This page intentionally left blank.

# Fish Distribution in Gatineau Park, Quebec, in Relation to Postglacial Dispersal, Man's Influence, and Eutrophication

PETER J. RUBEC

Department of Biology, University of Ottawa, Ottawa, Ontario K1N 6N5

Present Address: Department of Biology, Texas A&M University, College Station, Texas 77843

Rubec, P. J. 1975. Fish distribution in Gatineau Park, Quebec, in relation to postglacial dispersal, man's influence, and eutrophication. Canadian Field-Naturalist 89(4): 389-399.

**Abstract.** Postglacial freshwater and marine inundations have affected the distribution of fishes in Gatineau Park. Glacial Lake Frontenac allowed a cold-water fish fauna to enter higher altitude lakes. These were isolated by the Champlain Sea which also brought euryhaline species to lakes at medium elevation. Warm-water fishes from the Ottawa River were blocked from entering higher Gatineau Park lakes by isostatic rebound. More species were able to enter the Lac Lapêche drainage than the Meach–Philippe drainage.

During the last hundred years, a general decline in abundance of lake trout (*Salvelinus namaycush*), brook trout (*Salvelinus fontinalis*), cisco (*Coreganus artedii*), and lake whitefish (*Coregonus clupeaformis*) has occurred, probably abetted by commercial fishing, poaching, and angling. Both smallmouth bass (*Micropterus dolomieui*) and brook trout prey on minnows which are scarce in lakes where bass were introduced. Low oxygen levels noted in the hypolimnia of most Gatineau Park lakes is thought to limit the coregonids and salmonids. An attempt has been made to replace those fish species that have disappeared.

## Introduction

The present survey was part of a limnological study for the National Capital Commission. Previous studies include that of Dymond (1939) who compiled information concerning game fish and made collections of minnows in Ramsay and Meach Lakes. Cuerrier and Dadswell (1969) surveyed these lakes with gill nets, and Dadswell (1972) sampled the larger lakes with an otter trawl to locate deep-water forms. The present paper is an attempt to define species composition and distribution from previous records and a seining program carried out in 1971.

### *Geography of the Study Area*

Gatineau Park is an area of about 88 000 acres (35 613 ha) situated just north of Ottawa. The Gatineau Hills are part of the Laurentian Shield which was denuded and eroded by the Wisconsin glaciation, contributing to the rough, irregular topography by depositing glacial debris over the underlying igneous bedrock. Rock-rimmed, drift-lined depressions were formed in which water collected to form some 50 lakes. An irregular drainage pattern resulted as water spilled from basin to basin in several directions (Figure 1).

Most lakes belong to one of two drainage systems. The Meach–Philippe watershed contains three of the larger Gatineau park lakes: Lac Philippe, Lac Mousseau, and Meach Lake range in size from 714 to 800 acres (289 to 324 ha). Rivière Lapêche comprises the second drainage basin containing the largest lake, Lac Lapêche with 1923 acres (657 ha). The two main drainages enter the Gatineau River to the north, while a number of smaller drainages empty over the Eardley escarpment into the Ottawa River to the south. The maximum elevation of the escarpment is 1361 feet.[1] The lakes range in altitude from Lac Charette, at 1138 feet, to Fairy Lake at 194 feet.

## Methods

Twenty-five lakes and six streams were sampled utilizing a 35 × 8-foot seine (¼-in mesh, ⅛-in bag). A 15-foot (¼-in mesh) seine was used to sample adjoining streams and areas where the bottom precluded the use of a larger net. The specimens were initially

[1] Metric equivalents are given in Table 1.

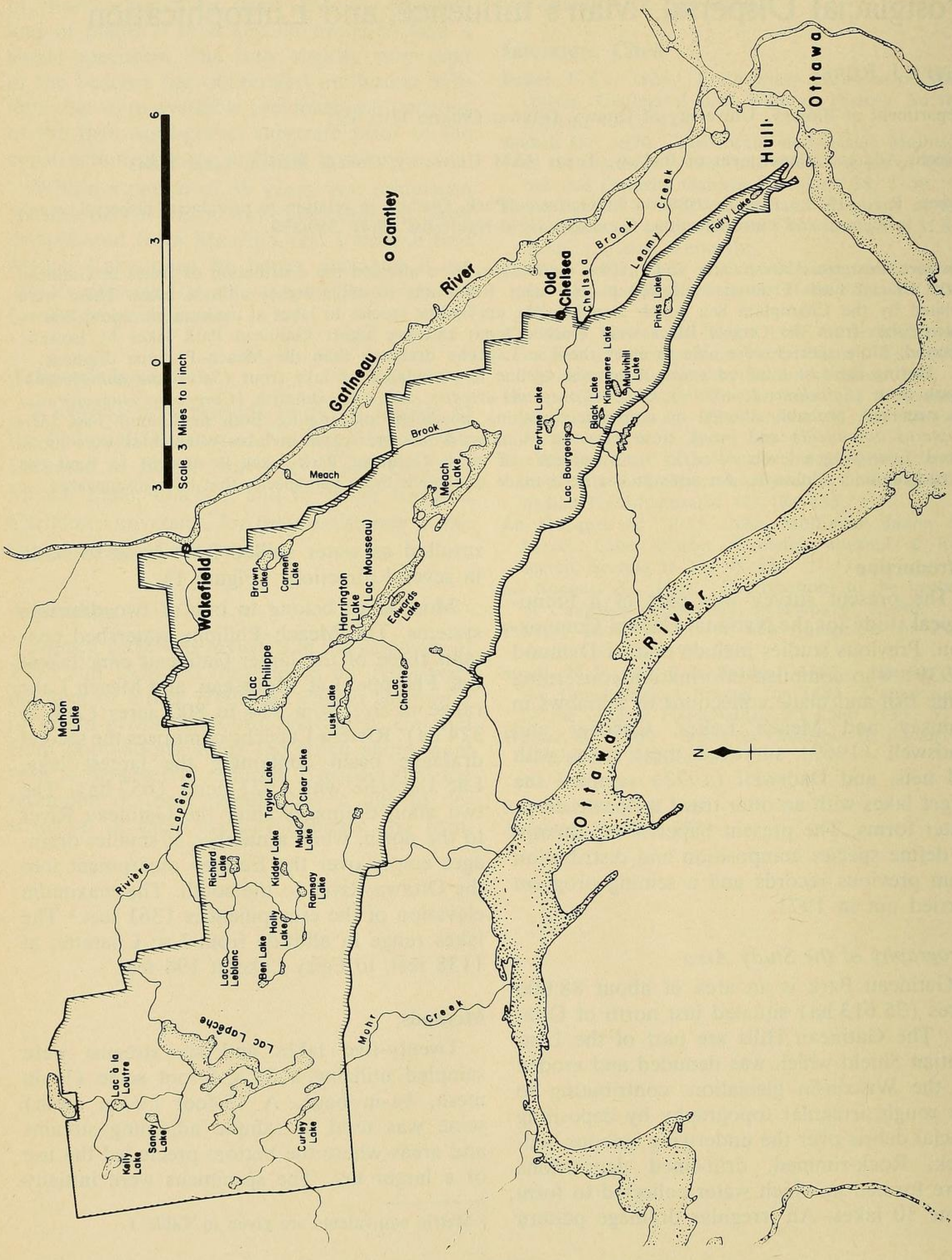


FIGURE 1. Drainage systems in Gatineau Park, Quebec.

preserved in 10% formalin and later placed in 40% isopropyl alcohol. All information concerning specimens and the nature of the sampling stations was recorded on National Museum of Natural Sciences field sheets where the collection is stored (NMC 73-104 to NMC 73-143). Specimens at the museum from 86 stations have been considered. Names used follow American Fisheries Society, Special Publication No. 6, *A List of Common and Scientific Names of Fishes from the United States and Canada*, Third Edition, 1970.

## Results

Very different fish faunas occur in the Gatineau Park and in the Ottawa River. The higher-altitude lakes and streams of the park contained, until recently, a predominantly oligothermic fauna characterized by such species as lake trout (*Salvelinus namaycush*), brook trout (*S. fontinalis*), cisco (*Coregonus artedii*), and lake whitefish (*C. clupeaformis*). The Ottawa River has a polythermic fauna characterized by such species as brown bullhead (*Ictalurus nebulosus*), channel catfish (*I. punctatus*), walleye (*Stizostedion vitreum*), sauger (*S. canadense*), smallmouth bass (*Micropterus dolomieui*), largemouth bass (*M. salmoides*), and northern pike (*Esox lucius*). Dymond (1939) noted that species such as walleye, northern pike, and channel catfish are distributed far up the Gatineau River but are absent above the highest falls on its tributaries. The waterfall at Wakefield on the lower reaches of Rivière Lapêche and the falls on Meach Brook at the outlet of Meach Lake appear to be barriers to the dispersal of the Ottawa River fish fauna into the park (Figures 2 and 3).

Within the Gatineau Park are forms which usually have a more northerly distribution and are adapted to cold-water conditions. Species such as the brook trout, white sucker (*Catostomus commersoni*), pumpkinseed (*Lepomis gibbosus*), northern redbelly dace (*Phoxinus eos*), fathead minnow (*Pimephales promelas*), creek chub (*Semotilus atromaculatus*), brassy minnow (*Hybognathus hankinsoni*), golden shiner (*Notemigonus crysoleucas*), common shiner (*Notropis cornutus*), blacknose shiner (*N. heterolepis*), pearl dace (*Semotilus margarita*), and central mudminnow (*Umbra limi*) are widely distributed in the park's two main drainages and in lakes at higher elevations draining from the Eardley escarpment (Table 1).

In the larger lakes at medium elevation Dymond (1939) has shown that forms such as the lake trout, brook trout, cisco, and whitefish were abundant until recent times. Also well established in these larger lakes are smallmouth bass, brown bullhead, yellow perch (*Perca flavescens*), and the bluntnose minnow (*Pimephales notatus*) which appear to be invading smaller lakes at higher elevation. In Meach Lake, Cuerrier and Dadswell (1969) have shown that the rainbow smelt (*Osmerus mordax*) is very abundant. Generally these species are absent from the smaller lakes along the Eardley escarpment.

Species such as the longnose dace (*Rhinichthys cataractae*), finescale dace (*Semotilus margarita*), banded killifish (*Fundulus diaphanus*), mottled sculpin (*Cottus bairdi*), brook stickleback (*Culaea inconstans*), and margined madtom (*Noturus insignis*) are found in the Lapêche drainage above the falls but are absent above the falls in the Meach–Philippe system, and are absent from the park's smaller drainages along the Eardley escarpment. The falls at Old Chelsea on Chelsea Brook appear to be blocking the upstream dispersal of the longnose dace and the johnny darter (*Etheostoma nigrum*). Northern pike, rock bass (*Ambloplites rupestris*), and the blackchin shiner (*Notropis heterodon*), which are absent from the rest of the park, are present in the Fairy Lake drainage. All these species, except the margined madtom, are known to be present in the Ottawa River and appear to have penetrated the Gatineau Park drainages to some extent at lower elevations (Table 1).

## Discussion and Conclusions

### *Postglacial Dispersal*

Present fish distribution within the park can be understood only if one considers the sequence of inundations which followed glaciation. The edge of the receding Wisconsin

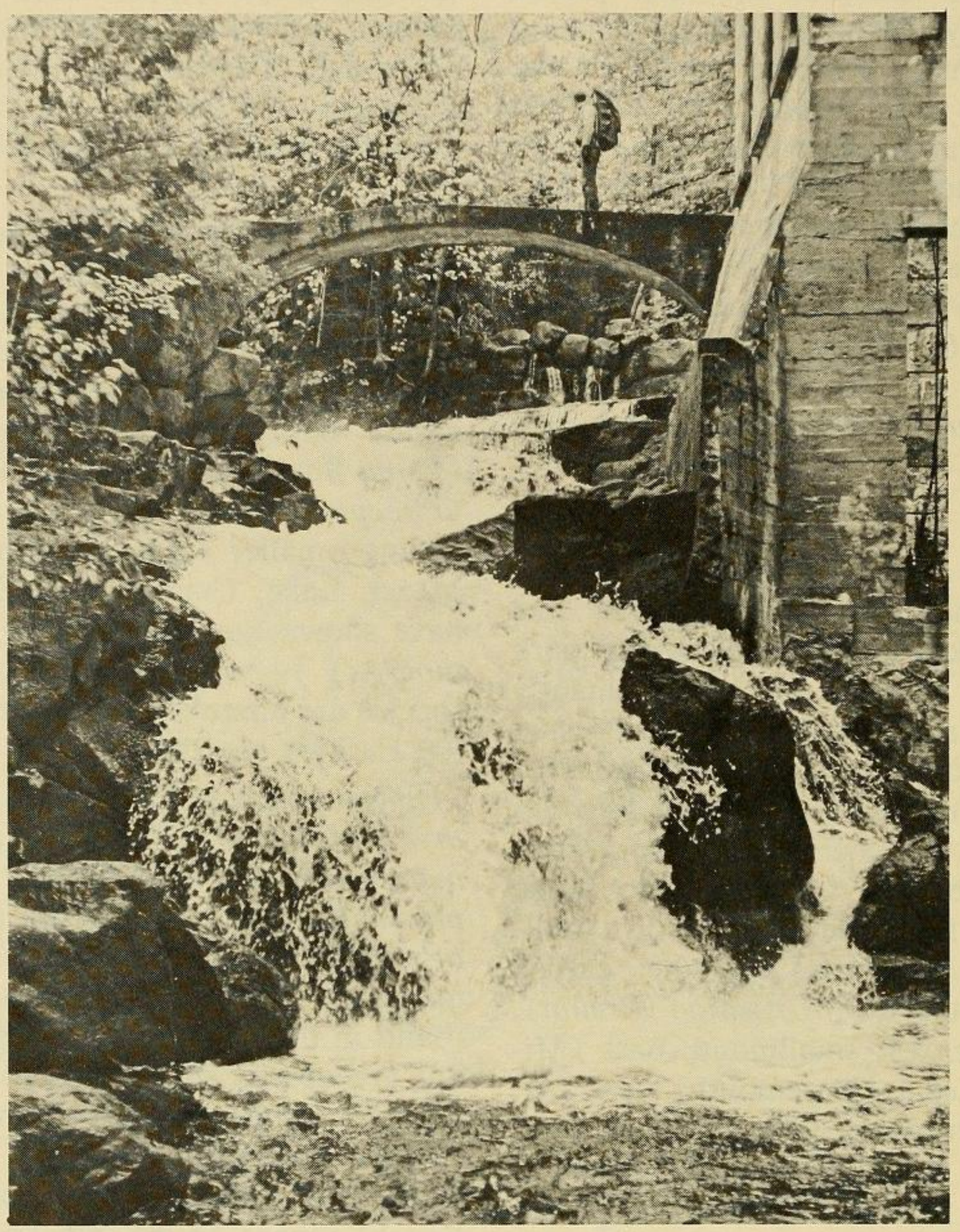

FIGURE 2. The waterfall on Rivière Lapêche near Wakefield.

ice sheet probably reached Ottawa about 12 300 years ago (Romanelli 1975). Varved clays in the Ottawa Valley indicate the Belleville – Fort Anne phase (Prest 1970) of glacial Lake Frontenac (Antevs 1925) occupied the area for 50 to 100 years (Gadd 1963). Goldthwait (1933) has suggested that Lake Frontenac reached the highlands north of Ottawa where Antevs (1925) has postulated it may have stood several hundred feet higher than the maximum marine limit of the Champlain Sea. Goldthwait has speculated that the highest marine beach of 690 feet (Johnston 1916) may have been part of this glacial lake. Most of the park was covered by ice, but lakes near the edge of the Eardley escarpment may have been ice free, and therefore it is possible that they were colonized at this time.

According to present evidence, Lake Frontenac was of relatively short duration in the Ottawa area but its overall history is much longer since it expanded in size as the glacier retreated (Prest 1970). Since this postglacial lake was confluent with glacial Lake Iroquois (present Lake Ontario) and glacial Lake Vermont (present Lake Champlain) it provided a corridor by which dispersal could have taken place from refugia beyond the maximum extent of the Wisconsin ice sheet. Fish species adapted to the cold postglacial lake environment could have dispersed into the Ottawa region.

The distribution of the brook trout, white sucker, and minnow species previously mentioned, which are found in escarpment lakes,

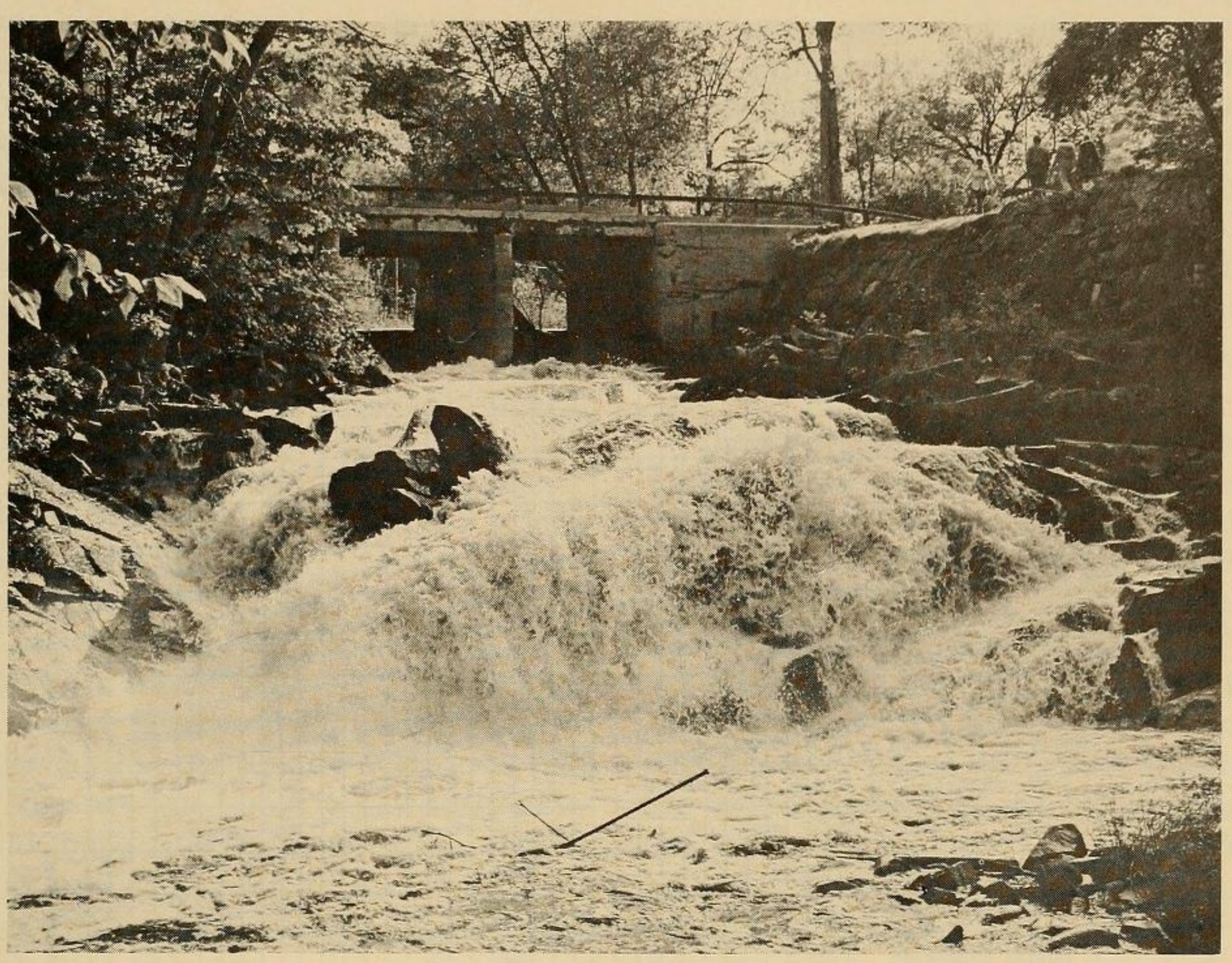

FIGURE 3. The waterfall on Meach Brook at the outlet of Meach Lake.

seem hard to explain in terms of upstream dispersal. Lakes such as Kingsmere, Mulvihill, Bourgeois, Curley, and Black drain over the Eardley escarpment. Other lakes such as Mud, Lusk, Ben, and Charette drain into the park's two main drainages in the other direction. These latter-named lakes are situated at altitudes above 700 feet and generally have steep intermittent drainages. The escarpment holding these lakes forms a sharp geological boundary which falls about 800 feet to the Ottawa Valley floor. It seems unlikely that as many species as are found at present could ascend these drainages to these lakes since the lakes have stood at their present elevation.

It has been suggested that perhaps these lakes originally lacked fish and that the fish found in them were introduced by anglers. It seems unlikely that the number of species found at present could have been introduced into so many separate drainages. During the Lake Frontenac phase the land was depressed about 400 feet and the waterplane of post-glacial Lake Frontenac stood close to the higher-altitude lakes facilitating fish dispersal.

Following Lake Frontenac, the Champlain Sea created a cold marine environment which blocked further dispersal of primary freshwater fishes into the area. Evidence for the presence of the Champlain Sea is found in marine beaches and their associated fossils (Harington 1971). Romanelli (1975) has noted a marine beach dating to 12 200 ± 160 years ago (GSC-1646) just east of the Gatineau River near Cantley at 635 feet. J. T. Buckley (1968. Gatineau Park geomorphology. National Capital Commission Manuscript Report. 15 pp.) has mapped marine sediments up to 620 feet in Gatineau Park.

It has been suggested that various fish species including the rainbow smelt, arctic char, or Quebec red trout (*Salvelinus alpinus*) and threespine stickleback (*Gasterosteus aculeatus*) owe their origin to the incursion of the Champlain Sea in the Ottawa area (Dymond 1939; Harington 1971). The marine form of the threespine stickleback is present in Pink Lake, Ramsay Lake, Holly Lake, and Kidder Lake

Table I — Fish distribution in Gatineau Park waters.

| | Alt. meters | Alt. feet | Salvelinus fontinalis | Catostomus commersoni | Lepomis gibbosus | Phoxinus eos | Pimephales promelas | Semotilus atromaculatus | Hybognathus hankinsoni | Notemigonus crysoleucas | Notropis cornutus | Notropis heterolepis | Semotilus margarita | Umbra limi | Gasterosteus aculeatus | Coregonus artedii | Coregonus clupeaformis | Salvelinus namaycush | Culaea inconstans | Etheostoma exile | Phoxinus neogaeus | Cottus bairdi | Rhinichthys cataractae | Esox lucius | Amblopliles rupestris | Notropis heterodon | Etheostoma nigrum | Noturus insignis | Fundulus diaphanus | Notropis hudsonius | Ictalurus nebulosus | Pimephales notatus | Perca flavescens | Micropterus dolomieui | Osmerus mordax | No. of species |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LAPECHE DRAINAGE | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rivière Lapêche | 168 | 550 | ● | ● | | ● | | ● | | ● | ● | | ● | ● | ○ | | | | ● | | ● | ● | ● | | | | | | ● | ● | | | | | | 9 |
| Lac Lapêche | 181 | 593 | ● | ● | ● | ● | ● | ● | | ● | ● | ● | | ● | | ○ | | | | ● | | | ● | | | | | ● | | ● | ● | | ● | | | 9 |
| Outlet stream Lac à Loutre | 198 | 650 | | | ● | | | ● | | | | | | | | | | | | | | | | | | | ● | | | | | | | | | 5 |
| Holly Lake | 199 | 653 | | ● | ● | ● | ● | ● | ● | | | | | ● | | | | | ● | | | | | | | | | | | | ● | | | | | 4 |
| Ramsay Lake | 200 | 657 | ○ | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | | ● | ● | ● | | | | | | | | | | | ● | | | | 6 |
| Leblanc Lake | 202 | 663 | | | ● | | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2 |
| Sandy Lake | 206 | 676 | ○ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | 2 |
| Kidder Lake | 207 | 679 | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | | | | ● | ● | | | | | | | | | | | ● | | | | 6 |
| Ben Lake | 216 | 708 | | | ● | ● | ● | | | ● | ● | | | ● | | | | | | | | | | | | | | | | | | | | | | 5 |
| Richard Lake | 218 | 716 | | ● | | ● | ● | ● | | | | ● | | | | | | | | ● | | | | | | | | | | | | | | | | 5 |
| Kelly Lake | 237 | 778 | ○ | ● | ● | | ● | | | | | | ● | | | | | | | | | | | | | | | | | | | ● | ● | | | 5 |
| MEACH-PHILIPPE DRAINAGE | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Carmen Lake | 144 | 473 | | | ● | | | ● | | | | | | | | | | | | | | | | | | | | | | | ● | | ● | ● | | 5 |
| Brown Lake | 145 | 474 | ● | ● | ● | | | | | ● | ● | | | ● | | | | | | | | | | | | | | | | | ● | ● | ● | ● | | 6 |
| Meach Brook | 152 | 500 | ● | ● | | | | ● | | | ● | | | | | | | | | | | | ● | | | | | | | | | ● | | | | 3 |
| Meach Lake | 170 | 550 | ● | ● | ● | | ● | ● | | ● | ● | ● | ● | | | ○ | ○ | ● | | | | | | | | | | | | | ● | ● | ● | ● | ● | 9 |
| Harrington Lake | 171 | 561 | ● | ● | ● | | | | | ● | ● | ● | ● | | | ○ | ● | ○ | | | | | | | | | | | | | ● | ● | ● | ● | | 8 |
| Edwards Lake | 172 | 564 | | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | ● | ● | ● | ● | | 5 |
| outlet stream Lac Philippe | 172 | 564 | | ● | ● | ● | ● | ● | | ● | ● | | ● | ● | | | | | | | | | | | | | | | | | ● | ● | ● | | | 6 |
| Lac Philippe | 172 | 564 | ● | ● | ● | | ● | | | | ● | | | | | ○ | | ○ | | | | | | | | | | | | | ● | ● | ● | ● | | 7 |
| Taylor Lake | 203 | 666 | ○ | ● | ● | | | | | | ● | | | | | | | | | | | | | | | | | | | | ● | ● | ● | ● | | 6 |
| Clear Lake | 242 | 793 | | | | ● | ● | ● | | | | | | | | | | | | | | | | | | | | | | | | ● | ● | | | 4 |
| Mud Lake | 253 | 829 | | | | ● | ● | | | | | | | ● | | | | | | | | | | | | | | | | | | | | | | 2 |
| Lusk Lake | 284 | 930 | ○ | ● | | | ● | ● | | ● | ● | | | | | | | | | | | | | | | | | | | | ● | | | | | 3 |
| Lac Charette | 347 | 1138 | ○ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 |
| OTHER DRAINAGES | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fairy Lake | 59 | 194 | | ● | ● | | | ● | | ● | | | | ● | | | | | ● | ● | | | | ● | ● | ● | | | | | ● | ● | | | | 7 |
| Chelsea Brook | 152 | 500 | ○ | ● | ● | ● | ● | ● | | | | | | | | | | | | | | ○ | ● | | | | ● | | | | | | | | | 3 |
| Pinks Lake | 162 | 532 | | ● | ● | ● | ● | ● | | | | | ● | | ● | | | | | | | | | | | | | | | | | | | | | 2 |
| outlet stream Curley Lake | 183 | 600 | | ● | ● | ● | ● | ● | | | | | | | | | | | ● | | | | | | | | | | | | | | | | | 2 |
| Curley Lake | 198 | 648 | ○ | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | 2 |
| Mulvihill Lake | 226 | 741 | | ● | ● | | ● | ● | | | | ● | ● | | | | | | | | | | | | | | | | | | | | | | | 3 |
| Kingsmere Lake | 231 | 759 | ● | ● | ● | | ● | ● | | ● | ● | ● | | | | | | | | | | | | | | | | | | | | | | | | 5 |
| Fortune Lake | 282 | 925 | ○ | ● | | | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2 |
| Black Lake | 301 | 988 | | | | | | | ● | ● | | | | | | | | | | | | | | | | | | | | | | | | | | 2 |
| Lac Bourgeois | 302 | 991 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |

● Present distribution

○ Formerly present (Dymond, 1939)

Lake Frontenac | Champlain Sea | Ottawa River fauna | Introduced species

(Table 1). It is not certain whether the last three lakes were inundated by the sea. They lie between 653 and 679 feet and may have been colonized by threespine sticklebacks while the sea was situated nearby. The rainbow smelt, native to much of the Gatineau Valley (Delisle and Veilleux 1969), was introduced into Meach Lake in 1924 from Lake Utopia, New Brunswick (Dymond 1939).

The marine waters of the Champlain Sea gradually fell as the land, free of the weight of the glaciers, gradually rose as a result of isostatic rebound (Antevs 1925; Romanelli 1975). With continued glacial retreat a large influx of water from the Great Lakes entered the shallow marine estuary and caused a decrease in salinity during the latter stages of the sea between 11 000 and 10 000 years ago (Terasmae and Hughes 1960; Elson 1969). Elson believed that the salinity during the final stages of the sea was about 6 $^{0}/_{00}$. Low salinities could have allowed euryhaline fish to invade the area.

Cold-water fish species such as lake trout, cisco, and lake whitefish may have dispersed through the Champlain Sea into the newly formed lakes such as Meach, Mousseau, Philippe, and Lapêche. The coregonid species are tolerant to saline conditions while the lake trout is generally considered a freshwater species which has occasionally been known to enter the sea (Ryder et al. 1964), Gruchy (1968) has described a fossil lake trout, found in the same area as marine forms near Green's Creek, which could indicate lake trout entered the estuary during the latter stages of the Champlain Sea (Harington 1971).

One could argue that the coregonids and lake trout entered the Gatineau area during the Lake Frontenac phase and survived the invasion of the Champlain Sea in lakes at higher elevation. While this is probably true for the brook trout and other species previously mentioned, I doubt whether it is true for the lake whitefish, cisco, or lake trout. It seems unlikely that the small Gatineau Park lakes at higher elevation could support these species. Lake trout are found at lower elevations than the Quebec red trout in the Gatineau region suggesting that the lake trout dispersed into the area at a later date (M. J. Dadswell, personal communication). The other possibility, that these forms entered after the Champlain Sea seems equally unlikely. The uplifting of the land, which caused a drop in the level of the Champlain Sea, exposed areas which were previously under the sea. Topographical barriers such as waterfalls were most likely formed during the Champlain Sea era and these would have blocked upstream dispersal into Gatineau Park lakes after the sea.

The formation of the Mer Bleue bog east of Ottawa indicates that the ancestral Ottawa River draining the Great Lakes stood at about 250 feet between about 10 000 and 7000 years ago, before occupying its present channel (Johnston 1916; Romanelli 1975). Rapid warming conditions about 10 000 years ago (Ogden 1965) led to a warmer climate than exists today. Warm-water fish species entered the region by way of the Ottawa River. With the exception of those species which have passed the falls on Rivière Lapêche, most were not able to disperse into Gatineau Park lakes because of the existing barriers.

The falls on Rivière Lapêche at 440 feet altitude appear to have been negotiable, although the steeper falls on Meach Brook at 550 feet have not. Most of the species which have penetrated the Lapêche drainage, with the exception of the spottail shiner and the banded killifish, are species, adapted to fastwater habitats, which could have penetrated the falls on Rivière Lapêche. The occurrence of these exceptions may be the result of bait introductions by anglers. The margined madtom is most probably an introduction (Rubec and Coad 1974). The greater diversity of the Lapêche drainage over the Meach-Philippe drainage is largely due to its greater accessibility. This has allowed some Ottawa River forms to penetrate Rivière Lapêche after the present drainage pattern had become established. Likewise, northern pike, rockbass, and blackchin shiners are present in the Fairy Lake drainage due to the relative accessibility of the lake at 194 feet from the nearby Ottawa River at 180 feet.

Forms such as the brown bullhead, yellow perch, bluntnose minnow, and pumpkinseed

are considered warm-water species on the basis of their physiology and limited northern distribution. If they entered the area after the Champlain Sea episode, the falls on Meach Brook would have blocked their dispersal into the Meach–Philippe drainage, where they are known to be present. If they entered before the Champlain Sea, they should be present in the lakes along the escarpment. Only the pumpkinseed is found in lakes draining over the escarpment. Dymond (1939) has suggested that the pumpkinseed may not have been native to Meach Lake, but this is difficult to believe in light of its widespread distribution in Gatineau Park drainages. Pumpkinseeds were present in Chelsea Brook when Small (1883) first fished these waters. In light of the distribution, I believe the pumpkinseed entered the Gatineau Park during the Lake Frontenac phase. The bluntnose minnow, yellow perch, and brown bullhead have distributions similar to that of the smallmouth bass which is known to have been introduced, leading me to believe that these species may be present due to introductions. Since the yellow perch, brown bullhead, and banded killifish have salinity tolerances as high as 10–15 parts per thousand, it is also possible that they entered the area during the latter part of the Champlain Sea.

*Man's Influence on the Fish Fauna*

Cuerrier and Dadswell (1969) found that the lake trout, brook trout, lake whitefish, and cisco, which were abundant in the late 1800s (Dymond 1939), had disappeared from many Gatineau Park lakes and had very reduced populations in the remainder. Cuerrier (personal communication) has talked to local residents who remember taking whitefish and lake trout from Lac Mousseau "by the barrel load" no more than 50 years ago. Intensive gill netting in the same lake showed that lake trout had disappeared and whitefish were on the verge of extinction (Cuerrier and Dadswell 1969). Dymond's information can be compared with data supplied by Cuerrier to show this general decline (Table 2).

The causes of the decline are difficult to assess. The lakes of the Gatineau district supported a substantial fishery in the late 1800s (Dymond 1939). Dymond cites a series of annual reports of the Department of Marine and Fisheries in which, in 1870, W. L. Holland reported that local residents used nets and spears in and out of season, wastefully fishing to supply American dealers. In 1875, 78 commercial fishing licences were granted in Gatineau district lakes. In 1873 Holland reported that local residents had complained that the lumbermen injured the fisheries by erecting dams at the outlet of lakes, thus preventing fish from reaching their spawning grounds. It was noted that the yield of fish had decreased in places where the dams had been constructed.

As the urban population of Ottawa and Hull grew, the Gatineau lakes became a resort area. Increased angling pressure may have been an important factor in depleting trout species, but this does not explain the decline of whitefish and cisco. Cuerrier and Dadswell (1969) cite illegal netting as one important factor which may have helped cause the disappearance of lake trout from Lac Lapêche and Lac Mousseau about 1940. With the creation of the park area in 1938 the remaining fish population have not recovered to their former abundance.

In 1908 smallmouth bass were introduced by anglers into Lac Lapêche, Lac Philippe, Lac Mousseau, and Meach Lake (Dymond 1939). My survey indicates they have also gained access to Brown, Taylor, Carmen, Sandy, Curley, and Leblanc Lakes where they were found to be abundant in the seine catches (Table 1).

In the larger lakes I found a low general abundance of minnows per seine haul. With the exception of the bluntnose minnow, most cyprinids were taken in secluded areas such as stream entrances, bays, and weedy areas where bass were uncommon. The smallmouth bass tended to be found over open areas, with either rock or sand bottoms, occupying the predominant habitat in these larger lakes.

In the small lakes, where bass were found to be present, minnows were either scarce or absent. No minnows were taken in Curley and Sandy Lakes, while Carmen Lake and Leblanc Lake, each yielded a single creek chub, after considerable seining effort. In Taylor and Brown Lakes minnows were captured but

TABLE 2—Present and past distribution of cold-water fish in Gatineau Park waters

| | Lac Lapêche | Lac Philippe | Lac Mousseau | Meach Lake | Curley Lake | Ramsay Lake | Taylor Lake | Lusk Lake | Kingsmere Lake | Kelly Lake | Sandy Lake | Fortune Lake | Mohr Creek | Chelsea Brook | Lac Charette |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Distribution in late 1800s | | | | | | | | | | | | | | | |
| *Coregonus clupeaformis* | | | X | X | | | | | | | | | | | |
| *Coregonus artedii* | X | X | X | X | | | | | | | | | | | |
| *Salvelinus fontinalis* | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| *Salvelinus namaycush* | X | X | X | X | | | | | | | | | | | |
| Present indigenous distribution | | | | | | | | | | | | | | | |
| *Coregonus clupeaformis* | | | X | | | | | | | | | | | | |
| *Coregonus artedii* | | | | | | | | | | | | | | | |
| *Salvelinus fontinalis* | X | X | X | X | | | | | X | | | | | | |
| *Salvelinus namaycush* | | | | X | | | | | | | | | | | |

appeared to be of larger size-classes. The scarcity of minnows in these small lakes seems unusual since abundant minnow populations were noted in tributary streams and in other nearby lakes lacking bass.

Dymond (1939) noted that it was unusual to find smallmouth bass and trout species occurring in the same water except in large lakes such as the Great Lakes. Competition for the same food supply usually results in the eventual elimination of either bass or trout in small and medium-sized lakes. The larger lakes in Gatineau Park have reduced populations of brook trout while these fish have completely disappeared from most of the smaller lakes (Table 2). Whether food competition between smallmouth bass and brook trout has occurred cannot be determined on the basis of this survey. It can only be stated that the introduction of smallmouth bass, especially in the smaller lakes, coincides with the depletion of the minnow fauna and the decline or disappearance of brook trout. Cuerrier and Dadswell (1969) showed that smallmouth bass in Lac Mousseau preferred the same foods as brook trout and yellow perch during the spring. Smallmouth bass, as well as being a predator on brook trout, appeared to be a direct competitor with trout for food with respect to mayflies, dragonflies, and small perch during June. Food competition with overpopulated bass and perch is believed to be the greatest factor affecting the trout population of Lac Mousseau.

While food competition between smallmouth bass and brook trout may have contributed to the decline of the trout, it cannot account for the disappearance of other species such as lake whitefish and cisco. Indeed, brook trout have disappeared from small lakes where bass were not introduced, suggesting that the competition with bass for food was only one factor leading to a decline of the original salmonid fauna.

*Oxygen Depletion*

The other major factor noted by Cuerrier and Dadswell (1969) was that most of the lakes in the Gatineau Park had hypolimnia containing very little oxygen during the late summer (0–2 ppm). M. Dickman (1971. Report to the National Capital Commission) confirmed this observation with detailed oxygen profiles. Intense phytoplankton production had caused an oxygen maximum to occur below the thermocline in Pink, Meach, and Kidder Lakes. In most lakes examined, a marked decline in oxygen levels, characteristic of eutrophic conditions, was noted below the thermocline.

This widespread depletion of the hypolimnia

of Gatineau Park lakes would seem to offer the most likely explanation for the disappearance of its cold-water salmonid species (Larkin and Northcote 1970). The persistence of lake trout in Meach Lake and their disappearance in Lac Lapêche, Lac Mousseau, and Lac Philippe becomes understandable in view of the relatively high oxygen values in the hypolimnion of Meach Lake compared with those of the other lakes (Dickman 1971. Report to the National Capital Commission). As recently as about 1960 abnormally warm summer conditions may have brought about an oxygen depletion resulting in a mass mortality which exterminated cisco in Lac Lapêche (D. Sauvé, personal communication).

The cause of the low oxygen levels in the hypolimnia of these lakes is not known. Deforestation between 1850 and 1924, a forest fire which swept along the escarpment from Old Chelsea past Luskville during the fall of 1924 (J. C. McCuaig, personal communication), and drainage from outdoor privies are factors which may have allowed excessive nutrients to enter the lakes, resulting in depletion of hypolimnia.

*Recent Introductions*

The decline of native cold-water species has created a sport fisherman's vacuum. Larger fishes are absent from such lakes which usually support abundant minnow populations. In other lakes stunted smallmouth bass (Doan 1940) and yellow perch are the only game fish available during the summer.

In an effort to maintain a fauna compatible with the original fish fauna, the National Capital Commission has initiated introductions of various fish species within the last 5 years. A limited number of cisco were introduced into Meach Lake to replace those which had disappeared. About a half million smelt eggs were introduced into streams adjoining Lac Mousseau (Cuerrier and Dadswell 1969). Limited introductions of lake trout, splake (*Salvelinus fontinalis* × *S. namaycush*), rainbow trout (*Salmo gairdneri*), and atlantic salmon (*Salmo salar*) have also been made mainly in the larger lakes of the Meach–Philippe system. Widespread introductions of brook trout have been made mainly in the smaller lakes, with partial success, suggesting that some of these lakes may still be capable of supporting trout species. Black Lake is an example where stocking of brook trout provided sport for anglers in the spring of 1972 and 1973.

The success or failure of such plantings may help clarify whether exploitation or environmental deterioration has been the dominant factor in causing a decline in the native cold-water fish fauna. It remains to be seen whether any of the introduced species will establish self-sustaining populations. Cuerrier and Dadswell (1969) noted limited reproduction of brook trout introduced into Lusk Lake. The introduction of about 4.5 million walleye fry into Lac Lapêche in 1968 may have failed owing to predatory yellow perch. Of about 80 adult walleye introduced into Lac Lapêche only one is known to have been recaptured and no signs of natural reproduction have yet been noted.

Gatineau Park is fortunate to have small lakes which can be manipulated and which lend to management techniques. Careful studies by biologists are needed to evaluate the effect of these introductions and to apply a consistent management policy.

**Acknowledgments**

I am grateful to G. Hamre and R. Plummer who assisted in making the collections; J.-P. Cuerrier of the Canadian Wildlife Service supplied unpublished data concerning game fish species and D. E. McAllister supplied advice and information from National Museum of Natural Sciences collections; M. Outhet and V. Edey of the National Capital Commission, D. Sauvé, J. Harrison, J. C. McCuaig, longtime local residents, and M. J. Dadswell supplied further information concerning the history of these lakes. The study that made this survey possible was directed by M. Dickman, Brock University. I thank G. Ben-Tchavtchavadze and J. Hélie for preparing the map and tabulations, and B. Woodley for photographing the waterfalls. I am also indebted to the reviewers who suggested improvements to this paper.

## Literature Cited

**Antevs, E.** 1925. Retreat of the last ice-sheet in Eastern Canada. Geological Survey of Canada Memoir 146: 59–89.

**Cuerrier, J.-P.** and **M. J. Dadswell.** 1969. Limnology and experimental fishery management studies in Gatineau Park during 1968. Canadian Wildlife Service Manuscript Report. 107 pp.

**Dadswell, M. J.** 1972. Postglacial dispersal of four deepwater fishes on the basis of new distribution records in eastern Ontario and western Quebec. Journal of the Fisheries Research Board of Canada 29: 545–553.

**Delisle, C.** and **C. Veilleux.** 1969. Répartition géographique de l'éperlan arc-en-ciel *Osmerus eperlanus mordax* et de *Glugea hertwigi* (Sporozoa: Microsporidea) en eau douce, au Québec. Naturaliste Canadien 96: 337–358.

**Doan, K. H.** 1940. Studies of the smallmouth bass. Journal of Wildlife Management 4(3): 241–266.

**Dymond, J. R.** 1939. The fishes of the Ottawa region. Contribution of the Royal Ontario Museum 15: 1–43.

**Elson, J. A.** 1969. Radiocarbon dates, *Mya arenaria* phase of the Champlain Sea. Canadian Journal of Earth Sciences 6: 367–372.

**Gadd, N. R.** 1963. Surficial geology of Ottawa map-area, Ontario and Quebec. Geological Survey of Canada 62-16: 1–3.

**Goldthwait, J. W.** 1933. Selected passages from the St. Lawrence lowland. *In* Pleistocene geology of the central St. Lawrence lowland. Geological Survey of Canada Memoir 359(1971): 113–153.

**Gruchy, C. G.** 1968. Two late Quaternary Salmonidae (Pisces) from the Ottawa area, Canada. Vêstnik Ceskoslovenské Spolecnosti Zoologické Acta Societatis Zoologicae Bohemoslovacae (32 (4): 337–341.

**Harington, C. R.** 1971. The Champlain Sea and its vertebrate fauna. Part 1. Trail & Landscape 5: 137–141.

**Johnston, W. A.** 1916. Late Pleistocene oscillations of sea-level in the Ottawa Valley. Geological Survey of Canada Bulletin 24: 1–14.

**Larkin, P. A.** and **T. G. Northcote.** 1970. Fish as indices of eutrophication. *In* Eutrophication: causes, consequences, correctives. National Academy of Sciences, Washington, D.C. pp. 256–273.

**Ogden, J. G.** 1965. Radiocarbon and pollen evidence for a sudden change in climate in the Great Lakes region approximately 10 000 years ago. *In* Quaternary paleoecology. *Edited by* E. J. Cushing and H. E. Wright. Yale University Press. pp. 117–130.

**Prest, V. K.** 1970. Quaternary geology of Canada. *In* Geology and economical minerals of Canada. 5th edition. Department of Energy, Mines and Resources, Ottawa. pp. 675–764.

**Romanelli, R.** 1975. The Champlain Sea episode: the Gatineau Valley and Ottawa area. Canadian Field-Naturalist 89. *This issue*.

**Rubec, P. J.** and **B. W. Coad.** 1974. First record of the margined madtom (*Noturus insignis*) from Canada. Journal of the Fisheries Research Board of Canada 31(8): 1430–1431.

**Ryder, R. A., W. B. Scott,** and **E. J. Crossman.** 1964. Fishes of northern Ontario, north of the Albany River. Contributions of the Royal Ontario Museum 60: 1–30.

**Small, H. B.** 1883. Fishes of the Ottawa District. Transactions of the Ottawa Field-Naturalists' Club 4: 31–49.

**Terasmae, J.** and **O. L. Hughes.** 1960. Glacial retreat in the North Bay area, Ontario. Science (Washington) 131: 1444–1446.

Received 2 October 1972
Accepted 21 May 1974

# Fish Distribution in Gatineau Park, Quebec, in Relation to Postglacial Dispersal, Man's Influence, and Eutrophication

Peter J. Rubec

Department of Biology, University of Ottawa, Ottawa, Ontario KIN 6N5

Present Address: Department of Biology, Texas A&M University, College Station, Texas 77843

Rubec, P.J. 1975. Fish distribution in Gatineau Park, Quebec, in relation to postglacial dispersal, man's influence, and eutrophication. Canadian Field- Naturalist 89(4): 389-399.

Abstract. Postglacial freshwater and marine inundations have affected the distribution of fishes in Gatineau Park. Glacial Lake Frontenac allowed a cold-water fish fauna to enter higher altitude lakes. These were isolated by the Champlain Sea which also brought euryhaline species to lakes at medium elevation. Warm-water fishes from the Ottawa River were blocked from entering higher Gatineau Park lakes by isostatic rebound. More species were able to enter the Lac Lapeche drainage than the Meach-Philippe drainage.

During the last hundred years, a general decline in abundance of lake trout {Salvelinus namaycush), brook trout {Salvelinus fontinalis), cisco {Coreganus artedii), and lake whitefish {Coregonus clupeaformis) has occurred, probably abetted by commercial fishing, poaching, and angling. Both smallmouth bass {Micropterus dolomieui) and brook trout prey on minnows which are scarce in lakes where bass were introduced. Low oxygen levels noted in the hypolimnia of most Gatineau Park lakes is thought to limit the coregonids and salmonids. An attempt has been made to replace those fish species that have disappeared.

## Introduction

The present survey was part of a limnological study for the National Capital Commission. Previous studies include that of Dymond (1939) who compiled information concerning game fish and made collections of minnows in Ramsay and Meach Lakes. Cuerrier and Dadswell (1969) surveyed these lakes with gill nets, and Dadswell (1972) sampled the larger lakes with an otter trawl to locate deep-water forms. The present paper is an attempt to define species composition and distribution from previous records and a seining program carried out in 1971.

## Geography of the Study Area

Gatineau Park is an area of about 88 000 acres (35 613 ha) situated just north of Ottawa. The Gatineau Hills are part of the Laurentian Shield which was denuded and eroded by the Wisconsin glaciation, contributing to the rough, irregular topography by depositing glacial debris over the underlying igneous bedrock. Rock-rimmed, drift-hned depressions were formed in which water collected to form some 50 lakes. An irregular drainage pattern

resulted as water spilled from basin to basin in several directions (Figure 1).

Most lakes belong to one of two drainage systems. The Meach-Philippe watershed contains three of the larger Gatineau park lakes: Lac Philippe, Lac Mousseau, and Meach Lake range in size from 714 to 800 acres (289 to 324 ha) . Riviere Lapeche comprises the second drainage basin containing the largest lake, Lac Lapeche with. 1923 acres (657 ha). The two main drainages enter the Gatineau River to the north, while a number of smaller drainages empty over the Eardley escarpment into the Ottawa River to the south. The maximum elevation of the escarpment is 1361 feet.^ The lakes range in altitude from Lac Charette, at 1138 feet, to Fairy Lake at 194 feet.

Methods

Twenty-five lakes and six streams were sampled utilizing a 35 X 8-foot seine (^/t-in mesh, Vs-in bag). A 15-foot (V4-in mesh) seine was used to sample adjoining streams and areas where the bottom precluded the use of a larger net. The specimens were initially

1 Metric equivalents are given in Table 1.



**[Begin Page: Page 390]**



t'^.J^f.^9-

vC^

Figure 1. Drainage systems in Gatineau Park. Quebec.

**[Begin Page: Page 391]**

preserved in 10% formalin and later placed in 40% isopropyl alcohol. All information concerning specimens and the nature of the sampling stations was recorded on National Museum of Natural Sciences field sheets where the collection is stored (NMC 73-104 to NMC 73-143). Specimens at the museum from 86 stations have been considered. Names used follow American Fisheries Society, Special Publication No. 6, A List of Common and Scientific Names of Fishes from the United States and Canada, Third Edition, 1970.

## Results

Very different fish faunas occur in the Gatineau Park and in the Ottawa River. The higher-altitude lakes and streams of the park contained, until recently, a predominantly oligothermic fauna characterized by such species as lake trout {Salvelinus namaycush), brook trout (5. fontinalis), cisco (Coregonus artedii), and lake whitefish (C. clupeaformis) . The Ottawa River has a polythermic fauna characterized by such species as brown bullhead {Ictalurus nebulosus), channel catfish (/. punctatus) , walleye (Stizostedion vitreum),

sauger {S. canadense), smallmouth bass (M/-cropterus dolomieui), largemouth bass (M. salmoides), and northern pike (Esox lucius). Dymond (1939) noted that species such as walleye, northern pike, and channel catfish are distributed far up the Gatineau River but are absent above the highest falls on its tributaries. The waterfall at Wakefield on the lower reaches of Riviere Lapeche and the falls on Meach Brook at the outlet of Meach Lake appear to be barriers to the dispersal of the Ottawa River fish fauna into the park (Figures 2 and 3).

Within the Gatineau Park are forms which usually have a more northerly distribution and are adapted to cold-water conditions. Species such as the brook trout, white sucker (Catos-tomus commersoni), pumpkinseed (Lepomis gibbosus), northern redbelly dace (Phoxinus eos), fathead minnow (Pimephales promelas), creek chub (Semotilus atromaculatus) , brassy minnow (Hybognathus hankinsoni), golden shiner {Notemigonus crysoleucas) , common shiner (Notropis cornutus), blacknose shiner

(A^. heterolepis), pearl dace (SemotiUis mar-garita), and central mudminnow {Umbra limi)

are widely distributed in the park's two main drainages and in lakes at higher elevations draining from the Eardley escarpment (Table 1).

In the larger lakes at medium elevation Dymond (1939) has shown that forms such as the lake trout, brook trout, cisco, and white-fish were abundant until recent times. Also well established in these larger lakes are small-mouth bass, brown bullhead, yellow perch (Perca flavescens) , and the bluntnose minnow {Pimephales notatus) which appear to be in-vading smaller lakes at higher elevation. In Meach Lake, Cuerrier and Dadswell (1969) have shown that the rainbow smelt {Osmerus mordax) is very abundant. Generally these species are absent from the smaller lakes along the Eardley escarpment.

Species such as the longnose dace {Rhinich-thys cataractae), finescale dace {Semotilus margarita), banded killifish {Fundulus dia-phanus), mottled sculpin {Cottus bairdi), brook stickleback {Culaea inconstans), and margined madtom {Noturus insignis) are found in the Lapeche drainage above the falls but are absent above the falls in the Meach-Philippe system, and are absent from the park's

smaller drainages along the Eardley escarpment. The falls at Old Chelsea on Chelsea Brook appear to be blocking the upstream dispersal of the longnose dace and the johnny darter {Etheostoma nigrum). Northern pike, rock bass {Ambloplites rupestris), and the blackchin shiner {Notropis heterodon), which are absent from the rest of the park, are present in the Fairy Lake drainage. All these species, except the margined madtom, are known to be present in the Ottawa River and appear to have penetrated the Gatineau Park drainages to some extent at lower elevations (Table 1).

## Discussion and Conclusions

### Postglacial Dispersal

Present fish distribution within the park can be understood only if one considers the sequence of inundations which followed glaciation. The edge of the receding Wisconsin

Figure 2. The waterfall on Riviere Lapeche near Wakefield.

ice sheet probably reached Ottawa about 12 300 years ago (RomanelH 1975). Varved clays in the Ottawa Valley indicate the Belleville-Fort Anne phase (Prest 1970) of glacial Lake Frontenac (Antevs 1925) occupied the area for 50 to 100 years (Gadd 1963). Goldthwait (1933) has suggested that Lake Frontenac reached the highlands north of Ottawa where Antevs (1925) has postulated it may have stood several hundred feet higher than the maximum marine limit of the Champlain Sea. Goldthwait has speculated that the highest marine beach of 690 feet (Johnston 1916) may have been part of this glacial lake. Most of the park was covered by ice, but lakes near the edge of the Eardley escarpment may have been ice free, and therefore it is possible that they were colonized at this time.

According to present evidence. Lake Fron-

tenac was of relatively short duration in the Ottawa area but its overall history is much longer since it expanded in size as the glacier retreated (Prest 1970). Since this postglacial lake was confluent with glacial Lake Iroquois (present Lake Ontario) and glacial Lake Vermont (present Lake Champlain) it provided a corridor by which dispersal could have taken place from refugia beyond the maximum extent of the Wisconsin ice sheet. Fish species adapted to the cold postglacial lake environment could have dispersed into the Ottawa region.

The distribution of the brook trout, white sucker, and minnow species previously mentioned, which are found in escarpment lakes,

**[Begin Page: Page 393]**



Figure 3. The waterfall on Meach Brook at the outlet of Meach Lake.

seem hard to explain in terms of upstream dispersal. Lakes such as Kingsmere, Mulvihill, Bourgeois, Curley, and Black drain over the Eardley escarpment. Other lakes such as Mud, Lusk, Ben, and Charette drain into the park's two main drainages in the other direction. These latter-named lakes are situated at altitudes above 700 feet and generally have steep intermittent drainages. The escarpment holding these lakes forms a sharp geological boundary which falls about 800 feet to the Ottawa Valley floor. It seems unlikely that as many species as are found at present could ascend these drainages to these lakes since the lakes have stood at their present elevation.

It has been suggested that perhaps these lakes originally lacked fish and that the fish found in them were introduced by anglers. It seems unlikely that the number of species found at present could have been introduced into so many separate drainages. During the Lake Frontenac phase the land was depressed about 400 feet and the waterplane of post-glacial Lake Frontenac stood close to the

higher-altitude lakes facilitating fish dispersal.

Following Lake Frontenac, the Champlain Sea created a cold marine environment which blocked further dispersal of primary freshwater fishes into the area. Evidence for the presence of the Champlain Sea is found in marine beaches and their associated fossils (Harington 1971). Romanelh (1975) has noted a marine beach dating to 12 200 ±160 years ago (GSC-1646) just east of the Gatineau River near Cantley at 635 feet. J. T. Buckley (1968. Gatineau Park geomorphology. National Capital Commission Manuscript Report. 15 pp.) has mapped marine sediments up to 620 feet in Gatineau Park.

It has been suggested that various fish species including the rainbow smelt, arctic char, or Quebec red trout {Salvelinus alpinus) and threespine stickleback {Gasterosteus aculeatus) owe their origin to the incursion of the Champlain Sea in the Ottawa area (Dymond 1939; Harington 1971). The marine form of the threespine stickleback is present in Pink Lake, Ramsay Lake, Holly Lake, and Kidder Lake

**[Begin Page: Page 394]**

**[Begin Page: Page 395]**



(Table 1). It is not certain whether the last three lakes were inundated by the sea. They lie between 653 and 679 feet and may have been colonized by threespine sticklebacks while the sea was situated nearby. The rainbow smelt, native to much of the Gatineau Valley (Delisle and Veilleux 1969), was introduced into Meach Lake in 1924 from Lake Utopia, New Brunswick (Dymond 1939).

The marine waters of the Champlain Sea gradually fell as the land, free of the weight of the glaciers, gradually rose as a result of

isostatic rebound (Antevs 1925; Romanelli 1975). With continued glacial retreat a large influx of water from the Great Lakes entered the shallow marine estuary and caused a decrease in salinity during the latter stages of the sea between 11 000 and 10 000 years ago (Terasmae and Hughes 1960; Elson 1969). Elson believed that the salinity during the final stages of the sea was about 6 °[oo- Low salinities could have allowed euryhaline fish to invade the area.

Cold-water fish species such as lake trout, Cisco, and lake whitefish may have dispersed through the Champlain Sea into the newly formed lakes such as Meach, Mousseau, Philippe, and Lapeche. The coregonid species are tolerant to saline conditions while the lake trout is generally considered a freshwater species which has occasionally been known to enter the sea (Ryder et al. 1964), Gruchy (1968) has described a fossil lake trout, found in the same area as marine forms near Green's Creek, which could indicate lake trout entered the estuary during the latter stages of the Champlain Sea (Harington 1971).

One could argue that the coregonids and

lake trout entered the Gatineau area during the Lake Frontenac phase and survived the invasion of the Champlain Sea in lakes at higher elevation. While this is probably true for the brook trout and other species previously mentioned, I doubt whether it is true for the lake whitefish, cisco, or lake trout. It seems unlikely that the small Gatineau Park lakes at higher elevation could support these species. Lake trout are found at lower elevations than the Quebec red trout in the Gatineau region suggesting that the lake trout dispersed into the

area at a later date (M. J. Dadswell, personal communication). The other possibility, that these forms entered after the Champlain Sea seems equally unlikely. The uplifting of the land, which caused a drop in the level of the Champlain Sea, exposed areas which were previously under the sea. Topographical barriers such as waterfalls were most likely formed during the Champlain Sea era and these would have blocked upstream dispersal into Gatineau Park lakes after the sea.

The formation of the Mer Bleue bog east of Ottawa indicates that the ancestral Ottawa River draining the Great Lakes stood at about 250 feet between about 10 000 and 7000 years

ago, before occupying its present channel (Johnston 1916; Romanelh 1975). Rapid warming conditions about 10 000 years ago (Ogden 1965) led to a warmer climate than exists today. Warm-water fish species entered the region by way of the Ottawa River. With the exception of those species which have passed the falls on Riviere Lapeche, most were not able to disperse into Gatineau Park lakes because of the existing barriers.

The falls on Riviere Lapeche at 440 feet altitude appear to have been negotiable, although the steeper falls on Meach Brook at 550 feet have not. Most of the species which have penetrated the Lapeche drainage, with the exception of the spottail shiner and the banded killifish, are species, adapted to fast-water habitats, which could have penetrated the falls on Riviere Lapeche. The occurrence of these exceptions may be the result of bait introductions by anglers. The margined madtom is most probably an introduction (Rubec and Coad 1974). The greater diversity of the Lapeche drainage over the Meach-Philippe drainage is largely due to its greater accessibility. This has allowed some Ottawa River forms to penetrate Riviere Lapeche after the

present drainage pattern had become established. Likewise, northern pike, rockbass, and blackchin shiners are present in the Fairy Lake drainage due to the relative accessibility of the lake at 194 feet from the nearby Ottawa River at 180 feet.

Forms such as the brown bullhead, yellow perch, bluntnose minnow, and pumpkinseed

**[Begin Page: Page 396]**



are considered warm-water species on the basis of their physiology and limited northern distribution. If they entered the area after the Champlain Sea episode, the falls on Meach Brook would have blocked their dispersal into the Meach-Philippe drainage, where they are known to be present. If they entered before the Champlain Sea, they should be present in the lakes along the escarpment. Only the

pumpkinseed is found in lakes draining over the escarpment. Dymond (1939) has suggested that the pumpkinseed may not have been native to Meach Lake, but this is difficult to believe in light of its widespread distribution in Gatineau Park drainages. Pumpkinseeds were present in Chelsea Brook when Small (1883) first fished these waters. In light of the distribution, I believe the pumpkinseed entered the Gatineau Park during the Lake Frontenac phase. The bluntnose minnow, yellow perch, and brown bullhead have distributions similar to that of the smallmouth bass which is known to have been introduced, leading me to believe that these species may be present due to introductions. Since the yellow perch, brown bullhead, and banded killifish have salinity tolerances as high as 10-15 parts per thousand, it is also possible that they entered the area during the latter part of the Champlain Sea.

## Man's Influence on the Fish Fauna

Cuerrier and Dadswell (1969) found that the lake trout, brook trout, lake whitefish, and Cisco, which were abundant in the late 1800s (Dymond 1939), had disappeared from many Gatineau Park lakes and had very reduced populations in the remainder. Cuerrier (per-

sonal communication) has talked to local residents who remember taking whitefish and lake trout from Lac Mousseau "by the barrel load" no more than 50 years ago. Intensive gill netting in the same lake showed that lake trout had disappeared and whitefish were on the verge of extinction (Cuerrier and Dadswell 1969). Dymond's information can be compared with data supplied by Cuerrier to show this general decline (Table 2).

The causes of the dechne are difficult to assess. The lakes of the Gatineau district supported a substantial fishery in the late 1800s

(Dymond 1939). Dymond cites a series of annual reports of the Department of Marine and Fisheries in which, in 1 870, W. L. Holland reported that local residents used nets and spears in and out of season, wastefuUy fishing to supply American dealers. In 1875, 78 commercial fishing hcences were granted in Gatineau district lakes. In 1873 Holland reported that local residents had complained that the lumbermen injured the fisheries by erecting dams at the outlet of lakes, thus preventing fish from reaching their spawning grounds. It was noted that the yield of fish had decreased

in places where the dams had been constructed.

As the urban population of Ottawa and Hull grew, the Gatineau lakes became a resort area. Increased angling pressure may have been an important factor in depleting trout species, but this does not explain the dechne of whitefish and Cisco. Cuerrier and Dadswell (1969) cite illegal netting as one important factor which may have helped cause the disappearance of lake trout from Lac Lapeche and Lac Mous-seau about 1940. With the creation of the park area in 1938 the remaining fish population have not recovered to their former abundance.

In 1908 smallmouth bass were introduced by anglers into Lac Lapeche, Lac Philippe, Lac Mousseau, and Meach Lake (Dymond 1939). My survey indicates they have also gained access to Brown, Taylor, Carmen, Sandy, Curley, and Leblanc Lakes where they were found to be abundant in the seine catches (Table 1).

In the larger lakes I found a low general abundance of minnows per seine haul. With the exception of the bluntnose minnow, most cyprinids were taken in secluded areas such as stream entrances, bays, and weedy areas where

bass were uncommon. The smallmouth bass tended to be found over open areas, with either rock or sand bottoms, occupying the predominant habitat in these larger lakes.

In the small lakes, where bass were found to be present, minnows were either scarce or absent. No minnows were taken in Curley and Sandy Lakes, while Carmen Lake and Leblanc Lake, each yielded a single creek chub, after considerable seining effort. In Taylor and Brown Lakes minnows were captured but

**[Begin Page: Page 397]**



Tahle 2 — Present and past distribution of cold-water fish in Gatineau Park waters



J £ S

kJ j

J E

TO ,

J H-1

U ei H

i4 ^ (>0

o

Distribution in late 1800s

Coregonus cliipeaformis

Coregonus artedii

Salvelinus fontinalis

Salveliniis namaycush

Present indigenous distribution

Coregonus cJupeaformis

Coregonus artedii

Salvelinus fontinalis

Salvelinus namaycush

X X

X X X X

XXXXXXXXXXXXXX

X X X X

X X X X

X

X

appeared to be of larger size-classes. The scarcity of minnows in these small lakes seems unusual since abundant minnow populations were noted in tributary streams and in other nearby lakes lacking bass.

Dymond (1939) noted that it was unusual to find smallmouth bass and trout species occurring in the same water except in large lakes such as the Great Lakes. Competition for the same food supply usually results in the eventual elimination of either bass or trout in small and medium-sized lakes. The larger lakes in Gatineau Park have reduced populations of brook trout while these fish have completely disappeared from most of the smaller lakes (Table 2). Whether food competition between smallmouth bass and brook trout has occurred cannot be determined on the basis of this survey. It can only be stated that the introduction of smallmouth bass, especially in the smaller lakes, coincides with the depletion of the minnow fauna and the decline or disappear-

ance of brook trout. Cuerrier and Dadswell (1969) showed that smallmouth bass in Lac Mousseau preferred the same foods as brook trout and yellow perch during the spring. Smallmouth bass, as well as being a predator on brook trout, appeared to be a direct competitor with trout for food with respect to mayflies, dragonflies, and small perch during

June. Food competition with overpopulated bass and perch is believed to be the greatest factor affecting the trout population of Lac Mousseau.

While food competition between smallmouth bass and brook trout may have contributed to the decline of the trout, it cannot account for the disappearance of other species such as lake whitefish and cisco. Indeed, brook trout have disappeared from small lakes where bass were not introduced, suggesting that the competition with bass for food was only one factor leading to a decline of the original salmonid fauna.

Oxygen Depletion

The other major factor noted by Cuerrier and Dadswell (1969) was that most of the

lakes in the Gatineau Park had hypolimnia containing very little oxygen during the late summer (0-2 ppm). M. Dickman (197L Report to the National Capital Commission) confirmed this observation with detailed oxygen profiles. Intense phytoplankton production had caused an oxygen maximum to occur below the thermocline in Pink, Meach, and Kidder Lakes. In most lakes examined, a marked decline in oxygen levels, characteristic of eutrophic conditions, was noted below the thermocline.

This widespread depletion of the hypolimnia

**[Begin Page: Page 398]**



of Gatineau Park lakes would seem to offer the most likely explanation for the disappearance of its cold-water salmonid species (Larkin and Northcote 1970). The persistence of lake

trout in Meach Lake and their disappearance in Lac Lapeche, Lac Mousseau, and Lac PhiHppe becomes understandable in view of the relatively high oxygen values in the hypolimnion of Meach Lake compared with those of the other lakes (Dickman 1971. Report to the National Capital Commission). As recently as about 1960 abnormally warm summer conditions may have brought about an oxygen depletion resulting in a mass mortality which exterminated cisco in Lac Lapeche (D. Sauve, personal communication).

The cause of the low oxygen levels in the hypolimnia of these lakes is not known. Deforestation between 1850 and 1924, a forest fire which swept along the escarpment from Old Chelsea past Luskville during the fall of 1924 (J. C. McCuaig, personal communication), and drainage from outdoor privies are factors which may have allowed excessive nutrients to enter the lakes, resulting in depletion of hypolimnia.

Recent Introductions

The decline of native cold-water species has created a sport fisherman's vacuum. Larger fishes are absent from such lakes which usually

support abundant minnow populations. In other lakes stunted smallmouth bass (Doan 1940) and yellow perch are the only game fish available during the summer.

In an effort to maintain a fauna compatible with the original fish fauna, the National Capital Commission has initiated introductions of various fish species within the last 5 years. A limited number of cisco were introduced into Meach Lake to replace those which had disappeared. About a half million smelt eggs were introduced into streams adjoining Lac Mousseau (Cuerrier and Dadswell 1969). Limited introductions of lake trout, splake (Salvelinus jontinalis X ^- namaycush), rainbow trout (Salmo gairdneri), and atlantic salmon (Salmo salar) have also been made mainly in the larger lakes of the Meach-Philippe system. Widespread introductions of brook

trout have been made mainly in the smaller lakes, with partial success, suggesting that some of these lakes may still be capable of supporting trout species. Black Lake is an example where stocking of brook trout provided sport for anglers in the spring of 1972 and 1973.

The success or failure of such plantings may help clarify whether exploitation or environmental deterioration has been the dominant factor in causing a dechne in the native cold-water fish fauna. It remains to be seen whether any of the introduced species will establish self-sustaining populations. Cuerrier and Dadswell (1969) noted limited reproduction of brook trout introduced into Lusk Lake. The introduction of about 4.5 million walleye fry into Lac Lapeche in 1968 may have failed owing to predatory yellow perch. Of about 80 adult walleye introduced into Lac Lapeche only one is known to have been recaptured and no signs of natural reproduction have yet been noted.

Gatineau Park is fortunate to have small lakes which can be manipulated and which lend to management techniques. Careful studies by biologists are needed to evaluate the effect of these introductions and to apply a consistent management policy.

Acknowledgments

I am grateful to G. Hamre and R. Plummer who assisted in making the collections; J.-P.

Cuerrier of the Canadian Wildlife Service supplied unpublished data concerning game fish species and D. E. McAllister supplied advice and information from National Museum of Natural Sciences collections; M. Outhet and V. Edey of the National Capital Commission, D. Sauve, J. Harrison, J. C. McCuaig, long-time local residents, and M. J. Dadswell supplied further information concerning the history of these lakes. The study that made this survey possible was directed by M. Dickman, Brock University. I thank G. Ben-Tchavtchavadze and J. Helie for preparing the map and tabulations, and B. Woodley for photographing the waterfalls. I am also indebted to the reviewers who suggested improvements to this paper.



Literature Cited

Antevs, E. 1925. Retreat of the last ice-sheet in Eastern Canada. Geological Survey of Canada Memoir 146: 59-89.

Cuerrier, J.-P. and M.J. Dadswell. 1969. Limnology and experimental fishery management studies in Gatineau Park during 1968. Canadian Wildlife Service Manuscript Report. 107 pp.

Dadswell, M.J. 1972. Postglacial dispersal of four deepwater fishes on the basis of new distribution records in eastern Ontario and western Quebec. Journal of the Fisheries Research Board of Canada 29: 545-553.

Delisle, C. and C. Veilleux. 1969. Repartition geographique de l'eperlan arc-en-ciel Osmerus epeilanus mordax et de Glugea hertwigi (Sporozoa: Microsporidea) en eau douce, au Quebec. Naturaliste Canadien 96: 337-358.

Doan, K. H. 1940. Studies of the smallmouth bass. Journal of Wildlife Management 4(3): 241-266.

Dymond, J. R. 1939. The fishes of the Ottawa region. Contribution of the Royal Ontario Museum

15: 1-43.

Elson, J. A. 1969. Radiocarbon dates, Mya arenaria phase of the Champlain Sea. Canadian Journal of Earth Sciences 6: 161 -'hll.

Gadd, N. R. 1963. Surficial geology of Ottawa map-area, Ontario and Quebec. Geological Survey of Canada 62-16: 1-3.

Goldthwait, J. W. 1933. Selected passages from the St. Lawrence lowland. In Pleistocene geology of the central St. Lawrence lowland. Geological Survey of Canada Memoir 359(1971): 113-153.

Gruchy, C. G. 1968. Two late Quaternary Salmonidae (Pisces) from the Ottawa area, Canada. Vestnik Ceskoslovenske Spolecnosti Zoologicke Acta Societatis Zoologicae Bohemoslovacae (32 (4): 337-341.

Harington, C. R. 1971. The Champlain Sea and

its vertebrate fauna. Part 1. Trail & Landscape 5: 137-141.

Johnston, W. A. 1916. Late Pleistocene oscillations of sea-level in the Ottawa Valley. Geological Survey of Canada Bulletin 24: 1-14.

Larkin, P. A. and T. G. Northcote. 1970. Fish as indices of eutrophication. In Eutrophication: causes, consequences, correctives. National Academy of Sciences, Washington, D.C. pp. 256-273.

Ogden, J. G. 1965. Radiocarbon and pollen evidence for a sudden change in climate in the Great Lakes region approximately 10 000 years ago. In Quaternary paleoecology. Edited by E.J. Gushing and H. E. Wright. Yale University Press. pp. 117-130.

Prest, V. K. 1970. Quaternary geology of Canada. In Geology and economical minerals of Canada. 5th edition. Department of Energy, Mines and Resources, Ottawa, pp. 675-764.

Romanelli, R. 1975. The Champlain Sea episode: the Gatineau Valley and Ottawa area. Canadian Field-Naturahst 89. This issue.

Rubec, P.J. and B. W. Coad. 1974. First record of the margined madtom {Noturus insignis) from Canada. Journal of the Fisheries Research Board of Canada 31(8): 1430-1431.

Ryder, R. A., W. B. Scott, and E. J. Grossman. 1964.

Fishes of northern Ontario, north of the Albany River. Contributions of the Royal Ontario Museum 60: 1-30.

Small, H. B. 1883. Fishes of the Ottawa District. Transactions of the Ottawa Field-Naturalists' Club 4: 31-49.

Terasmae, J. and O. L. Hughes. 1960. Glacial retreat in the North Bay area, Ontario. Science (Washington) 131: 1444-1446.

Received 2 October 1972

Accepted 21 May 1974