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Source: *Natural Areas Journal*, Vol. 6, No. 4 (October 1986), pp. 3-12
Published by: Natural Areas Association
Stable URL: https://www.jstor.org/stable/43910902
Accessed: 02-12-2020 01:10 UTC

A Review of the Selection and Design of the Forested Nature Reserves in Algonquin Park, Ontario

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INTRODUCTION

Algonquin Park is a protected natural area that is managed for both use and preservation of its natural ecosystems. Despite the objective of preservation, and like many other protected areas of the world, the ecosystems of Algonquin are becoming increasingly stressed as a result of human activities inside and outside of its boundaries. Stresses caused by recreation, timber harvesting, and watershed management result in both temporary and permanent ecosystem modifications (Martin 1959, Ontario Ministry of Natural Resources 1974, Cwynar 1977). In addition, fire suppression (Brown 1980) and atmospheric pollution act independently and synergistically with other stresses to cause further ecosystem modification.

Approximately 25 percent of Algonquin is currently protected from the effects of timber harvesting. Four percent of this area is composed of the nature reserve system which is further restricted to scientific, educational, and light recreational use. These reserves are valuable as representative study areas of the much larger Great Lakes-St. Lawrence forest cover type. But perhaps of greater importance is their value as a source of baseline ecological data (Jenkins and Bedford 1973) for assessment of the many unknown synergistic and independent effects of recreation, timber harvesting, watershed management, fire suppression, and atmospheric pollution upon Algonquin ecosystems. The value of using ecological reserves in this way has become increasingly recognized by ecologists (Callahan 1984). Before reserves can be applied as ecologically representative controls, however, their ecological characteristics must be carefully and critically assessed (Miller 1982).

The purpose of this paper is to assess the ecological characteristics of the forested nature reserves within Algonquin Park by reviewing and summarizing some of the original reserves survey data (Walshe 1969, Crins and Darbyshire 1977b). It is hoped that this work will provide continuity between the planning and application of the reserve system for forest ecosystem baseline and impact studies. The reader is cautioned that anomalies within the reserves survey documentation may have influenced observations that are presented in this paper.

THE PARK

Algonquin Park is located in the northern part of southern Ontario and occupies approximately 770,000 ha (Figure 1). Two topographic systems predominate in the park — the Precambrian uplands in the west and the Ottawa lowlands in the east. The highest elevations occur in the Precambrian uplands, which reach 580 m. Small, deep lakes scattered within a rolling, irregular topography are characteristic of the uplands. The Ottawa lowlands feature lower elevations ranging from 180 to 380 m with a more regular relief and a greater predominance of river systems and fewer lakes.

Compared to adjacent areas, the park has lower temperatures and greater precipitation due to higher than average elevations. The average July air temperature is 19° C, and in January the air temperature averages -11.5° C (Brown et al. 1980). Mean annual precipitation varies from 91 cm in the west to 66 cm in the east (Brown et al. 1980).

The bedrock underlying the park is the part of the Canadian Shield known as the Grenville Structural Province and is dominated by granitic gneiss interspersed with intrusive dikes of amphibolites (Adams and Barlow 1910). The soils of Algonquin are dominated by the brown podzolic type. Within the Precambrian uplands, the soils have been derived mainly from glacial deposits of ground moraine and loosely deposited and compacted till, and they range in depth from 0 to 3 m. The Ottawa lowland soils are derived from the same parent material found in the uplands as well as from glacial outwash deposits of sand and gravel. These plains vary in texture from coarse gravel to fine sands with depths to 3 m. All upland soils are generally coarse textured and acidic.

The forests of Algonquin Park fall within the Laurentian section of the

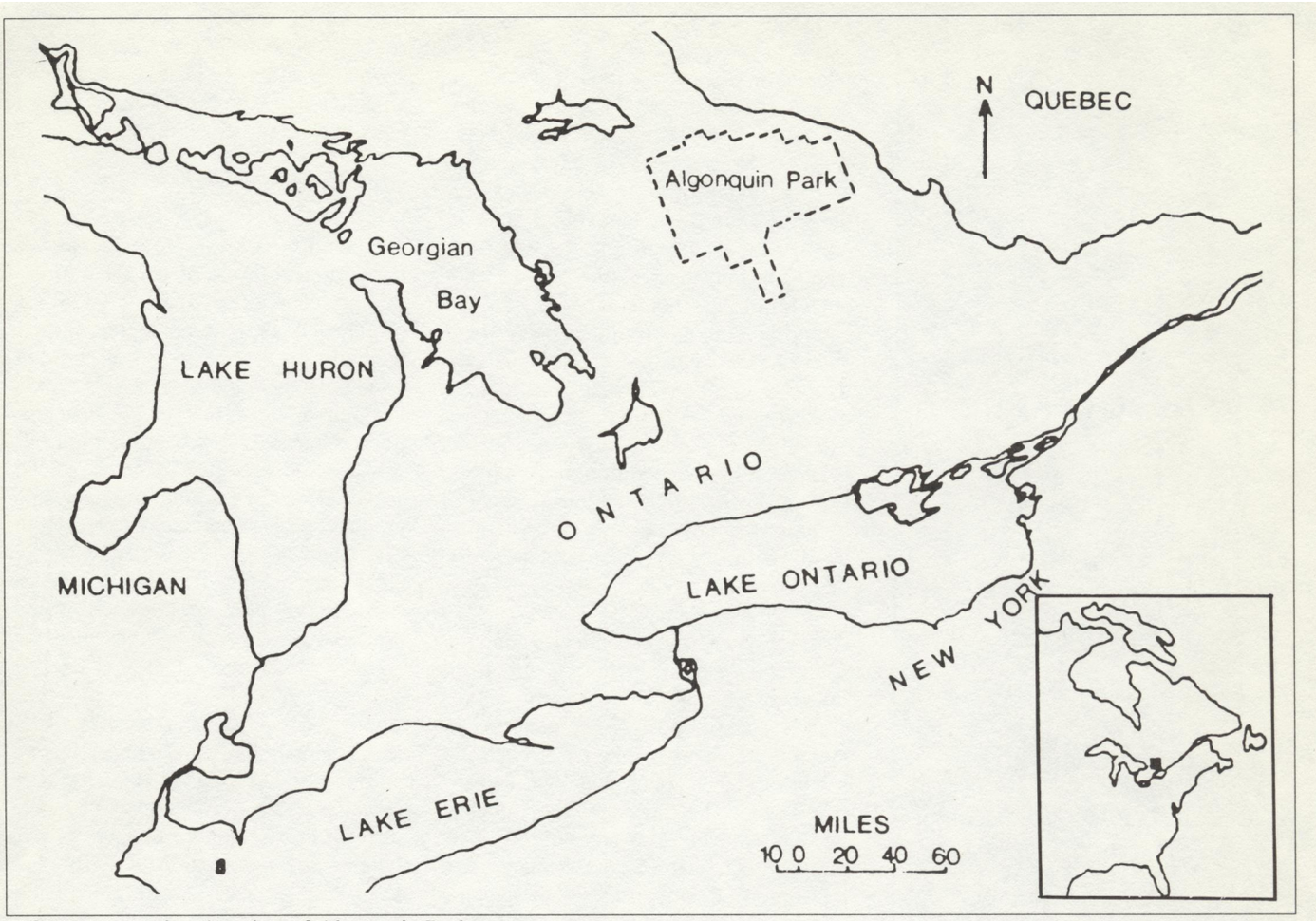

FIGURE 1. Regional setting of Algonquin Park.

Great Lakes-St. Lawrence forest type (Braun 1950, Rowe 1972). The western uplands are dominated by tolerant hardwoods including sugar maple (*Acer saccharum* Marsh.), yellow birch (*Betula allegheniensis* Michx. f.), and American beech (*Fagus grandifolia* Ehrh.), as well as the coniferous hemlock (*Tsuga canadensis* [L.] Carr.). The eastern lowlands are dominated by white pine (*Pinus strobus* L.), red pine (*Pinus resinosa* Ait.), jack pine (*Pinus banksiana* Lamb.), trembling aspen (*Populus tremuloides* Michx.), and largetooth aspen (*Populus grandidentata* Michx.).

RESERVES BACKGROUND

Nature reserve development in Algonquin Park began in the mid-1960's as part of the International Biological Program (IBP) (Walshe 1969). The IBP surveys were executed with the aim of identifying and describing areas representing the ecological diversity of the park. Survey results were reported on standard IBP check-sheets that emphasized description and mapping of vegetation with incidental notes on the flora, fauna, and other ecological features.

The results of the IBP assessment provided the basis for selection of the original nature reserve system as set out in the 1974 Algonquin Park Master Plan (Ontario Ministry of Natural Resources 1974). At that time, however, the system was incomplete and in some cases was lacking required detail. Therefore, between 1974 and 1979, a second survey conducted by the Ontario Ministry of Natural Resources was undertaken to refine the reserve system. The foundation of this survey was the Maycock vegetation matrix (Provincial Parks Council 1979), which utilized substrate and temperature on one axis and moisture regime on the other to classify the variety of ecosystem or site types that exist in the park. Using this matrix as a guide to community types, together with the information from the initial survey, additional representative and unique vegetation associations were located.

A quantitative approach (point quarter method) was applied in the initial stages of this second survey, but was quickly terminated due to time and financial constraints (Crins and Darbyshire 1977a). Instead, a qualitative survey was conducted that consisted of site and vegetation association descriptions, lists of

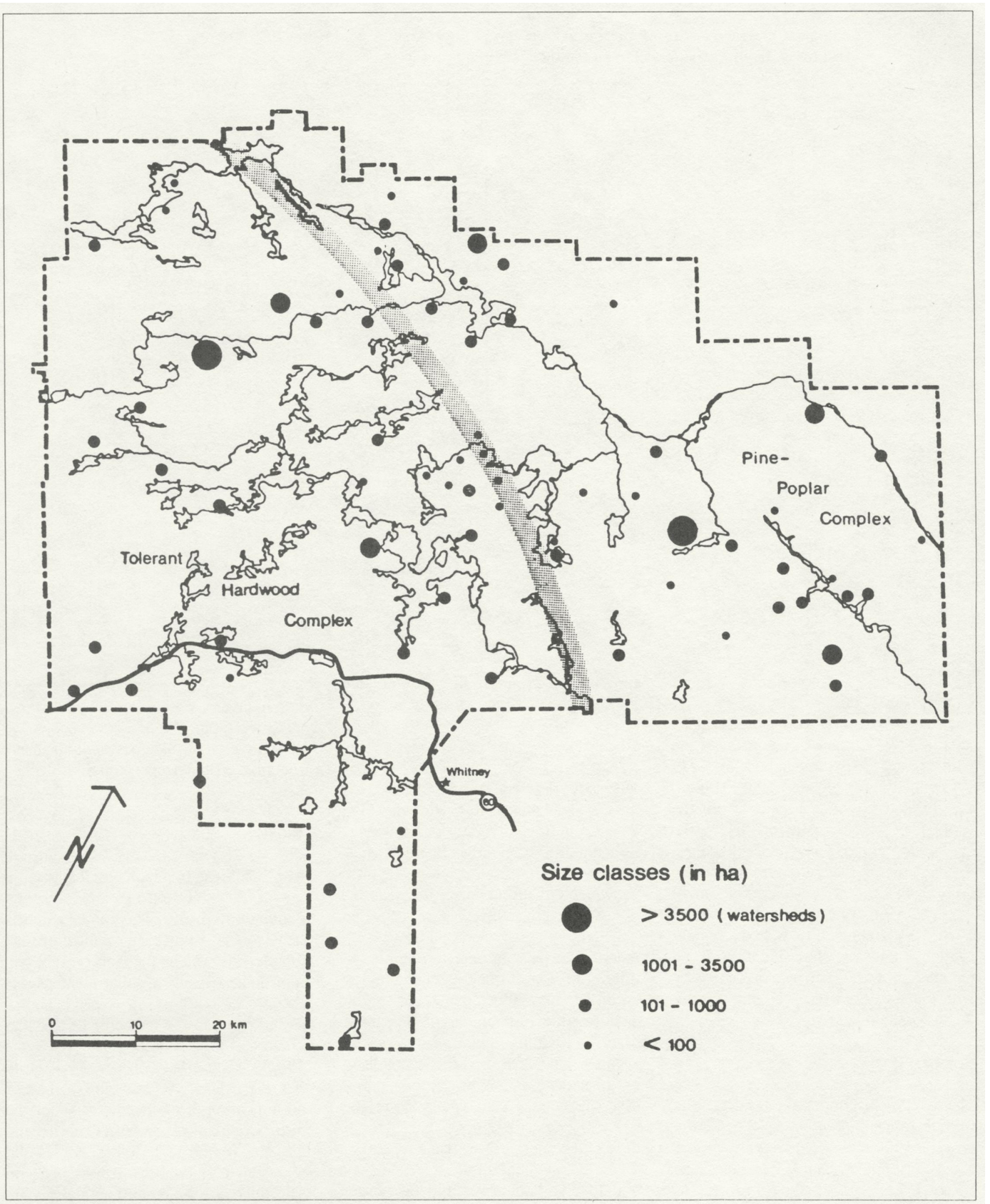

FIGURE 2. Algonquin Park Nature Reserve System as of 1979.

TABLE 1. Ecological characteristics of the nature reserve zones, Algonquin Park, Ontario (Adapted from Provincial Parks Council 1979)

Major Features	Area (ha)	Percent of Total System
Wetlands		
bogs	1,571	
marshes	1,085	
marsh-bog	3,073	
wet meadows	667	
sub-total	9,396	20
Hardwood Forest		
sugar maple	2,241	
silver maple (*Acer saccharinum* L.)	860	
red oak (*Quercus rubra* L.)	291	
basswood (*Tilia americana* L.)	83	
black ash (*Fraxinus nigra* Marsh.)	23	
sub-total	3,498	11
Coniferous Forest		
hemlock	595	
white pine	688	
red pine	322	
jack pine	413	
red spruce (*Picea rubens* Sarg.)	537	
sub-total	2,555	8
Exceptional Flora and Fauna		
high species diversity and/or rare species	5,214	
relict flora	1,334	
limestone flora	1,411	
sub-total	7,959	25
Natural Disturbance		
fire	1,131	
storm damage	1,038	
sub-total	2,169	7
Watershed		
Coldspring Creek	5,385	
Greenleaf Creek	3,722	
sub-total	9,017	29
TOTAL	**31,749**	**4.2 percent of park**

vascular plants, and collections of significant plant species. A total of seventy-one nature reserves, which occupied an area of 31,749 ha or 4.21 percent of the park, was finally designated in 1979 (Provincial Parks Council 1979) (Figure 2). Table 1 provides a summary of the ecological characteristics of the reserve system and approximate areas. Because 4.5 percent of the park was originally designated for reserve development (Ontario Ministry of Natural Resources 1974), approximately 2,000 ha remain available for reserve designation. The remainder of this paper will deal only with the sixty-four reserves that contain forest communities.

SELECTION

The five most commonly used criteria for selecting nature reserves are diversity, rarity, size, ecological representation, and level of disturbance (Margules and Usher 1981). It was with respect to these criteria that the selection of the forested nature reserves in Algonquin Park was assessed in this study.

Diversity

Diversity, defined here as species richness, was evaluated in two ways. First, an index to floral diversity was developed by summing the number of tree species occurring within each reserve. Figure 3 shows the distribution of tree species diversity within the system. Second, vegetation diversity for each reserve was determined by summing the number of different types of plant associations listed in the survey documentation. Figure 4 shows the distribution of vegetation diversity within the reserve system. Figures 3 and 4 show a greater frequency of reserves in the lower vegetation diversity classes than in the lower tree species diversity classes. These data indicate the possibility that vegetation diversity is underrepresented in the middle and high diversity classes and overrepresented in the lower diversity classes. The skewed shape of the vegetation diversity distribution may, however, be more a function of subjective classification of plant associations than a function of underrepresentation of plant associations.

Rarity

The documentation indicates that twenty-six of the sixty-four forested reserves contain rare plants. There is no comprehensive list, however, indicating the degree to which the reserve system represents the 149 vascular plant species that are rare throughout Algonquin Park as indicated in the checklist of vascular plants of Algonquin Park (Kotanen 1982). Such a list is necessary if rarity is to be evaluated. In addition, there is no indication of the degree to which the rare vascular plants of Ontario and Canada (Argus and White 1982) are represented within the reserve system. The only rare or unique animal habitat that was identified for protection as a

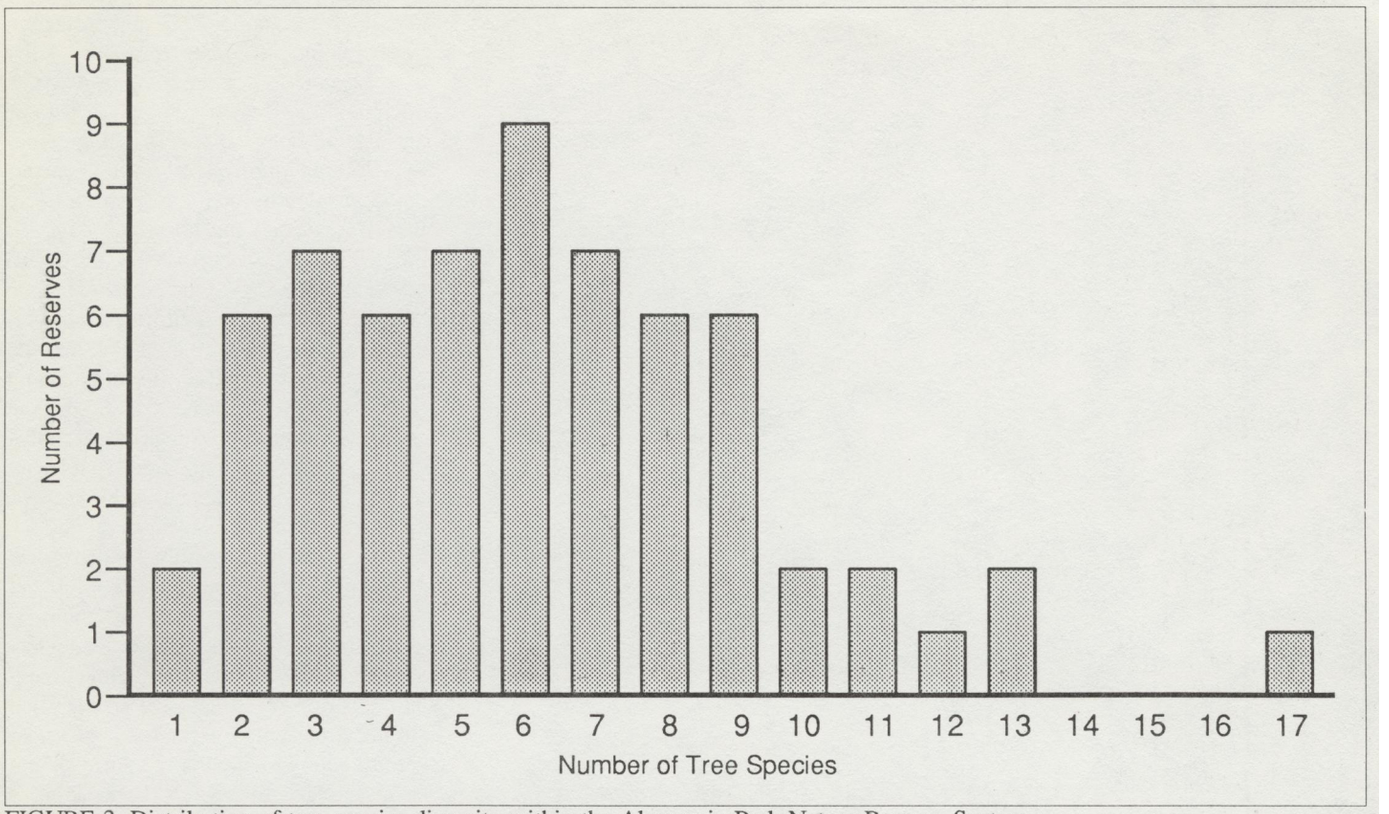

FIGURE 3. Distribution of tree species diversity within the Algonquin Park Nature Reserve System.

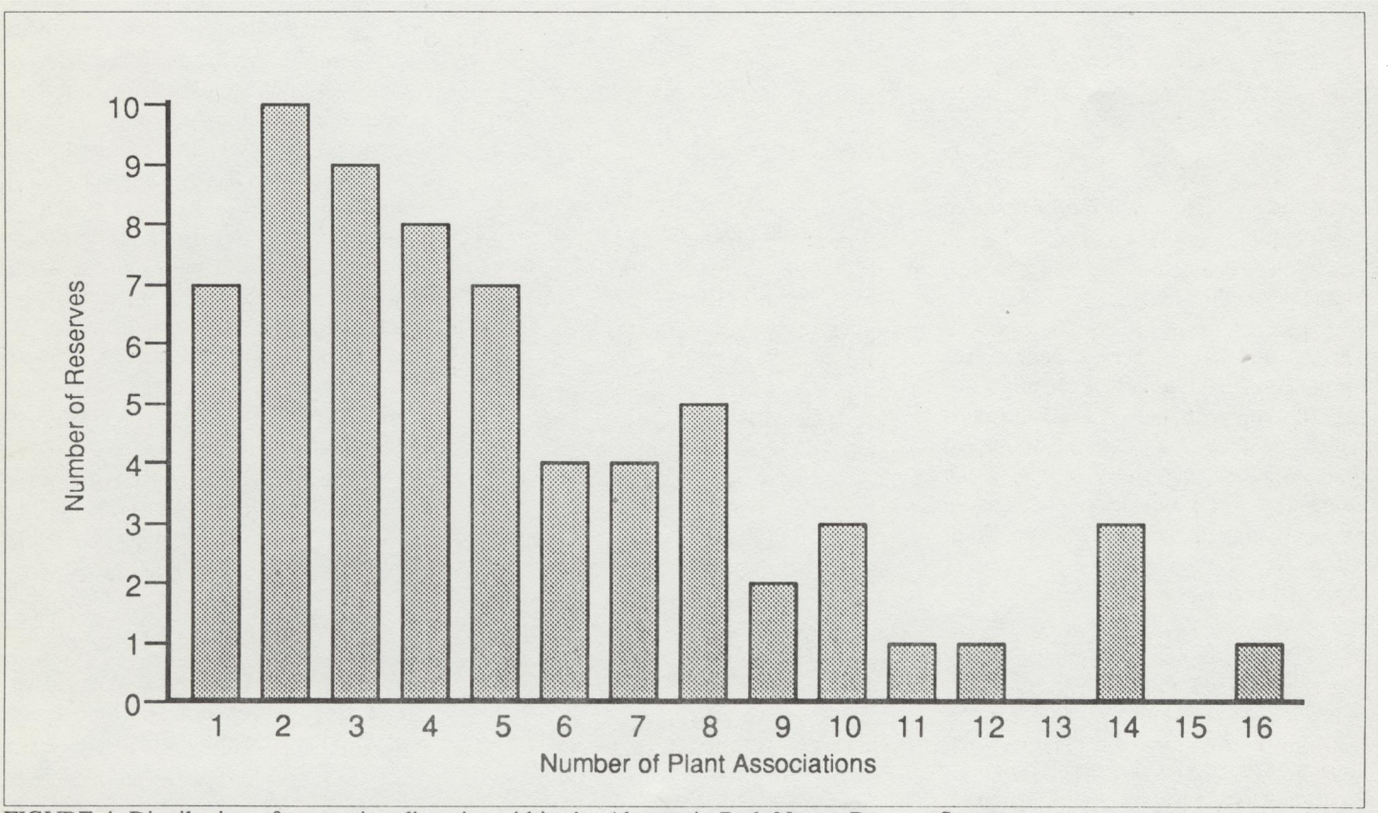

FIGURE 4. Distribution of vegetation diversity within the Algonquin Park Nature Reserve System.

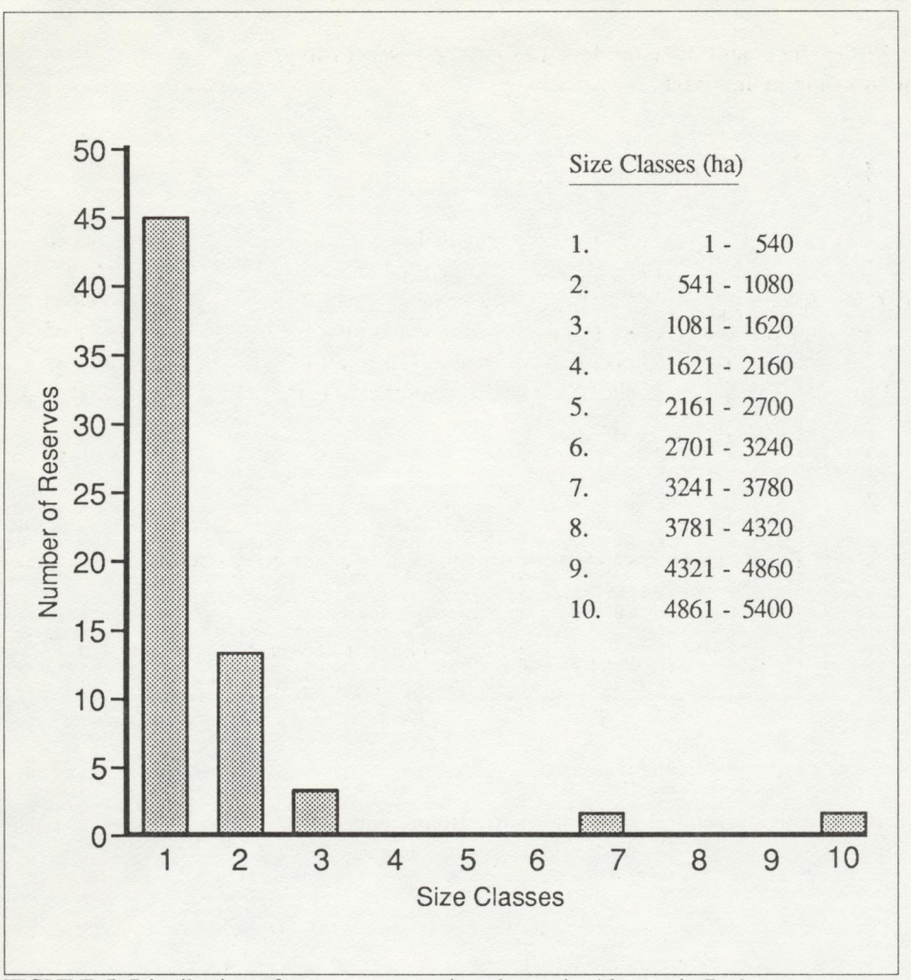

FIGURE 5. Distribution of nature reserve size classes in Algonquin Park.

forest reserve was that of the locally rare bog lemming (*Synaptomys cooperi*).

Size

The forested nature reserves range in size from 11 to 5,396 ha with a mean size of approximately 468 ha. Of all the individual reserves, the two watershed reserves most adequately represent the two major forest types, mainly because of their vast size. These include Coldspring Creek Watershed (5,396 ha) for the tolerant hardwood forest and Greenleaf Creek Watershed (3,730 ha) for the pine-poplar forest. These two reserves have the greatest potential for self-maintenance in the event of destructive natural disturbances. This is due to their substantial size (Pickett and Thompson 1978) and their location within the larger park landscape, which serves as a source of plant recolonization and as additional territory for wide-ranging, large carnivores (Noss and Harris 1986).

The distribution of forest reserves with respect to size class is shown in Figure 5. It shows that 97 percent of the reserves are represented within the smallest three size classes. Since reserves are absent from five of the seven largest size classes, the system may be deficient in large, self-maintaining reserves. Such a deficiency of large reserves within an extensive landscape is typical of large landscapes throughout the world (Frankel and Soulé 1981).

Ecological Representation

Assessment of the representative character of reserves was considered in terms of flora and vegetation. The representative flora was indentified by comparing a list of tree species produced from the reserves documentation with the checklist of known vascular plants in Algonquin Park (Kotanen 1982). From this checklist it was determined that approximately fifty tree species are known to occur in the park. Of these, a total of thirty-seven tree species were represented in the documentation. Of the thirteen tree species that were not included in the documentation, eight are introduced and five are native (Table 2). If reserve objectives include eradication of introduced species, then their absence from the reserve system is acceptable. However, if there are no plans for eradication, these species will remain a part of the Algonquin landscape and, therefore, at the very least, their location should be identified and their habitat adequately described. Assuming that the documentation is correct, those five species that are not represented in the reserve system but are native to southern Ontario should be included within a reserve as soon as possible.

In order to determine the representativeness of the reserves with regard to vegetation, an acceptable classification and a workable number of community types representing the entire area of Algonquin Park would be required. The only list of this type contained 1,200 vegetation types (Brunton 1981), a number much too high to make a realistic comparison with plant associations known to occur within the reserves. Also, the techniques used to classify the vegetation types for the park and for the nature reserves (Crins and Darbyshire 1977b) were each performed subjectively with no standardization. This subjectivity and lack of standardization precluded a reliable determination of community representativeness using the existing documentation.

Level of Disturbance

The only means of evaluating disturbance from the existing documentation was to determine the number and types of human disturbances that occurred within the reserves prior to official

TABLE 2. Tree species not represented in the documentation for forested nature reserves in Algonquin Park but known to occur in the park.

Species	Status	Species	Status
Bur oak (*Quercus macrocarpa* Michx.)	native	Pear (*Pyrus communis* L.)	introduced
Canada plum (*Prunus nigra* Ait.)	native	Pin cherry (*Prunus pennsylvanica* L. f.)	native
European white birch (*Betula pendula* Roth)	introduced	Scotch pine (*Pinus sylvestris* L.)	introduced
European white poplar (*Populus alba* L.)	introduced	Siberian elm (*Ulmus pumila* L.)	introduced
Gray poplar (*Populus canescens* [Ait.] Sm.)	introduced	Slippery elm (*Ulmus rubra* Muhl.)	native
Lombardy poplar (*Populus nigra* L. 'Italica')	introduced	White ash (*Fraxinus americana* L.)	native
Norway spruce (*Picea abies* [L.] Karst.)	introduced		

designation in 1974. Table 3 provides a listing of the twenty-seven different human disturbances that have occurred within the forested reserve system and the number of reserves within which each disturbance has occurred. Of these disturbances, selective logging is the most common, having occurred within 82 percent of the reserves. A thorough consideration of this criterion would require data indicating the size of the disturbed area and the intensity of the disturbance. These data, however, are not available.

Figure 6 shows the distribution of the number of reserves having different levels of human disturbance. Because it seems that only four reserves have not been noticeably disturbed by man, an attempt should be made to locate more undisturbed areas. As many as ten reserves have been influenced by five or more types of disturbance. In some cases, the effects of these disturbances may preclude the use of a reserve as a benchmark site.

TABLE 3. Human disturbances and their frequency of occurrence within reserves.

Type of Disturbance	Number of Reserves within which the Disturbance Occurred
Selective logging	55
Campsites	15
Roads	12
Trapping	11
Hunting	9
Predator removal	9
Altered drainage	9
Recreation	8
Trails	8
Hydro line	6
Research	6
Introduced plants	4
Floral disturbance	3
Interpretation	3
Railroad	2
Soil disturbance	2
Sport fishing	2
Parking lot	2
Fire tower	1
Gravel pit	1
Introduced animals	1
Plantation	1
Dam	1
Ranger cabin	1
Boat launch	1
Agriculture	1
Prescribed burning	1

DESIGN

Following general site selection, the reserves must be specifically demarcated both on maps and on the ground. This involves specific decisions regarding size, shape, and boundary location. The most serious omissions in the design of individual reserves were consideration of patch dynamics and demarcation of buffer zones. An understanding of regional

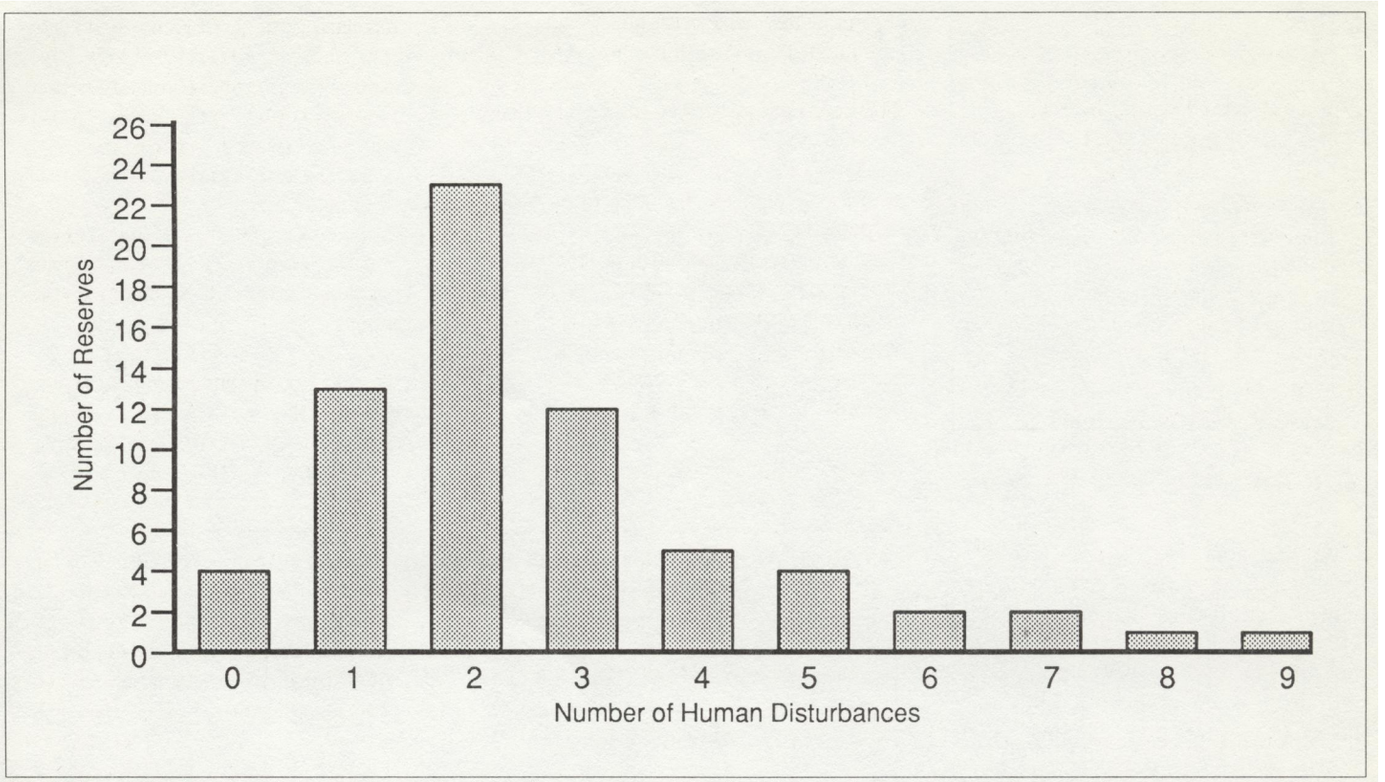

FIGURE 6. Distribution of the number of human disturbances within the Algonquin Park Nature Reserve System.

patch dynamics is necessary to determine the minimum self-sustainable size (also called the minimum dynamic area) of a nature reserve within a particular region. The minimum dynamic area is defined by Pickett and Thompson (1978) as the smallest area with a natural disturbance regime that maintains internal recolonization sources, and hence minimizes extinction.

The most significant causes of natural patch formation in Algonquin Park are senescence of large individual trees and windthrow within the tolerant hardwood forest (Runkle 1982) and fire within the pine-poplar forest (Quinby 1987). No attempt, however, was made as part of the reserve surveys to examine these causes and their influence on patch size, patch frequency, and patch longevity.

Patch dynamics should not be ignored in considerations for future reserves. Such information is not required with high resolution and precision for nature reserve design. Some information that is relevant to disturbance in Algonquin forest ecosystems is readily available from existing scientific literature on gap formation (Bray 1956, Runkle 1982) and fire ecology (Heinselman 1973, Cwynar 1977, Cwynar 1978). With appropriate modification of regional disturbance information to account for local ecological differences, a description of patch dynamics could be developed for Algonquin Park.

The major importance of buffer zones is to protect nature reserves from potentially disturbing forest land uses. Within the documentation, no discussion of the ecological criteria used to design buffer zones was presented nor were buffer zone boundaries provided on reserve maps. Because most reserves in Algonquin suffer from inaccurate boundary location and demarcation on the ground (Crins and Darbyshire 1977a, Provincial Parks Council 1979, Sheehy 1980), it would be difficult to determine if buffer zones exist. This represents a potentially serious problem because timber harvesting often occurs adjacent to nature reserves. Inaccurate reserve boundary marking may, therefore, lead to timber harvesting within reserves, which in turn may cause undesirable impacts upon the terrestrial and aquatic ecosystems included within those reserves.

Impacts to aquatic ecosystems within a reserve may also result from harvesting that occurs upstream. The only reserves that may be completely free from this type of impact are the two that are composed entirely of watersheds. The other reserves should be evaluated with respect to watershed position in order to determine the potential for aquatic impacts due to upstream harvesting operations.

CONCLUSION AND RECOMMENDATIONS

The process of developing a system of nature reserves must be viewed as an iterative process of survey, selection, design, and management. Although some major problems regarding the selection and design of the Algonquin Park forested nature reserves are appar-

ent, they are indicative of this process and are not beyond resolution. However, before this system of reserves is used in forest ecosystem studies, the following points should be addressed.

(1) An objective, quantitative method should be used to classify community types for evaluation of system representativeness both in terms of composition and diversity.

(2) The rare plants of Canada and Ontario that also occur in the park should be assessed with regard to representation within the reserve system.

(3) Native plant species not found in reserves should be included as soon as possible and undesirable introduced plant species should be eradicated.

(4) The minimum self-sustainable size of a forested landscape in the Algonquin region should be estimated with particular emphasis on spatial and temporal biogeographical features and their hierarchical levels.

(5) Deficiencies regarding buffer zones and reserve boundary markings should be identified and rectified.

(6) The potential for impacts upon reserves due to watershed position should be evaluated.

(7) The major strength of the reserve system is the representative character and the large size of the two watershed reserves. Because large reserves are rare in the park, elimination of a number of small reserves in favor of establishing a few larger reserves should be considered.

(8) The location of each reserve should be evaluated with regard to the overall spatial pattern of the entire reserve system and with regard to ecosystem development.

(9) Anthropogenic impacts upon nature reserve ecosystems should be as well understood as possible prior to application as a benchmark site.

(10) In order to maintain the ecological characteristics for which some reserves were originally designated, active management will be required. Thus, management plans, which include a clear set of objectives, should be prepared for each nature reserve as soon as possible.

ACKNOWLEDGMENTS

I would like to thank Tom Beechey of the Ontario Ministry of Natural Resources for providing the documentation necessary to conduct this work and for his editorial comments. I would also like to thank Dave Love and Mark Stabb of the Faculty of Forestry, University of Toronto for their editorial comments.

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