in each area. The sum of the lengths of all horizontal lines between any park/forest pair is a measure of how similar or dissimilar the areas are based on lichen species. The number of lichen species inventoried in each park/forest follows the area's name.

Lichen study areas in the Great Lakes region.

Indiana Dunes National Lakeshore has the fewest lichen species, is the most southern and most heavily influenced by human activities, and is the least similar to any other park. However, along with Apostle Islands National Lakeshore and Grand Portage National Monument, it also has two unique species. The relatively high number of single occurrences of species of lichens of all these areas is probably greater than that of the vascular plants, and they deserve consideration for special management and protection.

Investigators have analyzed more than 35,000 elemental chemistry records from lichens of 10 of these areas. Using the data for the four most common lichen





Mean concentration of chemical elements in four common lichen species sampled in 10 national park/forest areas, by state, 1982–2006.

species, they have found that some chemical elements increase and some decrease in parks from west to east (see graphs).

The soil elements aluminum, iron, and sodium decrease from west to east, probably because of increasing distance from blowing dust of the Great Plains. However, elements associated with human activities—copper, lead, sulfur, and zinc—increase from west to east with increasing proximity to eastern population centers. Investigators have also examined chemical patterns through time and have found, for example, that lead concentrations in lichens, which averaged from 17 to 23 parts per million (ppm) in the early 1980s, have decreased significantly to levels below 6 ppm in the mid-2000s in the three-state area.

In addition, the studies have identified elemental differences among parks and species using discriminant analyses. Differences among species appear to be greater than differences among parks. Biomonitoring of air quality in parks must therefore be done with certain species to control the precision and accuracy of data over time and space.

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Both the elemental data and the species presence data are now available on Web sites of the U.S. Geological Survey: *NPElement* at www.nwhc.usgs.gov/our_research/np_element.jsp (more than 70,330 data points) and *NPLichen* (more than 29,000 data points) at http://www.ies.wisc.edu/nplichen/.

Investigators continue their detailed analyses of many spatial and temporal patterns in this region. Their greatest challenge is interpreting results for the region as a whole. Parks are not distributed geographically in such a way that strong regional inferences can be made, but conclusions about the areas themselves will be possible. The lichen richness across these areas is greater than that of any of the states they are in, and the high degree of single occurrences of certain lichen species among them suggests that their special area protection has been responsible for this. Investigators hope to emphasize this in the future so that area managers will have more information to maintain and improve protection practices. Finally, the establishment of biomonitoring baselines for these areas has been enhanced by being able to compare individual areas with others, thus improving spatial and temporal trends results and interpretation. ■

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