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Restoring Natural Conditions in a Boreal Forest Park

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Introduction

Voyageurs National Park is located in northern Minnesota (Figure 1). Its northern and eastern boundaries parallel a historic fur trade route that influenced the location of the boundary between the United States and Canada. About two-thirds of the park's 344-square-mile (891 km^2) area is land, and the remainder is made up of numerous small and large lakes. The interspersion of forested land, massive rock outcrops and lakes make the park very scenic. It is also somewhat unique because it is the only U.S. park on the mainland in a southern boreal forest region. Isle Royale National Park is also in this region, but its biota is characteristic of island areas.

History of the Park

The park has a long history of human use. People from Asia emigrated into the area after the retreat of the last glaciers about 11,000 years ago (Martin et al. 1947). Their descendants became Sioux Indians, who were displaced by Chippewa Indians during the 1700s (Danziger 1978). European men traveled through the park and traded with these Indian people for furs between the 1660s and 1850s (Nute 1941).

Minnesota became a state in 1858, and in 1891 its representatives asked that a national park be established in the as yet unsettled area. This was not done and periods of uncontrolled hunting, logging, homesteading, and resort and summer home development followed. Dams were constructed at the outlets of Rainy and Namakan Lakes in the early 1900s. Facilities for generating up to 20 Mw occur at the Rainy Lake dam. State representatives again requested that a park be established in 1960. This finally occurred in 1975. According to its legislation, Voyageurs is supposed to conserve its scenery, natural and historic objects, and wildlife and

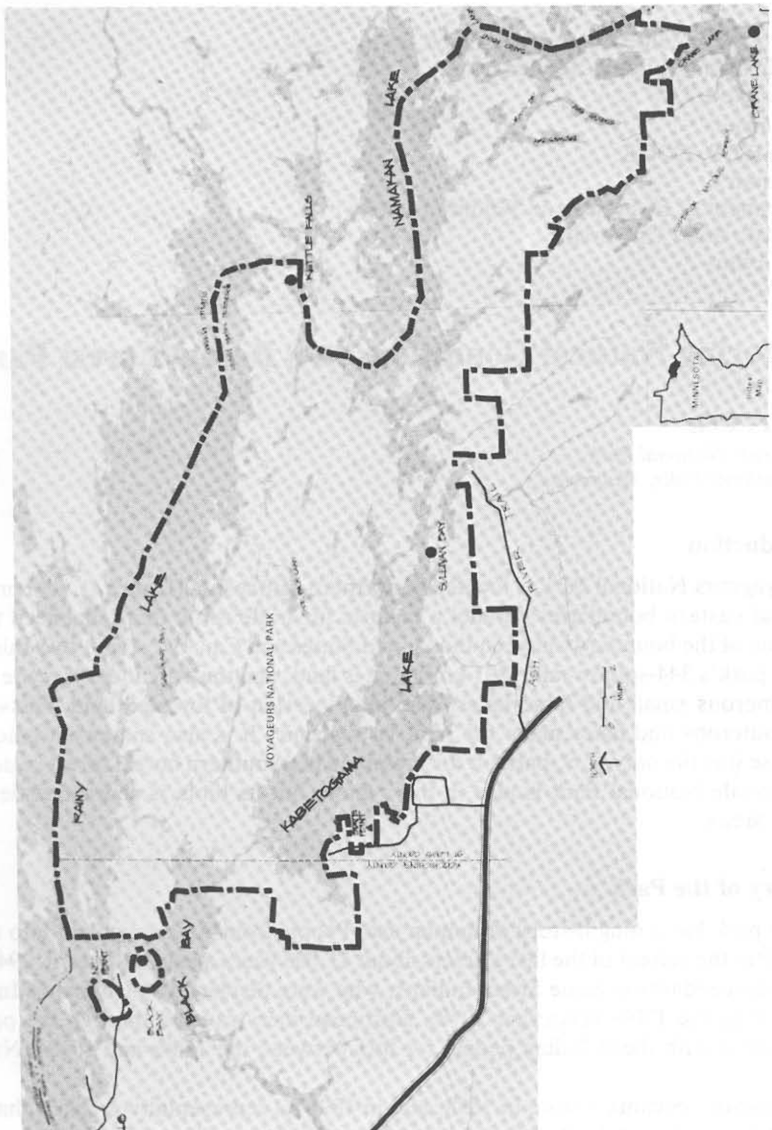

Figure 1. Location and boundaries of Voyageurs National Park.

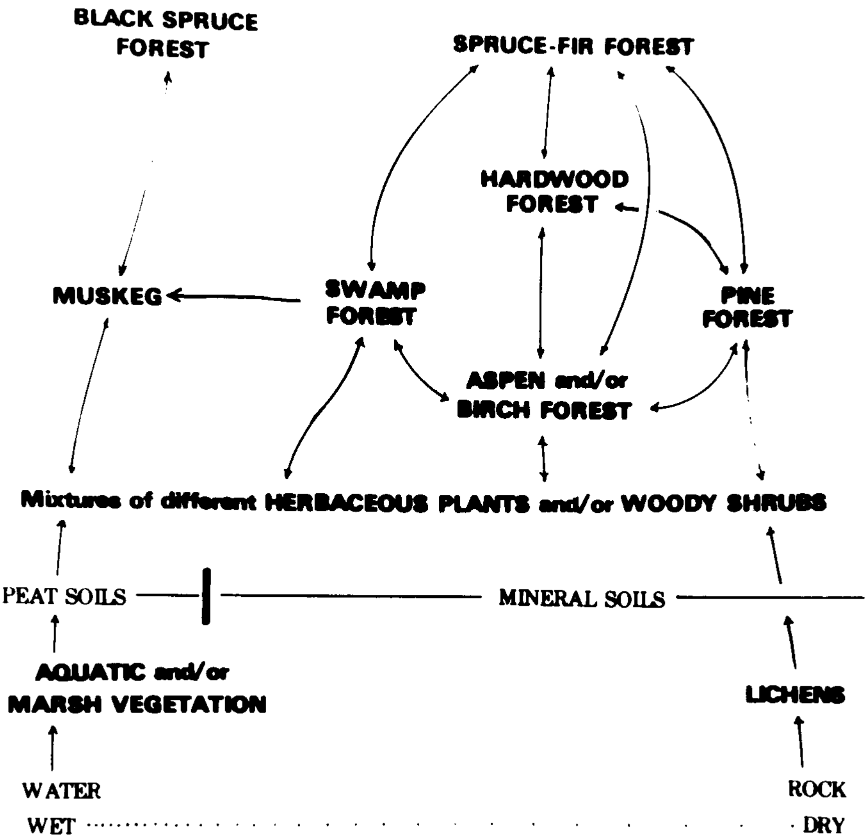

Figure 2. Plant community successional relationships in Voyageurs National Park: Succession converges toward Black Spruce or Spruce-Fir climaxes. Disturbances set back succession or maintain subclimaxes. Raised water tables allow Muskeg to replace Swamp Forests (Heinselman 1970).

provide for the enjoyment of same in ways that leave unimpaired conditions for future generations.

The establishment of the park led to a series of research studies on its vegetation and wildlife. This paper summarizes findings on what original conditions were like, the changes that have occurred over the past 100 years, and points out actions that could restore more natural conditions.

Vegetation

Succession and Disturbances

Figure 2 summarizes relationships reported by Cole (1979), Kurmis et al. (1980), and Coffman et al. (1980). In the absence of disturbances, succession is toward two types of climax vegetation. These are white spruce-balsam fir (*Picea glauca-Abis balsamea*) dominated communities on mineral soils, and black spruce (*P. mariana*) dominated communities on peat soils. Disturbances from fire, insects, flooding, or logging can set back these and other less advanced successional stages as shown. Additionally, periodic fires allow stands of white, red or jack pine (*Pinus strobus, P. resinosa, P. banksiana*) to replace themselves on drier sites. These pine stands are called subclimaxes, recognizing that without occasional fires they become seral stages. Natural fire frequencies in the region have been estimated at 70 to 150 years (Heinselman 1973, Swain 1973).

Original Vegetation

Early land surveys (1881–94) and logging company and fire records (Coffman et al. 1980) show that a fire-maintained mosaic of climax, subclimax, and seral forest vegetation occurred in the park before large scale logging began in 1913. Selective removals of large sawlogs, which averaged 2,750 board feet per acre, were 53 percent white and red pine and 47 percent other species. The size of logs taken indicate the latter were mostly mature white spruce. Later logging from 1930 to 1972 continued to cut large trees away from lake shores, but mainly removed smaller spruce, balsam fir, and aspen (*Populus tremuloides*) for pulpwood.

Present Vegetation

Studies by Kurmis et al. (1980), Coffman et al. (1980), and Swain (1981) show that logging and/or a series of fires up to 1936 set back a large portion of the original vegetational mosaic on mineral soils to aspen and/or white birch (*Betula paperifera*) forests. Mature spruce-fir forests appear to have been replaced to a greater extent than mature stands of pine. Swamp forests dominated by white cedar (*Thuja occidentalis*) or black ash (*Fraxinus nigra*) persisted on wet mineral soils. Black spruce forests and muskeg (stunted black spruce, evergreen shrubs, spagnum moss) that are representative of original conditions persisted on peat soils. Some lichen species may have become less abundant because of logging (Wetmore 1980).

Succession and natural disturbances can be expected to restore or maintain a representative natural forest vegetation in the park. However, fires have been effectively suppressed since the 1940s. If continued, this will allow pines to be replaced by other vegetation and cause other reductions in vegetational diversity.

Wildlife

Absent and Declining Species

Faunal records show that the native wildlife in this southern boreal forest region is a highly diverse mixture of northern and southern or resident and migrant species. The recent original fauna included at least 48 mammals, 241 resident and migrant bird species, 15 reptiles and amphibians, and 28 fish species. Since the early 1920s three mammal species have become absent, and an additional five have declined to remnant numbers (Table 1). At least 12 other mammal, bird, or fish species have become less abundant than previously on all or large portions of the park. Further study is expected to add to this list.

Main Causes

Table 1 lists what were considered the main causes for different species becoming absent or less abundant in the park. Market and subsistence hunting from the early 1890s to 1920s appeared to eliminate eventually woodland caribou and elk from the area and reduce moose to very low numbers. The failure of these moose to respond to subsequent protection from hunting, increases in seral vegetation, or recent declines in white-tailed deer, in combination with rare occurrences of twin young, suggested the possibility that their reproduction had been depressed by inbreeding (Franklin 1980, Senner 1980, Soule 1980). White-tailed deer harbored a meningeal parasite (*Parelaphostrongylus tenuis*) that could cause mortality in moose (or caribou) as functions of deer densities and other variables (Cole 1981), but such mortality would have tended to increase rather than decrease twinning. Genetic influences on moose twinning rates have been previously reported by Houston (1968). Mortality from trapping, shooting, or fishing contributed to some other species becoming less abundant, but such effects mainly occurred because other causes lowered a species reproductive success or habitat security (Errington 1946).

Table 1. Native wildlife species presently absent (A), reduced to remnant numbers (R), or less abundant than previously (L), in Voyageurs National Park.

Species	Status	Probable main cause
Woodland caribou (*Rangifer tarandus*)	A	
Elk (*Cervus elaphus*)	A	Uncontrolled
Moose (*Alces alces*)	R	hunting
White-tailed deer (*Odocoileus virginianus*)	L	Maturing forests
Grey wolf (*Canis lupus*)	L	
Coyote (*Canis latrans*)	L	
Red fox (*Vulpes fulva*)	L	
Wolverine (*Gulo luscus*)	A	
Canada lynx (*Lynx canadensis*)	R	Reduced food
Bobcat (*Lynx rufus*)	R	
Raven (*Corvus corax*)	L	
Bald eagle (*Haliaeetis leucocephalus*)	L	
Porcupine (*Erithizon dorsatum*)	R	
Red squirrel (*Tamasciurus hudsonicus*)	L	Logging
Pine marten (*Martes americana*)	R	
Beaver (*Castor canadensis*)	L	
Muskrat (*Odonata ziebethicus*)	L	Regulated
Loon (*Gavia immer*)	L	water levels
Walleye (*Stizostedion vitreum*)	L	in four large
Northern pike (*Esox lucius*)	L	lakes

The absence of competition from native cervids and increased seral vegetation from logging allowed white-tailed deer to increase to densities of 20 or more per square mile by the late 1930s (Erickson et al. 1961). Declines to the present low densities of five or less deer per square mile in the park were associated with progressively maturing forests, an increased frequency of harsh winters during the 1960s (Mech and Karns 1977), and, by the mid-1970s, the deer population declining below levels that could fully compensate for predation by wolves, which remained at densities of about one per 10 square miles. According to Pimlott (1967), wolves at these densities can cause uncompensated mortality after deer decline below 10 per square mile, and wolves must either switch to alternative prey or decline along with deer. Declines of deer to about one per square mile and of wolves from one per 10 square miles to one per 25 square miles occurred in an adjacent Superior National Forest area (Mech and Karns 1977, Floyd et al 1979).

A variety of carnivore species became less abundant as white-tailed deer declined. This suggested that declines in carnivores were caused by increased inter- and intraspecies competition for reduced food. However, such competition may have only occurred because species that previously provided alternative food were less abundant or absent. Calculations indicate that the amount of food the present less diverse cervid fauna provides to carnivores during critical winter and spring periods is one-third of pre-1920 or 1936–60 levels (Table 2). To date, wolves have been less adversely affected than smaller carnivores that mainly scavenge on cervids, but they have slowly declined from 41 individuals in 1976 to 30 in 1981. In comparison to other Lake State areas, where they may be less dependent on cervid carrion, the bald eagles that nested in the park area had low reproductive success (Grim, unpublished data).

Declines of porcupines to remnant status were also associated with declines of white-tailed deer, and probably largely caused by increased predation from food-stressed carnivores. However, predators may have only had these effects because logging reduced overmature trees with cavities. These allow porcupines to elude predators (Powell and Brander 1977). Declines in red squirrels and pine marten probably resulted from logging or associated slash fires temporarily reducing the amount and distribution of superior squirrel habitat (interspersions of mature spruce-fir and pine).

Records since 1941 (U.S. Army Corps of Engineers, unpublished data) show that Namakan, Kabetogama, and Sand Point lakes have been fluctuated an average of about 9 feet (3 m) each year to maintain fluctuations of about 3.5 feet (1.2 m) on Rainy Lake. Other records from a large upstream lake (Lac La Croix) suggest that natural fluctuations would have averaged about 4 feet (1.3 m) on Rainy Lake and, because of smaller storage capacities and constricting narrows, about 5 feet (1.7 m) on the other lakes. Natural fluctuations also differed from regulated fluctuations by usually peaking in late May or early June instead of late June or early July, by generally declining instead of being relatively stable over summer and fall, and by declining about 2 (0.7 m) instead of 6 (2 m) feet (only in lakes with 9-foot fluctuations) over winter periods. About half of these 6-foot declines appeared to be intentional drawdowns to avoid floods or ice damage to docks. Because Rainy Lake has three times the storage capacity of other lakes, allowing it to fluctuate 4 instead of 3.5 feet would reduce the 9-foot fluctuations on other lakes to 7.5 feet (2.5 m). These could be further reduced to 5-foot fluctuations in most

Table 2. Hypothesized November-April cervid-carnivore relationships in Voyageurs National Park for pre-1920, interim and present periods.

Species and periods	Density per square mile[a]	Total no. within 240 square miles[b]	Av. 20% overwinter mortality of cervids utilized by carnivores[c]		
			No.	Av. wt. lbs.[d]	Biomass lbs.
Pre-1920					
Caribou	2	480	96	200	19,200
Moose	2	480	96	400	38,400
White-tailed deer	1	240	48	90	4,320
Elk	0.5	120	24	300	7,200
	5.5	1,320	264		69,120
1936–60					
Caribou	0				
Moose	?				
White-tailed deer	16	3,840	768	90	69,120
Elk	0				
1978–81					
Caribou	0				
Moose	0.1	24	5	400	2,000
White-tailed deer	5	1,200	240	90	21,600
Elk	0				
	5.1	1,224	245		23,600

[a]Pre-1920 densities were never documented and hypothesized values were apportioned by assuming the average biomass production from four species was equal to that from deer alone during the 1936–60 period, and by inferring relative species abundance from historical accounts, interviews with early residents, and studies elsewhere. The 1936–60 density of 16 deer per square mile is the average of estimates for northern Minnesota by Erickson et al. (1961). These progressively decline from 20 to 13 deer per square mile. Estimated densities for 1978–81 tentatively assume that maximum winter counts of deer per mile on transects × 2 approximated deer per square mile, and about half of the moose that were actually present were accounted for by aerial and ground counts.
[b]Excludes 100 square miles of large lake areas.
[c]Assumed minimum overwinter mortality rates for naturally regulated or lightly exploited cervid populations extrapolated from Cole (1978).
[d]Assume overwinter mortality is ⅔ subadults and ⅓ adults.

years by only making additional drawdowns for flood control if they were necessary.

The six-foot (2 m) declines in lake levels over winter periods increased the vulnerability of beaver and muskrats to predators by leaving their lodges and food apart from water or frozen in ice. They also dewatered marsh areas to the extent that northern pike had marginal spawning conditions (Kallemeyn, unpublished data). Maintaining stable lake levels over summer and fall periods reduced the availability of wave-washed gravel for shoal spawning walleye. Chevalier's (1977) findings suggest this lowered the reproductive success of shoal spawning stocks to the extent that they could not fully compensate for mortality from fishing.

Regulated lake levels lowered loon reproduction rates by flooding nests. Only occasional young were noted from 1976 to 1978. Systematic counts in 1979 and

1980 (N = 338) gave adult:young ratios that varied from 5 to 6:1 on Rainy Lake, 13 to 60:1 on the lakes with the greatest fluctuations and 2 to 2.5:1 on 18 smaller lakes with natural fluctuations. Regulated lake levels approximated the magnitude and timing of natural fluctuations to the greatest extent in 1981 and counts (N = 169) gave adult:young ratios of 3:1 and 5:1 on Rainy and the other regulated lakes, respectively. Part of the differences between lakes could be due to human disturbances and small lakes having greater proportions of experienced breeders. Other obvious effects were that extensive beds of wild rice (*Zizania palustris*) were replaced by other aquatic vegetation in the lakes with 9-foot fluctuations, but still occur in Rainy Lake.

Discussion

The information in previous sections identifies four major man-caused problems (i.e. changes from natural conditions). These are:

1. Preventing all forest fires prevents the park from having a natural forest vegetation.
2. Two of the park's four native cervid species are absent and a third persists in precariously low numbers.
3. Reduced food for carnivores is causing further declines in the numbers and kinds of native wildlife species in the park.
4. Regulated lake levels are having adverse effects on wild rice, fish, and other wildlife.

Some possible solutions to these problems, in the form of hypotheses that can be tested by research, follow.

1. Allowing fires to burn within designated areas where they can be confined (by natural barriers or control) will reestablish mosaics of forest vegetation comparable to those before logging.
2. Introductions will reestablish viable populations of woodland caribou, moose, and/or elk.
3. Reestablishing caribou, moose, and/or elk populations will increase food for native carnivores.
4. The present adverse effects of regulating lake levels on various aquatic species can be reduced, without serious conflicts with other presently authorized uses of water, by approximating the magnitude and timing of natural fluctuations in most years and reducing the extreme fluctuations from occasional natural floods or droughts.

Alternatives to these solutions range from doing nothing to employing actions that solve one problem, but not others. For example, one alternative to reestablishing caribou, moose, or elk populations to provide food for carnivores is to prescribe burn forests to maintain high numbers of white-tailed deer. This would not restore the park's native cervid fauna or maintain a natural forest vegetation. Doing nothing seems certain to result in more native species becoming less abundant or absent. These and other alternatives relating to cervid introductions or fire are covered in greater detail in planning or environmental impact documents.

Alternative ways of regulating lake levels are being explored with different users of water and an International Joint Commission, which must authorize any changes. It is intended that any actions to correct problems be monitored and evaluated by research. This approach has been previously used to correct similar problems in other national parks (Hayden 1971, Kilgore 1971, Houston 1971). The introductions of native cervids should be of particular interest because they would allow various hypotheses about the effects of parasites, interspecies competition, and inbreeding to be tested in the field. More important, however, these and other appropriate actions could assure that representative examples of natural southern boreal forest environments and their native wildlife are preserved in Voyageurs National Park.

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