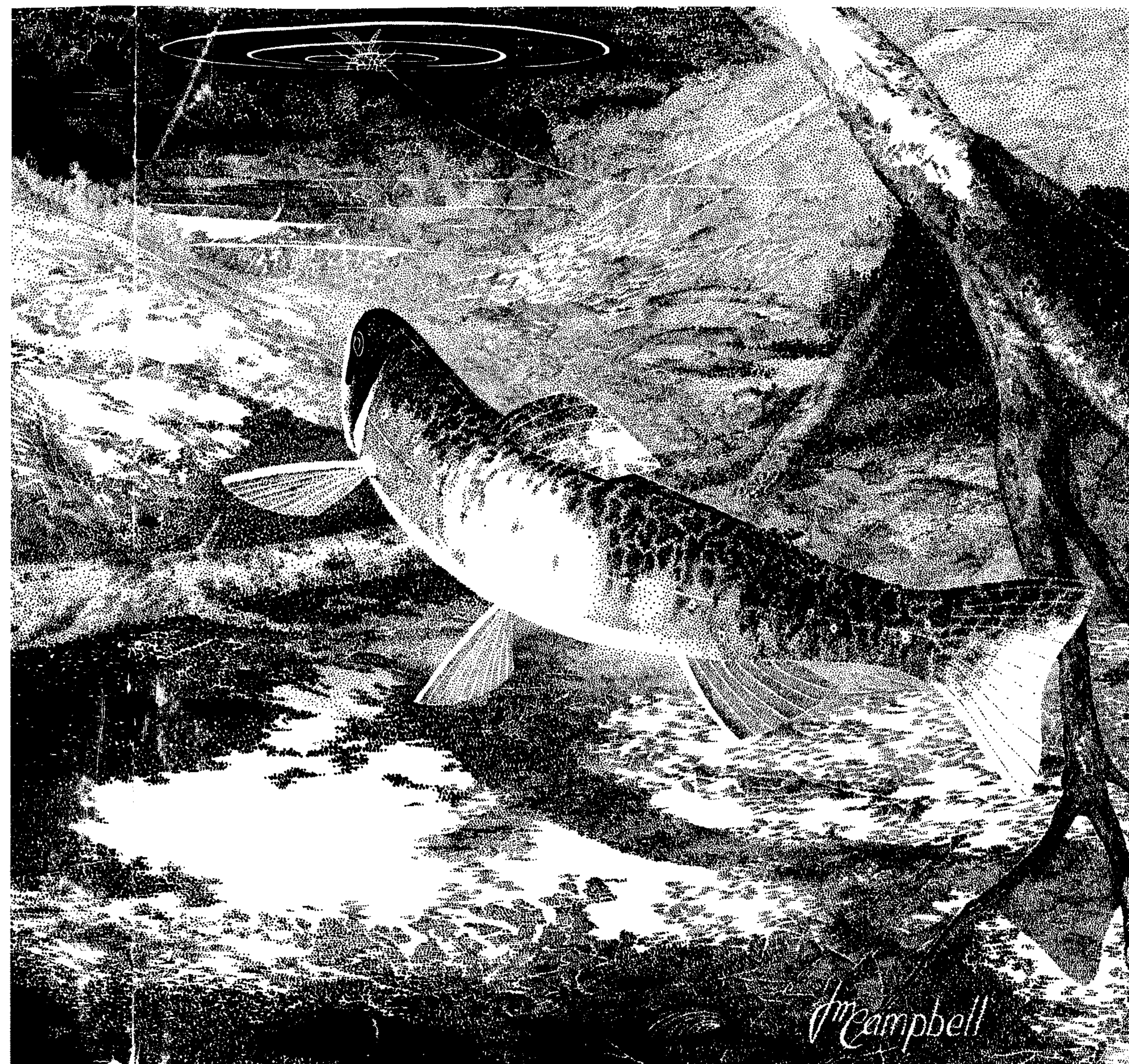
COVER — a brook trout, Michigan's State Fish, eyes a dry fly on a stretch of the Au Sable River. This ink drawing was done in stipple by James Campbell of the Department's Engineering Division.

MICHIGAN DEPARTMENT OF CONSERVATION

GEOLOGICAL
SURVEY
BULLETIN 3

MICHIGAN'S Au Sable River Today and Tomorrow



Man's mishandling of his natural world is the most critical conservation problem of our time. His ability to destroy what nature has created is limited only by the extent of his technological ingenuity. Much of what man does is necessary, and much is beneficial; but much, too, is both needless and destructive.

To live in harmony with his world, man must comprehend the complex processes that shape his environment and allow them to work for him. Otherwise, he risks destruction of the very values that he seeks to preserve.

Much of the change wrought by man on the face of the land is obvious and apparent. Some of it is insidious, hidden until he discovers too late that a supposedly "safe" resource has been damaged or lost.

Gerth Hendrickson's study of the Au Sable River system and what is happening to it is more than just another scientific report. It is a clear warning, and a challenge. We in the Department of Conservation believe "Michigan's Au Sable River Today and Tomorrow" is important. That is why we are publishing it, and that is why we hope it will be widely and thoughtfully read.

Ralph A. MacMullan
Director of Conservation

STATE OF MICHIGAN
DEPARTMENT OF CONSERVATION
Geological Survey

MICHIGAN
REFERENCE ROOM
SURVEY

BULLETIN 3

MICHIGAN'S AU SABLE RIVER

— *Today and Tomorrow*

By
G. E. Hendrickson

Illustrated by James M. Campbell

Prepared in cooperation with
The Geological Survey
United States Department of the Interior

Lansing
1966

STATE OF MICHIGAN
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DEPARTMENT OF CONSERVATION
RALPH A. MACMULLAN, *Director*

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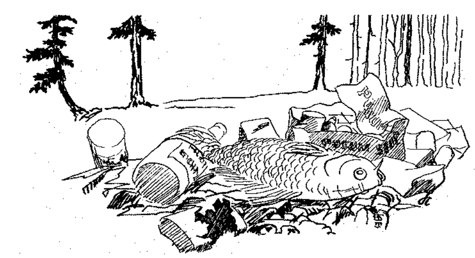
Foreword

Two south-flowing rivers rise in the country north of Grayling. One, the Manistee, turns west to Lake Michigan; the other, the Au Sable, turns east to Lake Huron. Both are famous trout streams, but the Au Sable is perhaps enjoyed and cherished by more people than any other Michigan river. Cool clean flowing water, natural cover, and gravel spawning beds make it an outstanding trout stream. Its natural beauty attracts canoeists, campers, and cabin dwellers. The kind of excellence typified by the Au Sable, however, is fragile and can easily deteriorate through neglect, mismanagement, and apathy.

If the fate of the river is left to chance, certain changes are inevitable, if not irreversible. Dwellings will line the banks everywhere except on public lands or on large private tracts. Protective forest cover will decrease. Water temperatures will rise, and the purifying oxygen content will fall off. Sunken logs and fallen trees, essential features in the aquatic habitat, will be removed to "clean up" the stream, and dredging will ruin the bottom. The only trout will be those planted from year to year. Fishermen and campers will be forced to seek waters not defiled by domestic waste and litter. Declining economic benefits from recreation will cause hardships for local residents.

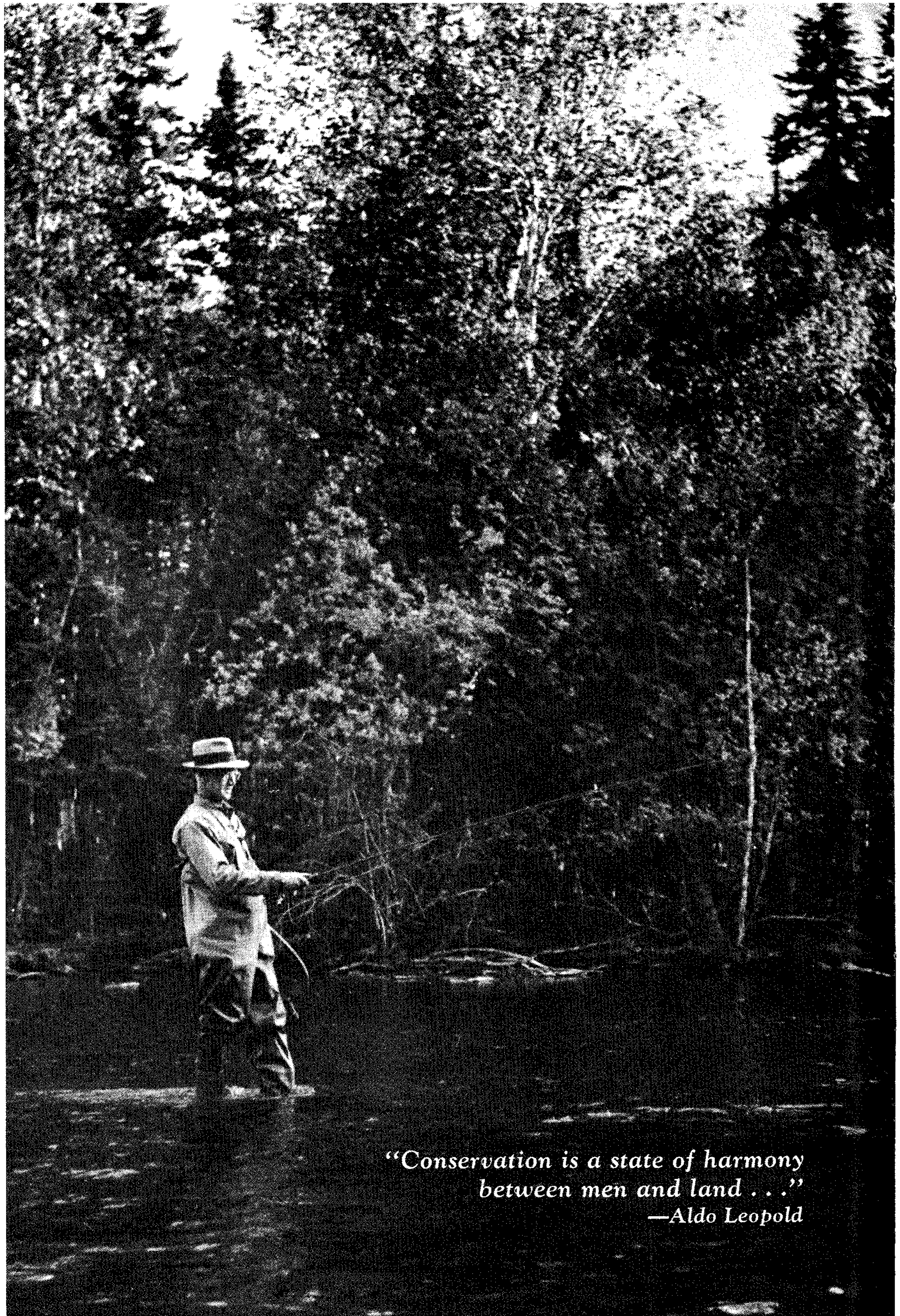


This need not happen. The Au Sable River can be saved by heeding the principles laid down in this report. The author is well qualified to bring this message to the people of this Water Wonderland State. Mr. Hendrickson has served as a geologist for many years with the United States Geological Survey. Commencing in 1962, he took charge of the ground-water activities of that organization in Michigan. Not only is he technically qualified and knowledgable, but readers will appreciate his easy-to-read style of writing.

These findings must be translated into action now, and I urge every citizen who loves our rivers to help bring about the needed reforms.

Gerald E. Eddy
State Geologist
Chairman of Water Resources Commission

Lansing



Preface

In my travels along the Au Sable River I talked with several old-time residents who told me plainly that the days of the Au Sable as a recreational paradise are numbered; the stream is doomed to die. Others doubted that such a fate is inevitable, but those who knew the river best seemed inclined to the pessimistic view.

What are the seeds of destruction, already planted, that threaten the life of this beautiful river? What can be done to save it for ourselves and our children, for our children's children? It can be saved. But we must advance and support programs that improve the stream for recreation, and oppose all activities that destroy or impair those values.

Although the central theme of this booklet is water-management, the subject includes biology, ecology, chemistry, economics, and forestry. I have been most fortunate in obtaining the advice and criticism of experts in many fields. I wish gratefully to acknowledge the help and encouragement of these experts: Leonard N. Allison, Fish Pathologist in the Michigan Conservation Department; Norman F. Billings, Chief of the Hydrology Division of the Michigan Water Resources Commission; P. W. Christenson, retired, long-time resident of the Au Sable region and local authority; Gerald E. Eddy, Chief, Geological Survey Division, Michigan Department of Conservation; Bernard J. Fowler, resort owner and fishing guide; R. M. Hayes of the Crawford County Chamber of Commerce; C. R. Humphrys, Professor of Resource Development at Michigan State University; Harold C. Jordahl, Jr., Regional Coordinator Conservationist, U. S. Department of the Interior; James T. McFadden, former chief of the Fish Division of the Michigan Department of Conservation; R. H. O'Neil, forester, Consumers Power Company; Donald M. Pierce, Chief, Wastewater Section, Michigan Health Department; J. G. Rulison, Hydrologist, Geological Survey Division, Michigan Department of Conservation; Dean H. Urie, Research Forester, U. S. Forest Service, and Roger G. Wicklund, Habitat Management, Fish Division, Michigan Department of Conservation.

In addition, I have had the unselfish assistance of my colleagues in the U. S. Geological Survey in reviewing and revising this paper.

This report is the product of a study for a Master's thesis in the Department of Resource Development, Michigan State University. The work was supported in part by the Water Resources Division of the U. S. Geological Survey.

Lansing, September, 1965 — Gerth E. Hendrickson

Illustrations

Photos

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Maps of the River

Other Illustrations

Full-color center—*Fishing the Au Sable,* oil painting by Ogden Pleissner.
All other figures and art work by James Campbell.

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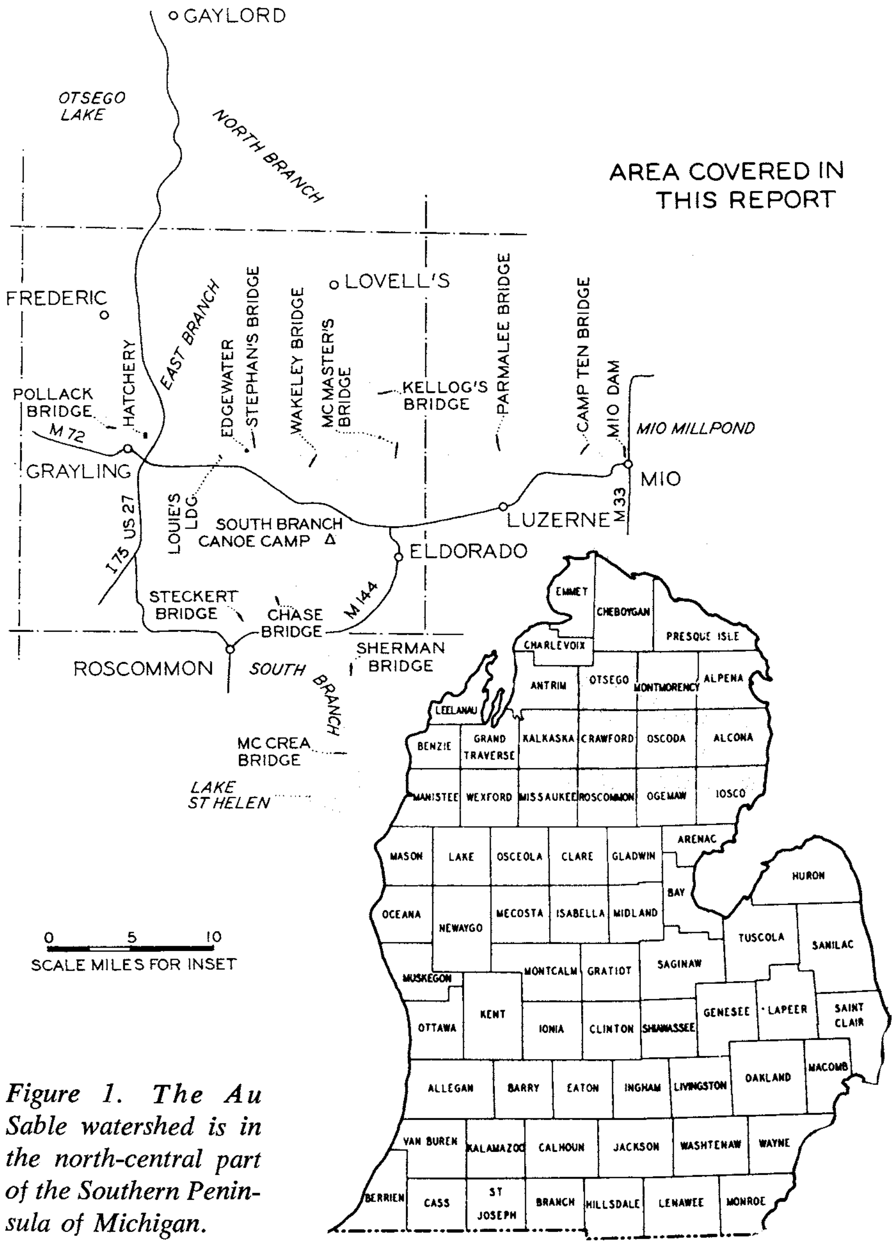


Figure 1. The Au Sable watershed is in the north-central part of the Southern Peninsula of Michigan.

MICHIGAN'S Au Sable River *Today and Tomorrow*

INTRODUCTION

The upper Au Sable River, in the north-central part of Michigan's Lower Peninsula, is enjoyed by more fishermen and canoeists than any other river in the state. Many cabin owners, campers, and occasional visitors also enjoy the peace and beauty of the river. The high quality of recreation provided by the Au Sable is dependent on streamflow, quality of water, and character of the river's bed and banks. The purpose of this report is to describe characteristics of the river that are favorable to recreation and to discuss water-management practices necessary to preserve and enhance those values. Other streams in the nation, now in danger of destruction, may also be saved by applying similar water-management practices.

This report deals only with that part of the Au Sable above Mio Dam (fig. 1). Subject matter is limited to recreational activities directly related to the river: fishing, boating, camping, aesthetic appreciation, and cabin-living, but not hunting or skiing. The term "water-management," as used here, includes all activities designed to improve or maintain recreational values of the river. In managing water resources of any watershed the needs of all users or potential users must be considered, but management for values other than recreation is not part of this study.

I lived on the Au Sable in tent, cabin, and canoe from August 7 to September 7, 1963. Most of the field work was done at this time. The study included a canoe reconnaissance to determine the character of stream and banks; and the collection of information on the velocity, temperature, and chemical quality of the water in the stream. Additional field work was done mostly on weekends from December, 1963 to June, 1964.

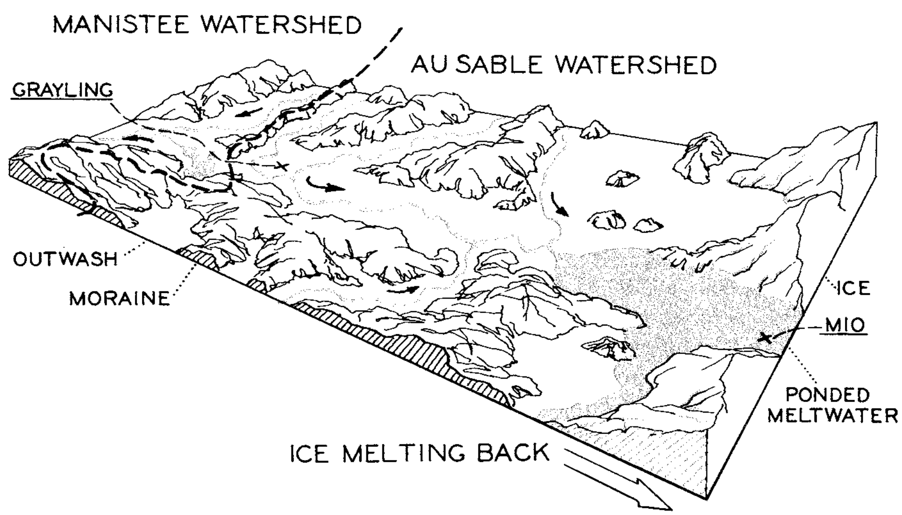


Figure 2. The upper Au Sable settled into its present course after the retreat of the glacial ice.

Chapter I

RECREATION – PAST AND PRESENT

The upper Au Sable is a young river, as rivers go, having settled down to its present course after the glaciers retreated about 12,000 years ago (fig. 2). It was named by early French explorers, the name meaning "River of Sands." Following close on the heels of the retreating ice, the earliest Indians moved into Michigan, and possibly into the Au Sable area. The Indians hunted for deer, bear, mastodons, giant beaver, caribou, and other wildlife. They also fished for many species. To the Indians the Au Sable was a source of food and drink and a highway for canoe travel. Early white traders and explorers used the river for the same purposes, while the lumbermen valued it chiefly for transporting logs.

Use of the river for recreation as a means of diversion, or as Webster phrased it, "refreshment of strength and spirits after toil," probably began when lumbermen fished the Au Sable for pleasure as well as food in the late 1800s. Fishing remained the chief recreational attraction for many years and is one of the major attractions to this day.

Fishing

Schoolcraft saw the Indians catching Sturgeon in the Au Sable in 1820, and doubtless, grayling also were caught. Early lumbermen called the grayling "white trout" or "Crawford Country trout". In 1874, the fish were identified as grayling. Local residents decided then to change the name of their town from Crawford to Grayling.

An interesting account of fishing on the Au Sable appeared in Scribners Monthly in 1879. Thaddeus Norris, the author, said grayling were caught in great numbers in both the Au Sable and the Manistee, but that no trout were taken from either of those rivers. Norris said grayling were spring spawners, did not migrate far upstream, were not cannibalistic, and took a fly much more readily than trout (fig. 3).

Grayling were abundant in the Au Sable as late as the 1880's but had become scarce by 1893. Mr. William Christenson, a resident of Grayling, told me he caught grayling in the Manistee River when he was thirteen years

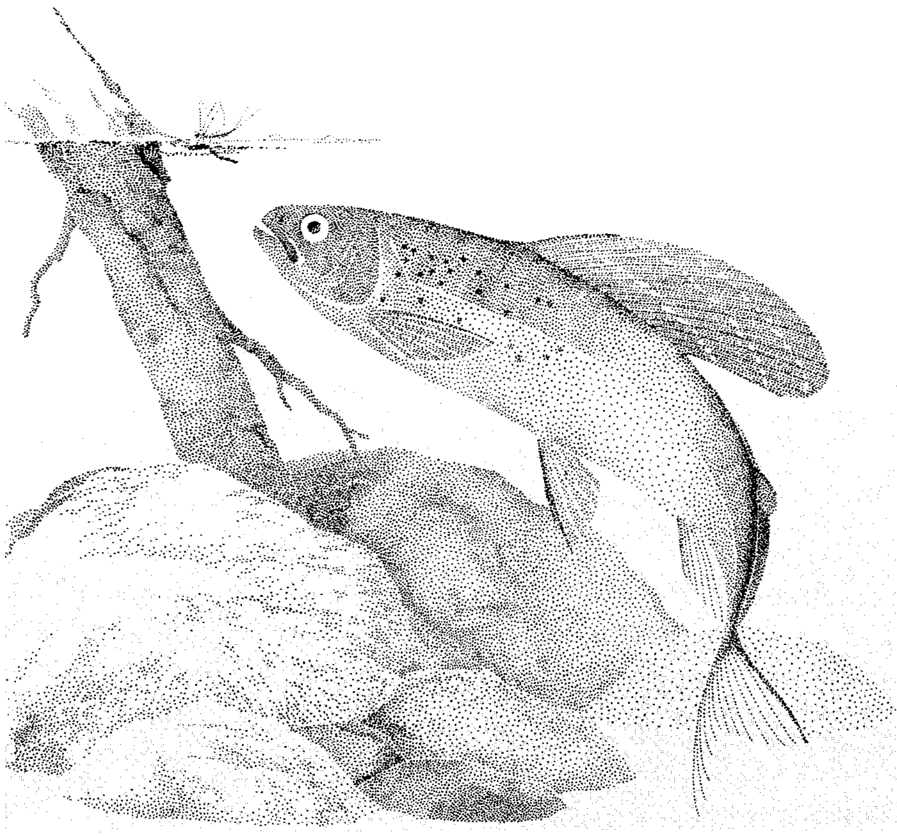


Figure 3. The Michigan Grayling is gone from the Au Sable.

old (1898). He said the grayling fought as vigorously as trout and were as good to eat. According to him, Dan Stephan, longtime Grayling-area resident, caught a grayling in 1908. The fish was taken from the "main stem" of the Au Sable three miles above McMaster's Bridge. Frank Servin, another local resident, said a grayling was caught in the East Branch of the Au Sable about 1915 — apparently the last caught in this part of the river.

What caused the disappearance of the Au Sable grayling? Grayling became scarce shortly after trout appeared in the river, about 1890, but none of the old timers interviewed place the blame on the trout entirely. Dr. Hazen Miller said in 1963: "The planting of the trout from the Jordan into the East Branch of the Au Sable by Rube Babbit was made long before the grayling disappeared; the two fish seemed to thrive in the same waters". Local inhabitants say timber removed from banks of the river, destruction of spawning grounds by floating logs, and depletion of fish by heavy fishing were factors in the demise of the grayling. All these are certainly possibilities and probably

contributing forces, although we can't be sure. P. W. Christenson tells of catching 65 grayling in the Manistee in 1899. The fish were to be kept alive for display at an exposition. Although placed in well-designed live-boxes in the river, half the grayling died overnight, and the rest were returned to the water. It appears that the grayling was a more delicate fish than trout, and it is unlikely the grayling could have survived even though trout had never entered the river.

Once trout entered the Au Sable, they multiplied rapidly. Christenson stated "a good fisherman could catch 40 or 50 nice trout in the Au Sable almost any day back around 1898 or 1899." Trout apparently were abundant and highly-prized from that day to the present.

Few of today's trout catches could equal the take of those early days, even if conservation laws permitted. Yet the Au Sable continues to reward anglers every year. The average catch during the 1962 fishing season was one trout over seven inches for every three hours of fishing on the main stream between Grayling and Burton's Landing. The average catch on the flies-only stretch between Burton's Landing and Wakely Bridge in 1962 was one trout over 10 inches for every seven hours of fishing. Averages mean little however, because many anglers are happy to catch a few legal-sized trout in a weekend, while others take a creelful 'most every time they wet a line.'

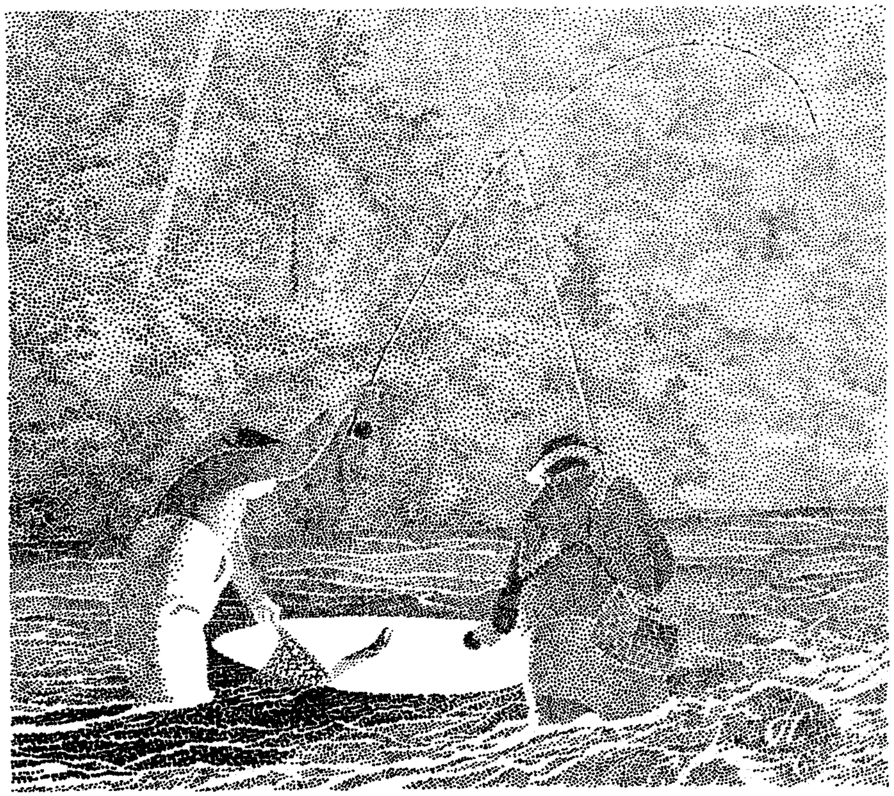
A full creel certainly adds to the enjoyment and satisfaction of the angler. It is by no means, however, the only element of importance. Most anglers desire to be alone while fishing. This is not simply to avoid competition, but chiefly to enjoy a sense of solitude and peace. Aldo Leopold described it as a "feeling of isolation in nature"—a desire not limited to fishermen. Thus, satisfaction of individual fishermen decreases as the number of fishermen increases.

Fishermen crowd the Au Sable at the opening of the season and again during important fly hatches, especially the "Caddis" or Mayfly hatch. In accessible areas at these times, fishermen may stand so close together that the back-cast of one entangles the forward-cast of another. At other times numbers of fishermen are more moderate. After the bass season opens in June, many fishermen desert trout streams in favor of bass waters. Late in the summer, as the river recedes and trout become more wary, only the most enthusiastic fishermen continue their quest for trout. Then it's usually possible to find a stretch of water where you can be alone, or perhaps in sight of only one or two others. Despite this generally heavy fishing pressure, the Au Sable is not over-fished in most places at the present time.

Boating

Indians, fur traders, and early lumbermen on the Au Sable used canoes and other boats mainly for transportation. The earliest use of boats primarily for recreation was in the late 1800's when fishing became popular.

The boats used in 1874 by Thaddeus Norris while fishing for grayling resembled the craft known today as the Au Sable River Boat. Here's what he said: "The boat used on my first trip is worth description. It was built of white pine; bottom, 1 inch thick; sides, ⅝; 16 feet long; 2 feet, 10 inches wide on top,



2 feet, 4 inches at bottom, and with a sheer of three inches on each side. The bottom was nearly level for eight feet in the center, with a sheer of five inches to the bow and seven inches to stern. The live-box was six feet from bow, extending back two feet. The sides were nailed to the bottom. Its weight was eighty pounds, and it carried two men—the angler and the pusher—with 200 pounds of luggage. With the two coats of paint it cost about fifteen dollars. The angler sits on the movable cover of the live-box, which is water-tight from other portions of the boat, and has holes bored in sides and bottom to admit of the circulation of the water to keep the fish alive, and as he captures his fish he slips them into holes on the right and left sides. An ax was always taken along to clear the river of fallen logs and sweepers."

Present-day "Au Sable River Boats" are 20 to 24 feet long with a beam of three feet. Many now are protected with a fiberglass coating. The guide sits

in the stern, maneuvering the boat by paddle, pole, drag chain, or outboard motor. The fisherman in the bow enjoys the comfort of a "captain's" chair, equipped with backrest.

Birch-bark Indian canoes, used on the river for centuries, were largely replaced by Au Sable River boats and similar wooden skiffs in the early days of lumbering. The Au Sable boat probably dominated the river after about 1875. Early in the 1900's, however, the canoe returned to popularity. Those were the days of cedar-strip and canvas canoes, light and strong, beautiful to use and handle.

Canoe liveries became important economically in Grayling about 1935, according to Christenson. By 1963, the business had grown to eight liveries in Grayling and three in Roscommon with a total annual rental of 18,000 (fig. 5, p. 20). The aluminum canoe, more durable and easier to maintain, soon replaced wood and canvas canoes in these and other liveries. Today, the few wood and canvas canoes seen on the river are manned by their owners, and none are available for rent at liveries.

Before canoe liveries, boating as a recreation in itself was enjoyed by few. The liveries provided convenient pick-up and delivery service and soon attracted recreationists who were often not interested in fishing. Probably less than ten percent of canoes rented now are used for fishing.

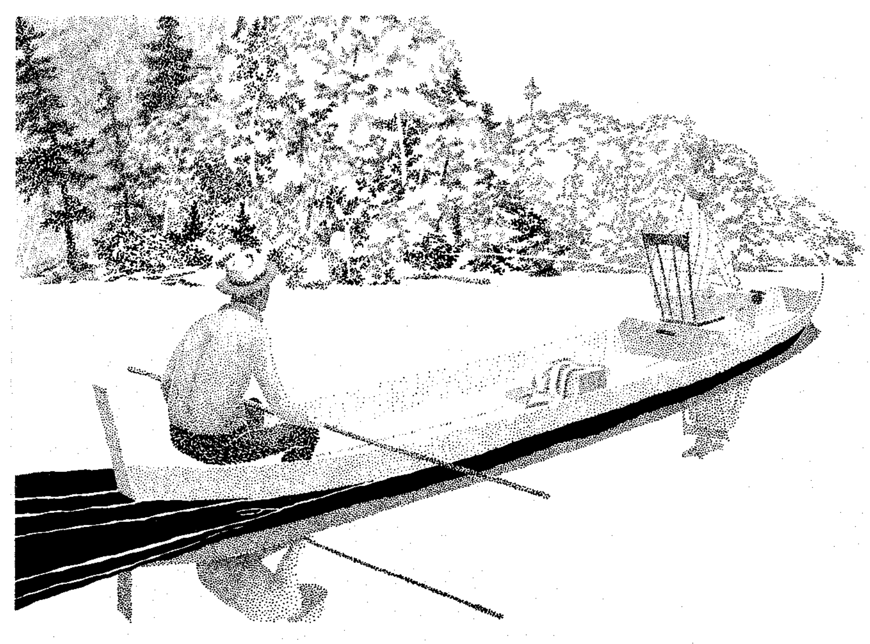
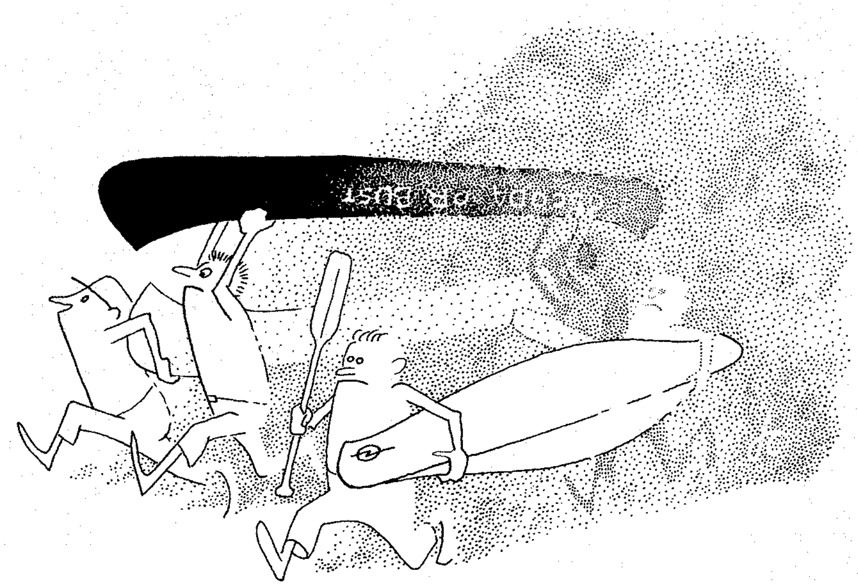


Figure 4. Au Sable river boat.
(See also pp. 39 & 40)

Today, the pressure of canoe traffic below Grayling is almost beyond belief. On a Sunday afternoon in August, 1963, I counted 60 canoes in 40 minutes. The count was made just above Stephan's Bridge, first major take-out point below Grayling. Canoe traffic thins at each succeeding take-out point, until at Mio only a few campers or local fishermen are seen on the river (fig. 6, p. 20).

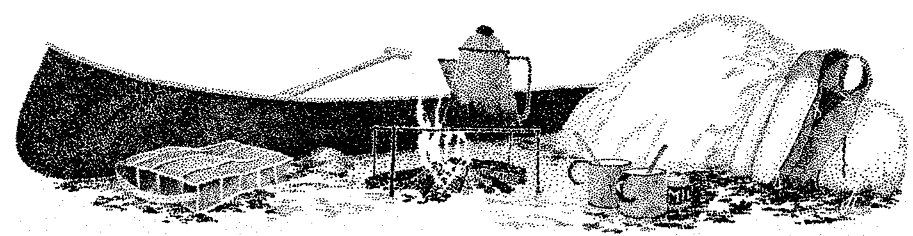
Boats, especially canoes, also provide access to good camping sites along the river. Whether the main attraction is camping or canoeing has not been determined, the two being closely interwoven.

A well-known feature of Au Sable River boating is the annual canoe race from Grayling to Oscoda, a distance of about 180 miles by river. The race is held in early fall. First prize in 1963 was $1200. Originally, this race was run in one heat and took about 18 hours. This was a grueling run, with the added difficulty of nighttime paddling. Portages around each of the five dams were made at a brisk trot. Bernard Fowler, stern-paddler in the winning canoe for three successive years, told me he trained several months before each race. Certainly no trip for weaklings. Today, the race is run in two heats, with an overnight stop at Mio. Even with this stopover the race is arduous. The first day's run from Grayling to Mio is 75 miles and takes nearly six hours. The second day's run, from Mio to Oscoda, is 105 miles and takes almost 10 hours.



Camping

Camping along the Au Sable, like boating and fishing, was a normal part of the life of Indians and early settlers. The earliest camping for recreation was done by fishermen, and most of today's campers also are fishermen. A few camp simply for the joy of outdoor life. In the late 1800's, most of the river bank was uninhabited, and "No Trespassing" signs were unknown. Early campers could select any campsite they pleased, but they had other problems. Camping equipment was bulky and cumbersome, and the camper accepted discomfort as part of camp life.



Today the campers on the Au Sable are restricted chiefly to state-owned lands or prepared campsites because most private lands are posted. However, modern lightweight equipment allows the camper to enjoy the outdoors in perfect comfort without burdening himself. Campers on the Au Sable are generally either canoe campers or car campers, and car campers outnumber canoe campers at all seasons.

The number of campers in Au Sable campgrounds varies with the season, the weather, and the eagerness of trout. During the first part of the trout season, most public campgrounds on the river are full or nearly full on weekends, and less than half full during week days. Later in the season, when fishing generally is not as productive, some campgrounds are unoccupied for days at a time. Intensity of use also is related to convenience of access. Remote campsites requiring a long drive over rough roads get little use even when well-developed camps on good roads are over-crowded. The few public sites accessible only by canoe are little used at all seasons.

Cabin Living

Anyone traveling by canoe from Grayling to Mio is well aware of the growing number of homes and summer cottages along the river. The density of cabins is greatest between Grayling and Wakely Bridge and least from McMaster's Bridge to the backwaters of Mio Pond, but cabin-free stretches of a mile or more are few in number. Streams tributary to the river also are becoming lined with cabins, except for the fourteen-mile stretch on the South Branch, donated for public use by the late George Mason.

While a comparatively recent development, cabin living is becoming a major recreational use of the river. "Cabins" range from small rustic shelters in wooded settings to spacious homes with well-groomed lawns. Most are occupied in summers only, but a few near Grayling are year-around homes.

Cabin-living is related to fishing and boating, as many cabins are used mostly by fishermen while practically every cabin has at least one boat tied to a dock. Nevertheless, I believe the cabin dweller is here primarily for the joy of living beside, seeing, and listening to the river.

Aesthetic Considerations

Almost all recreational users of the Au Sable appreciate its beauty. If the river were confined to a concrete canal—all its natural beauty lost, who would care to use it? No dedicated fisherman would cast a fly into it, no matter if it was stocked with trophy fish. Few canoeists would enjoy a ride in such a canal, even if swift current and artificial rapids were provided. No one would camp or build a cabin on the concrete banks, nor would an artist or poet try to capture the spirit of such a river, except, perhaps, to publish its loss.

What, then, makes up this essential ingredient, the aesthetic value of the Au Sable? Included are all things that please the senses and imagination of people: the glint of sunlight on the ripples, dark reflections in quiet pools, the sound of water rushing over rocks, grey mists rising on a cool summer morning, the white flag of a departing deer, the gleam of trout darting across the shallows, the warm odor of pine needles on a sunny autumn afternoon, the songs of birds in the willows, the moaning of the pines protesting the relentless beat of winter winds, the laughing clatter of popple leaves in the gentle summer breezes, the white carpet along the banks in winter, the warm red and yellow of fall, the pastel shades of spring and the deep cool green of summer—all things that make a river a living entity.

Creative Recreation

These recreational values—fishing, boating, camping, cabin-living, and aesthetics—are the goals of most who come to the Au Sable seeking "refreshment of strength and spirit after toil". Such values are "re-creative" in that they improve the individual and make it possible for him to accomplish greater works. Other types of uses, indirectly related to recreation, not only improve the participant but also result in benefits for others.

Under pines on a hill overlooking the river, an artist is at work, trying to express on canvas his perception of the Au Sable. A few miles downstream a poet in his canoe seeks to capture the song of the river in words. Standing in a shallow riffle, a biologist in hip boots studies bottom vegetation. He hopes to discover and publish a new interpretation of plant life and fish populations. Across the river, a landowner plants pines to check erosion of a sandy bank.

Each is creating something of value—a painting, a poem, a new principle of biology, or an improved watershed. Each also is enjoying recreation, though he may call it his work.

Few persons today participate in this type of recreation along the Au Sable. In five weeks of travel along the river, I came upon only one artist, no admitted poet, one student of nature, and two men constructing a rock rip-rap for bank protection. But if the number of participants is small, the intensity of their enjoyment is very great and the products of their recreation are an additional bonus to themselves and others.

The rainbow trout was not native to the Au Sable, having been introduced many years ago by the Michigan Department of Conservation.

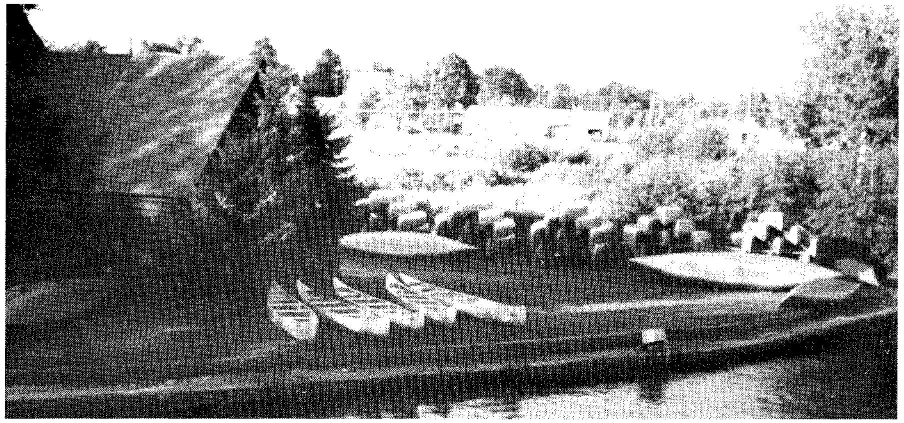
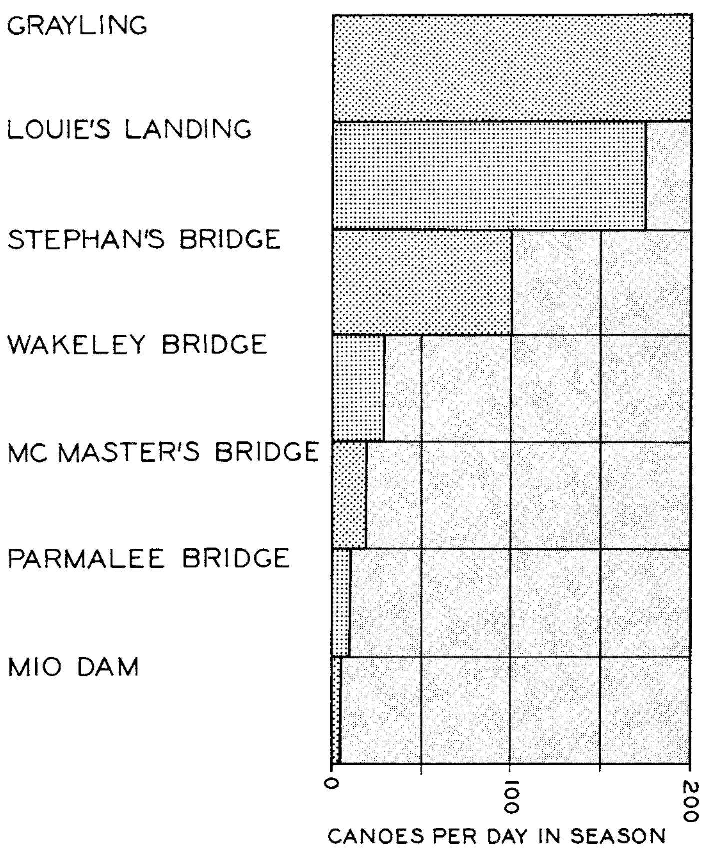
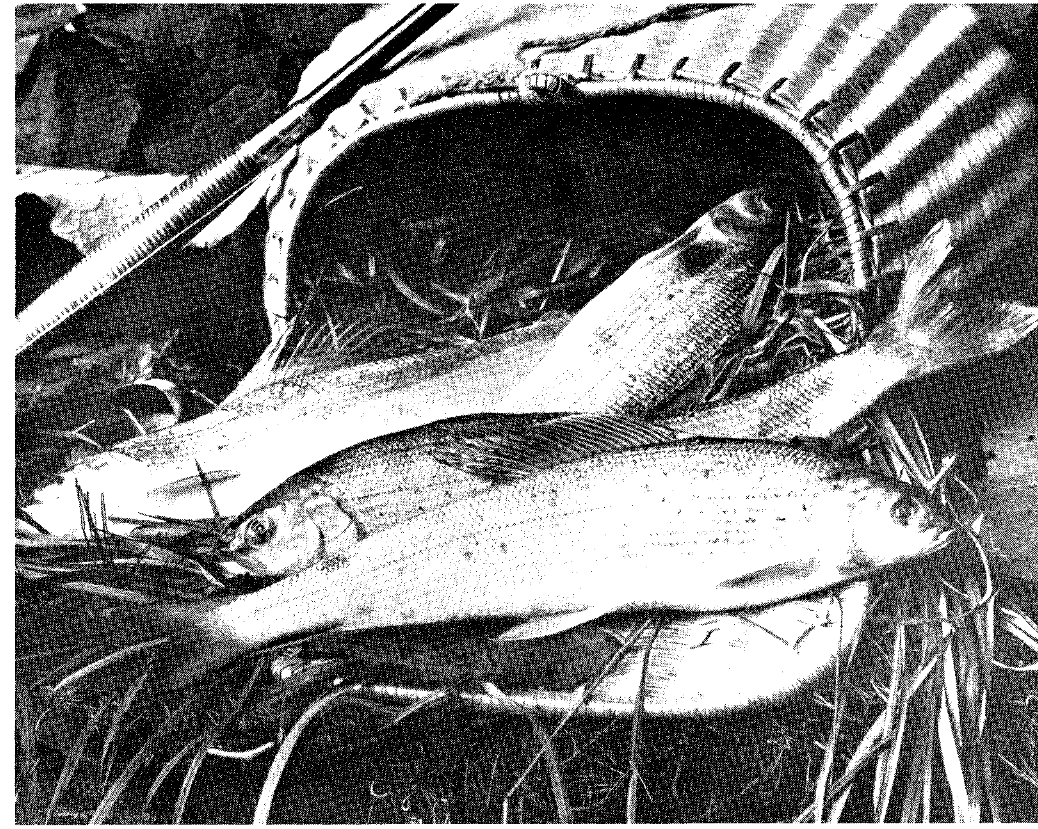


Figure 5. Canoe livery at Grayling.

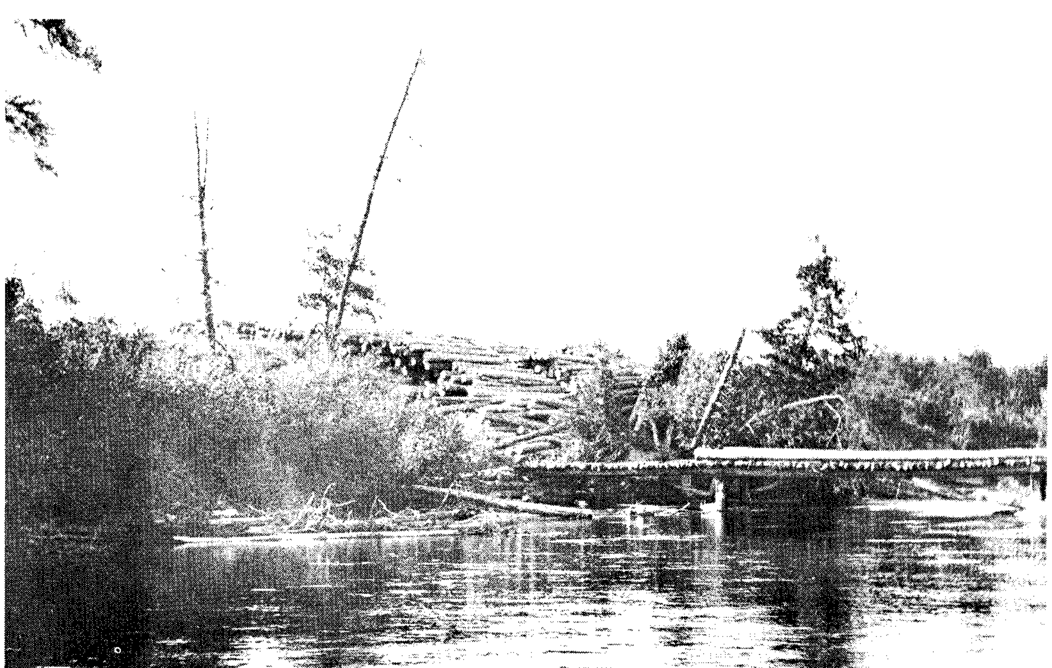
Figure 6. About half the canoes leaving Grayling go as far as Wakeley Bridge.





Scenes reminiscent of early days along the river. Above, a catch of grayling lies beside the creel; below, river "drivers" work to release a "jam" so the current can carry the logs downstream.

In days past, the river served as an important avenue of commerce. Above, a raft-like barge is used to carry lumber and freight; below, logs piled at a "rollway" await the day when they will be floated downstream to lumber mills at Oscoda.



Chapter II

WHY THE RIVER IS ENJOYABLE

To safeguard recreational values that make the river enjoyable, certain characteristics must be protected. These include streamflow, quality of water, and character of bed and banks. Each needs protection; each requires understanding.

Streamflow

A river that overflows its banks with every storm and declines to a trickle with every drought is not of much use for recreation. Floodwaters damage cabins and campgrounds and bring great loads of silt into the river. The trickle supports neither fish nor canoe. Rapid variations in river levels leave an unsightly zone of trash and mud.

The Au Sable is not such a river. It rises only moderately in the spring, sustaining a high flow during summer months. These flow characteristics are chiefly the result of earth material, vegetation, topography, and climate of the watershed. Flow characteristics can, however, be radically changed by man.

Three components of streamflow are stage or water level, velocity, and discharge. Each is vital to recreational values of the Au Sable. A moderately high stage is generally favored by fishermen because it provides more cover for trout. High stage is always favored by canoeists because rocks and logs are less troublesome than in low stage. Because campers and cabin dwellers usually fish and canoe as well, they also favor a high stage. Streams are generally much more attractive during sustained high stage than at low or rapidly-fluctuating stages.

Canoeists enjoy a fast current because it makes them travel faster and makes the trip more challenging. A fast river is more interesting than a slow one and the song of the rapids is a delight to hear. A fast current in rapids promotes aeration of water favorable to fish. When the current is too fast, however, wading fishermen have trouble maintaining footing. A rule of thumb for safe wading is that depth in feet, multiplied by velocity of the water in feet per second, should not exceed 10. For example, a velocity of four feet per second in three feet of water would not be safe for wading.

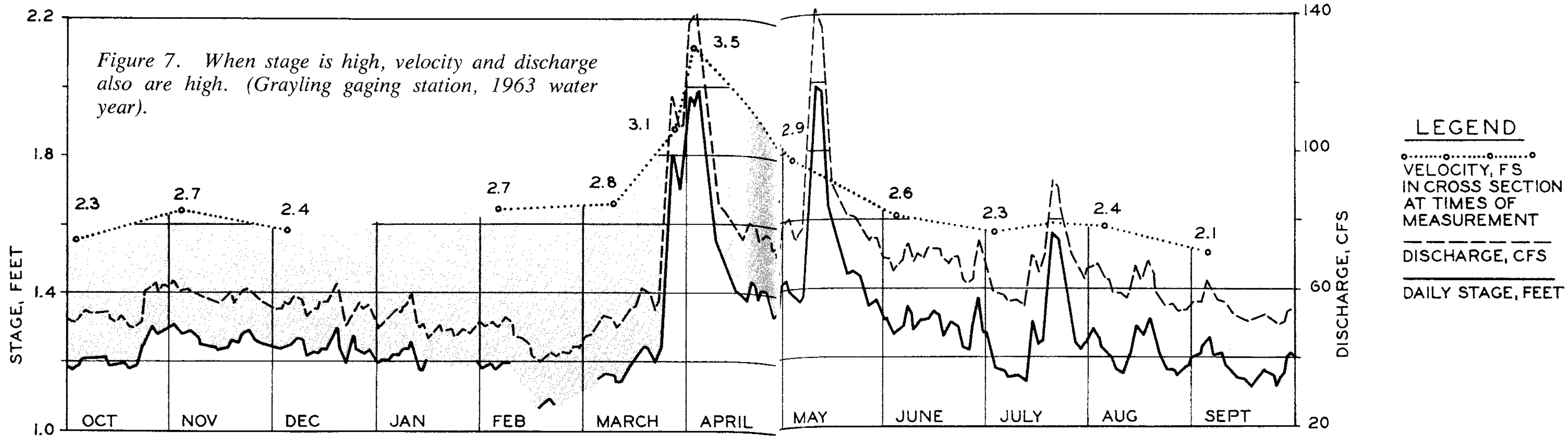


Figure 7. When stage is high, velocity and discharge also are high. (Grayling gaging station, 1963 water year).

The discharge of a river is the volume of water that moves past a certain point in a given time. It is equal to a cross-section area of the river multiplied by the average velocity and is usually expressed as "cubic feet per second." A relatively high rate of sustained discharge is favorable to all recreational uses because it dilutes contaminants and reduces temperature loading. Because of this dilution the dissolved oxygen (oxygen available to fish) in the river does not drop so low, the temperature of water does not become so high, and the unpleasant odors and appearance that may accompany contamination are not so pronounced.

Thus, a moderately high stage, a relatively high rate of sustained discharge, and small fluctuations in stage and discharge, favor recreational values of the river. High velocities also are favorable to most recreational values. How does the Au Sable River meet these requirements?

Stage, velocity, and discharge of the Au Sable at Grayling from October 1, 1962 through September 30, 1963 are graphed in figure 7.

These components of streamflow are interrelated. Normally, when the stage is high, velocity and discharge are high, and when the stage is low, velocity and discharge are low. The seasonal effects of surface ice, anchor ice, and bottom and bank vegetation cause some variations, but in general the relationship holds for all seasons.

Stage

Stages of the Au Sable are highly favorable for recreational use. Stage, or river level, usually rises about half a foot to one foot during snowmelt in

March or April, and gradually declines about the same amount during the summer (see figures 7 and 8). The spring rise in 1964 was somewhat less than usual because snow cover was less than usual. After killing frosts in September, the river usually maintains a fairly uniform stage until the next spring rise. Heavy rains at any season may cause an abrupt rise in water level, but these rises usually are less than half a foot and last only a few days.

Fluctuations in stage on the Au Sable are less than on many other Michigan rivers (fig. 9). This small variation is one of the favorable attributes of the river.

Velocity

Anyone paddling down the Au Sable knows that the velocity varies greatly in different stretches of the river. If discharge remains constant, the smaller the cross-section the faster the current or velocity. Velocity also varies with stage and discharge, high stages producing high velocities (fig. 7). Canoeists on the Au Sable often estimate water velocity in the riffles to be more than five miles per hour, but the fastest measured velocity in several riffles during the summer of 1963 was less than three miles per hour.

Velocities usually are faster at the surface than near the bottom, and also faster at mid-channel than near the banks. These differences may be great or small depending on the character of banks and bed. If the banks of the river are irregular or jagged and choked with vegetation, the flow along the banks will be greatly retarded. Smooth banks, bare of vegetation have less slowing effect. A rough bed or bottom composed of rocks, drowned logs, or aquatic vegetation reduces bottom velocities more than a smooth bottom.

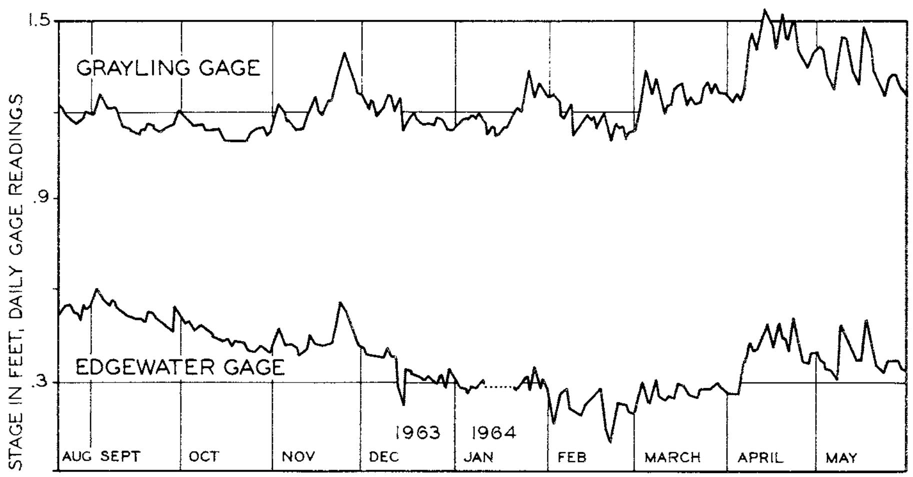
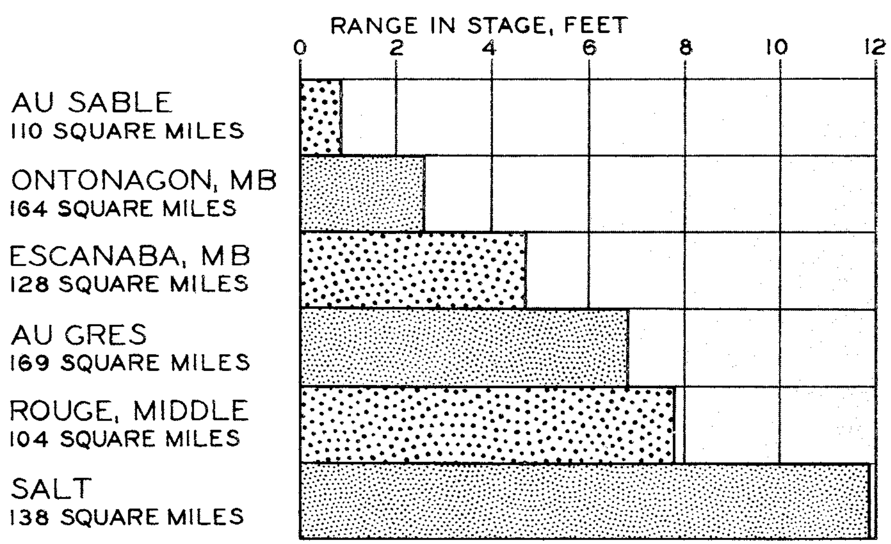


Figure 8. Fluctuations in stage in the free-flowing river at Edgewater are similar to those at Grayling.

Figure 9. Changes in stage on the Au Sable are less than most unregulated rivers in Michigan (1962 water year).



The gradient, or fall, of a stream also affects its velocity. The average velocity is equal to the volume of discharge divided by the area of the cross-section. If discharge is to remain constant while increasing the gradient, then the cross-section must be decreased. Average gradients of various reaches of the Au Sable are:

From	*To*	*Distance, River Miles*	*Gradient Feet Per Mile*
Frederic	Grayling	20	2.8
Grayling	Stephans Bridge	17	2.9
Stephan Bridge	Wakely Bridge	8	4.4
Wakely Bridge	McMasters Bridge	15	1.7
McMaster Bridge	Parmalee Bridge	9	3.1

No records of average velocities are available, but velocities in the riffles generally increase downstream from about one mile per hour at Frederic to nearly three miles per hour below Parmalee Bridge.

Typical velocity cross-sections on the Au Sable and tributaries are shown in figure 10. The slow areas along bottoms and banks provide resting points for fish. The fast areas at the surface speed the canoe on its way.

Discharge

Discharge of the Au Sable at Grayling has varied from a maximum of 274 cubic feet per second on June 2, 1943 to a minimum of 28 cubic feet per second on April 21, 1946. Both of these extremes were the result of unusual and unseasonal conditions. The usual annual maximum flow since 1953 has been about 140 cfs (cubic feet per second) and the minimum about 45 cfs.

A high sustained discharge is favorable to recreation at all times, but is especially needed in summer when water temperatures and sewage effluent are increased. Unfortunately, the height of the vacation season in the late summer is also a time of low flow on Michigan rivers. The time of low flow then, becomes critical for recreationists. The average minimum flow on the Au Sable at Grayling is about 45 cfs. How does this figure compare with other Michigan streams?

In comparing discharges, adjustments must be made to account for differences in watershed areas above the gaging stations. For example, discharge may be expressed as inches of runoff. A runoff of six-tenths of an inch in July means that the amount of water passing the gaging station in July is equal to 0.6 inches over the entire watershed area. The monthly low flow, in inches, of several Michigan streams during the 1962 water year is shown in figure 11. The low flow of the Au Sable exceeds most Michigan rivers of comparable size—another characteristic favorable to recreation.

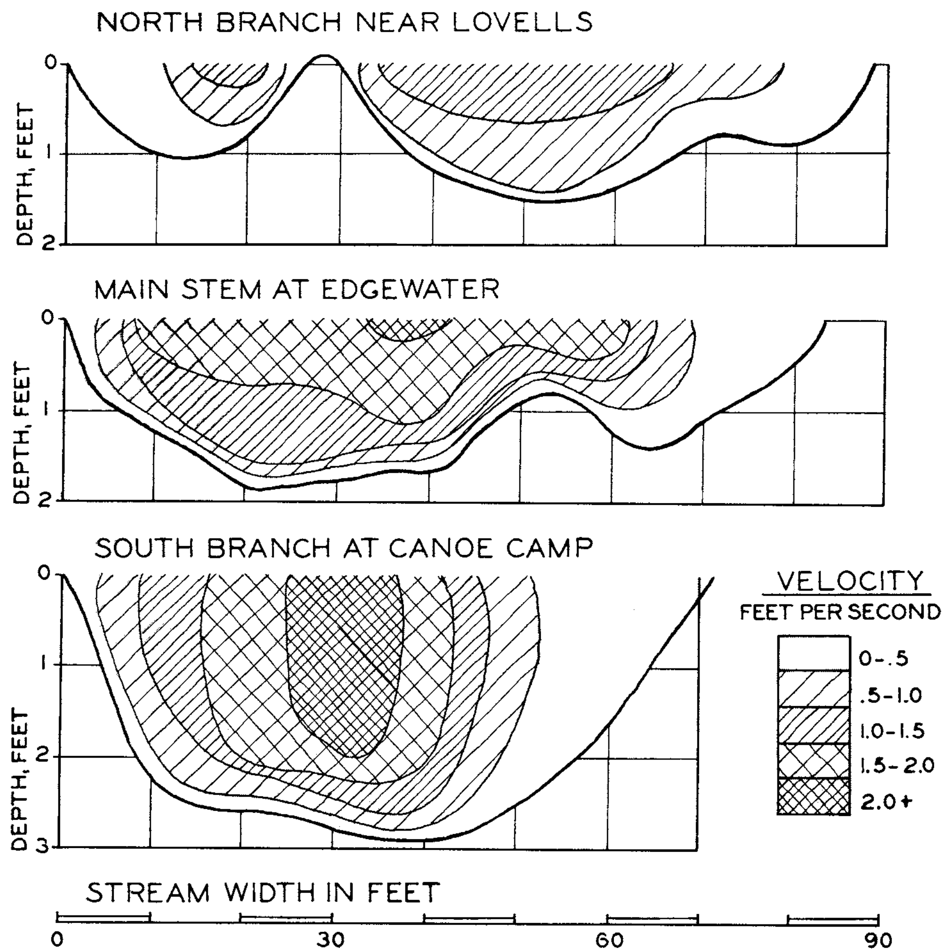


Figure 10. Cross-sections of stream. Velocity is least near bed and banks (August, 1963).

Figure 11. (opposite). Monthly low flow of the Au Sable is greater than most unregulated rivers in Michigan (1962 water year).

Natural Controls of Streamflow

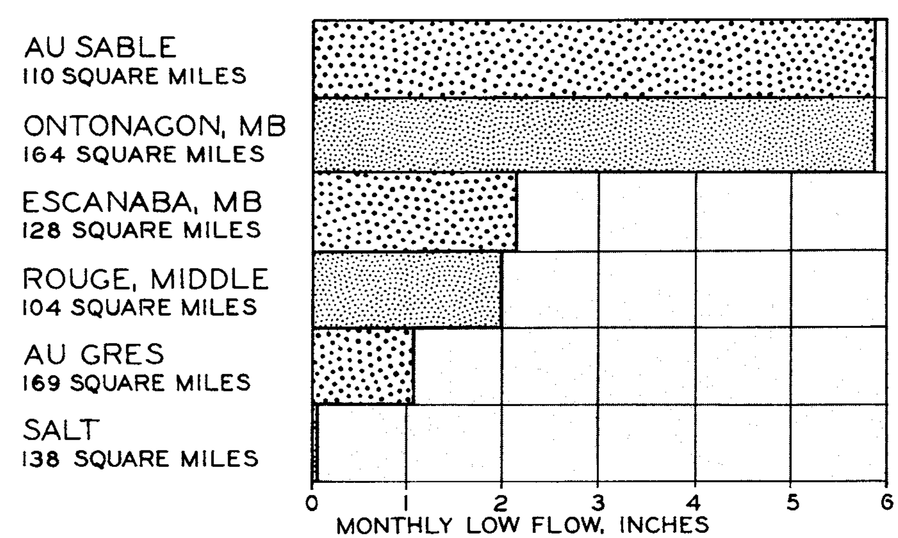
The flow characteristics of the Au Sable generally are more favorable for recreation than those of most Michigan streams. These favorable characteristics are controlled chiefly by the climate, topography, soils, geology, and vegetation of the watershed area. These are the natural controls.

Climate

The twenty-nine inches of precipitation falling annually on the Au Sable watershed travels three different routes. Part runs over the surface to the river or one of its tributaries; part is held in soil and on plants to be lost by evaporation and transpiration; and part goes down to the "zone of saturation" below the water table, then moves laterally as groundwater to discharge into swamps, springs, and streams.

The amounts taking the three different routes control the streamflow characteristics of the river. If a very large amount of precipitation is lost to evaporation and transpiration, the annual flow of the river will be small. If most of the water reaching the river flows overland, the discharge will be extremely variable and in times of drought will be very small. If most of the water goes into the ground-water flow, discharge of the river will be relatively uniform and the drought flow will remain large. A relatively uniform flow and a high drought flow are favorable to recreational values. It follows, then, that the more water entering the ground-water flow, the better the river is for recreation.

If total precipitation is great, a correspondingly large amount of water is available for each of the three routes. If the precipitation falls mostly as short intense downpours of rain, the amount of overland flow will be large while evaporation and transpiration and ground-water flow will be correspondingly small. Prolonged rains of moderate intensity favor ground-water recharge. Rain is usually more effective in producing ground-water recharge in early



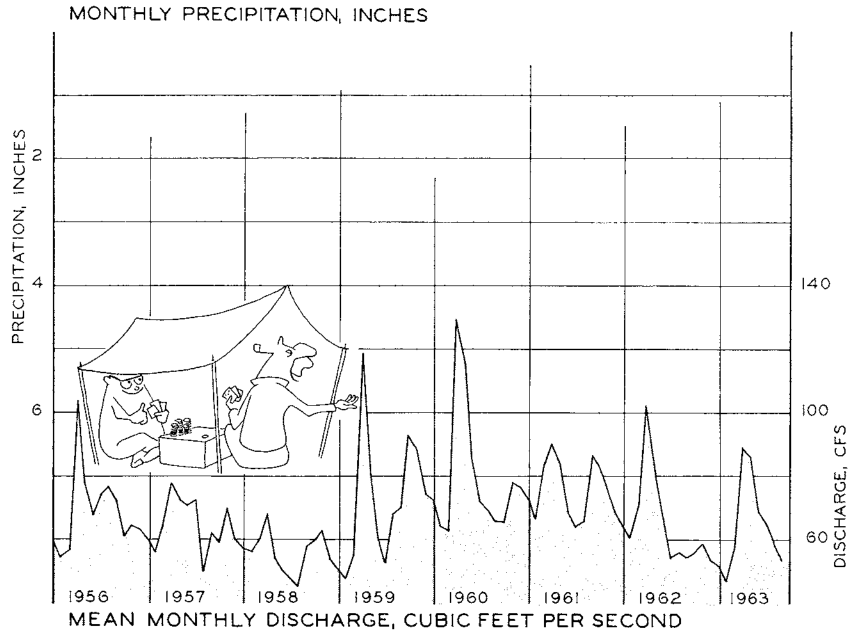


Figure 12. Heavy rains and snowmelt bring high streamflow.

spring and late fall than during other seasons. The effect of snowfall on the watershed is delayed until the spring thaw. If the thaw is very rapid and the ground remains frozen, surface runoff will be large. If the thaw is very slow, much of the snowmelt may be lost by evaporation. If the thaw is moderately rapid and the ground is not frozen, much of the snowmelt percolates down to the water table. The spring thaw in 1964 brought a relatively small increase in discharge (fig. 8) because the snow cover was lighter than usual. The relationship of streamflow to precipitation on the Au Sable is shown in figure 12.

The amount of water entering the ground-water flow is reflected in changes in the elevation of the water table. When the water table is high, the rate of groundwater flow to the river is high; when the water table is low the rate of groundwater flow to the river is low. The relationship of the flow of the Au Sable to groundwater levels is shown in figure 13.

Topography and Soils

Climate is not the only control on the relative amounts of water entering overland flow, evaporation and transpiration, and groundwater flow. A flat landscape reduces overland flow and favors groundwater recharge and "evapotranspiration"—the combination of evaporation and transpiration. A clay soil favors overland flow, reduces groundwater recharge, and generally retains more moisture for evapotranspiration. A sandy soil over water-bearing

formations favors rapid infiltration, increases ground-water discharge and reduces overland flow and evapotranspiration. A dense vegetative cover generally reduces overland flow, but increases the amount of evapotranspiration.

The soils and the native vegetation of the upper Au Sable basin are also closely related to the hills, valleys, and plains formed by the retreating glaciers (fig. 14).

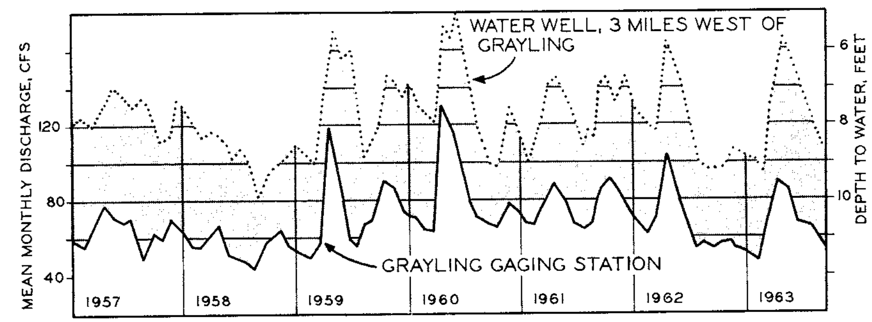


Figure 13. High groundwater levels cause high discharge.

Geology

Areas mapped as moraines and ground moraines are underlain by a mixture of sand, gravel, silt, clay, and stones called *till.* These materials were deposited directly from glacial ice with little sorting by meltwater. Bedding or layering is not usually apparent. The till deposits in the Au Sable basin are chiefly sand, but in places silt, clay, stones, and gravel are also present. The hilly moraines are pronounced ridges marking the temporary halts of the ice front. Ground moraine is a gently-rolling "sag and swell" land form lacking a ridge-like character.

Outwash and lake beds are sorted gravels, sands, silts, and clays deposited as relatively flat surfaces by glacial meltwater. In the Au Sable basin these deposits are chiefly permeable sand, with some gravel and a little silt and clay.

About forty percent of the Au Sable watershed above Grayling is fairly flat and is underlain by sandy soils and permeable outwash. The remainder of the area is rolling moraine with somewhat less permeable soils and drift. The sandy outwash plains contribute to a sustained groundwater flow with small fluctuations. The hilly moraines contribute a small amount of surface runoff, but their contribution to the low flow of the river is less than the outwash plains. Bedrock formations, buried under 200 feet or more of glacial drift in this region, do not affect streamflow characteristics.

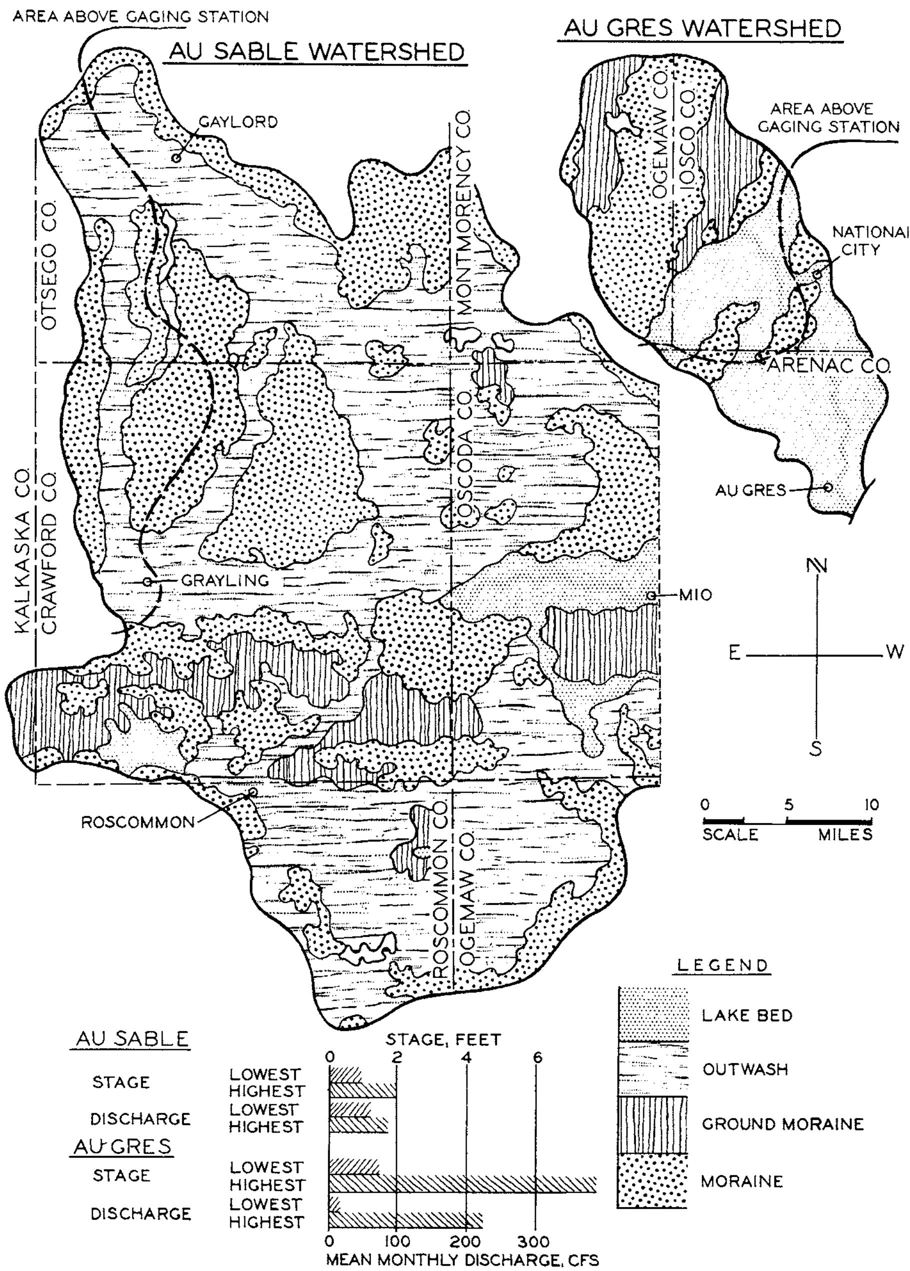


Figure 14. Au Sable watershed. Sandy soils and permeable glacial drift contribute to stable discharge and stage.

Figure 15. Au Gres watershed. Tighter soils and less permeable drift result in wide fluctuations.

By comparison, look at the watershed of the Au Gres River near National City. About eighty percent of this watershed is rolling moraine underlain by only moderately permeable till. Most of the rest of the watershed is abandoned glacial lake plain with silty or sandy soils underlain by silty and sandy lake beds. The predominantly hilly terrain, and relatively dense soils all contribute to high runoff, wide fluctuations in water levels, and low drought flow on the Au Gres (fig. 15).

In summary, streamflow characteristics and recreation are directly related. Desirable characteristics are relatively high stage, velocity, and discharge with small fluctuations in each. Flow characteristics are determined primarily by the amount of precipitation, by the amount lost to evaporation, and by the way water flows to the river after hitting the ground—that is, whether it stays on the surface or enters the ground-water system. The greater the amount of water entering the ground-water flow, the greater the sustained flow, hence the better the river will be for recreation. Favorable ground-water flow results from favorable climate, topography, geology, soils, and vegetation. As yet little or no control can be exercised over climate, topography, and geology, but favorable soils and vegetative cover can be maintained as will be described later.

Quality of Water

Many rivers in the densely populated areas of the Midwest have little value for recreation. Some are handicapped by undesirable streamflow characteristics while others have such unattractive bed and banks that recreational use is discouraged. But pollution is the prime reason so many streams are unfit for swimming and fishing and in many instances even for boating, camping, and cabin-living.

What are the characteristics of water quality favorable for recreation? Requirements differ in accordance with the activity. Probably the most restrictive are requirements for fish habitat, especially trout. Good trout water is moderately hard (calcium bicarbonate type) being slightly alkaline, with temperatures not exceeding 77.5 Fahrenheit for more than a few hours and preferably never exceeding 68 Fahrenheit. Dissolved oxygen should not go below five parts per million for more than a few hours, and preferably, should stay above six parts per million. The sediment load of the river should be low at all times, especially during spawning. Oil slicks and floating debris on the river are particularly undesirable because they retard oxygenation of the water.

The Au Sable river easily meets all these quality requirements for trout except for small stretches of river where the temperature may occasionally go higher and the dissolved oxygen lower than desirable for the best trout waters. But the present high quality of Au Sable water is no guarantee of immunity from future problems. Unrestricted development can ruin the recreational value of this river as it has other rivers.

The chemical and physical attributes of Au Sable River water and the "suspended load" are discussed below. Chemical attributes include chiefly the dissolved solids and gasses. Physical attributes include temperatures and pH (a measure of acidity or alkalinity). Suspended load includes all undissolved matter being moved within the stream.

The water in the Au Sable is of the calcium-bicarbonate type, low in dissolved solids, and slightly alkaline. Sulfates, chlorides, and nitrates are low in all samples.

CHEMICAL ANALYSES OF TYPICAL WATER SAMPLES FROM THE AU SABLE RIVER, MICHIGAN AUGUST 30, 1963

(Dissolved materials in parts per million)

Dissolved Materials	*Sampling Location*				
	Main Stem at M-72 Bridge	*Main Stem below Grayling disposal plant*	*East Branch below Trout Hatchery*	*Main Stem at McMasters Bridge*	*Main Stem below Mio Dam*
	Parts per Million of dissolved materials				
Calcium (Ca)	46	44	46	40	39
Magnesium (Mg)	11	11	12	9.5	11
Sodium (Na)	2.2	3.7	3.2	4.0	3.9
Potassium (K)	.5	.8	.2	.3	.3
Bicarbonate (HCO_3)	194	189	196	170	176
Sulfate (SO_4)	6.5	6.8	8.0	8.4	8.4
Chloride (Cl)	2.0	4.0	3.0	4.0	3.0
Nitrate (NO_3)	.3	1.4	1.8	.3	1.1
	Temperature in degrees Fahrenheit				
	60	62	56	58	63
	pH Factor				
	7.5	7.4	7.5	7.6	7.6

The above table does not include dissolved oxygen, a critical factor in stream quality. Because the amount may vary widely from hour to hour, a meaningful picture of dissolved oxygen content requires 24 hours of sampling several times a year. Such a record for the Au Sable at Stephan's Bridge is shown in fig. 16.

To supplement this record dissolved oxygen content was measured at several stations of the Au Sable and tributaries during August and September, 1963. For this information see fig. 17, p. 38, and fig. 18, p. 43. The values of dissolved oxygen shown in those two figures were measured by color and results averaged about six percent lower than obtained by titration.

At all these stations the daily cycle of dissolved oxygen is apparent during warm months. The high oxygen content usually culminates at mid-afternoon when aquatic plants are giving off large amounts of oxygen. After sunset,

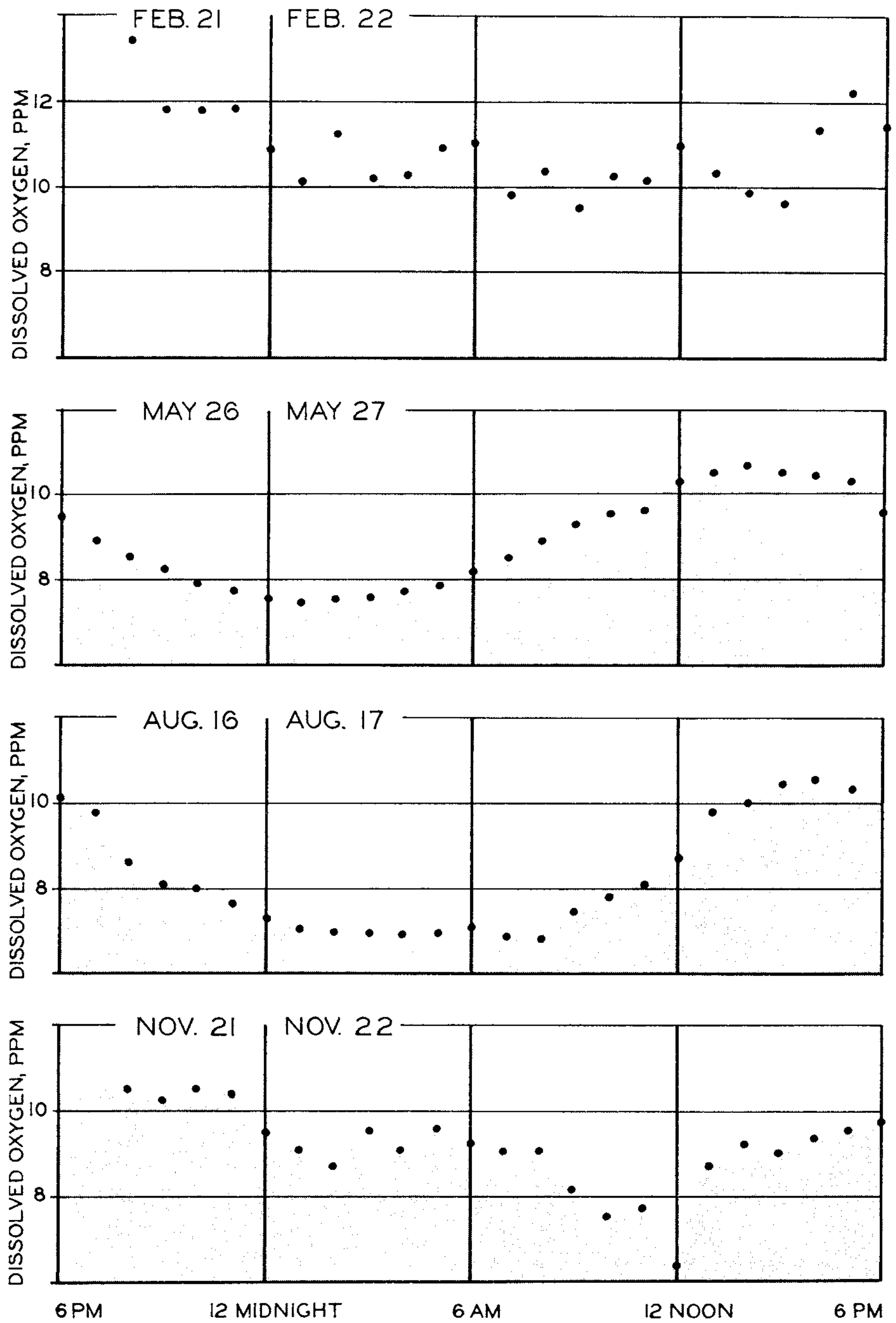


Figure 16. Daily seasonal variation in dissolved oxygen at Stephan's Bridge.

oxygen produced by plants as part of the process of photosynthesis declines rapidly. The first rays of the rising sun stimulate renewed activity, and the rising cycle of dissolved oxygen begins again, interrupted only by such factors as changing water temperatures, cloudy skies, and introduction of pollutants.

Although the solubility of oxygen in water declines with rising temperature, the cycle of plant photosynthesis partly masks the effect of temperature during summer months. Thus, dissolved oxygen declines at night even though temperature of the water is also declining.

The daily cycle becomes weak in the autumn when aquatic vegetation reduces its activity, declines after the first hard frost, and almost disappears by the end of November. Green vegetation on the river bottom is very sparse in winter, except in a few areas where springs enter the stream. Much of the vegetation is pruned by anchor ice during the winter season. The generally high dissolved oxygen content of the water in winter is the result of low water temperatures. As water becomes warmer in the spring, green bottom vegetation begins to recover, and the daily cycle again appears, as noted in figure 16.

The fluctuation in dissolved oxygen was much greater on the North Branch than on the South Branch (fig. 17). The drop in dissolved oxygen to less than six parts per million on the North Branch probably resulted from the rise of water temperature above 70° F in the late afternoon, followed by a decline in plant photosynthesis after sunset. The high water temperature here may be attributed partly to the wide pools and open meadows upstream where the river is not shaded.

Fluctuations in both temperature and dissoved oxygen were smaller at the canoe camp on the South Branch because the river is shaded and the bottom vegetation is less dense.

Dissolved oxygen varies in place as well as in time. Differences in various stretches of river may be caused by activities of man that warm or contaminate the water (see fig. 18, p. 43).

One cause of the drop in dissolved oxygen between Pollack bridge and M-72 bridge may be the warming effect of the lake above the old power dam. Another probable cause is the oxygen demanded by bacteria as they consume sewage — referred to as B.O.D. or biochemical oxygen demand. The sources of sewage are the cabins and homes on the lake and river between these two bridges. The drop in dissolved oxygen between M-72 bridge and a point just above the sewage disposal plant may also be caused partly by the sewage effluent from homes and cabins. A slight temperature rise in this stretch may also contribute to the decrease in oxygen.

The abrupt decrease in dissolved oxygen just below the disposal plant is attributed to the B.O.D. of sewage effluent from the plant. A slight warming effect of the effluent may also be a factor. Below the sewage plant, dissolved

(text continued p. 43)

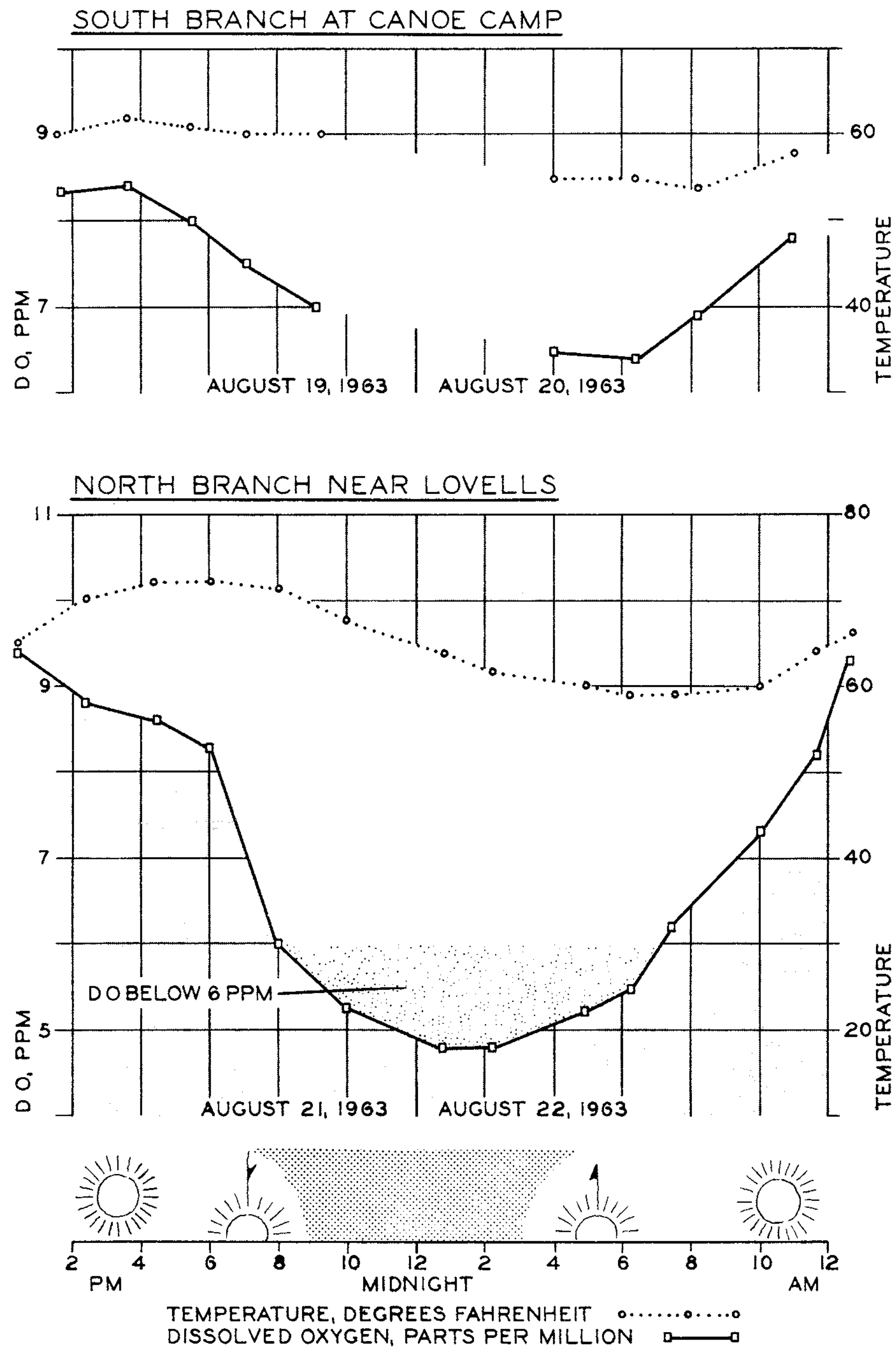


Figure 17. Vegetation and sunlight affect dissolved oxygen content.

Fishing the Au Sable

The painting *Fishing the Au Sable,* by Ogden Pleissner, now hangs in the dining room of the Conservation School at Higgins Lake, where it has been seen and enjoyed by thousands of conservationists in recent years. Pleissner painted the scene in the late 1940's, and it was first exhibited in the renowned J. L. Hudson collection of *Michigan On Canvas.* The Hudson Company subsequently gave the painting to the Conservation Department, and it has been "on exhibit" ever since at the Conservation School. The typical early morning scene along the river, with mist rising, captures a preoccupied moment in the lives of two men, who can only hear their own thoughts and the soft ripple of the river.

The Au Sable Boat

The Au Sable boat was probably "invented" in 1890 by Ed Auger, an early Michigan boat builder and Au Sable resident. Auger lived at Burton's Landing, and created his design from other double-ended skiffs then in use by river guides. At left and below were two early methods of moving the boat upstream.