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LONG RANGE TRANSPORT OF AIRBORNE POLLUTANTS

ENV085E

Ecosystem Classification and Acid Rain

To ensure that measures designed to control acid rain will effectively reduce damage to the natural environment, scientists from various government departments and agencies are studying forest ecosystem processes in five representative watersheds across Eastern Canada. These studies will improve our understanding of how various forest ecosystems function, and how acid rain affects the long-term health of these ecosystems.

GETTING THE DETAILS — THE FINGERPRINT OF ACID RAIN

Acid rain affects individual ecosystems and their component parts differently. Some plants and animals respond immediately to elevated levels. Others may be resistant, or show gradual deterioration over a long period of time. Damage to one part of the ecosystem often has an impact on other components of the system. Increased leaching of certain elements from soil, for example, may limit the availability of nutrients to the forest vegetation. The leached elements may in turn become concentrated in the aquatic ecosystem to the point that they become toxic to certain species, and perhaps limit their ability to reproduce.

To evaluate the long-term effects of acid rain on the various forest ecosystems, intensive monitoring of the various components comprising these systems is necessary. As these studies progress, models depicting the various ecosystem processes are being developed and will assist scientists in their study of the sensitivity of these ecosystems to various levels of acid rain. These studies will eventually enable scientists to propose realistic guidelines for the development of emission standards to control the levels of acid rain.

The Turkey Lakes watershed is one of a series of calibrated watersheds where detailed, long-term, benchmark monitoring studies are in progress. By being labelled 'calibrated', these constitute sites where detailed investigations and monitoring studies by a team of interdisciplinary scientists have been established. Data on land, water, and air quality as well as biota are being effectively interlinked to permit understanding of how these small ecosystems function and respond to acid rain.

THE TURKEY LAKES WATERSHED

One of the five representative watersheds being studied in Eastern Canada is located 60 km north of Sault Ste. Marie, Ontario (Figure 1). The other four are located near Kenora (Experimental Lakes Area) and Dorset in Ontario, near Quebec City (Montmorency Forest) in Quebec, and in the Kejimkujik National Park in Nova Scotia. The Turkey Lakes watershed measures 1090 ha and is typical of the rugged, rolling terrain of the Algoma section of the Canadian Shield (Plate 1). The watershed is readily accessed by numerous logging roads, which are maintained to ensure access year-round, and features seven small lakes and numerous streams (Plate 2).

The watershed is representative of the Great Lakes-St. Lawrence Forest Region, which is typical of much of southeastern Canada, and is dominated by Sugar Maple, Red Maple, Yellow Birch, White Spruce, and White Pine.

The predominantly podzolic soils of the watershed have developed in a compact, bouldery, sandy-loamy moraine, which is typically 1-2 m in depth.

In 1980, as part of a multidisciplinary research effort, the Lands Directorate initiated a study to document the various soil and vegetation types in the watershed. Specific goals of the study were to:

a) establish a classification for the soils and vegetation;
b) examine the soil/site/vegetation relationships; and
c) map the distribution of the soil and vegetation types (Forest Ecosystem Types) within the watershed.

The classification forms a basic ecosystem framework within which other more detailed, component-oriented process research can be organized. Further, the work provides a means by which results of the research in the Turkey Lakes watershed can be extrapolated and applied to other similar areas.

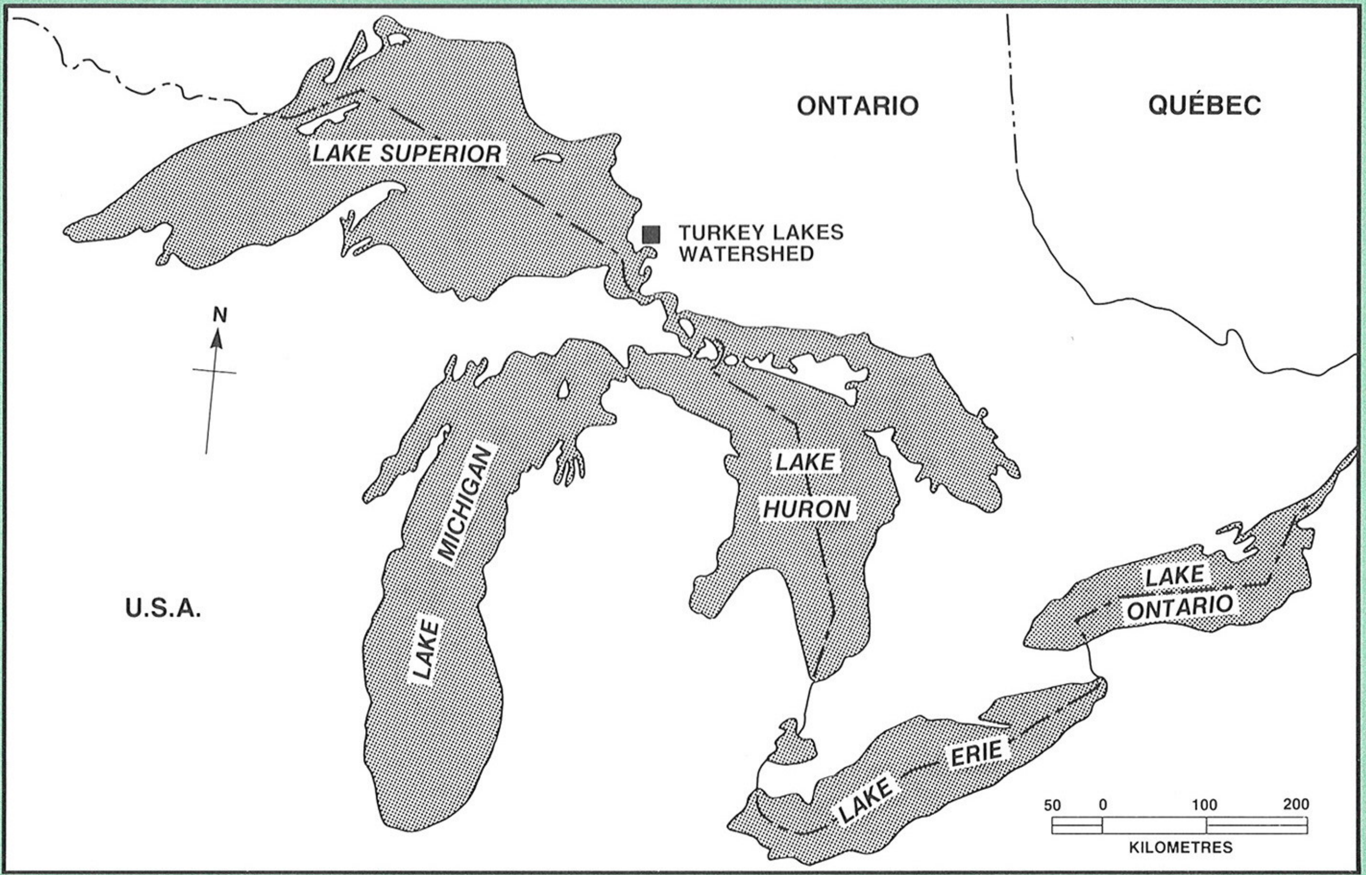

FIGURE 1. LOCATION OF THE STUDY AREA

FIELD SURVEYS

Field surveys were carried out during parts of three summers, beginning in 1980. Eighty 10 × 10 m plots for intensive sampling were established as the basis for defining the vegetation types in the watershed. At 30 of these plots, detailed soil information was collected and formed the basis for the soil classification. In addition, information on slope, aspect, elevation, exposure, and microtopography was also collected. During the mapping phase, 420 sites throughout the watershed were classified using the system developed earlier in the project.

COMPUTER ANALYSES

Results from the field surveys were compiled into an extensive data base of soil, site, and vegetation characteristics for the watershed. This data base was analysed using computer analysis programs developed at Cornell University. Soil and vegetation types were defined using TWINSPAN, a polythetic divisive classification program, which enables the analyst to construct hierarchical classification keys (dendrograms). These keys can be subsequently used to classify other sites not sampled as part of the original data base. Six soil types and 15 vegetation types were recognized during this phase of the analysis. A number of additional types were later included as a result of work done in the mapping phase.

PLATE 1. VIEW WEST OF THE TURKEY LAKES WATERSHED FROM THE TOP OF BATCHAWANA MOUNTAIN

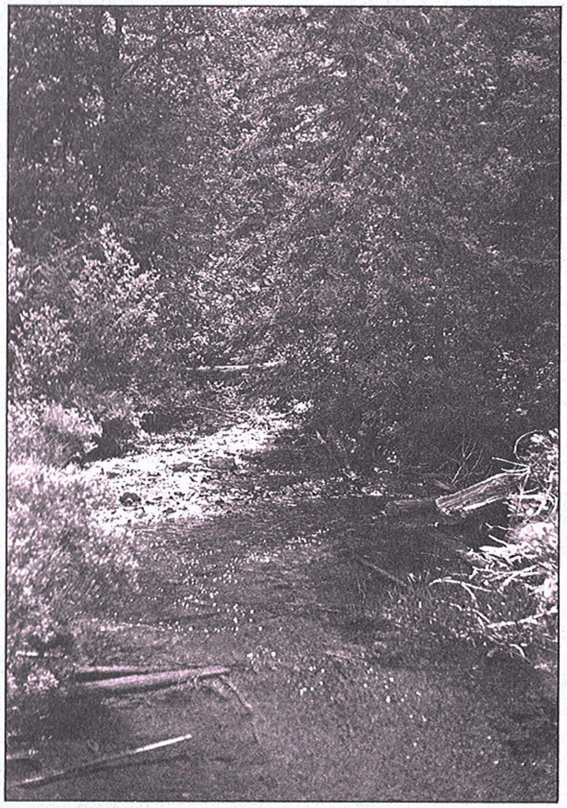

PLATE 2. TYPICAL VEGETATION ALONG A SMALL STREAM ABOVE THE INLET TO LITTLE TURKEY LAKE

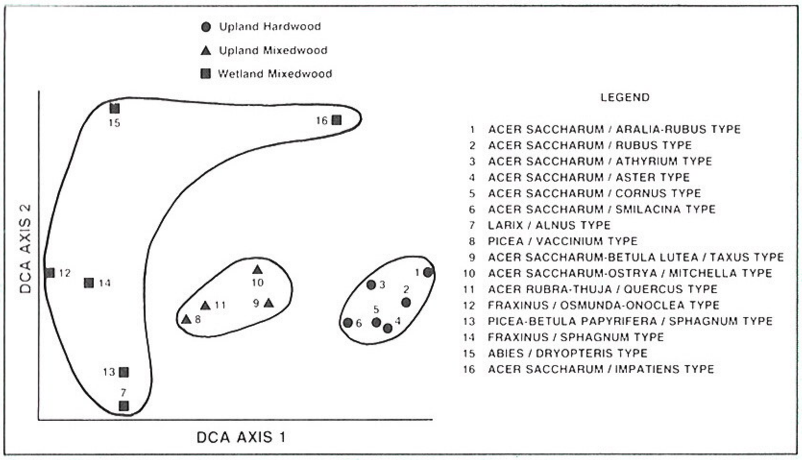

FIGURE 2. DECORANA-DERIVED VEGETATION ORDINATION IN THE TURKEY LAKES WATERSHED

DECORANA, an ordination program, was also used to examine the relationships between the various soil and vegetation types. Figure 2 illustrates this analysis of the 15 vegetation types. Three distinct groupings can be readily discerned: an upland hardwood group, an upland mixedwood group, and a wetland mixedwood group. These groups reflect, along axis 1, a moisture gradient, and along axis 2, a complex gradient including such environmental factors as elevation, slope position, aspect, and exposure. A similar analysis was carried out on the soil types.

Vegetation types seemed to correlate well with elevation and location within the watershed. Data analysis showed that there were three broad elevational zones, which corresponded closely with the three broad vegetational groupings. These zones and the corresponding vegetation groupings are:

zone 1: mean elevation 467 m, upland hardwood group;
zone 2: mean elevation 425 m, upland mixedwood group; and
zone 3: mean elevation 374 m, lowland mixedwood group.

In summary, the watershed was dominated by the 'Sugar Maple-False Solomon's Seal' vegetation type, which occurs almost 60% of the time. Other subdominant types include the 'Sugar Maple-Yellow Birch/Canada Yew' type (17%) and the 'Red Maple-White Cedar-Red Oak' type (15%). The soils were somewhat more variable, with the 'Silt Loam' type (31%) and the 'Loam-Silt Loam' type (26%) being most dominant. The 'Loamy Sand-Silt Loam' type (17%) occurs subdominantly.

MAPPING THE WATERSHED'S FOREST ECOSYSTEMS

Mapping the distribution of the soil and vegetation types over the watershed was done once the classification system was complete. Using aerial photographs, the watershed was subdivided into 125 polygons. A combination of photo interpretation and field checking enabled the researchers to annotate 58 of the polygons with the percentage occurrence of each soil and vegetation type. The annotated polygons were then analysed using TWINSPAN to define nine 'Forest Ecosystem Types' or Map Unit Types. The remaining 67 polygons were then allocated, using the TWINSPAN dendrogram, to one of the nine Forest Ecosystem Types. A portion of this map, reduced from the original scale of 1:12 000, is shown in Figure 3.

Table 1 provides a summary of the areal distribution and characteristics of each Forest Ecosystem Type within the watershed. The Chippewa and Algoma types were the most dominant in the watershed, covering 28% and 23% of its area, respectively.

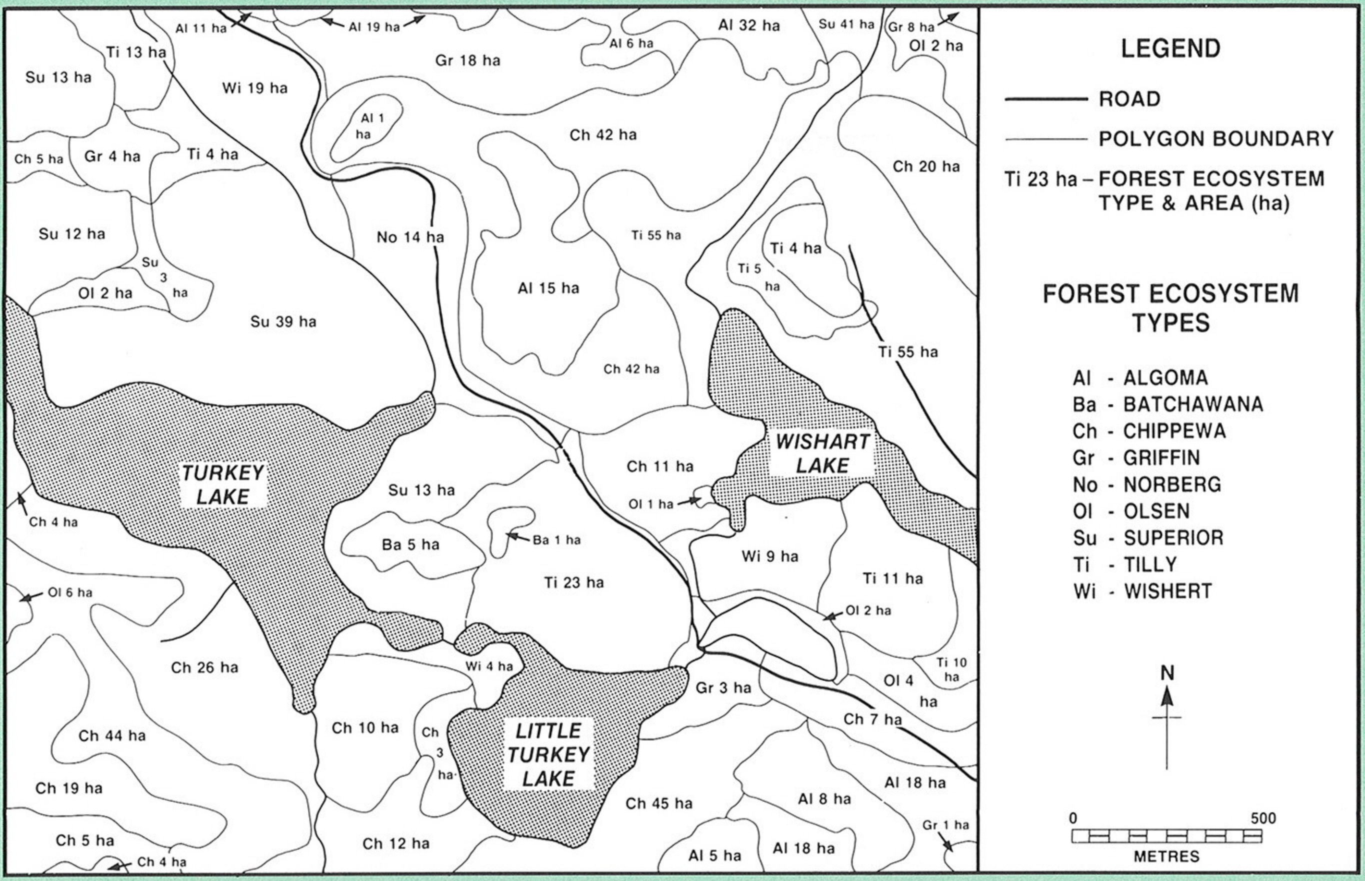

FIGURE 3. PORTION OF THE FOREST ECOSYSTEM TYPE MAP OF THE TURKEY LAKES WATERSHED

Mapping Symbol – Name	Area within Watershed (%)	Dominant Vegetation Types	Dominant Soil Textures
Al – Algoma	23%	*Acer saccharum-Smilacina racemosa* (shrub and herb variants)	sandy loam; loamy sand; loam; silty loam
Ba – Batchawana	2%	*Acer saccharum-Rubus allegheniensis; Acer rubrum-Thuja occidentalis/Quercus rubra*	sandy loam
Ch – Chippewa	28%	*Acer saccharum-Smilacina racemosa* (shrub and *Acer rubrum* variants); *Acer rubrum-Thuja occidentalis/Quercus rubra* and *Acer saccharum-Betula lutea/Taxus canadensis* (*Taxus* variant)	loam; silt; silty loam
Gr – Griffin	7%	*Acer saccharum-Betula lutea/Taxus canadensis; Acer saccharum-Smilacina racemosa* (shrub variant)	loam; silt; silty loam
No – Norberg	1%	*Acer saccharum-Betula lutea/Taxus canadensis* (*Thuja* variant)	silty loam
Ol – Olsen	6%	Open fen, bog (sedges, shrubs); mixed woods with *Sphagnum* moss	organic
Su – Superior	13%	*Acer saccharum-Smilacina racemosa* (shrub variant); *Acer rubrum-Thuja occidentalis/Quercus rubra*	loamy sand; silty loam; sand
Ti – Tilly	13%	*Acer saccharum-Smilacina racemosa* (shrub variant)	silty loam
Wi – Wishart	7%	*Acer rubrum-Thuja occidentalis/Quercus rubra*	loam; silty loam; silt

TABLE 1. FOREST ECOSYSTEM TYPES OF THE TURKEY LAKES WATERSHED

USES OF THE TURKEY LAKES STUDY

The classification system developed for the Turkey Lakes watershed provides other researchers working in the area with an ecological framework within which they can evaluate the results of their process-oriented research. Studies on nutrient cycling in the various ecosystems can readily be compared, and sensitivity to acid rain evaluated; and potential effects of acid rain on forest productivity can be compared between the various soil and vegetation types. The classification also provides a basis for comparing the effects of acid rain in the Turkey Lakes watershed with results obtained from other studies in similar ecosystems in eastern North America. These will lead to effective evaluations of the environmental and socio-economic costs of acid rain in Canada.

FOR MORE INFORMATION

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