PROBLEMS AND LIMNOLOGICAL ASPECTS OF RECREATIONAL LAKES OF THE BOUNDARY WATERS CANOE AREA

Thesis for the Degree of M. S.

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ABSTRACT

PROBLEMS AND LIMNOLOGICAL ASPECTS OF RECREATIONAL LAKES OF THE BOUNDARY WATERS CANOE AREA

by James William Langdon

This thesis deals with a survey to: (1) establish the general characteristics of the lakes of the Boundary Waters Canoe Area (BWCA); (2) investigate reports of pollution of Shagawa Lake and lakes within the BWCA; (3) observe use of the area, examine habits and attitudes of users, and estimate the extent of overuse, littering, vegetation and campsite destruction, and incompatible uses; (4) determine the attitudes of people living in the area surrounding the Boundary Waters Canoe Area and to examine the economic situation in these surrounding areas; and (5) observe Forest Service management techniques and attitudes.

The BWCA lakes are primarily soft water lakes of low productivity. Physical, chemical, and biological characteristics of specific BWCA lakes are discussed.

Shagawa Lake lies outside the BWCA, but its waters flow into some of the most important "wilderness" lakes. Data indicate that Shagawa Lake is polluted; and that the wilderness lakes downstream from it appear to be becoming enriched. The practice of drinking untreated water from the lakes is discouraged.

Many undesirable camping habits were observed, such as littering, campsite defacement, and timber destruction. A permit system, requiring an educational briefing, in conjunction with strict regulations, fines, and enforcement, is discussed as a means of reducing these behaviors which are destructive to the wilderness qualities of the area.

Characteristics of local residents and recreational users of the BWCA are presented. Impact of the BWCA regulations upon the local economy is discussed.

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It is proposed that management of the BWCA be placed in the hands of one man who has a broad background in recreation and management of resources — especially water resources. Working under this man should be personnel assigned exclusively to the BWCA. These workers should have training to develop their perception toward protecting and enhancing the wilderness aspects of the area.

PROBLEMS AND LIMNOLOGICAL ASPECTS OF RECREATIONAL LAKES OF THE BOUNDARY WATERS CANOE AREA

By

James William Langdon

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Plate I. Typical BWCA Lakes

INTRODUCTION

The Boundary Waters Canoe Area is an expanse of 1,038,000 acres of lakes and forest which lies along the Canadian border in northeastern Minnesota. It begins about 20 miles inland from Lake Superior and continues west for another hundred miles or more, reaching almost to Rainy Lake. The character of the land is rocky and rugged, though of relatively low relief. The lakes are very numerous, nearly adjoining, and often interconnected. Long canoe trips can be taken through a myriad of lakes, by portaging over short distances of land between lakes.

One trip consists of 235 miles of paddling, nine miles of portaging, and requires about three weeks of steady paddling. This trip traverses more than forty lakes, many connecting rivers, and includes many portages around falls and rapids. A typical one-week trip involves 50 miles of paddling, 4 miles of portaging, and spans 22 lakes.

Because of the dense lakes and unique scenic value of the area, it historically has been a Mecca for canoeists. From the voyageurs of the 1700's to today's business executive who is just getting away from it all, people have paddled over these lakes, enraptured by the endless pristine waters, by the sheer rock bluffs, and the deep silence — shattered only by the call of a loon or the snort of a deer.

Over the years, there have been a series of laws enacted in an attempt to maintain these lakes as an essentially unmodified wilderness-type canoe area. Today, the Boundary Waters Canoe Area (BWCA) is entirely within the Superior National Forest; and is under the administration of the U. S. Forest Service, which manages it as a multiple use area.

Problems presently besieging the Boundary Waters Canoe Area partially include overuse, littering, vegetation and campsite destruction, possible pollution, algal blooms, conflicts in management policies, pressures for development and exploitation of the area, and incompatible uses — such as logging, motor boats, houseboats, large party boats, and canoe ferries.

My purposes in this study were several:

1. To obtain firsthand knowledge of, and experience in, the area.
2. To survey the lakes in order to learn their general characteristics and variability.
3. To investigate pollution reports, find possible pollution sources, and analyze lakes and streams for chemical and biological indications of pollution.
4. To observe use of the area, examine habits and attitudes of users, and estimate the extent of overuse, littering, vegetation and campsite destruction, and incompatible uses.
5. To determine the attitudes of people living in the area surrounding the Boundary Waters Canoe Area and to examine the economic situation in these surrounding areas.
6. To observe Forest Service management techniques and attitudes.

Many special regulations and policies are in effect. No public roads exist, or may be built, inside the area. No buildings may be constructed and no vehicles may pass inside its boundaries. Planes may not fly below 4,000 feet over the area. They may not land on any of the lakes, except in emergencies. Logging is restricted to the southern portion of the area; and, there, no trees may be cut within 400 feet of any body of water. This leaves a strip of trees 400 feet wide around lakes and on both sides of rivers.

A high proportion of the land within the Boundary Waters Canoe Area is owned by the federal government, and the land which remains in private ownership is being purchased by the Forest Service as rapidly as possible. A few structures, such as cabins and resorts, still exist; but they will be removed as soon as purchases are completed. In some cases, condemnation proceedings have been required to affect government acquisition.

Table 1. Land Ownership in the BWCA as of February 14, 1963[1]

Ownership	Acres	Percent
Federal	736,204	84.4
State	104,111	11.9
County	14,728	1.7
Private	17,197	2.0
Total Land (excluding water)	872,240	100.0

[1] R. C. Lucas, Recreational Use of the Quetico-Superior Area, U. S. Forest Service Research Paper LS-8 (St. Paul: Lake States Forest Experiment Station, 1964), p. 6.

Quetico Provincial Park

Directly north of, and connected to, the Boundary Waters Canoe Area is Quetico Provincial Park. In 1909, the same year that President Theodore Roosevelt established the Superior National Forest, the province of Ontario established the Quetico Provincial Park adjacent to the Superior. The park covers 1,132,800 acres and measures roughly 60 miles east to west and 40 miles north to south. It is managed in the same manner as the Boundary Waters Canoe Area. It's development has virtually paralleled that of the BWCA. Considerable cooperation exists between the United States and Canada in managing the two areas. Quetico Park is considered to be wilder, less used, and have better scenery and fishing by many United States citizens. Often, the two areas are considered together and referred to as the Quetico-Superior area.

Figure 1. The Quetico-Superior Area

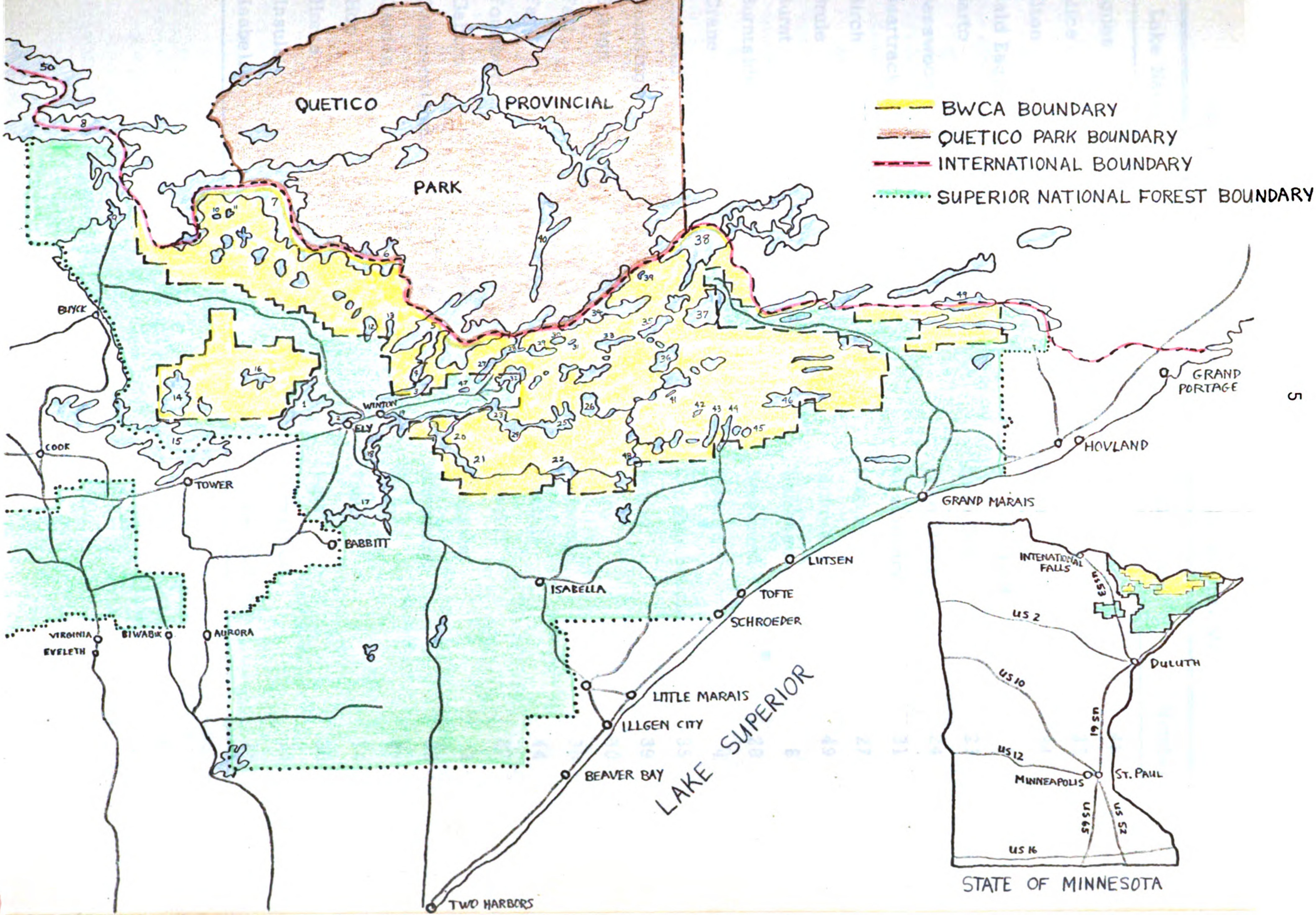

Table 2. Names of Lakes Numbered on Locational Map

Lake Name	Number	Lake Name	Number
Agnes	40	Kawishiwi	48
Alice	26	Kekekabic	33
Alton	43	Knife	34
Bald Eagle	21	Lac La Croix	7
Barto	42	Lake One	23
Basswood	5	Lake Three	24
Beartrack	11	Missionary	31
Birch	17	Moose	27
Brule	46	Mountain	49
Burnt	45	Namakan	8
Burntside	1	Newfound	28
Crane	9	Newton	4
Crooked	6	Ogishkemuncie	35
Cummings	16	Rabbit	39
Ensign	29	Rainy	50
Fall	3	Saganaga	38
Fat	10	Sawbill	44
Fourtown	12	Seagull	37
Gabbro	20	Shagawa	2
Gabimichigami	36	Snowbank	32
Garden	19	Tofte	47
Hop	41	Trout	14
Horse	13	Vera	30
Insula	25	Vermillion	15
Isabella	22	White Iron	18

CHAPTER I

HISTORY OF THE BWCA[1]

The Canoe Country was occupied by the Sioux Indians until the middle of the eighteenth century when the Chippewas drove them to the southwest.

The eighteenth century also saw the arrival of the French fur traders, the voyageurs. They traveled by canoe through the many inland waterways trapping furbearers and transporting furs.

After the British succeeded the French in controlling the area, continuing trapping pressure into the nineteenth century reduced the populations of furbearers, forcing the larger fur trading companies to move west.

In 1854 the Treaty of LaPointe with the Chippewas of Lake Superior opened the area for exploration and settlement. Several gold rushes followed; but little gold was found. The real "find" was the discovery of iron ore. In the late 1800's, mines were opened at Soudan and Ely — both a few miles south of the present BWCA boundaries. In the ensuing two decades, many mines were developed in the area, accompanied by several boom towns. In this period, timber cutting was flourishing and populations of miners were augmented by lumberjacks and sawmill workers.

In 1909 President Theodore Roosevelt established the Superior National Forest composed of three separate blocks of land which contained only about one-quarter of the present Boundary Waters Canoe Area. Thus began the reign of the U. S. Forest Service over the Canoe Country. In this same year, the Province of Ontario established the Quetico Provincial Park directly north of, and connecting with, what is today's BWCA.

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[1] Sources of material for this chapter are: R. C. Lucas, Recreational Use of the Quetico-Superior Area, U. S. Forest Service Research Paper LS-8 (Forest Service, U. S. Department of Agriculture, 1964), pp. 6-7; Boundary Waters Canoe Area Review Committee, Report to the Secretary of Agriculture Orville L. Freeman, December 16, 1964; Quetico-Superior Committee, Report to the President of the United States, December 1953.

In 1912 under the authority of the Weeks Act of 1911, the boundaries of the Superior National Forest were extended to include about 380,000 additional acres.

Following World War I, there was an influx of recreational users to the area; and in 1919 there were an estimated 12,750 visitors to the Superior National Forest.

The following decades have brought bitter controversy concerning the management of the area. Increased interest in travel and outdoor recreation, plus the increase in automobile transportation, caused the proposal that roads be built into the interior of the area. This, plus the increased interest in timber harvesting, and a proposal for water power development along the border lakes, created a sharp conflict between exploitive and wilderness interests.

The problem was that the BWCA was not a true wilderness area and could not simply be subjected to the strict management policies of a wilderness area. There were extreme pressures both for exploitation and development on one hand, and for protection, preservation, and return to natural conditions, on the other. This was the dilemma facing the Forest Service.

One attempt to solve the problem was made in 1919 when the Forest Service hired Arthur H. Carhart as a landscape architect to study the area and make recommendations. He recommended that "if Minnesota wishes to retain the scenic beauty that is hers, there must be some immediate action." He advised that the cutting of timber could continue, but that timber on lakeshores and riverbanks should be protected. He concluded that "the scenic and recreational values are so precious to the nation that, so far as the lake unit itself is concerned, they should take precedence over all other possible uses of the lakes." In 1922 Mr. Carhart resigned with the comment, "the recreation needs more funds and organization to work with in order to approach the needed recreation progress."

In 1926, Secretary of Agriculture Jardine issued the first statement of policy for the management of the primitive area. The main provisions were:

To maintain as much wilderness as possible.

To build no roads.

To prohibit recreational developments.

To build simple campground facilities.

To judiciously utilize timber.

In 1930, the Shipstead-Newton-Nolan Act was passed. It stated that there be no further alterations of water levels except by special act of Congress; and that there be no logging within four hundred feet of natural shore lines, except for practical reasons.

In 1933, Minnesota passed a similar law protecting state-owned shorelines within the area.

In 1939, the Forest Service enlarged the "Roadless Area" to a total of 1,038,743 acres.

In 1941, the Forest Service prohibited timber cutting on 362,000 acres in the northern BWCA along the Canadian border. Also in this year the Canoe Country began to be invaded by airplane fishing camps on private land inside the "Roadless Area."

In 1948, a bill was passed which appropriated $500,000 for acquisition of private lands within the area.

In 1949, President Truman issued an executive order establishing an air space reservation over the area, the order to become effective in 1951. The order restricted landing on the lakes and flying below 4,000 feet, except in emergencies for for safety reasons.

In 1956 and 1961, a total of four and a half million dollars was appropriated to acquire the remaining private lands. The Forest Service was also authorized to employ the right of eminent domain on tracts that could not otherwise be acquired.

In 1958, Boundary Waters Canoe Area was selected as a more appropriate name for the area. In 1964, Secretary of Agriculture Orville Freeman appointed a committee to review management of the Boundary Waters Canoe Area. As a result of their recommendations, 272,000 acres were added to the "no-cut" zone.

Still today, in 1965, the Boundary Waters Canoe Area is coveted by opposing interest, fraught with management problems, torn with controversy, debated with bitter emotions, and clouded with misconceptions and ignorance.

CHAPTER II

THE LAND AND FOREST

Terrain

The terrain of the Boundary Waters Canoe Area (BWCA) is rough and even rugged in certain areas. Rock outcrops are common; and much of the area soil is merely an inch or two of recently disintegrated rock underlying lichens or moss. Trees often seem to be growing right out of solid rock. Actually, in such cases, the roots are growing down into soil-filled fractures in the exposed rock.

Steep rock bluffs are common, although their magnitude is usually small. Fifty to one hundred degree "cliffs" are everywhere, but they often are only ten to thirty feet high (see Plate II). Occasionally a craggy bluff from fifty to over one hundred feet in height is seen — usually at the water's edge of the lake.

Relatively flat areas are not unusual, however. Bogs and swamps are common. In the southern reaches of the BWCA, the terrain tends to be smoother. Greater amounts of glacial drift are apparent in the southern portion.

Geology

The Boundary Waters Canoe Area is underlain by Pre-Cambrian igneous and metamorphic rock. Bodies of granite, basalt, gabbro, slate, and Ely Greenstone are found in the Canoe Country. Iron ores such as magnetite and hematite are present, mostly in low proportions mixed with other minerals and rock, forming low-grade ores. In at least one location I saw what appeared to be an extensive area of phyllite. Veins of quartz are common. The entire area has been extensively glaciated, leaving much of the exposed rock smoothed and rounded. Still, many sharp, jagged rock bluffs exist. I recall one, seldom used, canoe portage-trail where I found myself carrying an 18 foot boat on my shoulders while tiptoeing along a foot-wide trail, the right

Plate II. Typical Rock Bluff Shoreline

edge of which dropped 30 feet straight down a jagged 90 degrees. There exists scattered, thin layers of glacial drift. Large boulders and glacier-transported erratics are common.

Climate[1]

The Canoe Country has an essentially continental climate. Some slight moderation probably results from the large proportion of lake surface within and around the area and perhaps from Lake Superior to the east. Sharp variations in temperature are common.

Winter lows of 50 degrees below zero are not rare. Summer highs are usually in the 70's, sometimes in the 80's, and occasionally in the 90's. The mean annual temperature for this part of Minnesota is 39.2 degrees. Mean monthly temperatures are 10 degrees for January, 43 degrees for April, 52 degrees for May, 60 degrees for June, 65 degrees for July and August, and 55 degrees for September. The normal growing season is 90 days. Frost has been reported for every month except July.

Annual mean precipitation is 27.3 inches. Almost half this amount falls during June, July, and August, time time period of heaviest recreational use. There is an average of about 30 thunderstorms per year. Experienced BWCA travelers take considerable amounts of rain gear on their wilderness trips. Winter precipitation is relatively light — averaging about 1 inch per month, from December through March.

Hydrology

The solid-rock nature of the area causes infiltration and ground water storage to be low. The water levels of the lakes are primarily dependent upon surface runoff. Stream flows fluctuate widely. Streams are often simply overflow values between one rocky basin lake to another. See Plate III, page 13.

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[1]Source for much of the material in this section: Minnesota Department of Conservation, Hydrologic Atlas of Minnesota, Bulletin No. 10 (St. Paul, April 1959).

Plate III. Typical Short "River" Between Two Lakes

Ground water is generally restricted to fractures in the bedrock and depressions filled with glacial drift. Such conditions are accompanied by variable permeability, often allowing ground water to move rather rapidly from one point to another. This is illustrated by a well at the U. S. Forest Service cabin on Basswood Lake. The well was located a reasonable distance from the toilet, yet tests of the well water indicated very high concentrations of ammonia, chloride, and coliform bacteria.

Forest Cover

The forest cover of the BWCA is primarily small to medium-sized jack pine, aspen, spruce, fir, and white birch, in that approximate order of importance. Scattered specimens, mixed stands, and a few pure stands of white pine and red pine still exist; but only 3 percent of the area has these species as the dominant cover.

In spite of the "wilderness" character of the Canoe Country, much of the forest cover has been subjected to cutting or burning at some time. Portions of the area were cut over before it became part of the Superior National Forest; and considerable cutting has taken place since then. Apparently, fires were common preceding the twentieth century. Scanty records dating as far back as the early 1700's indicate this. A Jesuit priest, Father Jean Pierre Aulneau, wrote, "that in 1735 he 'journeyed nearly all the way' from Lake Superior to Lake of the Woods 'through fire and a thick stifling smoke' which prevented him from 'even once catching a glimpse of the sun.' "[1]

Originally, white and red pine were the dominant species of the area; but today, the most common trees seen are relatively small jack pine with a few scattered, but not uncommon, large white and red pine. Aspen, spruce, and fir are also common. White birch provide an attractive contrast to the evergreens. An interesting fact is that many quaking aspen in the area have bark nearly as white as the white birch.

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[1] Boundary Waters Canoe Area Review Committee, op. cit., p. 2.

Table 3. Percentage Distribution of BWCA Forest Cover Types[1]

Jack pine	27
Aspen	23
Spruce	19
White birch	14
Balance (cedar, tamarack, & unreported)	14
Red and white pine	3
	100

[1]C. R. Humphrys, "Problem Area Analysis of the Boundary Waters Canoe Area, Superior National Forest, Minnesota" (unpublished report in files of author), p. 157.

CHAPTER III

RECREATIONAL USE IN THE BWCA

Public demand has directed the development of management policy for the Boundary Waters Canoe Area. The public has always perceived the Canoe Country as a wilderness-type area, and has used it as such. This attitude and use has forced governmental policies to be formulated to maintain the wilderness aspect of the area. Whenever an incompatible use has arisen, public pressure has brought about prohibitive regulations to stop the disagreeable usage. Public pressures have resulted in recent regulations prohibiting resorts, aircraft landings, use of vehicles, snowmobiles, motorboats (in the interior lakes), and storage of boats on public land.

Recreational use of the BWCA has increased from an estimated 50,000 in 1953 to approximately 230,000 in 1963.[1] It can be predicted that in the near future between one-third and one-half million visits per year will be made to the area. Over 50,000,000 people live within a 750 mile radius of the Boundary Waters Canoe Area. By the year 2,000 nearly 800,000 visits are projected for the BWCA.[2]

Types of Use

The prime intended use of the Boundary Waters Canoe Area is, of course, canoeing. The majority of canoeists rent canoes from local canoe outfitters; although some bring their own canoes. Food, utensils, and extra clothes are put into packsacks for carrying over portages. Small tents are the most common shelters used by most canoeists. The paddling canoeists usually take

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[1] Boundary Waters Canoe Area Review Committee, loc. cit.

[2] Wildland Research Center, Wilderness and Recreation — A Report on Resources, Values, and Problems, Outdoor Recreation Resources Review Commission Study Report 3 (Washington: U. S. Government Printing Office, 1962), p. 236.

trips of one week or more. Paddling canoeists make up the majority of the users on the interior lakes; however, other types of use do exist.

Motorized canoes are a common sight in the BWCA. Both square stern canoes and the double-end types with motors on side brackets are used. This tends to be a rather specialized group. Few are traveler-campers. Most are fishermen or campers on short distance trips. The bulk and weight of motor and cans of gas are a hindrance during portaging, and the amount of gas required for a long trip is prohibitive.

Outboard powered runabouts and fishing boats are common in many of the larger lakes which are accessible by direct water route, by road, or by mechanized portage. Even small houseboats and pontoon boats are not uncommon. A few large commercial houseboats and passenger boats operate on the BWCA lakes, particularly on Basswood Lake.

People are constantly devising new methods to transport large boats over portages. I have seen 12 to 16 foot runabouts and fishing boats equipped with retractable bicycle-type wheels, rollers, and dollies with small rubber wheels (see Plate V, page 19). However, these are useful only on the easier, smooth, wide portages.

Large lakes which have direct water access from outside the BWCA, road access, or a mechanized portage usually have heavier use by motor boats than by canoes.

Robert C. Lucas's study of recreational use of the Quetico-Superior area, in 1961, revealed some unusual facts.[1] He estimates that during the study period, June 11 through September 16, 1961, 38,200 people canoed in the BWCA and 37,500 used motor boats. Further, he estimates that in 1961 there were 117,000 "visits" by motor boaters, compared to 76,000 for canoeists. A key factor here is that many motor boat users are local fishermen who enter the area several times each year for a single day's fishing. Many motor boat

[1] R. C. Lucas, op. cit., pp. 11-13.

Plate IV. Motorized Canoe on Basswood Lake

Plate V. Dollies Extend the Range of Motor Boats Beyond the Easier Portages vacationers camp, or stay at resorts, outside the BWCA and make daily forays into the area. Lucas calculated that 41 percent of the visitors did not stay overnight in the interior.

Canoeists, especially paddling canoeists, tend to camp within the area. One of their "visits" might be equal to from five to twenty motor boat "visits."

Camping

At present, camping is allowed anywhere. The Forest Service has developed many campsites on the lakes, supplying usually a wooden table, a fireplace, and often a latrine. Campers continually make more campsites, often simply any 6 foot by 4 foot flat spot that is available. Islands are, by far, the favorite spots for making camp. Islands seem to have a universal attraction — isolation and privacy, freedom from bears and insects, plus a magical something that is undefinable.

Factors Affecting Use

Geographically speaking, the use of the area is very non-uniform. A few lakes are used heavily, and the rest are used very lightly. Important factors are ease of access and proximity of the lake to the main routes. Over the years, routes have evolved which course through the greatest amount of water, but with the least amount of portaging. One non-mechanized portage will stop most motor boats.

A few mechanized portages exist within the BWCA located on a few long or difficult portages. These do provide a means of extending the range of boats which are too heavy to be carried across a portage.

Routes have come to follow the course of least resistance. Generally, the only lakes which are used heavily are lakes which are easily accessible themselves and also allow easy access to a string of other lakes. Consequently, a few well-traveled routes carry tens of thousands of people every year and countless other routes are used by only a few people per year.

A rough count indicates that there are approximately 20 good access points to the BWCA and roughly 30 marginal access points. Figures indicates that

Plate VI. Typical Rock Island,
the Favorite BWCA Camping Spot

over 50 percent of all paddling canoeists begin their trips from the same access point, Moose Lake. Only 34 starting points had measurable use.[1]

The reasons for Moose Lake's popularity point up the most important factors affecting use of a lake or route. There is a good road to Moose Lake. There are several canoe outfitters located on the lake itself. There is a U.S. Forest Service camp ground, boat-launch area, and large parking lot on the lake. Moose Lake is situated in the middle of the most desirable lake area. It offers a direct water route of less than 10 miles to the nearest point of entry into Quetico Park. It is also the closest entry point to many of the favorite routes and lakes, including Knife, Ensign, eastern Basswood, Birch, Louisa, Agnes, and Kawnipi Lakes.

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[1] Ibid., p. 19.

Plate VII. The BWCA Is Not for Men Only

CHAPTER IV

THE PEOPLE

The residents of the area surrounding the BWCA are typical northern people — rugged and independent. The nationalities represented are primarily Finnish and Slovenian, with Swedish, Norwegian, German and others also present. The strong Finnish influence is seen in the numerous saunas — Finnish steam baths. These are usually small buildings standing near houses or cottages. The sauna ritual is so firmly entrenched that many people, when building, construct a sauna before the house or cottage is built.

The local residents tend to be rather suspicious of government agencies and large government projects. Many people are antagonistic toward the Forest Service and its BWCA policies. It is commonly felt that the Forest Service has pushed the local people out of the BWCA in an arbitrary way, having little or no concern for the economic losses suffered locally.

The vocations of the local people are primarily natural resource based, recreation based, or services. Logging, mining, and Forest Service employment make up the majority of the natural resource based employment. Recreation based occupations include work connected with resorts, canoe liveries, sporting goods stores, and motels. Many people eke out a living doing seasonal work such as logging or trapping in the fall and winter, guiding in the summer, and odd jobs whenever available. Farming is virtually nonexistant in the area.

Lucas' study showed some interesting characteristics of the recreational users of the BWCA.

Table 4. Characteristics of BWCA Users[1]

Category	Canoeists Motor	Canoeists Paddle	Boat Campers	Day Use	National Average
OCCUPATION (Census Bureau Definitions) Percent of Total Males Over 17, Not Still in School					
Professional, technical	26	71	15	6	9
Proprietor, manager, official	32	13	2	0	12
Clerk, sales	0	7	11	6	12
Skilled labor, foreman	13	2	39	31	17
Other labor	19	6	22	57	34
Farmer, farm manager	5	1	2	0	6
Retired	5	0	9	0	10
ANNUAL INCOME OF HEAD OF HOUSEHOLD (Before Taxes) Percent of Total					
$ 0 - 1,999	0	0	2	0	15
2,000 - 3,999	12	12	2	6	22
4,000 - 5,999	30	21	55	44	23
6,000 - 7,999	19	28	22	38)	27
8,000 - 9,999	11	9	10	6)	
10,000 - 14,999	19	16	7	0	9
15,000 - 24,999	3	9	2	6	3
25,000 & over	6	5	0	0	1
EDUCATIONAL LEVEL OF THOSE WHO HAD COMPLETED SCHOOL Percent of Total					
0 - 8 years	13	0	9	20	50
9 - 11 "	13	4	28	7	15
12 "	23	17	38	63	22
13 - 15 "	15	12	9	10	8
16 "	25	42	13	0)	5
17 and over	11	25	3	0)	

[1] *Ibid.*, p. 45.

The most striking characteristics of the user groups can be seen when their statistics are compared with the national averages. Almost three-quarters of the paddling canoeists come from the professional-technical group, compared to one-quarter for the motor canoeists. The national average is 9 percent.

Eighty-nine percent of the paddling canoeists have some college education, compared to a national average of 13 percent. Twenty-five percent of the paddling canoeists have had at least one year of post-graduate college education!

Fifty percent of 381 respondents questioned in 1958 resided in a metropolitan area with a population center of 500,000 or more. Only 15 percent came from rural areas.[1]

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[1] M. Taves, W. Hathaway, and G. Bultena, Canoe Country Vacationers, Misc. Report 39, Agricultural Experiment Station (Minneapolis: University of Minnesota, 1960).

CHAPTER V

WILDERNESS

What Is Wilderness?

Webster's dictionary defines wilderness as "a tract or region uncultivated and uninhabited by human beings; a wild; waste; hence, a pathless waste of any kind." In general usage, "wilderness" usually has the connotation of naturalness, vastness, ruggedness, being unknown, uncharted, unmapped, and perhaps being savage and dangerous. The Outdoor Recreation Resources Review Commission Study Report 3, defines a wilderness tract as an area of public or Indian land available for overnight recreation use (1) at least 100,000 acres in extent, (2) containing no roads usable by the public, (3) within a reasonably unified boundary configuration, and (4) showing no significant ecological disturbance from on-site human activity — except that domestic livestock grazing is an accepted disturbance in the West and early day logging is accepted for Eastern tracts.

The U. S. Forest Service administers many areas which it designates as "wilderness areas." Forest Service regulation U-1 states that

> Upon recommendations of the Chief, Forest Service, national forest lands in single tracts of not less than 100,000 acres may be designated by the Secretary as "wilderness areas," within which there shall be no roads or other provision for motorized transportation, no commercial timber cutting, and no occupancy under special use permit for hotels, stores, resorts, summer homes, organization camps, hunting and fishing lodges, or similar uses.

Grazing is allowed in national forest wilderness areas in the West. The landing of airplanes on national forest land or water and the use of motorboats on national forest waters within the designated wilderness area "are prohibited, except where such use has already become well established or for administrative needs and emergencies."

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The Boundary Waters Canoe Area is not, strictly speaking, a wilderness area, since some timber cutting is allowed. However, in the eyes of the people that use the area, its true value is its wilderness character.

"Wilderness" is a nebulous concept. It has different meanings to different people. A typical city dweller may enter the "wilderness" when he passes the last town and both sides of the highway are forested. A died-in-the-wool wilderness recreationist is in his wilderness only when he is far removed from the nearest building, road, trail, and human being. The sight of a tin can or scrap of plastic on the ground, or an axe-cut tree, ruins his wilderness.

Lucas' study illustrated these differences.[1] Paddling canoeists seemed to be the group with the most discerning wilderness concepts. This group of users, generally speaking, considered most, but not all, of the BWCA as wilderness. Many of the large lakes which receive heavy motorboat traffic, but which are inside the BWCA, were not considered wilderness by paddling canoeists.

Motorboaters considered a much larger area to be wilderness. All of the BWCA was included plus considerable adjoining area. This group included areas which contained roads and buildings.

Auto campers and resort guests considered an even larger area to be wilderness. Their "wilderness" extended almost all the way to Lake Superior on the east and to the southeast, an area which included many roads, highways, cabins, homes, and small settlements.

"Wilderness," then, is more a function of perception than of physical land characteristics, or government declaration. Even the most critical connoisseur of wilderness would likely have to admit that he has found certain spots, near cities or among inhabited areas, that had a definite wilderness feeling. Perhaps the essence of "wilderness" is a feeling, rather than the fact that a geographical area has had little use.

[1] R. C. Lucas, op. cit., pp. 1-50.

The Importance of Wilderness Recreation

Why this emphasis on wilderness? It would seem that as life becomes increasingly complex and modern, we should drift farther away from wilderness recreation. The facts seem to indicate the opposite.

The Outdoor Recreation Resources Review Commission Report 3 projects a tenfold increase in wilderness recreation by the year 2000. U. S. Forest Service data indicates that wilderness recreation is the fastest growing type of recreation on national forest lands. Recreational use-increase data on designated areas within national forests from 1946 through 1959 show that wilderness recreation increased 308 percent, as compared to 214 percent for campground, 209 percent for picnic area, and 200 percent for winter sports recreation increases.[1]

The BWCA has seen increases equal to, or greater than, these figures. The increase in visits from 1946 through 1959 was approximately fourfold.[2] One projection estimates 319,000 yearly BWCA visits by 1976 and 785,000 by the year 2000.[3] The Wildland Research Center projects a yearly BWCA use of nearly two million man-days, by the year 2000. However, these projections seem extremely conservative. Actual figures indicate that use, in terms of "visits," doubled from 1959 to 1963. These figures might, however, reflect a change in sampling techniques or a trend toward more frequent, shorter trips by BWCA users.

Why the Need for Wilderness Recreation?

The causes of the rapid increase in wilderness-type recreation are, of course, unknown. At least, no certain cause and effect relationships have been worked out. This would be quite difficult, since the entire matter is highly subjective.

Americans identify strongly with "wilderness," nature, and healthy outdoor living. We tend to feel that a life spent indoors performing essentially

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[1] Wildland Research Center, op. cit., p. 124.

[2] Calculated from U. S. Forest Service data.

[3] R. C. Lucas, op. cit., p. 41.

non-physical tasks leads to degeneration of body and soul; while outdoor living, fresh air, sunshine, and vigorous exercise molds a robust, healthy body and mind. This is one notion that seems to have some basis in fact.

Much of America's formation and history is based upon the conquering of wilderness and carving a living out of the wilderness. We tend to see wilderness as a thing of beauty, uncorrupted by centuries of civilization. Many Americans tend to perceive Europe as the latter. Strangely enough, many Europeans would probably view wilderness with disgust and antipathy.

Probably the most active cause for our need for wilderness recreation is our rapidly complicating society. Ours is a culture in a rapid state of flux. We are undergoing revolutionary changes in our pace of living, standards of living, education, and technology; even our moral and spiritual concepts are changing. Wilderness represents a timeless, unchanging, sereme model of life. It is calm, yet dynamic. Here, there is time to live, to feel, to experience the pure joy of simply being alive. Here, you can feel the pulse of nature. Somehow, these surroundings seem to nurture positive thoughts about life and values. Most people being back something from the wilderness — something that modifies their life in a beneficial way. Even if the wilderness experience doesn't modify their life in some permanent way, simply the respite from hectic everyday modern life is beneficial. It seems that the more complex and hurried our lives become, the more we need recreational reconstitution by experiencing just the opposite — communion with nature and a simple, uncomplicated, natural way of life.

Wilderness Use

Actually, the terms wilderness and use, or wilderness and recreation, are to some degree incompatible. "Wilderness" is, by definition, uninhabited, unmodified, and unusued. But, to speak of that sort of absolute wilderness is senseless.

It is true that the more a wilderness is used, the less it is a wilderness — man does have a strong tendency to modify any area he uses — but what value has wilderness that is completely unused? Perhaps "just knowing it's there" is of some value, but very little compared to the immense value wilderness has if properly used. We need to use wilderness. We need its beneficial effects. What is needed is to use wilderness without modifying it — to use, but not abuse.

CHAPTER VI

THE LAKES

Continental glaciers have scoured the entire area, gouging very irregular depressions and long, jagged grooves which have filled with water to form the lakes of the BWCA.

Morphometry

Lake shapes are extremely irregular; and there is some tendency for the lakes to have their lengths lie northeast to southwest. An exception to this is that lakes in the eastern BWCA, near Lake Superior, tend to be oriented east to west. Lakes in this area are long, narrow and nearly parallel. Shorelines tend to be very irregular and sinuous. Shore development indexes of 5 or higher are not uncommon. Basin-profiles would tend to be serrate, with reefs, boulders, and islands being very common.

Sizes and depths of lakes run the gamut from very small to very large and from very shallow to very deep. Mountain Lake, near Lake Superior is 7 miles in length, averages less than a half mile in width, and is over 200 feet in depth. Kawishiwi Lake in the south-central BWCA is 1-1/2 miles long; its area is 400 acres; and its maximum depth is 12 feet. Only about 1 percent of this lake is over 10 feet in depth and about 50 percent is 5 feet or less in depth. Surprisingly, this lake is an excellent walleye producer. Rabbit Lake, in the north-central BWCA, is approximately 150 acres in area, and has a maximum depth of 100 feet or more. Lac La Croix, one of the very large border lakes in the northwestern BWCA is approximately 25 miles long, very irregular in shape, has a maximum effective width of 4 miles, and a maximum depth of 145 feet, although much of the lake is between 20 and 30 feet in depth. Mean depths are not available for most of the BWCA lakes and maximum depth data might be questionable. Mapping has been done on some of the lakes, however, some of this work appears to have been rather cursorily done.

Plate VIII. Typical Steep Rocky Shore

Plate IX. Typical Island

Lake Four, in the south-central BWCA, is a typical medium-sized irregularly shaped lake. Its area is 624 acres; its length is 3.1 miles; its shoreline length is 22.2 miles, and its shore development index is 6.35. It has a maximum depth of 25 feet.

Trout Lake, in the western BWCA, is a typical, large, lake trout lake. It is 7.6 miles long; it has a surface area of 7,641 acres, a shoreline length of 43 miles, and a shore development index of 3.51. Its maximum depth is 98 feet.

Vera Lake is a small lake, of medium depth, with a relatively regular shoreline. It is 1.9 miles long; it has a shoreline length of 6.2 miles, an area of 244 acres, and a shore development index of 2.83. Its maximum depth is 60 feet.

Physical and Biological Characteristics — Methods

The study period for this survey was the summer and early fall of 1963. In addition, most of the month of August of 1964 was spent in and around the BWCA, personally traveling the canoe routes, observing the lakes, campsites, portage-trails, and my fellow BWCA recreationists. The area to be studied exceeded 3,000 square miles and included 2,000 lakes or more. This fact, together with the fact that the study of biological and physical characteristics of the lakes comprised only a portion of the work to be accomplished during the study period, decreed that work in this field be primarily descriptive in nature, rather than interpretive.

The study was undertaken for the purposes of (1) gaining personal experience and knowledge of the area and the lakes, (2) surveying the lakes to establish some of their general characteristics, variances, and peculiarities, (3) investigating pollution reports and possible pollution sources, (4) observing use of the area, habits and attitudes of BWCA users and local residents, overuse, littering, vegetation and campsite destruction, (5) observing Forest Service practices, management policies and attitudes.

My center of operation was Ely, a town of about 5,000 population located near the center of the BWCA. Here, I had a small lab in which I performed chemical and biological analyses of water samples.

Much of the field work in 1963 was accomplished with the aid of a seaplane. Considerable field work was also done by boat. Airplanes used were DeHavilland Beavers and a Cessna 180, all equipped with floats. These craft were indispensible in the performance of the great amount of work to be done; and they were uniquely suited for such work. In this large roadless area, with its rough terrain, rivers and lakes blocking possible land travel, no other type of transportation (except a helicopter) could match a floatplane. The floatplane's speed was only part of its utility, however. These craft proved to be exceptionally serviceable limnological tools. In addition to being a most comfortable means in which to travel over rough terrain at 100 miles per hour, the floatplanes were extremely steady on the water and highly maneuverable. The widely-spaced floats, together with the weight of the airplane, gave the craft the stability of a large, heavy catamaran. Floats with flat tops provide ideal footing. The Beavers have 4-foot wide cargo doors which lock open flat with the fuselage, revealing a large, flat floor space which is at waist level when one is standing on a float. This cargo space amounts to an open, 4-foot square equipment cabinet and working space located right at one's elbow.

The "maneuverability" of these craft included the ability to navigate easily in the water, the ability to move quickly from station to station or lake to lake, and the ability to be held motionless in the water in a wind. In moving from place to place, one has the option of moving slowly at 4 to 8 miles per hour, planing at 15 to 60 miles per hour, or hopping (short flights) at 80 to 100 miles per hour. If a wind of over 10 miles per hour were blowing, the plane could be held still in the water by heading into the wind and, with the engine running slowly, adjusting the engine speed, flaps, and elevators to compensate for the wind. Of course, an anchor could be used, but use of one would have been more time consuming.

Temperatures were measured with an electronic thermistor instrument. Water samples were taken with a 1200 c.c. Kemmerer bottle. Field determinations were made of dissolved oxygen, carbon dioxide, pH, and alkalinity.

Titrations were performed using accurate hypodermic syringes — a separate one for each reagent — instead of cumbersome burets. The syringes proved more accurate than burets. They were easily readable to 0.05 ml. and, with practice, readable to 0.03 ± 0.01 ml. Their advantages include reading a flat black line (the bottom of the plunger), as opposed to a meniscus, and delivery of very small drops of 0.02 ml. each. A Wisconsin type plankton net was used to collect qualitative and semi-quantitative plankton samples. Where plankton concentrations were dense enough, the Kemmerer bottle was used to obtain quantitative samples. A 6-inch Ekman dredge was used to collect bottom samples.

Dissolved oxygen was determined using the Rapid Winkler — Sodium Azide method. Carbon dioxide and alkalinity were determined using the methods as outlined in "Standard Methods for the Examination of Water and Sewage" (11th ed.). Hydrogen ion concentrations were determined using a Hach Chemical Company field kit, accurate pH papers, and cross checking results with a nomogram. The pH papers were found to be of insufficient accuracy, even though they were reputedly accurate to 0.2 of a unit.

Water samples were retained in special sterile plastic bags for transport to the laboratory. In the laboratory I conducted tests for color, turbidity, nitrate, ammonia, phosphate, iron, copper, tannins and lignins, chloride, and sulfate. A private commercial laboratory in Duluth performed some of the determinations for all of the preceding tests, plus total Kjeldahl nitrogen, detergents, and coliform bacteria.

The basic instrument used in my laboratory was a Bausch and Lomb Spectronic-20 colorimeter, transistorized model, with a voltage regulating transformer. All tests employed were those found in "Standard Methods for the Examination of Water and Sewage" (11th ed.), except that iron, copper, tannins and lignins, chloride, and sulfate were analyzed using Hach Chemical Company reagents and methods. All methods employed the colorimeter except the chloride test, which involved titration with mercuric nitrate using diphenylcarbazone indicator. Standard curves were prepared from standard solutions for each test, including the chloride titration method.

The private laboratory in Duluth determined nitrate nitrogen polarigraphically by the reduction of nitrate in the presence of a uranium catalyst.

Plankton counts were accomplished with the aid of a compound microscope (100X, 430X, and 1000X) and a binocular microscope (20X and 40X). A normal slide was used for identification of genera, and for counting very dense concentrations of plankton or very small types of plankton. Best results were obtained when a counting cell was used. The cell was circular, 16 mm in diameter, 2.5 mm in depth, and held a volume of 0.5 ml.

Algae counts were normally accomplished using the counting cell and 100X magnification. The diameter of the field at 100X was 1.65 mm; the area of the field was 2.14 mm^2; and the volume of water viewed in one field is 5.35 mm^3. One organism per field, therefore indicated 186,916 organisms per liter of sample. When 10 fields were counted, the minimum detectable number was 18,692 organisms per liter of sample.

Actually, the number 186,916 is mathematically incorrect and should be stated as 187,000. The last three digits represent unrealistic, misleading, implied accuracy. Considering plankton population dynamics, collecting methods, microscope calibrations and computations, and the small sample actually counted, any figures beyond the third (or perhaps even the second) are insignificant, and imply misleading accuracy. This very likely holds true for <u>all</u> quantitative plankton methods.

I used a standard plankton haul of 120 seconds at a rate of 2 feet per second. The diameter of the plankton net opening was 11.3 centimeters. This, when multiplied by the area formula and distance factor, yields a total volume of 734 liters which should <u>theoretically</u> pass through the net. The concentrate obtained from each netting was diluted to a volume of 100 ml; thus, the concentration factor for this technique was 7,340.

The plankton net method of sampling plankton is, at best, semi-quantitative. By carefully controlling the speed at which the net was pulled through the water, I believe that error resulting from water spilling around the net was minimized. Some zooplankton, especially copepods, avoid the oncoming net to some degree; but this is also true of most other methods. Many very small plankton organisms pass through the mesh of the net and are not collected, even though the netting has 200 mesh to the inch. These very small plankton, referred to as nannoplankton, are less than 30 or 40 thousandths of a millimeter in size. For the purposes of this study, only the larger plankton, referred to as net plankton, are important.

Keeping the shortcomings in mind, the data will be treated as quantitative data. Since the methods of collection and counting were kept uniform, the data will be equivalent and comparable between lakes.

Physical and Chemical Characteristics

Most of the lakes of the BWCA are rock basin lakes, with their littoral areas usually consisting of solid bedrock, fractured bedrock, or rock rubble. At depths greater than 15 to 20 feet, lake bottoms are usually covered with depositions of muck — often quite thin.

Most of the lakes are oligotrophic — low in nutrients and productivity. Many lakes, however, appear to be mestrophic — possessing basically oligotrophic characteristics, but showing some signs of enrichment and increased productivity.

One of the most striking characteristics of the lakes is the softness of the water. Total hardnesses of 20 parts per million, or less, were not uncommon. The lakes were not necessarily acid, however. The pH ranges of typical soft water BWCA lakes were 6.9 to 7.4 in the epilimnion — the upper, circulating water, 6.7 to 7.2 in the metalimnion — the middle, transitional layer of water, and 6.6 to 7.1 in the hypolimnion — the lower, non-circulating water.

Much of the water in the BWCA is colored to some degree, although scattered throughout the BWCA are numerous crystal clear, virtually colorless lakes. The only area seeming to be lacking colorless lakes is the south-central portion of the BWCA, where glacial drift is thicker, the terrain in flatter and more muskeg-like in nature. The clear lakes seem to be more characteristic in areas where the bedrock is covered with little or no soil, and where swamps and bogs are less common. The color of typical lakes ranged from 8 to 15 on the platinum-cobalt scale, with many lakes in the 20 to 30 range, and several in the 30 to 60 range. The numerous "colorless" lakes had color readings of 5 or less, several having a color of between 1 and 3.

Turbidity tended to be low in all lakes, except in stagnant, de-oxygenated lower waters of enriched lakes.

In general, the waters of the BWCA could be described as tending to be low in the concentrations of all substances.

Chlorides generally ranged from 0.05 milligrams per liter to 0.5 mg/l. In a few lakes chlorides were found to range from 1.0 to 2.0 mg/l. These lakes constituted a chain of lakes, two of which are located outside the BWCA. The second lake in this chain, Shagawa Lake, has situated on its shores a community of 5,000, or more, people, an iron mine, many homes and cottages, and several resorts. The lake receives treated municipal sewage, untreated sewage and mine wastes from the mine, and seepage from countless septic tanks. Shagawa Lake's waters flow directly into some of the Boundary Waters Canoe Area's largest, most beautiful, most heavily used lakes including Fall, Newton, Basswood, Crooked, Iron, Lac La Croix, and Loon lakes. This situation will be treated more fully under "pollution."

Sulfates in the BWCA were also low, ranging from 1 to 5 mg/l in most lakes and up to 10 or 11 mg/l in a few lakes.

Iron was highly variable. Usually, iron content was low (0.01 to 0.1 mg/l), in well oxygenated water; although, in a few cases the concentrations in waters where dissolved oxygen concentrations neared zero, iron concentrations varied from 0.11 mg/l to 2.5 mg/l. In the oxygen-deplete hypolimnion of Shagawa Lake, the lake which receives iron mine wastes, iron concentrations reached 9.5 mg/l.

Copper concentrations were not found to be significantly variable. Concentrations generally varied from 0.01 mg/l to 0.05 mg/l. A few samples ran as high as 0.15, however these might have been samples which were held in the Kemmerer sampler for a short period of time. The sampler is constructed of brass, which is an alloy of copper.

Tannin and lignin concentrations were found to be proportional to the color of the water, as should be expected. Lakes having low color (2 to 5) had tannin-lignin concentrations of 0.1 mg/l to 0.3 mg/l; medium-colored lakes (15 to 30) had concentrations of 1 to 2 mg/l; and darkly-colored lakes (40 to 60) had concentrations of 2.5 to 4 mg/l.

Nitrogen concentrations presented some difficulties. Ammonia determinations proved to be unreliable, although extreme precautions were taken, i.e., triple-deionized lab water, de-colorized samples, etc. Nitrates were generally very low in concentration and their accurate determination was very time consuming. Since time was precious, only a few nitrate determinations were performed. Some total Kjeldahl nitrogen determinations were made by a private laboratory in Duluth. This analysis determines ammonia nitrogen and organic nitrogen. This nitrogen test is more indicative of the total productivity of a lake, than is the nitrate test or the ammonia test.

Nitrates varied from 0.01 to 0.12 mg/l in oligotrophic and mestrophic lakes. Concentrations ranged up to 0.35 mg/l in a few lakes. The richer lakes generally had lower nitrate concentrations. The reason for this is that, in the upper water of these lakes, phytoplankton utilized most of the nitrate; and the deeper water of these lakes was often oxygen-deplete; and apparently under these conditions, nitrate is reduced to nitrite or ammonia.

Total Kjeldahl nitrogen usually varied from 0.05 mg/l to 0.25 mg/l in oligotrophic lakes, and from 0.2 to 0.7 in richer lakes. In a few cases, apparently oligotrophic, lake trout lakes yielded total Kjeldahl nitrogen results of 0.3 to 0.5, in the lower hypolimnion. Shagawa Lake, the "enriched" lake has yielded total nitrogen results of over 1 milligram per liter.

Phosphorous was another substance which posed problems of determination. Only tests for total phosphate were employed, as total phosphate is the most reliable indicator of phosphorous in a lake. Various analyses for phosphate were tested, including the "standard" stannous chloride ammonium molybdate-strong acid method, the Hach Stannover method, and several variations of the Stannover method. Triple deionized water and distilled water were used, all glassware was acid washed for each examination, and very accurate standard solutions were used, but reliability of all tests fell off sharply as phosphate concentrations decreased below 0.2 mg/l (0.067 mg/l of phosphorus). Concentration of samples by evaporation increased the accuracy and reliability of the tests; however, these procedures were so time consuming that the Duluth laboratory was relied upon for most phosphate analyses.

Total phosphate (reported as PO_4) varied from less than 0.01 mg/l to nearly 0.05 in the upper waters and 0.01 to 0.2 mg/l in the lower water of oligotrophic lakes; although a few apparently oligotrophic lakes, yielded results of nearly 0.1 in the upper waters and 0.4 in the lower waters. Total phosphate in richer lakes varied from less than 0.01 to 0.5 mg/l in the upper waters, and 0.1 mg/l and over in the lower waters. Analysis of the hypolimnion of Shagawa Lake on August 1, 1963, indicated a total phosphate concentration of approximately 6 milligrams per liter. On September 16, 1963, analysis indicated a concentration of nearly 8 milligrams per liter.

The phosphate concentrations found in many lakes seemed high, in relation to nitrogen concentrations. Phosphorous tests are very tricky and can yield high results; therefore, this data, as all phosphorous data, should be viewed with caution. However, since the procedure was uniform, the results should be equivalent and comparable between lakes. If the test results are exact, phosphorous is present in most BWCA lakes in sufficient quantity to support much higher populations of aquatic life; and nitrogen is the limiting factor in these lakes.

Alkalinity varied from 10 to 20 mg/l in most lakes, with a few as low as 7 and one as high as 72. This lake, Tofta Lake, is outside the BWCA; and apparently there is a very localized calcium or magnesium deposit in the watershed. Total hardness of this lake was approximately 100 mg/l.

Carbon dioxide concentrations were found to vary from 1 milligram per liter to 3 mg/l in the epilimnia of oligotrophic lakes, and from 3 to 7 mg/l (occasionally higher) in the hypolimnia of the same lakes. Richer lakes generally contained 0.5 to 1.5 mg/l in their upper epilimnia, where algal metabolism utilizes much of the available CO_2. Concentrations in the oxygen-deplete hypolimnia of richer lakes ran as high as 16 mg/l. Just before fall overturn, the lower water of Shagawa Lake was found to contain 24 mg/l of CO_2. During algal blooms, Shagawa Lake had no CO_2 in its upper epilimnion. During these blooms, the pH of Shagawa's upper water rose as high as 8.6.

Dissolved oxygen concentrations were relatively high due to the low temperatures of the water and the generally oligotrophic nature of the lakes. The concentrations in upper waters usually varied between 8 and 9 mg/l, with some between 7 and 8, and several over 9. During a dense bloom of Anabaena sp., the upper 3 or 4 feet of water in Shagawa Lake contained as much as 11.6 mg/l of dissolved oxygen. Since the water temperature was 75^{o} F. at 3 feet, this 11.6 mg/l of oxygen was in a state of supersaturation (135 percent saturation). The lower water of deep oligotrophic lakes usually remained above 7 mg/l through mid-October, when the field work was ended. The fall of 1963 was unusually warm; therefore, the deeper lakes remained thermally stratified throughout the entire study period.

The lower, non-circulating water of many lakes contained low concentrations of dissolved oxygen (0.0 to 4 mg/l). The oxygen content of the hypolimnia of several lakes was reduced to 0.0 by early September (Shagawa, Basswood-Pipestone Bay, Alton, Garden, Moose, and Fenske Lakes). The hypolimnia of several lakes contained no dissolved oxygen at some time during the study period (Beartrack, Missionary, Tofte, and Ge-Be-On-E-Quet). Several lake trout lakes of high repute showed low oxygen content.

Snowbank Lake, a 4,300 acre lake with a maximum depth of 145 feet, is a well known lake trout lake on the edge of the BWCA. About one-half of the lake is inside the BWCA. By September, the dissolved oxygen concentration of the lower hypolimnion had dropped to 2 mg/l. At this time, however, the dissolved oxygen concentration was between 6 and 8 mg/l at a level where the temperature was between 45 and 50 degrees Fahrenheit.

Trout Lake, a 7,600 acre lake with a maximum depth of 98 feet, is another reputedly good lake trout lake. This lake not only had low oxygen in the hypolimnion (4 mg/l in August); but in early October there was a sudden bloom of Aphanizomenon flos-aquae.

Brule Lake, 4,000 acres in area and 66 feet in maximum depth, is classified as a lake trout lake. In early September the oxygen content at 40 feet, the uppermost part of the hypolimnion, was 4.8 mg/l. At 50 feet depth the oxygen content was 3.3 mg/l. Poor fishing has been reported from this lake.

Burntside Lake, a 7,100 acre lake with a maximum depth of 140 feet, is located just outside the BWCA. It has many cabins and summer homes located on its shores; and the lake is heavily used. The lake has produced good lake trout fishing in the past; but fishing has reportedly fallen off in recent years. In the deep holes over 120 feet, oxygen levels lakely remained above 5 mg/l; however, in areas where the depth was from 40 to 80 feet, the lower water became oxygen-deficient. In mid-September, a station, at which the depth was 58 feet, showed a dissolved oxygen content of 3.1 mg/l at the 40 foot level and 1.6 mg/l at the 55 foot level.

The preceding trout lakes can be compared to several good trout lakes which maintain high oxygen levels at all depths throughout the year. Knife, Kekekabic, Gabimichigami, and Mountain Lakes indicated dissolved oxygen levels of at least 7 mg/l at all depths.

Kekekabic Lake was sampled at two stations; station 1 with a depth of 98 feet and station 2 with a depth of 178 feet. On September 24, station 1 indicated a concentration of 9.5 mg/l at 92 feet; and on October 10, station 2 indicated 7.8 mg/l of dissolved oxygen at the 170 foot level. The lake was still stratified on October 10.

Mountain Lake was sampled on October 3 at a station where the depth was 196 feet. At 50 feet the oxygen concentration was 8.5 mg/l; and at 185 feet the concentration was 7.4 mg/l.

Knife Lake was sampled on October 10, at a station depth of 104 feet. At 50 feet the oxygen concentration was 7.8 mg/l; and at 100 feet the concentration was 7.0 mg/l.

Gabimichigami Lake was sampled on September 17, at a station depth of "greater than 90 feet." Oxygen concentrations were 9.1 mg/l at 50 feet, and 8.5 mg/l at 90 feet.

One non-trout lake showed an interesting oxygen characteristic. Burnt Lake, a shallow, holomictic lake (non-stratifying, complete mixing), which had dense algal blooms all summer and fall (according to reports from pilots) contained low oxygen in the lower water, even though the lake was constantly circulating. The lower water (approximately 15 feet in depth) contained 5.4 mg/l of dissolved oxygen. As a result of the dense algae, little or no light reached the lower water. Concentrations of living algae were fairly dense in the lower water; and the algae's utilization of oxygen for metabolism exceeded their production of oxygen from photosynthesis in the dimly-lit water.

Most lakes became thermally stratified, and remained so during the entire summer. The deeper lakes remained stratified through the entire study period — likely due to the unusually warm fall weather. Shallow lakes and very large medium-depth lakes quickly became complete mixing.

Biological Characteristics

Vegetation, both riparian and littoral, was very sparse. Tree species of the surrounding forest type usually extended to the shoreline of the lakes. In some cases alder, white cedar, or spruce specimens would be scattered along a shoreline, usually mixed with the type-species of the area. Occasionally, a portion of a shoreline would be of a marshy or boggy nature. Such spots would contain characteristic marsh grasses, rushes, or leatherleaf.

Littoral vegetation was usually sparse or absent. In general, vascular aquatic plants were rare. Occasionally, aquatic mosses were found at depths of 20 feet or more in some of the nearly-colorless lakes. A few lakes contained small patches of aquatic plants such as Potamogeton sp., rushes, cattail, white and yellow water lilies, water shield, or wild rice.

The factors of solid-rock lake basins, generally soft water, together with the fact that a high proportion of the BWCA lakes were either oligotrophic or colored, caused plankton to be generally sparse. The solid rock bottoms and associated lake of vegetation create poor habitat for many plankters. The term "soft water" means that there is little dissolved matter in the water — especially calcium, magnesium, and carbonate. This usually means that there is a deficiency of not only nutrients, such as phosphorous and nitrogen; but also CO_2, which is necessary for photosynthesis. Oligotrophic lakes are necessarily low in nutrients. Colored water, which was common in the BWCA, reduces the penetration of sunlight, which is necessary for photosynthesis; therefore, the factor of color tends to limit the growth of algae to some degree. This tendency toward sparsity in the numbers of plankton was only a tendency; there were great exceptions.

The most characteristic, predominating organisms of oligotrophic lakes were: phytoplankton — diatoms, zooplankton — copepods, bottom fauna — amphipods. The predominating organisms in eutrophic lakes were: phytoplankton — blue-green algae, zooplankton — cladocerans, bottom fauna — *Tendipes* sp. and annelids. This is not to say that each type of organism will be found only in the type of lake with which it is listed; for diatoms can be found in eutrophic lakes, and blue-green algae are often found in oligotrophic lakes. The essential differences are found in the numbers of organisms — the total numbers and relative numbers of the different types of organisms.

Oligotrophic lakes contained from a trace to 10,000 green algae, from trace to 20,000 blue-green algae, from a trace to 50,000 diatoms, from 0 to 30 copepods, and few, or no, cladocerans, per liter of surface water. Bottom fauna would include 100 to 3,000 amphipods and few or no *Tendipes* sp., annelids, or *Chaoborus* sp. per square meter.

Mountain Lake contained approximately 10,000 diatoms, and trace numbers of blue-green and green algae, and 3 copepods per liter at 2 feet depth. Both at 50 feet in depth and at 196 feet in depth, 5 copepods per liter were found. These deep water copepods had a bright red spot in the center of the "body." Bottom fauna at a station, where the depth was 90 feet, included 516 amphipods and 43 annelids per square meter.

Trout Lake, a lake trout producing lake, exhibits all of the characteristics of an oligotrophic lake, except that in October of 1963 the lake experienced a dense bloom of Aphanizomenon flos-aquae and contained only 4 mg/l of dissolved oxygen in its hypolimnion. Classification of such a lake is difficult — oligotrophic or mesotrophic? Throughout the summer the lake contained only moderate amounts of algae — on August 27, 37,000 blue-green algae, 20,000 diatoms, and 5,000 green algae, 17 copepods and no cladocerans per liter. On October 8, the upper water of the lake contained 780,000 blue-green algae, 21,000 diatoms, 15,000 green algae, 9 cladocerans, and 5 copepods per liter. Bottom fauna of Trout Lake included 2,150 amphipods, 43 Tendipes sp., and 86 Chaoborus sp. per square meter.

The algal bloom on this lake might have been triggered by the unusually warm fall. Normally, in this area, the first ephemeral snows fall in September; and by October, the weather is usually quite chilly. In 1963, through October 25, when I left, the temperatures remained in the 70's and 80's.

Mesotrophic lakes usually were relatively colorless. The exceptions to this rule were lakes in the "Shagawa chain" (lakes which are downstream from polluted Shagawa Lake and which receive its flow). These are Fall, Newton, Basswood, Crooked, Iron, and Lac La Croix Lakes. Two more colored lakes were apparently enriched — Vermillion and Crane Lakes. Both of these lakes are just outside the BWCA; both have numerous cottages, homes, and resorts; and both have very heavy recreational use. Most of these waters are colored in the range of from 15 to 35 Co-Pt units. They experience blooms or near-blooms of blue-green algae; and the lakes of these that remain stratified, suffer from oxygen deficiency in their hypolimnia.

Mesotrophic lakes (lakes which showed signs of medium fertility) usually contained from trace to 200,000 blue-green algae, trace to 50,000 green algae, trace to 100,000 diatoms, 0 to 120 copepods, and 0 to 50 cladocerans per liter. Bottom fauna typically included up to 1,000 Tendipes sp., up to 1,000 Chaoborus sp., and up to 1,000 annelids per square meter.

Ensign Lake, a generally holomictic lake — although isolated undiscovered "holes" might remain stratified — usually did not experience algal blooms, according to local reports. However, in September of 1963 the lake experienced a moderately heavy bloom of blue-green algae, primarily Anabaena sp. Bottom fauna consisted of 990 Tendipes sp., 1120 Chaoborus sp., and 172 annelids per square meter.

Alton Lake, according to some reports, had produced lake trout in the past; and apparently recent plantings of lake trout had been made. The lake appeared to be an oligotrophic lake. It supported a moderately heavy population of Gloeotrichia sp. (approximately 20 colonies per liter) most of the summer. In September the population of total blue-green algae was in the range of 100,000 organisms per liter. Diatom populations were low. At a station where the depth was 51 feet, the lower 5 or 10 feet of water contained 0.0 to 0.8 mg/l of dissolved oxygen. Chaoborus sp. was found in the deeper water (5 per liter) and in the bottom samples (40 to 200 per square meter). These characteristics seem to place the lake somewhere between oligotrophic and eutrophic in nature. If this lake is still a "trout lake," it seemingly is a marginal one. Local fishermen could not confidently report that a single trout had ever been taken from the lake.

The only obviously eutrophic lake observed was Shagawa Lake. It receives sewage effluent from the city of Ely; it suffers from very dense blooms of blue-green algae all summer and early fall of every year; and the hypolimnion of this lake experiences early and prolonged oxygen depletion and putrification. By late July, the water of the hypolimnion was oxygen-deplete, foul smelling, black-hued, and contained from 3 to 8 milligrams per liter of total phosphate, in a layer of water extending from the bottom to from 5 to 10 feet above the bottom of the lake.

The plankton of this lake were extremely interesting. The algae of the lake exhibited a sort of plant succession. In late June, the algae populations resembled that of an oligotrophic lake, except that the total numbers were rather high. The most numerous organisms were diatoms (from 300,000 to 1,000,000 per liter). Green algae numbered approximately 140,000 per liter, Ceratium hirudinella numbered 50,000 per liter and blue-green algae ran just under 100,000 per liter. Cladocerans averaged about 3 per liter at this time.

Very soon Volvox sp. began to increase rapidly in numbers. Diatoms and Ceratium seemed to be dying. Volvox increased to a near-bloom condition. Gloeotrichia sp. was common, but not dominant. This genus increased to relatively dense proportions, and Volvox numbers became somewhat reduced. Soon, Anabaena sp. began to increase sharply; Volvox decreased rapidly; and Ceratium had all but disappeared. Diatoms were sharply reduced. Anabaena sp. soon reached bloom proportions (2,390,000 per liter on July 21). Diatoms showed in only trace amounts, Ceratium was not found, cladocerans averaged about 15 per liter, and green algae numbered 35,000 per liter at this time. During this bloom, algal decarbonation raised the pH of the upper water to over 8.5. This bloom of Anabaena continued until July 23 when copper sulfate was applied to the lake. Application was accomplished by pulling bags of the chemical behind boats. Within two days, the water was apparently free of all algae, to the naked eye.

Nine days after the copper sulfate had been applied, analysis indicated that the algae were recovering. On August 1, Anabaena sp. was found to number 105,000 per liter.

About this time, Aphanizomenon flos-aquae began to increase in numbers faster than other blue-green algae. Other algae also increased in numbers, but no at so high a rate. At one time, populations of Anabaena and Aphanizomenon were found to be of nearly equal proportions — 346,000 and 261,000 per liter, respectively. Soon however, Aphanizomenon completely dominated the picture, reaching over one million filaments per liter by mid-August (see Plate X, page 50).

On August 24, copper sulfate was again applied to the lake. It seemed to reduce algae populations to some degree. Much Aphanizomenon died and decomposed causing the greasy, blue-green scum and the "pig-sty" odor so characteristic of this genus of algae (see Plate XI, page 51). Much algae remained alive and by mid-September total blue-green algae numbers reached over 2 million per liter, with Microcystis forming floating scums. Microcystis numbered 914,000 per liter; however Anabaena was found to number 1,523,000.

Plate X. Bloom of Aphanizomenon flos-aquae on Shagawa Lake. The algae are forming 1/4" to 3/4" globular clumps.

Plate XI. Scum Resulting from Bloom of Aphanizomenon flos-aquae on Shagawa Lake

Aphanizomenon numbered 57,000 per liter at this time. When I left the area in mid-October, Microcystis appeared to predominate all other genera of algae.

This succession-like sequence of predominating algal genera might have been the normal yearly chain of events; or the applications of copper sulfate might have been the major factor influencing the changes. The sequence of predominating genera was Fragilaria — Volvox — Gloeotrichia — Anabaena — Aphanizomenon — Microcystis. The algal succession seemed to progress from those genera characteristic of clean, oligotrophic lakes to those increasingly characteristic of richer, even polluted, lakes. This might have been simply a result of increased temperature and photoperiod, however.

One interesting factor was noted concerning the various genera of algae. Anabaena was the only genera to accomplish complete removal of CO_2 from the upper water. This genus was also the only one to cause apparent supersaturation of oxygen in the upper water. This might indicate some characteristic of the genus; or the cause might simply be that Anabaena was the first algae to bloom, and therefore more nutrients were available then, causing the rate of metabolism to be unusually high.

The bottom fauna of Shagawa Lake indicated extreme fertility. From 1,000 to 5,000 Tendipes sp., 200 to 4,600 annelids, and 0 to 1,800 Chaoborus sp. per square meter were found.

The applications of copper sulfate to Shagawa Lake appeared to have a lethal effect upon midge larvae and annelids. After the chemical was applied, midge larvae, which were normally blood-red, would turn partially green, white or gray. Most discolored larvae lethargic, inactive, or dead. Some annelids were found dead and discolored.

Another lake which was apparently rich in nutrients was Burnt Lake, which had a steady, dense, algal bloom all summer and early fall. On September 19, the lake was found to contain 1,475,000 blue-green algae — mostly Anabaena sp., 25 cladocerans, and 3 copepods per liter. Bottom fauna included 301 Tendipes sp., 900 Chaoborus sp., and 990 annelids per square meter.

In many lakes, other organisms than those mentioned were found. Mayfly, beetle, and "no-see-um" (Heleidae) larvae were occasionally found, but of insufficient numbers to be significant. One specimen of Mysis oculata, a small, cold water shrimp-like crustacean, was found in Raven Lake. Virtually all rock was covered with aufwuchs — the slippery crust of organisms, mostly microscopic, which develops on most submerged surfaces. This crust is composed principally of diatoms and other algae, bryozoans, rotifers, protozoans, roundworms, and often, annelids, insects and crustaceans.

Several large colonies of the bryozoan Pectinatella sp. were found in Birch Lake, which is south of the BWCA. The specimens were found in shallow, protected coves. This lake is highly colored — approximately 45 on the Co-Pt scale. Colonies ranged from 4 inches to 8 inches in length — most were nearly spherical to hemispherical.

One specimen of fresh water sponge (Spongillidae), was found in Garden Lake — another colored lake just outside the BWCA. This specimen was almost double-fist sized, about 5 inches long and 3 inches across. It was growing on a dead, submerged branch in still water.

Characteristics of Selected BWCA Lakes

The following table lists certain characteristics of 18 BWCA lakes. The function of this table is merely to give an idea of the general types of lakes found in the BWCA. One lake, Shagawa Lake is outside the BWCA, but its waters flow through the BWCA. The last 4 lakes are important lakes of the Shagawa Chain which receive nutrient and algae-laden water from Shagawa Lake.

The first 4 columns contain general information pertaining to each lake. The columns beginning with date and ending in Cl pertain to analyses of water samples from a particular depth of a particular date. All information to the right of the date column refers to that date. The only differences lie in the depths of sample. Under stratum is found the zone from which the samples were taken, followed by the water temperature, in degrees Fahrenheit, at the actual sample depth. All of the chemical and physical analyses from color through Cl (chloride) are of water samples from that depth. MPN coliform, and plankton samples were taken at the same stations but at depths from 1 to 2 feet below the surface. Bottom fauna were sampled at the depth (in feet) indicated. All chemical concentrations are stated in milligrams per liter. Color is in cobalt-platinum units; and turbidity is in Jackson units. Alk stands for alkalinity, D.O. — dissolved oxygen, NO_3 — nitrate. Fe — iron, and Cl — chloride. N.F. stands for not found; and T stands for found in trace numbers. Blank spaces mean that no test was performed. The superscript following the lake names represent: B — suffered from algal blooms, C — one of the Shagawa Chain lakes, P — polluted.

Fish Populations

The most common fish species which originally populated the lakes of the BWCA were lake trout, whitefish, cisco, tullibee, suckers, northern pike, rock bass, and perch. Apparently smallmouth bass and walleyes were rare in the area. The walleyes and smallmouth bass now found in many BWCA lakes have, for the most part, been established by planting. Largemouth bass have been introduced into a few lakes. Sunfish and crappies are not common in the BWCA.

Most BWCA lakes have limited productivity; that is, the production of organic matter — and pounds of fish per acre — is relatively low. The common fish species in a deep oligotrophic lake are lake trout, whitefish, tullibee, ciscoes, suckers, and often, sparse populations of smallmouth bass, pike, walleyes, rock bass, perch, and burbot. Lakes which are shallower or richer in nutrients often contain any, or all, of these same species, except lake trout. Whitefish, tillibees, and ciscoes are cold water species and are seldom found in very shallow or very rich lakes. Tullibees are common in polluted Shagawa Lake; however, many die every year in the late summer months. During this time there is only a narrow band of water in which the temperature is low enough, yet which contains enough dissolved oxygen to support the tullibee.

This requirement of low water temperature and high dissolved oxygen content is characteristic of many of our most desirable fish species — especially

Lake	Size Acres	Max Depth Feet	Description	Date	Stratum	Color	Turb	pH	Alk	D.O.	CO_2	Total Phos-phate	NO_3	Total Kjeldahl Nitrogen	Fe	Cl	MPN Coli-form	Net Phytoplankton 1,000's Per Liter: Diatom	Green	Bluegreen	Net Zooplankton Per Liter: Copepod	Cladoceran	Bottom Fauna Per Square Meter: Depth	Amphipod	Chaoborus	Tendipes	Annelid
Kekekabic	1620	195	Oligotrophic	7-29	Epilimnion (25',69°)	3	1	7.1	15	9.2	2	0.01	0.03	<0.1	0.01	0.2	0	23	1	0.45	7	N.F.					
				"	Hypolimnion (90',40°)	3	1	6.9	15	9.0	4	0.03	0.05		0.02	0.2											
			Lake Trout	10-10	" (170',40°)	4	3	6.7	16	7.8	6	0.03			0.04	0.2							98	86	43	602	N.F.
Mountain	2088	200	Oligotrophic	10-3	Hypolimnion (50',46°)	1	<1	6.9	12	8.5	3	0.20	<0.01	0.43	0.01	0.05		10		0.1	5	N.F.					
			Lake Trout	"	" (185',40°)	3	1	6.5	13	7.4	7				0.02	0.05							90	516	N.F.	N.F.	43
Trout[B]	7641	98	Oligotrophic	8-27	Metalimnion (40',52°)	7	2	7.0	10	8.0	2	0.03			0.03	0.4		20	5	37	17	N.F.					
			Lake Trout	"	Hypolimnion (90',40°)	8	4	6.7	11	4.0	10				0.08												
			Late Algae-Bloom	10-8 (Bloom)	Epilimnion (10',)	5	2	7.1	10	7.8	0.5				0.01			21	15	780	5	9	95	2,150	86	43	N.F.
Insula	2608		Irregular	9-30	Holomictic (28',60°)	20	7	6.9	12	9.0	3	0.12	0.06	0.20	0.22	0.2		T	T	12.5	6	4					
Gabro	1207	45	Rocky, Dark	9-5	Epilimnion (16',67°)	56	21	7.0	24	8.2	4	0.08			0.73	1.0		N.F.	N.F.	T	15	3					
Ensign[B]	1086		Unus. Blm.	9-24	Holomictic (18',61°)	10	11	7.6	21	8.4	1	0.26	<0.01	0.27	0.09	0.5		3	41	960	27	5	22	N.F.	1120	990	172
Alton	1030	~60	Mesotrophic	9-17	Epilimnion (5',)	13	4	7.1	13	8.7	2				0.10	0.2		2	0.5	68.7	N.F.	3	58	N.F.	43	N.F.	N.F.
					Hypolimnion (52',)	30	11	6.4	14	0.8	13	0.25	<0.01	0.70	2.42	0.2	0										
Vera	244	~60	Oligotrophic	9-24	Epilimnion (10',62°)			7.5	38	9.3	2.5									T							
			L.M. Bass		Hypolimnion (37',50°)	8	7	6.8	38	0.1	12	0.03	<0.01	0.30	0.11	0.4											
Burnt[B]	~500		Const. Blm.	9-19	Holomictic (17',62°)	19	9	6.7	14	5.4	5.5	0.21	<0.01	0.40	0.50	0.3		N.F.	N.F.	1,475	3	25	18	N.F.	903	301	990
Kawishiwi	~400	12	Very Shallow	9-5	Holomictic (9',65°)	22	10	7.2	8	9.1	1	0.04			0.20	0.4		T		T							
Beartrack	~150	>50		10-8	Epilimnion (28',59°)	3	2	6.7	9	8.3	4	0.02	<0.01	0.24	0.02	0.2		12	9	15	N.F.	N.F.	50	N.F.	172	688	43
					Hypolimnion (45',45°)	17	11	6.4	10	0.0	13				0.90	0.2											
Fat	~100	~40	Isolated	10-8	Epilimnion (25',60°)	3	1	6.7	8	8.5	4	0.02	<0.01		0.04	0.2		34	T	T	3	N.F.	40	N.F.	N.F.	215	N.F.
					Hypolimnion (38',47°)			6.4	9	4.1	9																

Table 5. Characteristics of Selected BWCA Lakes

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Lake	Size Acres	Max Depth Feet	Description	Date	Stratum	Color	Turb	pH	Alk	D.O	CO_2	Total Phos-phate	3	Total Kjeldahl Nitrogen	Fe	Cl	MPN Coli-form	Net Phytoplankton 1,000's Per Liter			Net Zooplankton Per Liter		Bottom Fauna Per Square Meter				
																		Diatom	Green	Bluegreen	Copepod	Cladoceran	Depth	Amphipod	Chaoborus	Tendipes	Annelid
Rabbit	~300	~100	Deep, Small	9-19	Epilimnion (10',64°)	6	1	7.2	22	8.9	2				0.01	0.2		T	T	T	4	N.F.					
					Hypolimnion (50',42°)	8	1	7.0	22	7.5	4	0.05			0.02	0.2											
					" (91',)			6.7	23	1.8	10												93	1,120	215	86	N.F.
Barto	~100	~20	Isolated	9-19	Holomictic (14',61°)	24	8	6.7	7	7.6	3	0.02			0.31	0.3		N.F.	T	T	N.F.	N.F.	17	N.F.	N.F.	43	N.F.
Shagawa[CBP]	2370	48	Polluted	7-4	Epilimnion (5')			7.0		7.0								1,035	155	97.5	2	5	41	N.F.	85	4,171	1,590
			Heavy Al-	7-21	" (20',73°)			7.5		7.0	1.5	0.48	36	0.47	2.36	1.0	49	N.F.	2	2,185	N.F.	40	28	N.F.	43	5,350	1,290
			gal Blooms	9-16	" (5')	10	7	7.3	24	8.5	2.0				0.08	1.2		N.F.	N.F.	2,599							
				"	Hypolimnion (35')	108	40	6.7	70	0.0	24	8.0			9.5	1.2											
Basswood[CBP]	29,400	>100	Enriched	7-30	Epilimnion (22')	30	10	7.0	17	8.0	3	0.01			0.15	1.2		47	0.3	26	2	N.F.					
			Algal Blms.	9-12	Metalimnion (25')							<0.01		0.26	0.08	0.5	22	17	N.F.	206	2	3					
				9-11	Hypolimnion (30',55°)	36	11	6.6	24	0.1	13	0.06	5	0.33	0.31	1.4	7.8	23	N.F.	148	3	1	38	N.F.	85	387	N.F.
Crooked[CBP]	10,000	>92	Enriched	10-10	Epilimnion (16')	23	7	7.0	19	8.5	3	0.43	1		0.11	0.6	2										
			Algal Blms.	9-12	Metalimnion (30')	23	10	6.9	21	7.0	5	0.03	1	0.24	0.08	1.7	39										
				8-27	Hypolimnion (80')	24	8	6.7	19	1.8	10				0.10	1.2		11	N.F.	257	3	6					
Lac La Croix[CBP]	34,070		Algal Blms.	8-27	Epilimnion (28')	21	8	7.1	14	8.2	2	0.05			0.10	0.9		T	N.F.	165	4	1					
			Colored	9-12	Metalimnion (35')							<0.01	5	0.16		1.4	4.5	T	T	412	1	5					
			Pike-Bass	10-4	Hypolimnion (39')	25	9	6.7	16	6.0	7	0.23	12	0.34	0.15	1.5	13	N.F.	N.F.	926	N.F.	N.F.	43	N.F.	N.F.	215	43
" " " (Lower)			Deeper	10-4	Epilimnion (30')	11	3	6.8	16	8.0	5	0.07	2	0.14	0.01	0.2	2	22	T	90	N.F.	N.F.					
			Lake Trout	"	Hypolimnion (95')	20	10	6.5	17	1.6	12				0.24	0.2							105	2,967	129	T	N.F.

Table 5 — Continued

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trout and salmon. It is a requirement that drastically reduces the number of lakes that can support these fish. Shallow lakes, lakes of moderate depth, warm lakes, and lakes which are rich in nutrients are all unable to support these types of fish.

Fishing

Fishing in the BWCA is very erratic. The lakes are of limited productivity, and in many lakes the great majority of the fish populations are non-game species, including ciscoes, tullibees, whitefish, and suckers.

The BWCA is famous for its large fish. In the BWCA, and surrounding area, bass of 10 pounds, lake trout of 25 pounds, pike of 25 pounds, and walleyes of 15 pounds are taken every year — yet constant complaints of poor fishing are heard everywhere. It is generally true that many of the BWCA lakes are underfished and contain a few, large fish of a given species, rather than many small fish. In such cases, fishermen most often catch no fish, but occasionally catch large fish. It is a case of many days with no success, and a few days with great success. There are certain lakes which support fair populations of small to medium-sized game fish, however.

Many canoeists do not spend very much time fishing while they are in the area. They are there to travel and enjoy scenery; fishing takes considerable time and requires staying in one spot or moving very slowly. In addition, most fishermen are not very successful when fishing a lake with which they are not familiar. It usually takes many years of fishing for a man to become familiar with a lake; seldom do BWCA users spend more than one day, or occasionally a few days, on any one lake. In addition many BWCA canoeists are novice fishermen. For many canoeists, the fishing attempted while in the BWCA is the first of their lives.

The heaviest fishing is done on the lakes that have road access or a direct water route from a road access. Most fishermen prefer to use motorboats or motorized canoes. The people who penetrate the deepest into the BWCA are paddling canoeists who generally fish only incidentally. Often, the canoeist fishes only for the short period of time in the evening between the time when camp making is completed and darkness falls.

Fish in the BWCA lakes seem to lie in deeper water than fish of the same species elsewhere. In most lakes there is a poverty of vegetation, stumps, or other cover to localize fish. With this general lack of cover, most fish seem to seek a somewhat deeper, more pelagic environment. In many lakes, smallmouth bass and northern pike are not found in the coves and bays where the depth ranges from 5 to 15 feet as one might expect; but they can be caught in open water by fishing 20 to 30 feet below the surface in water 50 feet deep or more. Most fishermen fish their lures far shallower than this.

Even with all these factors, the BWCA holds some of the best fishing available today in the United States.

CHAPTER VII

PROBLEMS OF THE BOUNDARY WATERS CANOE AREA

The Boundary Waters Canoe Area is the only large area east of the Rocky Mountains officially preserved and managed as a wilderness-type area. This 1,600-square-mile mosiac of lakes, rivers, and forests is within easy driving distance of tens of millions of people. Use of the area has been soaring during the past decade. Management and control of the area have been extremely difficult due to the fact that the Forest Service manages the area, yet has no precedent for jurisdiction over the water. There have been continual, strong opposing pressures favoring wilderness preservation on one hand and development and exploitation on the other. All of these factors have combined to create many unique problems for this unique area.

Pollution in the BWCA

In recent years, cries of "pollution!" have been heard with increasing frequency in and around the BWCA. Guides, fishermen, pilots, and local residents claim that certain of the larger, most heavily used lakes have been experiencing increasing concentrations of algae during the past 10 or 20 years. These lakes include Fall, Newton, Basswood, Crooked, Iron, and Lac La Croix. All of these lakes are downstream from Shagawa Lake and receive water from it.

Shagawa Lake

Shagawa Lake has suffered from serious nuisance blooms of blue-green algae for several decades — as far back as the early 1900's. Residents state that the blooms have been getting worse in the last decade or two; and the older natives affirm that the blooms of the early 1900's were neither as intense nor as frequent as the blooms of recent years. Much controversy has developed over whether or not Shagawa Lake is technically polluted, whether or not the sewage effluent is the cause of the blooms, and whether or not the chain of lakes downstream from Shagawa Lake are becoming polluted.

The lake originally received raw sewage from Ely and mine wastes from several mines; now the lake receives effluent from Ely's secondary-type sewage treatment plant, untreated mine wastes from the Pioneer Iron Mine, and an unknown quantity of untreated sewage from non-intercepted sewers and septic tanks. One fairly large section of old Ely, known as "Finn Hill," very likely is not serviced by the sewage treatment plant. Many sewers in this area likely empty directly into the lake. Ely, along with homes and cottages outside of the town, is built on a slope which falls toward the lake. This slope is mostly solid bedrock. Decomposition products from septic tanks and outdoor toilets are undoubtedly washed slowly into the lake in runoff water from rain and snowmelt.

Shagawa Lake likely receives much nutrient material from the septic tanks of homes, cottages, and resorts situated on or near the shore; but the main sources of nutrients are the municipal sewage effluent and the mine wastes. Results of the analysis of these were as follows:

	Ely Municipal Sewage Effluent	Pioneer Mine Effluent
Most Probable Number Coliform Bacteria Per 100 cc	540,000	350,000
Total Kjeldahl Nitrogen	16.7	2.8
Nitrate Nitrogen	0.31	0.50
Total Phosphate	3.85	2.10
Chloride	10.0	4.0
Detergents (ABS)	3.16	0.86
Iron		1.36
B.O.D.	27.5	55.6

All results are stated in milligrams per liter, except MPN Coliform Bacteria. B.O.D. is biological oxygen demand.

The primary source of water flowing into Shagawa Lake is the Burntside River. Three small creeks also flow into the lake; but throughout most of the year, these creeks have little or no flow. The flow of the Burntside River is

Plate XII. Air Photo of City of Ely and Shagawa Lake. White Iron, Garden, and Fall Lakes are in the right, center and left background, respectively. Iron mine is seen in the left center.

on the magnitude of 100 cubic feet per second. The municipal sewage flow and the mine effluent flow are both on the order of one cubic foot per second. The Burntside River drains Burntside Lake, a clear oligotrophic lake trout lake, which lies little more than a mile northwest of Shagawa Lake.

The water which flows from the Burntside River into Shagawa Lake is of very high quality. A comparison of the waters of the two lakes amounts to a comparison of before-and-after enrichment by sewage and mine wastes.

The following table lists results of analysis of the two lakes. All results are stated in milligrams per liter, except MPN Coliform Bacteria. Numbers listed as ranges represent reliable maximums and minimums.

Table 6. Analysis Results of Burntside and Shagawa Lakes

	Burntside Lake	Shagawa Lake
MPN Coliform Bacteria Per 100 cc	0	40 - 350
Total Kjeldahl Nitrogen	<0.1	1.2
Nitrate Nitrogen	0.04	0.36
Total Phosphate	0.01 - 0.05	0.4 - 8.0
Chloride	0.03	1.0 - 1.5
Iron	0.0 - 0.20	0.01 - 9.5

An apparent result of this enrichment are almost constant algal blooms in Shagawa Lake. The water from Shagawa Lake flows downstream through Fall, Newton, Basswood, Crooked, Iron Lakes, and Lac La Croix, carrying its load of nutrients, algae, and bacteria to these lakes.

All of these lakes had much higher concentrations of blue-green algae, chloride, and coliform bacteria than other lakes in the area.

Chloride

The lakes of the "Shagawa Chain" contained higher chloride concentrations than the surrounding lakes; however, not all of the additional chloride found in the "Shagawa Chain" of lakes originated in the sewage effluent and mine wastes; some of this higher than average chloride entered the chain through Garden Lake, which receives water from lakes to the south of the BWCA which contain higher chlorides. Chloride content of most waters in the area varied from 0.2 to 0.5 milligrams per liter. Chloride content of water entering Shagawa Lake was approximately 0.3 to 0.4 mg/l. The chloride content of Shagawa Lake averaged 1.2 to 1.5 mg/l. This concentration level gradually decreased as the water moved down the chain until in lower Lac La Croix, approximately 50 miles downstream, the chloride content ranged from 0.2 to 0.4 mg/l.

Coliform Bacteria

Coliform bacteria tests produced positive results in nearly every Shagawa Chain sample, while nearly every nearby "wilderness" lake yielded negative coliform tests. Most probable number indexes for Shagawa Lake ranged from 49 to 350; Basswood Lake indexes ranged from 7.8 to 22; Crooked Lake, 2 to 39; and Lac La Croix, 2 to 13. These coliform indexes are not high; but when compared to zero, the index of the majority of the isolated lakes, they become more significant.

The simple presence of coliform bacteria cannot be considered as positive proof of contamination by human sewage. Coliform bacteria are present in the digestive tracts of all warm-blooded vertebrates. There is, therefore, the <u>chance</u> of finding coliform bacteria of nonhuman origin. However, such occurrences of nonhuman coliforms should be very small and scattered. When large bodies of water are uniformly populated with coliform bacteria; and when these bodies of water receive sewage effluent, and are heavily used by overnight-camping recreationists, human origin of such coliforms can be confidently assumed. However, the best indicators of pollution or enrichment in the Shagawa Chain were the phytoplankton.

Phytoplankton

Blue-green algae were the dominant form of phytoplankton in all of the lakes of the "Shagawa Chain"; while in surrounding lakes, diatoms were the dominant phytoplankter. In the surrounding lakes, blue-green algae usually were present only in trace numbers.

Water from Shagawa Lake flows through the Shagawa River directly into Fall Lake. Fall Lake has been suffering from increasingly dense blooms of blue-green algae of the same genera that plague Shagawa Lake. On September 4, 1963, blue-green algae numbered 758,000 per liter and consisted primarily of Aphanizomenon flos-aquae.

Newton Lake seemed to contain lower concentrations of algae than either Fall Lake, which feeds Newton Lake, or Basswood Lake which receives Newton's water. This was likely a result of the fact that Newton Lake is more a slow river, than a lake. Nutrients and plankton constantly move through the lake and little accumulation takes place. On September 12, 1963, 283,000 blue-green algae per liter were found.

Water from Newton Lake passes over Pipestone Falls into Basswood Lake. Basswood Lake is one of the largest, most heavily used lakes in the BWCA. It is the first "wilderness" lake in the chain. For decades, outdoor writers have lauded its pristine waters so pure that one can drink water directly from the lake — as people do from most BWCA lakes. However, the fact is that Basswood Lake received water laden with nutrients and bacteria derived from from sewage. Blue-green algae were found to be dense from August through October, when the study period ended. Concentrations when sampled varied from 100,000 to 320,000 blue-green algae per liter, although in October, when no samples were taken, heavy scums of algae were seen from the air indicating higher populations than those sampled.

Crooked Lake, another large, important, wilderness lake is the next in the chain. It is not as heavily used as Basswood Lake; but because of its scenic value it is an even more important lake. Crooked Lake supported populations of blue-green algae nearly as dense as Basswood Lake.

Iron Lake is a small extension of Crooked Lake, and when sampled appeared to have essentially the same characteristics as Crooked Lake.

The water then flows into Lac La Croix, the largest lake of the BWCA. The upper lake is vast, very sinuous, and relatively shallow (20 to 40 feet deep). Here, on October 4, blue-green algae were found to number 926,000 per liter. The lower, downstream portion of the lake is deeper (over 100 feet deep), and supported lower concentrations of blue-green algae, 90,500 per liter. Here, in the deeper portion of the lake, diatom populations were found to be denser (22,000 per liter) than in the upper portion of the lake.

Figures 2 and 3 on pages 67 and 68, portray the populations of blue-green algae and coliform bacteria through the Shagawa Chain of lakes. The coliform indexes represent average figures; and the blue-green algae figures represent the average counts of the maximum population-period sampled for each lake.

Dissolved Oxygen

All of the lakes of the Shagawa Chain which remained stratified suffered from low dissolved oxygen concentrations in their hypolimnia. Even the lower portion of Lac La Croix, which was the most distant from Shagawa Lake, and the most oligotrophic body of water in the chain, contained low oxygen concentrations (1.6 mg/l in the lower hypolimnion).

Bottom Fauna

Bottom fauna populations through the lakes added evidence to favor the hypothesis that Shagawa Lake is "polluted" and that the other lakes of the chain are enriched. Tubificid worms, generally considered to be tolerant of enrichment and pollution, were most numerous in Shagawa Lake (200 to 4,600 per square meter), and sparse in the other chain lakes. True-midges (<u>Tendipes</u> sp.), considered to be tolerant of enrichment and pollution to some degree, were found throughout the chain of lakes in approximately the following concentrations: Shagawa Lake, 1,000 to 5,500 per square meter; Fall Lake, 100 to 1,300 per m^2; Basswood Lake, 400 per m^2; upper Lac La Croix, 200 per m^2; and lower Lac La Croix showed only a trace of these organisms.

Are the Lakes of the Shagawa Chain Polluted?

All of the biological and chemical data strongly suggest that Shagawa Lake is polluted; and that the downstream lakes are enriched. Judging from the algae populations and the past histories of these lakes, the enrichment appears to be causally connected with Shagawa Lake. Whether, or not, the

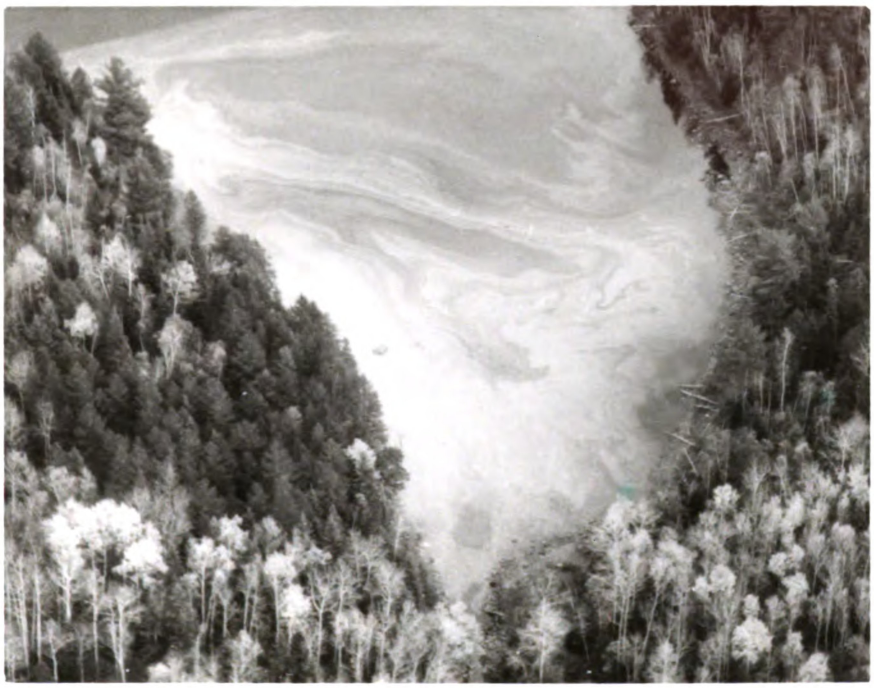


Plate XIII. Blue-Green Algae Scum on Basswood Lake

Figure 2. Shagawa Chain of Lakes
Maximum Blue-Green Algae Concentrations

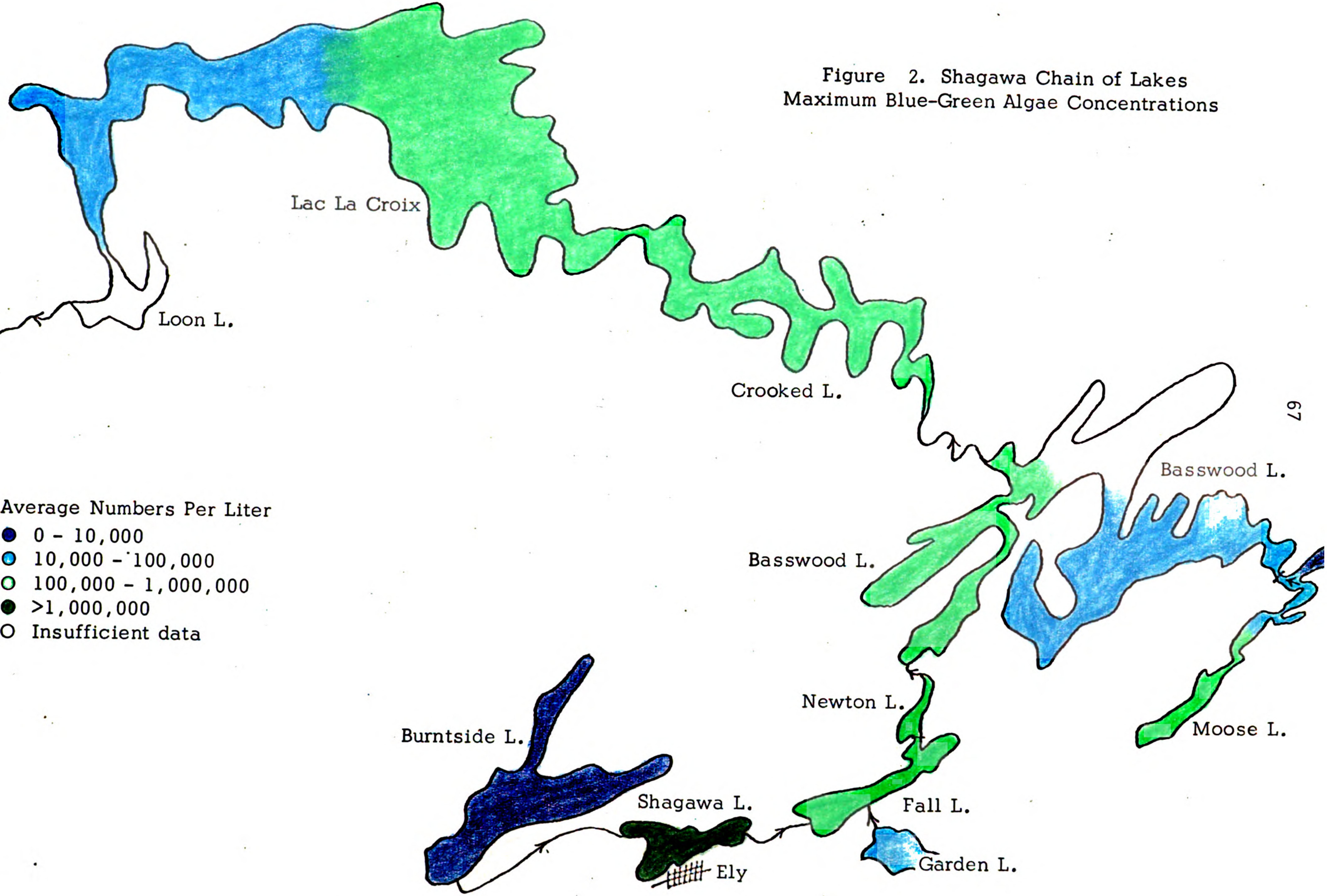
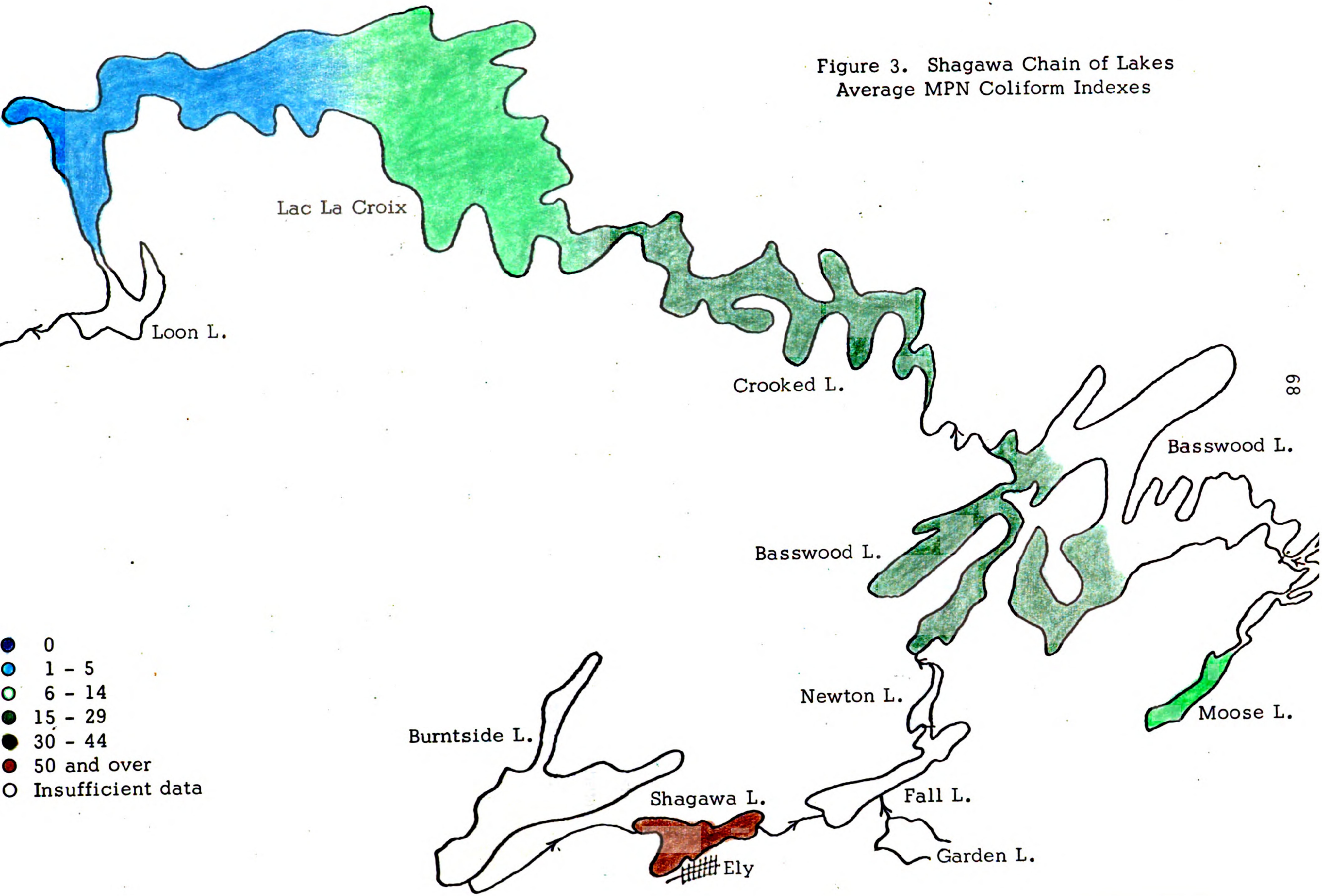


Figure 3. Shagawa Chain of Lakes
Average MPN Coliform Indexes



algal blooms on Shagawa Lake are caused entirely by nutrients supplied by sewage effluents cannot be determined. Certainly, these effluents can be assumed to be a major source of nutrients, and continued discharge of sewage effluent into the lake can only worsen the conditions, both of Shagawa Lake and the chain of wilderness lakes downstream.

Pollution

One of the causes of the controversies concerning "pollution" in the BWCA has been the reluctance of government agencies to call what is happening to the Shagawa Chain "pollution." Some individuals even seem to be highly resistant to recognizing that something undesirable is happening to the Shagawa Chain of lakes.

Part of the trouble lies in the fact that the term pollution is defined rather strictly by government agencies, and that little attention or concern is paid any water contamination that does not injure the health of the public. Too often, public officials are reluctant to place the term pollution on any but the most obvious, rankest forms of water degradation. Effects of pollution upon the capacity of water to provide enjoyment for people is seldom, if ever, considered important enough to justify remedial action. Recreational and aesthetic values are usually not given substantial weight when decisions are made, or policy is formulated; because decisions and policy are usually based upon costs versus benefits; and it is difficult to affix monetary values to such intangible things as aesthetics and recreation. Yet, in some cases these may be the most important aspects of a resource's value.

The effects of these algal blooms in the "wilderness" lakes are to destroy their wilderness quality and to destroy the pleasure of the user. The knowledge that one has to chlorinate the water for drinking because it contains sewage effluent is equally destructive to the wilderness feeling. Somehow, the feelings of wilderness, pureness, or "being close to nature" get a little lost when one looks at scums, and clouds of algae; and when he realizes that some of the water at which he is looking passed through someone's toilet not long before.

The Self-Purification Myth

There exists in the minds of many people a general notion that if undesirable substances are placed in water, the water will eventually purify itself. It is thought that water can somehow absorb wastes. The fact is that the best water can do is only change the form of wastes. In some cases the change in form might seem to make the wastes disappear or at least become less offensive; however, often the new form of the wastes causes nuisances as obnoxious as the original wastes. For example, raw sewage, or organic wastes consist primarily of solid organic matter, urea, and ammonia; and as such, create disagreeable odors and unsightly appearance. When these substances are broken down by biological activity within the water, products such as nitrates and phosphates are formed. These are prime nutrients for plants and cause immediate increases in the growth of algae and/or rooted plants. The increase in the growth of algae can cause: the water to become discolored and turbid; rapid changes in the concentration of dissolved oxygen present in the water, often resulting in the death of fish and other organisms; floating scums or sticky masses of growth; and highly disagreeable odors and tastes. Increases in the growth of rooted plants can cause most of the above; and in addition can clog a body of water. Dense growth of plants can reduce boating, ruin fishing habitat, cover spawning grounds, ruin swimming, and cause filling of a lake or stream with decomposed plant remains.

Sewage treated by our most modern, complete treatment plants produces an effluent which is best described as a powerful liquid fertilizer. This effluent is usually discharged into a stream or lake. These treated effluents have the same effect upon waters as does raw sewage.

Industrial wastes, or silt and clay from erosion, often <u>seem</u> to become diluted and disappear when discharged into streams and lakes. However, these can, in time, cause changes in the water which will greatly reduce the capacity of the water to produce enjoyment, recreation, and utility. Seemingly minor changes in water quality can drastically change the biology of a stream or lake. Foreign matter, such as oils, oxides, silt, or clay can form coatings on lake and stream bottoms, disrupting the habitat of fish food organisms, and can cover fish spawning beds. Desirable species of fish disappear and are replaced by undesirable species such as carp. The water might become discolored, cloudy, and odorous — greatly reducing its aesthetic value.

Water is not the medium in which our wastes should be placed. Wastes do not disappear in water. Too often, the wastes only become more obnoxious and exact a much greater cost, than if they were disposed of properly.

Cost is the basic reason that wastes are discharged into bodies of water. What could be cheaper than to allow wastes to flow into a river? A river removes a city's or an industry's wastes absolutely free to that city or industry. The real cost is paid by the public. The people downstream must drink contaminated water, or treat it at a cost. The public's recreational use of the water is reduced. Property values of land adjoining the water are reduced.

In the case of the BWCA, a unique recreation area used by millions of people from all over the United States could well be damaged or ruined by the wastes of a few.

Other BWCA Lakes Showing Pollution-Like Characteristics

Moose Lake is a large, moderately deep lake, which is partially inside the BWCA. It is one of the major starting points for trips into the Canoe Country. Located on the lake are a Forest Service campground and boat launch area, a large Boy Scout camp, and many cottages and cabins. The lake is very heavily used by canoeists, motorboat enthusiasts, fishermen, and campers.

The Scout camp hosts large numbers of Boy Scouts each summer. Sewage, mess hall wastes, and waste water from showers is placed in septic tanks which discharge into drainfields, pits and low areas near the lake. Odor nuisance has been reported in the camp area, apparently resulting from septic tank effluents in the shallow soil. Often, soils are only a few inches thick or less, overlying solid rock. It was the opinion of the Minnesota Department of Health that the present sewage disposal systems constitute a hazard to the health of the camp users.[1] It seems likely that this camp contributes quantities of pollutants to Moose Lake.

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[1] C. R. Humphrys, *op. cit.*, p. 170.

During the study period in 1963, the lake supported higher than average populations of blue-green algae all summer; however, populations reached only near-bloom proportions — between 100,000 and 200,000 organisms per liter, mostly *Anabaena* sp. In early summer, this lake supported a near-bloom of *Gloeotrichia* sp.

Snowbank Lake, a large deep lake trout lake, shows signs of possible enrichment — low dissolved oxygen, and above average populations of blue-green algae (*Gloeotrichia* sp.). A few resorts and cottages stand on the shores of the west end of the lake. To state that these few sources are polluting this large body of water would seem foolish; however, coliform counts on the magnitude of 10 per 100 ml. were found 300 yards from the nearest cottage.

Isabella Lake is another lake which is partially inside and partially outside of the BWCA. There is a small lumbering town near the shore of the lake. Coliform bacteria were found to be present in the magnitude of 5 per 100 milliliters. Blue-green algae populations were low in the lake.

Sawbill Lake is a medium sized, shallow lake in the eastern BWCA. A portion of the lake is outside the boundaries of the BWCA. Cottages and a resort are present in that portion of the lake. That end of the lake yielded positive coliform results on the magnitude of 2 per 100 ml. Blue-green algae concentrations were low in this lake.

Vermillion Lake is a very large, colored lake (37,000 acres and 22 Co-Pt units) located just south of the western BWCA. The lake is highly used recreationally, and many homes and cottages line parts of its shores. The lake suffered from near blooms of blue-green algae in the fall — approximately 253,500 organisms per liter, mostly *Aphanizomenon flos-aquae*. Water samples taken from the lake yielded no positive coliform bacteria.

Crane Lake receives water from the Vermillion River which drains Vermillion Lake. Crane Lake has a small village located on its shore; and the lake is heavily used. It also suffered from high concentrations of blue-green algae — over 500,000 per liter, mostly *Aphanizomenon flos-aquae*. Low levels of dissolved oxygen were apparent in the hypolimnion of this lake. Coliform bacteria indexes varied from 7 to 33 per 100 ml.

Drinking Water

Virtually no one carries drinking water into the BWCA. Containers of drinking water have considerable weight, and must be carried across portages. The amount of water required for an extended trip would constitute a prohibitive weight and bulk. When one is travelling over "pure, wilderness waters," why should one carry water on his back? It is much more sensible to simply drink lake water. This, apparently, is the general line of thinking followed by most people.

The drinking of any unpurified surface water is always potentially unsafe; and in the BWCA, especially on lakes of the Shagawa Chain, such drinking should be discouraged. Knowledge of simple tablet chlorination of drinking water should be disseminated; and an effort should be made to make chlorine tablets available to all BWCA users. Seldom do BWCA travellers use any type of purification for their drinking water.

Human Tapeworms

Another aspect of sewage pollution is the presence of the broad tapeworm of man, Diphyllobothrium latum. The larval stages of this tapeworm encyst in the flesh of such fish as pike and walleyes. When the fish are incompletely cooked, the larvae remain viable; and when they are ingested by man, the adult worm develops in the intestine. This species of tapeworm can cause an extreme loss of vitamin B-12, weakness, and loss of vigor. The eggs of the adult worm leaves the host in the feces, and when the eggs enter the water they are ingested by copepods. The eggs hatch in the digestive tract of the copepods and the larvae migrate to the muscle tissue. Small fish eat the copepods, whereupon the larvae migrate to the muscle tissue of the small fish. When a large fish eats the small fish, the larvae migrate to the muscles of the large fish. When man ingests fish flesh which contains unkilled larvae; the larvae mature in the intestine and attach to the intestinal wall by means of suckers.

According to a state fisheries inventory, the walleyes of Shagawa Lake are heavily infested with Diphyllobothrium larvae. There is a strong possibility that broad tapeworm larvae are present in fish inside the BWCA. Water from Shagawa Lake flows through the BWCA, allowing passage of copepods and fish into the BWCA lakes. In addition, some of the people who use the BWCA lakes are likely infected with the tapeworm and deposit eggs in close proximity to the water. Other wilderness hosts for the adult tapeworm are possible, such as bear, wolf, coyote, fox, and bobcat.

Two factors increase the probability that viable larvae will be ingested by outdoor recreationists. The first in that these larvae tend to concentrate near the backbone of the fish, where the flesh is thickest, therefore, the most difficult to cook completely. The second is that outdoor cooking methods often produce incompletely cooked fish. Camp-cooked fish are often slightly raw along the backbone.

Insecticides

Fenske Lake is a small, colored lake (approximately 100 acres and 25 Co-Pt units) located just outside the BWCA. There is a well used Forest Service campground on the lake. The balsam and spruce at the lake's edge had suffered from spruce budworm attack, and for two years the area had been sprayed with DDT, approximately 1/3 pound per acre.

A 9-inch smallmouth bass was removed from the lake and analyzed for DDT content. The concentrations found were 3.4 parts per million of DDT and 0.06 p.p.m. of DDE, on the whole fish basis. The analysis was performed by the Detroit Laboratory of the Department of Health, Education and Welfare, Food and Drug Administration.

This level of DDT in fish does not render the fish unsafe to eat; however, it is certainly a significant concentration.

Radioactive Strontium

Analysis for radioactive strontium was performed on a sample from a small, isolated oligotrophic lake, Missionary Lake. The concentration of Strontium 90 was 2.2 ± 0.3 picocuries per liter, and Sr 89 was 0.4 ± 0.1 pc/l. This analysis was performed by Dr. B. Kahn of the R. A. Taft Sanitary Engineering Center, Cincinnati, Ohio.

Mining Operations

Local residents have voiced fears that iron mining operations cause undesirable substances to enter the waters of the area. Apparently the mine on Shagawa Lake does allow sewage and perhaps some mine water or ore-washing water to enter the lake, judging from the high amounts of organic matter, coliform bacteria, iron and clay-like turbidity in the waste water entering the lake. At times, this effluent is variously an opaque red, gray, or tan color, and sometimes relatively clear. The bay which receives this effluent has a coating of reddish-brown particulate matter on the rock and sand bottom. On windy days wave action circulates this precipitate and the water becomes a turbid red color.

Stronger concern had been heard about a very large pit mining operation to the south of the BWCA. The Dunka River flows through the mining area, then directly into Birch Lake, the water from which flows through White Iron, Farm, and Garden Lakes into Fall Lake; then through the "Shagawa Chain" of lakes in the BWCA. The mining company states that no effluent of any kind is discharged into the river. Samples of river water were analyzed and were found to contain over 2 mg/l of iron and 11 mg/p of chloride. These high concentrations cannot <u>necessarily</u> be considered effects of mining operations; the area through which the river flows contains iron ore (in poor grades), and might contain sources of chloride.

The Dunka River is a small stream, generally swift, is in rocky terrain, contains riffles and rapids, and its water is well oxygenated. The water is very highly colored (120 Co-Pt units).

A similar comparison river very near the Dunka River is the Birch River. It flows through the similar terrain, and is also highly colored. Iron concentrations in this river were approximately 0.85 mg/l and chlorides were found to average 3 mg/l. The differences between these two rivers seem significant, however, they may reflect only differences in the watersheds of the rivers. The Dunka watershed may contain greater amounts of iron ore and chloride contributing substances.

Part of the expanding mining operation in the area included installing a very large culvert in the river bed. This involved much earth moving and considerable introduction of silt into the river. An aerial view of the operation revealed an immediate change in the color of the river, from a clear brown to an opaque yellowish-tan at the point of earth disturbance. Such operations can impart tremendous amounts of silt into the river, thence into Birch Lake (see Plate XIV, page 77).

This same company is planning a very large diversion of the channel of the Dunka River to facilitate their mining operations. In view of the large amounts of silt introduced into the river from this relatively small culvert installation, the planned channel diversion would seem to be a potentially seriously destructive modification.

Unusual Algal Blooms

A few isolated lakes supported blooms of blue-green algae. These were Trout, Burnt, Ensign Lakes, and one small unidentified lake. The blooms in Trout and Ensign Lakes were late in the season, and were likely a result of the unusually warm fall — both blooms occurred when water temperatures would have normally been falling. Neither lake normally experiences blooms, according to reports.

Burnt Lake, however, was reported to support dense blue-green algal populations every summer. On September 19, 1963, it was found to contain 1,475,000 blue-green algae per liter. This lake is isolated, and has no inflow of water except from two small, short creeks. The watershed of the lake is small and isolated. No unusual source of nutrients is obvious. The lake is located just outside of the Laurentian Shield area. There are three other lakes very close to Burnt Lake, but none of these showed any signs of algal blooms.

At least one other lake was seen to have gray-green turbid water of the shade characteristic of a dense bloom of blue-green algae (see Plate XV, page 78). The lake was too small to allow a safe landing, and it was extremely isolated, making land or water access very time consuming; therefore, close inspection of the lake was impossible. Another lake of nearly equal size and

Plate XIV. River Siltation as a Result of Culvert Installation to Facilitate Mining Operation just South of BWCA. Notice clear water at top of photo.

Plate XV. Contrast Between Adjacent Lakes — the One on Left Has Algal Bloom; the Other Does Not shape lay beside the turbid lake, parallel to it. Only a narrow strip of land separated the two lakes; yet the second lake was very clear. The clear lake appeared to be quite deep; but so did the turbid one — judging from the slope of the shorelines, the lack of islands, emergent rocks, and aquatic vegetation. Why should just one of the two lakes bloom? Why does Burnt Lake bloom densely, while many other lakes in the area with apparently the same characteristics bloom not at all?

These isolated lakes which support blooms have small watersheds (in relation to the lake area); they have no inflow from rivers or creeks which would likely carry appreciable amounts of nutrients; and they are located in a primarily igneous area, characterized by very soft water. Even speculation as to possible causes of these blooms is difficult.

The possibility that phosphatic rock exists in isolated pockets cannot be completely discounted; but it is very highly unlikely. Unusual sources of nitrogen are equally unlikely. Odd causes, such as a particular lake being used century after century by large flocks of waterfowl and their droppings causing the enrichment, are even more remote.

One possible cause, which is perhaps more likely than any of the preceding, is that the change from predominantly coniferous to predominantly deciduous forest type has caused a greatly increased amount of organic matter (leaves) to enter the lakes every year. Following fires or cutting, the conifers thus removed were often replaced by aspen or birch. Records indicate that large fires were common in the 1700's, and cutting has been common since the 1800's. This yearly crop of organic matter entering the lakes for 50 years, a century, or two centuries, could conceivably be the major cause of these odd blooms.

This process could also be involved in the early blooms of Shagawa Lake. Early fires and timber cutting in conjunction with early settlement, could have caused an unusual amount of organic matter and nutrients to enter Shagawa Lake.

Campsite Destruction

To experience the true value of the BWCA, extended wilderness trips are required. Overnight camping is a necessary part of such trips. This can be a very important part of wilderness enjoyment — the quiet darkness spiced with the soft sounds of the night, a warm fire, and time — a timelessness to relive the day's experiences, to enjoy the company of companions or simply to contemplete private thoughts. Camping is very satisfying — providing one's own shelter, cooking in the open, and perhaps providing some of the food by fishing, gives a person a feeling of being a part of nature and a feeling of invincibility. However, the effects of human use on wilderness demonstrates just how non-invincible wilderness is.

Campsites are not hard to find in the BWCA; if there is a campsite located on a lake, it will usually be easily visible for a long distance. "Camp-scars" are common in the BWCA (see Plate XVI, page 81). These occur where a well used campsite on the shore of a lake has had the earth beaten bare by heavy use; no ground vegetation remains; trees are sparse — usually only large ones remain; saplings are absent for perhaps a hundred yard radius; and most of the trees remaining have all branches removed below six feet above the ground. When one approaches a well used campsite, it is further identified by the presence of makeshift tables, chairs, tent frames, lean-tos, discarded equipment, cans, refuse, and garbage.

Earth compaction, resulting from very heavy use, has many negative effects; among which are unnatural, unattractive appearance, and a probable reduction in the growth rate of trees. Heavy use and soil compaction usually results in tree roots being exposed and being debarked (see Plates XVIII and XIX, pages 82 and 83). This can facilitate infection of the tree roots with bacteria, fungi, nematodes, or insects.

The removal of ground cover plants by cutting or trampling increases erosion, causes an unnatural appearance, and over time, reduces the humus content of the soil.

Plate XVI. "Camp Scar" Resulting from Very Heavy Use of a Shoreline Campsite

Plate XVII. Typical Unscarred Shoreline

Plate XVIII. A Very Heavily Used Campsite. Notice the bare-beaten earth, exposed tree roots, broken down bank.

Plate XIX. Heavily Used Undeveloped Campsite, Without Table or Fireplace; Yet Heavy Use Has Trampled Soil and Vegetation, Exposing Tree Roots

On and around most heavily used campsites, trees under two inches in diameter are seldom found; they are usually cut for use in construction of camp articles — furniture, shelters, storage racks, supports for cooking pots, and innumerable miscellaneous structures. Such cutting destroys the natural appearance of the campsite area, and in addition, the constructed articles remain to destroy the wilderness quality of the campsite (see Plate XX, page 85).

Trees in the campsite area are usually stripped of branches as high as people can reach. Conifer branches are usually used as mattress substitutes, and deciduous tree and shrub branches are used as skewers for roasting.

On many of the heavily used campsites it is not uncommon to see large trees fallen by ax. On Alice Lake, in the central BWCA, a large red pine was found lying on a ridge 30 yards behind a well used campsite. The majestic old tree had measured over 3 feet in diameter and nearly 100 feet in height. It had been cut down with an ax. It was common to find 4-inch to 8-inch diameter trees felled by ax in the vicinity of many campsites (see Plate XXI, page 86). Seldom were any of these trees used. I was told by a Forest Service employee that two men had been discovered in the BWCA, cutting an extensive area of aspen with boisterous vigor, "just for the hell of it." They had no idea that they were doing anything wrong.

Tree barking and ringing is very common. Children often take up the camp hatchet and chip away at the bark of a tree (see Plate XXII, page 87); but often trees are found which have been skillfully ringed with an ax. These trees almost certainly die quickly, and usually become firewood within a year. This might well be a clue to the real cause of this apparently senseless destruction. In a heavily used camping area, all deadwood is quickly used as firewood. As time goes on, campers search for firewood in wider and wider areas. Soon, the distance required for a camper to travel to find firewood is such that many of the more callous recreationists cut or ring trees in the vicinity of the campsite to produce deadwood for the next year's campfires.

This cutting, barking, and stripping of trees, and building of campsite furnishings are bewildering processes. Most BWCA users travel great distances,

Plate XX. Campsite on Newfound Lake. Notice cooking tripod, two user-built fireplaces, stripped birches, litter.

Plate XXI. Ax-Cut, but Unused Four-Inch to Six-Inch Red Pine, Jack Pine and Birch on BWCA Campsite

Plate XXII. Ax-Barked Red Pine

expend much energy and money to enjoy this natural, unmodified scenery; why then, should they expend more effort to destroy the very thing they seek? It very likely is partially the result of cultural conditioning. Americans have ingrained concepts which glorify such things as, conquering nature, carving an existence out of the wilderness, ingenuity, and constructiveness. "How to" booklets, magazines, and books for adults and children; Boy Scout, Girl Scout, and school woodcraft classes all are filled with lessons about building the "necessities" for good camp living. Almost all involve the cutting of green saplings. Even on television outdoor programs, and public service programs the same lessons are seen. How can people who grow up in this atmosphere be expected to behave otherwise?

Even U. S. Forest Service photographs — which are used in Forest Service publications, and which are available to the public for use in publications, displays, or camping promotion — show much the same thing. In looking through a few Forest Service photographs relating to the BWCA, most of the photographs including tents showed tent-frames and supports made of freshly cut saplings. Photograph FS 498987 illustrates a camp on Lac La Croix. Seen in the photograph is a wall tent with an external support-frame consisting of 5 large saplings. Each appears to be over 10 feet long, 2 to 3 inches in diameter, and of a coniferous species. All appear to have been live-cut rather than dead wood. Photograph FS 451819 shows 4 tents, each with 5-pole external frames of apparently live-cut white birch and red pine saplings.

However, all undesirable camping practices cannot be blamed on the culture. Some of the most serious, widespread, and irritating problems involve the lack of simple cleanliness and consideration for others.

Littering

Most BWCA campsites are littered to some extent. A typical campsite and surrounding area contains cans, plastic containers, aluminum foil, cardboard, paper, discarded and broken equipment, old utensils, garbage, bones, fish cleanings, and piles of feces and toilet paper (see Plates XXIII and XXIV, pages 89 and 90). Foot trails near campsites are often lined on both sides,

Plate XXIII. Litter and Garbage on Basswood Lake Island

Plate XXIV. An Abandoned BWCA Campsite

and on the trail itself, with piles of human manure. Islands are commonly reminiscent of old, well used cow pastures.

Why should people who are brought up in a society which is so concerned with neatness and cleanliness be so much the opposite when outside the confines of that society? Perhaps to some people, an important part of "getting away from it all" is being able to forget such things as cleanliness, neatness, and consideration. To most people, it is likely that it simply is easier to let things fall where they may. However, such an attitude has a serious destructive effect upon the wilderness aspect of a campsite and upon the enjoyment of the next camper who uses the site. The next camper must clean up the mess, live in the previous camper's squalor, or move on to a fresh campsite.

The Forest Service sends out cleanup crews to clean campsites periodically; however, soon after they leave new litter accumulates. This is an effective tool; but it is, at best, expensive and effective only for a short period of time. A change in the user's habits is the only truly effective way to cure this problem.

Campers should be encouraged to carry small, light weight, folding shovels. The Forest Service could easily accomplish this by offering these for sale at below cost prices, nearly free, and including instructions designed to inspire their use. Garbage, plastic, paper, cardboard, and wood should be burned and the remains buried. Fecal wastes should be buried. Cans, metal foil, and all compressible non-combustible material should be flattened and carried out. All glass containers should be carried out. After all, all of these containers were carried in when they were full and heavy; why should they not be carried out when they are empty, light, and often compressed? A typical can containing 1 pound of food might weigh 17 ounces, and be 20 cubic inches in volume when full; yet when empty and compressed weigh 1 ounce and be 5 cubic inches in volume. Glass containers are non-compressible, but they certainly weigh less when empty. There are no stores inside the BWCA; all materials must be carried in. Anyone not rugged enough to carry out the lightweight, empty containers of those materials which he carried in, should not use the BWCA.

I suggested this "carry out empty, what you carried in full" idea to several BWCA users and Forest Service personnel. The general reaction was highly negative. Even members of cleanup crews thought the idea was ridiculous. They felt that users should bury all containers or sink them in the lakes.

The problem is that with very heavy use, very thin soil, and the slow decomposition rate of containers — especially aluminum, plastic, glass, and plated cans — very quickly a campsite area becomes saturated with these materials which require years for complete decomposition.

To promote the "carry out" habit the Forest Service could supply free, thick, waterproof, airtight plastic bags to BWCA users. A series of regulations inspections and stiff fines should be adopted to assure their use.

Overuse and Underuse

A few lakes which have easy access, suffer from very heavy overuse, resulting in crowding, serious campsite destruction, dense littering, excess wear on portage trails, destruction of wilderness aspect, and dissatisfaction among users. Some canoe routes have an almost constant flow of boats, while others are used only rarely. Some of the little used routes are the most scenic, and they certainly have much higher wilderness quality.

The section of the BWCA located west of Ely and south of the Echo Trail, is virtually unused by canoeists. Many routes are possible through small, little used lakes and and streams, but these are not well known to the average BWCA user. These numerous small lakes are a virtually untapped resource of the Canoe Country.

Many lakes are used so heavily that when evening falls all available campsites are quickly occupied. Many travellers are then faced with the choice of making camp on unsuitable camping spots, or pushing on to another lake. This results in the shorelines and islands of the heavily used lakes becoming densely dotted with tents, boats, and campfires.

Economic Aspects

The small boom towns that sprang up during the timber and iron mining era, have mostly vanished. Today, where many hundreds, even thousands, of people lived at the turn of the century, there are only clearings or a few old foundations. The town of Winton is only a remnant of its most prosperous size. The community of Ely has been declining since the iron mines began to close. Where, only a few years ago, three large mines were operating, today only one remains open; and its future is very insecure.

Most workers in the area are only partially employed. Mine work is spotty. Many men cut or haul timber in the winter, and some guide in the summer. The Forest Service hires seasonal help in the summer. Most of the young people leave the area soon after graduating from high school. A few remain to attend the local junior college; but then, most leave following graduation.

Ely's prosperous time is summer and fall when canoeists, fishermen, and hunters visit the area. Then, the many canoe outfitters, sport shops, stores, and motels are filled with recreationists.

When timber harvesting and mining began to fall off, some of the lost income was offset by large numerous resorts located on private land within the BWCA. These resorts employed operators, managers, maintenance personnel, maids, cooks, cabin boys and girls, and guides. These resorts were served by boat and seaplane. Flying fishing trips were very common and were the source of considerable income. When the clampdown came and both aircraft and resorts were banned in the BWCA, further economic depression occurred. This reduced income is slowly being replaced by increased recreational visitors.

There are always pressures for exploitation and development of areas such as the BWCA. Commercial recreation facilities, timber, minerals, and water use are some of the major developments possible for the BWCA. Regardless of how large is the value of the undeveloped area and how small is the value of the resource to be exploited, there will always be someone with the will and the way to exploit it. We must somehow unconditionally protect these few remnants of wilderness, natural beauty, and areas of historical or scientific significance, against development. Even when some valuable, needed mineral is discovered in large quantities and removed "for the public benefit," it brings wealth to a few and minor utility to many, then is gone. In the long view, the products of such exploitations are used almost immediately and their importance is over; while the undisturbed area, that could have produced utility for as long as man could maintain it in its natural state, after exploitation, is also gone; and nothing remains.

Forest Service Management Techniques

At present the BWCA is not managed as a unit. There are no special personnel assigned exclusively to the BWCA. All personnel must fit into the rigid organization of standard Forest Service divisions. The Superior National Forest is divided into six districts, each of which contains a portion of the BWCA. Each district is managed by a district forester, who has the responsibility for timber management, fire protection, forest disease control, road maintenance, fisheries and wildlife management, and recreational development of the forest; and in addition, he must manage his portion of the BWCA. Each portion of the BWCA, then, is managed by a separate ranger, each with different attitudes and management practices.

An example of this is seen in the various methods of garbage disposal used by crews which clean campsites in the BWCA. Most districts exercise liberal techniques — crews may dispose of wastes wherever convenient. Many crews have discovered that the simplest method is to simply dump the garbage, litter, and wastes into the lake. Some crews bury wastes at the periphery of the campsites. Where more strict procedures are set down by rangers or foremen, wastes are required to be buried at a distance inland from the campsite; and in some cases, refuse is removed from the BWCA entirely.

The Superior National Forest lands outside of the BWCA have a completely different status than does the BWCA. The normal national forest lands are managed with a primary goal of timber production. Recreation and other uses, which are not incompatible with timber production, are allowed on national forest lands. Major objectives for these lands are to produce timber, forest products, recreation, and to maintain desirable watershed characteristics. Proper management of these lands requires the construction and maintenance of roads and campgrounds, the conducting of timber inventories, the overseeing of logging operations, and the controlling of fire, insects and disease.

The proper management of the BWCA requires a quite different set of attitudes and goals. The main objectives for the BWCA are to maintain the wilderness character of the land and the lakes, and to provide wilderness recreation. Lakeshores, islands, and campsites must be regularly patrolled for the purposes of removing litter, garbage, and wastes, and to ensure that destructive practices are not taking place.

The most efficient management of the BWCA would seem to be facilitated by the creation of a special management unit of personnel assigned only to the BWCA.

Incompatible Uses

Logging

"To cut, or not to cut" has long been the controversial question concerning the U. S. Forest Service and Boundary Waters Canoe Area users. The Forest Service has continuously advocated timber cutting (excluding a 400-foot wide strip around lakes and streams), and many BWCA users have clamored for a complete ban on cutting. Many casual BWCA users were not aware that logging operations were allowed inside the BWCA; however, organized groups, and individuals interested in wilderness preservation were aware of the logging and constantly lobbied for its prohibition. As a result of public pressure, in 1941 the Forest Service prohibited timber cutting on 362,000 acres of the BWCA along the international boundary. Since then, the Forest Service has actively promoted timber cutting on the remaining 700,000 acres.

Continued public pressure existed, and in 1964, the Secretary of Agriculture, Orville L. Freeman, appointed a committee to review the management of the BWCA. As a result of the committee's recommendations, in 1965 Secretary

Freeman directed the Forest Service to add an additional 150,000 acres to the "no-cut" area. Thus, approximately one half of the BWCA is exempt from logging. The question of cutting on the other half still remains open.

One might well question, "Why should there be any controversy over timber cutting in the Boundary Waters Canoe Area?" The area is a poor timber producer, with its rocky terrain, short summers, and long cold winters. Few trees of saw-timber quality exist there, and those that do exist are highly valuable for their scenic aspect. The trees in the BWCA are primarily useful only for wood pulp. In addition, much of the area's harvestable acreage is in small birch and aspen, which are less desirable species' even for pulpwood. Timber harvesting is further complicated by difficulty and expense encountered in entry, and removal of timber, as a result of the rough terrain, innumerable lakes, streams, and swamps. There are thousands upon thousands of square miles of land in Minnesota, and other Northern states, which have standing timber which would be easier to remove and which is of superior quality to that in the BWCA. Why, then, is there any pressure at all to cut timber in the BWCA — one of the least suited uses of the area, and one which tends to destroy the area's best use?

The best reason, very likely, is that the stumpage fee set by the Forest Service is so low (about $25 per acre) that the timber harvesters can make a profit. It is questionable that funds derived from stumpage fees cover the true costs of administration of the forestry program for the BWCA.

Just how destructive is logging to wilderness? Where logging is carried out, wilderness is completely destroyed. When a zone of uncut timber remains around lakes and streams, the wilderness aspect of the lakes and streams is injured little; however, the potential use of the adjacent land areas by recreationists is destroyed. As the lakes of the BWCA become more highly used, canoeists will, more and more, make hikes inland to enjoy the solitude of the wilderness forest — as an adjunct to their lake travel. Another negative quality connected with logging is noise. The noise of even a small logging operation carries over great distances and completely destroys the wilderness quality of a large area.

One of the justifications for logging, and for the low stumpage fee, is that the employment is needed in the area. The employment supplied by cutting inside the BWCA is minor. It primarily consists of spotty, part-time winter employment for a few cutters and haulers.

In the past few years, between 2,500 and 4,000 acres each year have been harvested in the BWCA. Yearly volumes of wood removed have been between 30,000 and 50,000 cords. The Forest Service uses the figure 50,000 cords and an average value of $20 per cord to estimate a value of nearly $1,000,000 as the value of wood taken yearly from the BWCA. This is a maximum, theoretical value; the actual amount of money earned by local workers is likely less than this figure.

The figure $1,000,000 does not look very large when compared to the probable amount spent by the one-quarter to one-third million recreationists that visit the BWCA yearly. Expenditures for a typical one-week trip for two adults would include: boat rental — $20, food — $25, fishing licenses — $12, motel for one night upon return — $10, miscellaneous supplies, special wilderness gear, and personal articles — $10. This total of $77 represents the likely local purchases, and is more a minimum than a maximum. Traveling expenses are excluded. Gas and oil would be purchased locally, throughout Minnesota, and in other states which would be passed through. Many recreationists spend much more money than this amount, renting or buying camping equipment, fishing tackle, cameras, film, liquor, clothes, and special dehydrated foods. Some fishermen hire guides at a cost of from $10 to $30 per day. On the other hand, a one-day fishing trip by a local resident is counted as a "visit." Expenditures in these cases would vary from perhaps 2 or 3 dollars to as much as 10 dollars, or more.

In the face of these considerations and the expected increase in recreational use of the Canoe Country, the Forest Service has continually tried to "sell" logging in the BWCA. In the summer of 1964, I heard a local radio program in Ely, which features reports and discussions by the Forest Service. One of the top local administrators in the Forest Service was explaining the advantages of logging in the BWCA and the possibility of a paper mill being established in, or near, Ely. He expounded upon the immediate economic advantages connected with having a paper mill in the area. He did not discuss the fact that such a paper mill would necessarily pollute the waters of the area, and eventually the BWCA, with substances far more destructive to lakes and streams than sewage. Very likely he didn't know this. It certainly seemed as though he was trying to sell the public the idea of continued, even increased, logging in the BWCA (a practice somewhat destructive to the BWCA) in order to attract a large paper mill, the presence of which would be profoundly destructive to the BWCA lakes, over time.

The Sylvania Tract

The Forest Service in general seems highly reluctant to exclude timber cutting from any lands it manages, except certain large tracts of land in the Western United States which satisfy the Service's stringent criteria for its "Wilderness Areas." An example of the Service's strong predisposition to subject land to timber cutting, regardless of the land's characteristics, is the Sylvania tract in Michigan's Upper Peninsula. It is a privately-owned tract of 14,000 acres of land and 4,000 acres of water, including 36 named lakes. The land has never been cut — the timber is virgin and the lakes are unmodified. It has been an exclusive private preserve held to maintain its primitive wilderness atmosphere. The land is dotted with large, knarled old trees.

This jewel of an area has been put up for sale by its owners, and the Forest Service has been attempting to obtain it for a reported 6 million dollars or more. The only thing that sets this area aside from the surrounding area of dense lakes and forest, is that the trees are knarled, towering old monarchs, and that the lakes are undeveloped. This is the essence of the tract's value.

What does the Forest Service plan to do with this area if it achieves ownership? It's management plan includes cutting most of the timber and constructing roads, campgrounds, and picnic grounds on all of the larger lakes except 3 or 4. In other words, the Forest Service is going to pay a very high price to obtain this unique tract; then, it will spend more money to destroy this uniqueness. Small exhibits of large timber will be left standing; however, the majority of the land will be subjected to cutting and timber production.

The Sylvania tract is surrounded by national forest land containing numerous lakes of all descriptions, and timber of all types. There is little demand for either the timber or the lakes. The Forest Service has recently constructed campgrounds on several lakes in the vicinity of the Sylvania tract. The great majority of these campgrounds are <u>almost completely unused</u>. When I surveyed these campgrounds in the summer of 1964, only three campgrounds showed detectible use. These were located on lakes which were producing good fishing.

If the Forest Service constructs roads, campgrounds, and allows the timber to be cut, the Sylvania tract will be reduced to more of the sameness with its surroundings. It will be used fairly heavily by local people while the fishing remains good, but as soon as the fishing success is reduced to a normal level, use will fall off, and the Sylvania tract will simply become 18,000 more acres of the Ottawa National Forest.

One possible reason for this strong predisposition to cut might be that most Forest Service personnel are <u>foresters</u>. That is, they were educated as foresters and their basic perceptual set is toward timber production. If a particular forester had a course or two in college which concerned recreation or planning, he might later become a recreation specialist or a planning specialist; but still, his basic attitudes are those of a trained, experienced forester. Apparently, the Forest Service cannot hire pure planners, or recreation specialists or watershed managers — they must, by regulation, be foresters. If they also have some background in these other fields, they may still be hired; but they must first and foremost be foresters. Exceptions to this rule are landscape architects and perhaps, engineers.

A forester tends to look upon the old knarled monarchs of the Sylvania tract as worthless relics which are simply taking up space that could be producing good healthy saplings. Such old trees are past their most efficient wood production stage and very often are hollow. Many of the beautiful old trees contain little usable bolts of good lumber. Their real value lies in their scenic aspect.

Another reason might well be a result of the Forest Service's multiple use doctrine. This doctrine was designed in part to combat the tendencies of many foresters to completely ignore any use except forestry. The doctrine promotes the idea that a resource should be managed for several uses, rather than only one. The multiple use concept is a very good one for most situations, except where unique areas are involved. Certain scattered areas remain in the United States which have a single, unique "best use" — other uses often being incompatible with the best use. The multiple use concept rejects the idea of one best use. The multiple use doctrine has been none-too-jokingly translated by foresters as "let's please everybody a little, but nobody a lot."

A third possible reason, for the continued pressure for logging from within the Forest Service, might be simply that the Forest Service feels that it will be thought to have no business managing an area where there is no timber production. Many people feel that a purely recreational area should be managed by the National Park Service, or some other agency, rather than the Forest Service. The Forest Service is supposedly not in the recreation business. The fact is, however, that it _is_ in the recreation business; and it probably should be, since recreation is an important forest use, and since our national forests contain much of our best lake and stream resources. The only things remaining to be done are that the Forest Service must realize that it _is_ in the recreation business; it must give to recreation the consideration it deserves; and it must staff itself with well rounded, natural resources managers and recreation specialists, rather than pure saw-timber foresters.

Motorboats

Motorboats and wilderness are at least somewhat incompatible, and their use inside the BWCA has long created friction among wilderness enthusiasts and boaters. Most BWCA motorboaters are fishermen. Many of these users are not interested in the wilderness aspect of the area, as such. Lucas' study showed that paddling canoeists disliked seeing motorboats, but that motorboaters did not mind seeing other motorboaters.

Regulations exist which prohibit motorboats inside the BWCA, except where their use has already been well established. These regulations have little meaning since motorboats have been used on almost all of the lakes where their use is physically possible. Thus far, this regulation has not been enforced.

The storage of boats on federal lands should be effectively prohibited. As of the summer of 1964 many boats, especially motorboats, remained stored at the portages on many wilderness lakes. These large heavy boats are usually skidded in over the ice and snow in winter, deep within the BWCA. They are then left locked and chained to trees to be used periodically by the owner for years, until the boat deteriorates beyond repair. Then another boat is skidded in and the old boat is often abandoned.

These boats (often brightly painted) are highly incompatible with the wilderness flavor of the Canoe Country. The old, rotting derelicts constitute even worse eyesores.

Houseboats, charter boats, passenger boats, and canoe ferries are even more incompatible with wilderness than are ordinary outboard motorboats. In 1964, all of the above sorts of boats were present inside the BWCA (see Plates XXV, XXVII, XXVIII, and XXIX on pages 102, 104, 105, and 106). A large 40-foot passenger boat-canoe ferry was seen. Several wide 18 to 20-foot long, high speed canoe ferries were also seen. These had racks for carrying several canoes, and they would speed the canoes and passengers far into the BWCA so that the paddling trip could be begun as deep within the Canoe Country as possible.

Another service available to reduce the paddling for wilderness trips is the tow service. Here, a small outboard boat tows a string of canoes for a distance into the BWCA (see Plate XXVI, page 103).

Plate XXV. Light Motorboats Penetrate Deep Within the BWCA

Plate XXVI. Canoe-Tow Arrangement. These "wilderness" travelers needn't paddle.

Plate XXVII. Houseboat on BWCA Lake

Plate XXVIII. Canoe Ferry on Moose Lake

Plate XXIX. Canoe Ferry and Passenger Boat
on Basswood Lake, Pipestone Bay

Mining

Mining would almost certainly be a highly incompatible use within the BWCA. It is likely that valuable mineral deposits are present in the rock formations of the BWCA. Iron, copper, nickel, titanium, silver, and gold are some of the possible future "finds" in the BWCA. There is some evidence that these minerals exist inside the BWCA. The mineral rights to some of the BWCA lands lie in private hands, and the State of Minnesota owns the mineral rights to 91,616 acres of BWCA lands. Mining stands as a serious potential threat to the Boundary Waters Canoe Area.

Firearms and Hunting

Some people feel that the use of firearms in the BWCA is an incompatible use. The soundness of this proposal is questionable. It might simply be a result of the modern tendency to abolish the use of firearms whenever the question arises.

As people become more urban oriented, fewer individuals have actual personal experience with firearms. They have no concept of the sensible, functional aspects or sporting qualities and safety of good firearm use. Most of these people have an automatic negative feeling toward "guns" and associate them only with gangsters, crime, and violence.

The effects of the anti-gun, anti-hunting emotion is seen in many national parks, where unbalanced, unhealthy overpopulations of game have resulted, often ruining the food supplies of large areas of game habitat. This is usually the case where hunting is not allowed. Game soon multiplies beyond the carrying capacity of the land; and overbrowsing, and serious vegetation damage occurs.

In the BWCA, hunting represents a potentially valuable recreational pursuit — in terms of the aesthetic and recreation values derived, meat produced, and profits to the local economy.

Aircraft

Aircraft are presently banned from flying at altitudes of less than 4,000 feet when over the BWCA, because their presence is destructive to the wilderness character of the area. It is true that the sight and sound of aircraft are destructive in this way. Even the sight of the con-trails of high flying jets cutting across the wilderness sky have a negative effect. For this reason, the necessity of <u>any</u> aircraft flying at <u>any</u> altitude over the BWCA should be critically examined. The most frequent aircraft seen flying over the BWCA are private "bush pilots" flying fishermen into the back country. These planes are usually flying at about 4,000 feet — which is low enough so that their sound is quite audible. Since planes cannot land in the BWCA or in the Quetico Park directly to the north, it would seem that it would be practical to require that these planes fly <u>around</u> the BWCA or follow the Gunflint trail. Commercial and military flights should be urged to fly around the area.

Other Incompatible Uses

The improper use of portable radios can constitute a use which is highly destructive to the wilderness quality of a wilderness-type area. This is especially true in the evening, when one quietly reflects upon the day's experiences or enjoys the company of companions. At these times — when the only sounds are the breeze whispering through the pines, or a loon calling in the distance — the sounds of rock and roll records or the play-by-play of a baseball game completely destroy the wilderness flavor of the night. Sounds such as these carry very long distances over water. One radio can affect an entire large lake.

Brightly-colored tents can be destructive to the wilderness qualities of an area. Campers on the other side of a lake might well find it distasteful to look across their wilderness lake at a red, yellow, or blue tent. Passing canoeists also must view these gaudy structures.

CHAPTER VIII

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

BWCA Lake Characteristics

The BWCA lakes have as their most outstanding characteristics: numerousity and proximity to one another, very irregular shapes, numerous islands, rocky littoral areas and shores, sparse vegetation, very soft water, and low productivity. However, little detailed information is available concerning the biology, chemistry, or physics of the BWCA lakes. More research is needed. The Forest Service and the State of Minnesota should encourage research by providing financial support for research in and around the BWCA. University researchers should be attracted to the area. One way of accomplishing this would be for the Forest Service, the Minnesota Conservation Department, and others, to compile a list of problems — needed research to be performed in the BWCA. This list could then be sent to nearby Universities to stimulate the interest of scientists, faculty, and graduate students. Much research personnel might be attracted to the area in this way. Financial aid could be provided to those who would do research of particular interest to the various agencies.

Incompatible Uses

The "best use" of the Boundary Waters Canoe Area seems to be wilderness-type recreation. Potential timber production is low, due to the rocky nature of the area, the long, cold winters, and short growing season. There is the possibility that mineral deposits of commercial magnitudes exist within the BWCA. However, the exploitation of these would produce wealth for a few, and short term utility for some; at the cost of long term, unique recreation for many. With proper management, this area can produce recreation with unique aesthetic aspects, for hundreds of thousands of people <u>per year</u> for as long as man exists.

To protect the BWCA from these and other destructive uses, measures should be taken to permanently prevent the onset of such uses. The Forest Service should close the entire BWCA to logging. Mineral rights still held by private interests or by the State of Minnesota should be obtained by the federal government. This could be a complicated task; but, as long as these mineral rights remain outstanding, there exists the possibility that the BWCA will be opened to mining.

Legislation should be formulated which would protect the BWCA, and watersheds which are influent to the BWCA, from any new use or increased use which would, or could affect the quality of water within the BWCA. This must include areas just outside the BWCA, the water from which enters the BWCA lakes. These uses would include: the establishment of paper mills or other industry; the discharge of mine wastes, ore-wash-water, sewage effluent, industrial wastes, fertilizers, insecticides, silt, clay, or organic matter; the cutting of timber to the water's edge; large earth moving operations, and others.

Incompatible recreational uses should be excluded. These include: motorboats, houseboats, commercial powerboats, "tent cities," aircraft, all forms of mechanized travel such as snowmobiles, "woods scooters," and the use of retractable wheels, rollers, or dollies for transporting boats over portages. Regulations strictly forbidding these uses should be adopted by the U. S. Forest Service and the State of Minnesota.

Pollution

The use of wilderness lakes for the dilution of wastes is a highly destructive and incompatible use. Wilderness waters are the most sensitive to the introduction of pollutants, and undesirable changes can occur from even the smallest amount of pollutants. In addition, recreational users have the most sensitive perception toward pollution. "Aesthetic pollution" (pollution which reduces the aesthetic value of water) is caused by much smaller amounts of pollutants than are required to cause public health pollution.

Shagawa Lake appears to be polluted, by any but the narrowest criteria.

The "wilderness" lakes downstream from Shagawa Lake appear to be becoming enriched, if not polluted — aesthetically speaking.

To end the heavy algal blooms on Shagawa Lake, and to halt the enrichment process taking place in the wilderness lakes downstream from Shagawa Lake, the inflow of sewage effluents and mine wastes to this lake must be halted. These wastes should be discharged into a stabilization lagoon, the effluent from which could be pumped into a sealed basin, bog, or used or irrigation of a forest area. Care must be taken to allow no effluent from the lagoon to seep into Shagawa Lake, or to enter any of the watersheds which flow into the BWCA. Old sewers should be intercepted, and new sewers be constructed to replace septic tanks, wherever possible. Methods to prevent septic tank effluents from entering the lake, should be investigated.

The halting of this continual increase of nutrients will have some immediate beneficial effects. The algal booms would likely be less severe, becoming continually moderating with the passage of time. However, much nutrient material is tied up in the lake bottom muds, which have accumulated over the years. These will continue to slowly release nutrients into the water. The feasibility of removing some, or all, of these muds by large high-speed dredges, or other means, should be investigated. This would be an expensive project; however, considering the long-term benefits to the entire BWCA, and considering the availability of federal monies for such a project, it well might be a workable undertaking. Since these muds are primarily found where the water is 20 feet, or more, in depth, the entire lake bottom would not require dredging. Approximately 60 to 70 percent of Shagawa Lake is greater than 20 feet in depth.

There has been some concern voiced as to the safety of drinking untreated water from BWCA lakes. Most BWCA travelers simply fill a container with surface water and use it immediately. Actually, the drinking of untreated surface water is potentially unsafe anywhere. The BWCA is no exception. The fact is that the great majority of BWCA is usually perfectly safe; however, there is always the possibility that pathogenic organisms can be present. Sources of pathogens include: sewage effluent from Ely's sewage treatment plant and septic tanks, effluents from septic tanks in Winton, sewage seepage from cottages and resorts located on lakes outside the BWCA which are influent to the BWCA lakes, discharges from travelers while inside the BWCA, and natural sources. Some lake travelers are in the habit of "obeying nature's call" at the shoreline of a lake, or while on the lake itself. When one dips a cupful of water from a lake, he cannot be certain that someone has not relieved himself at that very spot within the preceding half hour. For these reasons BWCA users should be encouraged to use chlorine tablets to purify drinking water.

Blue-green algae of the genera found in Shagawa Lake and the Shagawa Chain of lakes are known to be somewhat toxic. Their toxicity is most likely very low at the concentrations at which they are found in the "chain lakes." Research should be conducted to investigate the effects of long term intake of moderate concentrations of these algae. It is a simple matter to remove these algae from drinking water. Pouring the water through a double-folded, tight weave handkerchief removes the majority of the larger algae.

Many large important lakes which are partially within the boundaries of the BWCA show certain signs which indicate the possibility of pollution. These lakes include Moose, Snowbank, Sawbill, Alton, Isabella, and Seagull Lakes. Research should be encouraged on these and comparable isolated lakes. Efforts should be made now, to halt the inflow of sewage seepage and organic matter into these lakes.

Certain isolated lakes have unusual characteristics, which should be investigated. These lakes suffered from algal blooms — Trout, Ensign, and Burnt Lakes. Further knowledge of the dynamics of these lakes might reveal the causes of algal blooms in lakes. This is a process that is not yet fully understood.

Overuse and Underuse

Many lakes and routes are very heavily used, such that available campsites are filled to overflowing; while other lakes and routes are seldom used.

This leads to crowding and resulting dissatisfaction, destruction of campsites, vegetation, and portages.

Undesirable Camping Habits

Littering, timber cutting, barking, and ringing, the indiscriminate depositing of feces, and the building of structures such as tables, seats, racks, clothes poles, reflector ovens and tent frames, are the most undesirable camping habits.

The problems of overuse, underuse, campsite defacing, littering, and timber-destruction (felling, barking, stripping, and ringing) could be controlled by the initiation of a permit system. A certain number of permits could be issued for each route — this would distribute use more uniformly. The permit system could function to reduce littering, campsite defacing and timber destruction by requiring, as a part of the permit acquisition, that all members of the group attend an instructional briefing. This briefing would include instruction in safety, good campsite habits, helpful hints to aid novice campers, fishing advice, and instruction as to the regulations, enforcement, and penalties for infractions. However, the basic function of these briefings must be to develop a "conscience" among wilderness users. The BWCA users should be inspired to perceive the effects of their actions upon the enjoyment of others. An effort should be made to motivate the BWCA users to identify with wilderness, woods, and water, in a positive way — to feel that what they do to these, their natural resources, they are doing to themselves. In addition, long-term educational programs should be initiated, using the public information media, even the public schools. Educational programs usually yield results slowly, but lastingly.

To effect an immediate reduction in the undesirable habits, stricter regulations, higher fines, frequent patrols, and strict enforcement are necessary. The knowledge that at any time an officer might drop in and check one's camp for infractions, the penalties for which are stiff fines, would tend to reduce these infractions.

A practicable method to reduce timber destruction would be to provide supplies of firewood at campsites. It would be an expensive operation; however, the benefits would be great. The added expense could be offset by permit fees.

The use of permits, regulations, and patrols are, to some degree, incompatible with "wilderness"; however, these practices are certainly the lesser evils. It is likely that the frequent patrols would be necessary only initially. As the educational program becomes effective, and as the knowledge of the strict law enforcement becomes widespread, the need for patrols would be greatly reduced.

Economic Impact of the BWCA

The immediate effects of the BWCA restrictions were negative. The results were loss of income from flying fishing trips, commercial passenger boats, resorts, and private cottages, within the BWCA. The positive effects of the restrictive management of the BWCA are long term, but will likely outweigh the long term effects of non-restrictive management.

To boost the sagging economy of the area, an effort should be made to encourage recreational development of lakes just outside the BWCA. Such development would tend to reduce the pressures of incompatible recreational uses upon the BWCA, by providing a better suited, more accessible environment for such uses. In addition, the local economy would be encouraged to become more recreation-based. This should tend to reduce the interest in mining and logging. The recreational developments should include the development of new semi-wilderness canoe routes and the encouragement of commercial recreational facilities. This semi-wilderness, with facilities and frequent access points, would provide an opportunity for shorter, less demanding trips for the busier or less vigorous recreationists. Recreation developments on large lakes outside the BWCA would attract motorboat and houseboat users away from the BWCA.

Forest Service Management Techniques, Attitudes, and Personnel

At present, the management of the BWCA is in the hands of six district foresters, each of which has control of a portion of the Superior National Forest, each of which contains a portion of the Boundary Waters Canoe Area. The result of this is a non-uniformity of management attitudes and techniques.

The Forest Service should reorient the management organization for the BWCA. Management of the entire BWCA should be the responsibility of one man who has a broad background in resource management, recreation (especially wilderness recreation), the aquatic sciences (water resource use, aquatic biology, and pollution control), and watershed management. Working under this man should be foresters, recreation specialists, biologists, limnologists, engineers, landscape architects, enforcement and maintenance personnel. These people should be trained to develop attitudes attuned toward wilderness preservation. In this way the management techniques, policy decisions, and policy interpretations would best serve the BWCA and the nation.

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