Isle Royale National Park

J. Robert Stottlemyer

For the past several years widespread attention has been focused on the national and international question of acid precipitation and other forms of anthropogenic atmospheric deposition. Much of this attention has been brought about by the popular press which has often poorly interpreted the problem—largely due to its complexity. This brief paper presents some of the generally accepted aspects of the problem, gives some of the preliminary acid precipitation research results for Isle Royale National Park, and briefly discusses the need to use an ecosystem approach in evaluating such issues.

Acid precipitation is widespread in the United States and quite possibly globally. Present levels of acidity, due primarily to the strong mineral acids H_2SO_4 and HNO_3, and other man-induced atmospheric contaminants are such that land managers should be concerned and be knowledgeable about the issue.

In part due to the complexity of the problem, Federal policy on this subject has been criticized. Present policy emphasizes continuing research into the causes, presence, and effects of acid precipitation. A recent National Academy of Sciences report (1981) takes strong issue with this policy suggesting that the problem is more significant than given credit and needs immediate regulatory action.

A major difficulty in assessing the status of this problem is the absence of reliable historical baseline data. A lack of consistency in measurement technique aggravates this data deficiency. The first nationwide precipitation monitoring network, placing heavy emphasis on standardized measurement techniques, is the National Atmospheric Deposition Program which is only a few years old. Numerous national parks are participating in this increasingly important program. In the United States one of the best scientific data bases on the subject is that for Hubbard Brook in New Hampshire where a 15-year record exists.

An indirect approach often used for determining precipitation quality is the measurement over a long time period of SO_4 and NO_3 in stream discharge—especially during spring runoff periods following snowpack melting. In undisturbed watershed ecosystems there are numerous mechanisms whereby much-needed plant nutrients are retained during times of high water discharge. This is indicated by a general decline in nutrient concentration with increased stream discharge. Substances which increase in concentration with increasing stream discharge often indicate precipitation inputs in excess of what the ecosystem can use, or internal ecosystem disturbance.

Despite past information limitations, as new data are obtained scientists are in general agreement that the problem is worsening, that man is responsible for putting up some of the precursors to acid precipitation, and that the effects of these increased atmospheric depositions will be very difficult to define due to the lack of baseline data (Hornbeck 1981). The need for baseline precipitation and ecosystem data brought about the present research on this topic in Isle Royale National Park, a recently designated Biosphere Reserve.

Isle Royale is a 56,000 ha island in northwestern Lake Superior. Its substrate is predominantly metamorphosed Precambrian basaltic lava flows (Huber 1975). The island has been glaciated numerous times, and glacial till is much in evidence in the southwest third of the island. The island's vegetation consists mostly of boreal forest species, with some northern hardwood species especially common in areas of abundant glacial till. Such geological substrates, due to their poor buffering capability, bring about conditions that can cause aquatic resources to be very vulnerable to the direct impacts of acid precipitation. A lowering of stream pH to 5 or so is lethal to many aquatic species, and the slow neutralization of this acidity can result in the release of metals such as Al or Mn at toxic levels.

The research objective on Isle Royale is to use small watershed ecosystems in evaluating the effects and fate of atmospheric inputs. Specifically, I am looking at seasonal variation in precipitation quality, qualitative change with increasing elevation above Lake Superior, how vegetation affects the quality and quantity of precipitation, the influence of alkaline glacial till on streamwater quality and defining the biogeochemical cycling for specific nutrient inputs such as Ca, K, and NO_3. Of particular interest is snowpack quality since much precipitation in the Upper Great Lakes occurs as snowfall. The snowpack can accumulate a considerable load of chemical substances which are released in large amounts over a short period during spring melt. The research design places emphasis on the study of small "first order" headwater streams which are the most sensitive and likely to show the effects of mineral acid inputs. Larger streams are rarely acidified since their pH is largely determined by the carbonic acid system.

Three Isle Royale watersheds are being studied: two on substrates with widespread extensive glacial till, one of which is extensively dammed by beaver, with the third in an area of only scattered glacial till deposits. The latter is more typical of Canadian Shield systems. Additional watersheds at Pictured Rocks and on the Keweenaw Peninsula, 180km southeast and 115km south respectively, along Lake Superior's south shore are also monitored.

The results to date show all precipitation to be acidic (Figure 1). Mean pH values range from 4.88 at the southwest end of the park (Windigo) to 3.87 for the northeast end (Mott Island). Any pH value below 5.7 is considered acidic since this is the value naturally reached with water in the presence of atmospheric CO_2. The amount of precipitation occurring as snowfall significantly increases with elevation above the lake but does not change in quality. The deterioration of precipitation quality with increasing elevation is a problem in the Adirondacks. Interestingly, the snowfall on Isle Royale had a lower pH than did the summer rains which is normally not the case since snow falling through the atmosphere is a poorer "collector" of aerosols and particulates. The much reduced pH for Mott Island compared to Windigo (70km distance) over the same time period is probably due to relatively local sources of contamination within the region.

When this precipitation reaches the forest canopy it is significantly altered both in quantity and chemically. The degree depends on the species of plant—especially whether it is conifer or hardwood. Three seasons of data indicate that throughfall from conifers (*Thuja occidentalis*, *Picea glauca*) has a pH lower than atmospheric precipitation and much higher levels of cations such as Ca, Mg, and especially K. Anions, especially NO_3 and SO_4, also significantly increase in concentration. Why these changes occur is not fully clear. The decreased pH could be due to washing off excess hydrogen ions which collect in the canopy from aerosols and dry deposition. Hydrogen could be replacing other cations in the vegetation, which would accelerate leaching. The excess NO_3 and SO_4 is due to the canopy trapping dry precipitation and aerosols which are then washed off with rainfall. The ecological significance of these added nutrients and their concentration is not clear.

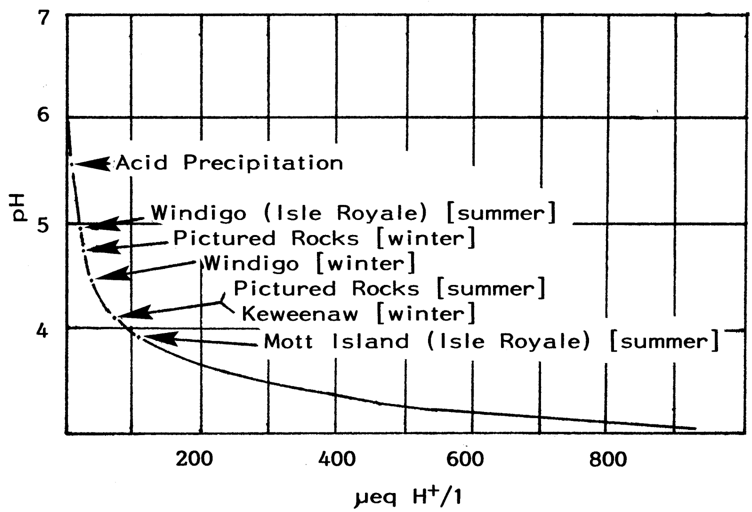

Figure 1. *Concentration of hydrogen ions (microequivalents/1) for CY 1979.*

Throughfall from hardwoods (*Acer saccharum*) has a pH one full unit higher than that falling through conifers, and is higher than for incident precipitation in the same area. This is probably due

...continued on page 34

...continued from page 8

to the higher concentrations of neutralizing substances normally found in hardwood leaf tissue. It may also be that hardwoods are less efficient collectors of acidic aerosols and dry precipitation.

Once the precipitation reaches a small first-order stream it is very rapidly neutralized when there is abundant glacial till. Neutralization occurs through carbonate buffers which would not be expected on Isle Royale. The presence of beaver dams clearly slows the rate of neutralization, probably due to the fact that they increase the amount of organic substrate over which the stream flows. It's an important difference since beaver dams are the rule in Isle Royale drainages.

About two-thirds of Isle Royale is without extensive deposits of alkaline glacial till, however, and here the story is much different. Stream pH values are lowered with precipitation inputs, and neutralization is slow. The neutralization involves aluminum salts (probably among others) and soluable Al has been observed. The ecological consequences of this for Isle Royale are unclear at present. It is important to note that those streams with least buffering capacity also tend to have more conifers in their watershed, thus aggravating the acidity of precipitation. But such interactions can in time be effectively studied using the small watershed ecosystem approach.

A survey of Isle Royale lakes shows many also to be of low buffering capacity, and the effects of acid precipitation and altered stream chemistry contributions to them has not been quantified.

The U. S. Geological Survey has been monitoring water quality in Washington Creek on the southwest portion of Isle Royale since 1965. Analysis of these data show increased concentrations of SO_4 during peak spring runoff, and in recent years some increases in NO_3 . This is important since undisturbed watersheds such as Washington Creek are very conservative in regulating the loss of plant mineral nutrients. Such losses in this instance can only come from excess nutrient contributions from snowfall. Interestingly, a statistical analysis of these data shows no significant changes in SO_4 discharge over the period of record.

To conclude, it appears from the Isle Royale experience, and that of others, that much more attention needs to be given to use of an ecosystem approach in assessing threats to national park resources. This is especially important for Biosphere Reserves where the commitment is explicit to maintain functioning ecosystems. Extensive research on selected ecosystem components has lulled some into believing we know much about national park resources. The study of the interactions of these ecosystem components has but begun, and reveals that we really know very little about the structure and functioning of ecosystems. Such knowledge is absolutely essential if we are to understand and mitigate the subtle and complex threats to which national park resources are increasingly subjected. □