MICHIGAN ACADEMY OF SCIENCE, ARTS AND LETTERS

VOLUME XL

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The annual volumes of Papers of the Michigan Academy of Science, Arts and Letters are issued under the joint direction of the Council of the Academy and of the University of Michigan Press. The editor for the Academy is William R. Steinhoff; for the University, Grace E. Potter.

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PAPERS OF THE MICHIGAN ACADEMY OF SCIENCE ARTS AND LETTERS

VOLUME XL
(*1954 Meeting*)

EDITORS

GRACE E. POTTER AND WILLIAM R. STEINHOFF

ANN ARBOR: THE UNIVERSITY OF MICHIGAN PRESS
LONDON: GEOFFREY CUMBERLEGE, OXFORD UNIVERSITY PRESS
1955

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Volume XXXIX (1953 meeting) was published on May 5, 1954.

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FISH REMAINS FROM ARCHAEOLOGICAL SITES IN THE LOWER COLORADO RIVER BASIN, ARIZONA

ROBERT RUSH MILLER

EVENTS initiated by man around the turn of the century and culminating in the completion of Davis Dam and the establishment of a large bait fishery in 1950 (Miller, 1952) have brought about a profound change in the fish fauna of the lower Colorado River (Fig. 1). Formerly a swift, silt-laden stream subject to spectacular fluctuations in volume and turbidity, the river has been transformed into a series of deep, placid reservoirs with connecting channels of clear water and controlled flow. These ecological changes and competition and predation by introduced game and forage fishes have decimated the limited indigenous fish fauna of the river (Dill, 1944: 144-146; Miller, 1946a; Wallis, 1951). Only three species—a sucker and two minnows—are known to have been adapted to the extreme environmental conditions that were characteristic of most of the lower Colorado. But a third species of minnow evidently once lived there, as is indicated by remains reported in the present paper. Another species of sucker (*Catostomus latipinnis*) probably also occurred here, since it now inhabits tributaries of the Colorado River just above Lake Mead and also the Gila River basin, the lowermost tributary of the Colorado. Although typically scorned by the white successors of the aborigines, at least three of these species provided the Indians with a ready source of food and probably were important during part of the year in the diet of those tribes who obtained their food mostly by hunting.

In 1949 a group from the Department of Anthropology of the University of Arizona excavated Catclaw Cave, a small cave on the east bank of the Colorado River 15 miles below Hoover Dam (Fig. 1). Stratigraphic determination of age was not possible, since the 2-foot level that contained animal and cultural remains had been thoroughly churned by the action of wind and animals. This level overlay at least 18 feet of sterile sand. The cultural remains, according to Barton A. Wright,[1] of the Amerind Foundation (Dragoon, Arizona), appear to date from A.D. 750 to A.D. 1100, as determined from comparison with a cultural site at Willow Beach (Albert Schroeder, manuscript). The Willow Beach dating includes the periods known as Basket Maker III to Pueblo II, but excludes the Pueblo I horizon, which is absent in that area. Catclaw Cave, six miles by water south of Willow Beach, is now inundated by Lake Mohave.

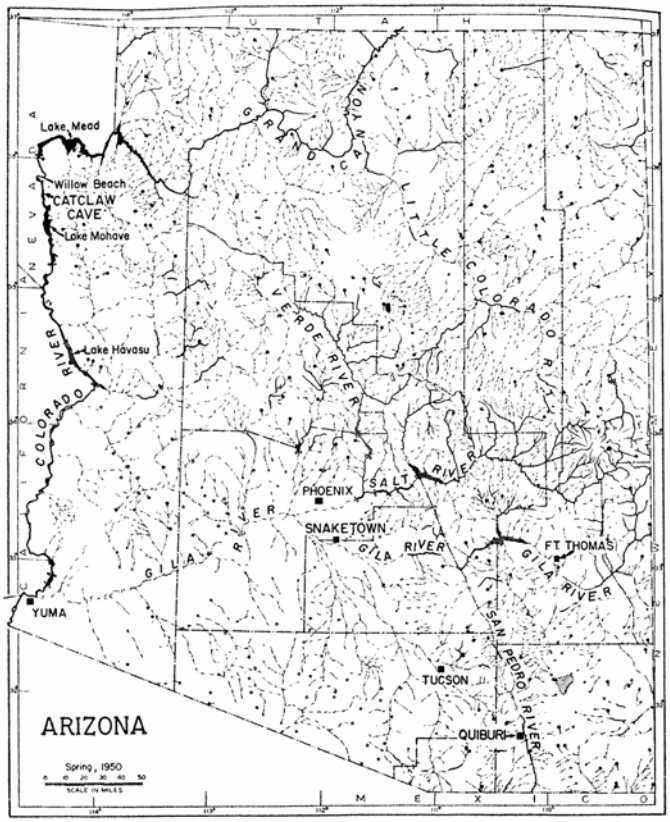

FIG. 1. Drainage map of Arizona showing archaeological sites

The numerous fish remains collected in 1949, including over 375 bones and bone fragments, are well preserved, and there is a sufficient number of critical bones to permit confident identification of species. Somewhat less than half of the material may be readily identified, and about 100 bones have been. Many of the rest are fragmentary and may not be identifiable, or are probably not worth the effort. Two families of fishes are represented: the suckers, Catostomidae, and the minnows, Cyprinidae. At least three species were secured, one of which has never been reported from the Colorado River below Grand Canyon. A fourth species may be represented in the unidentified fragments since it was formerly abundant in this area, is still caught occasionally, and has been used for food (Ellis, 1914: 56; Snyder, 1915: 581).

Fishes have been identified from two other archaeological sites in Arizona—at Snaketown, a prehistoric site of the Hohokam people, and at Quiburi, a historic settlement occupied by the Sobaipuri Indians (Fig. 1). The few fish remains from these two localities are discussed separately below.

The largest and most important food fishes were the humpback sucker and the so-called Colorado salmon. Each of these species, which were abundant and easy to catch before 1915, grows to a large size and has considerable flesh. The humpback chub, another large minnow, was less desired as food, since, like its close relative the bonytail, it is very bony.

The following institutional abbreviations are used: CAS (California Academy of Sciences), UMMZ (University of Michigan Museum of Zoology), and USNM (United States National Museum).

CATCLAW CAVE

FAMILY CATOSTOMIDAE

Xyrauchen texanus (Abbott)

Humpback Sucker

(Pl. I*A*; Pls. II-III)

The humpback sucker, so named because of the high keel on its back (Pl. I), attains a length of about 3 feet and commonly weighs from 10 to 14 pounds, or occasionally 16 pounds (Hubbs and Miller 1953: 226). As Rostlund (1952: 31-32) pointed out, the value of suckers as food fishes has probably been underestimated. Their use by aborigines is attested to by identified bones in archaeological sites (references in Rostlund) and by abundant remains at Catclaw Cave. In the past, the Mohave Indians took this species in numbers from the Colorado River near Fort Mohave, not far from the California-Nevada boundary line (Ellis, 1914: 31). Dr. Edgar Mearns, a surgeon-naturalist with the United States and Mexican International Boundary Survey from 1892 to 1894, noted that the flesh of this species was excellent and of fine flavor (Snyder, 1915-580).

Particularly diagnostic of the species are the operculum, neural complex, tripus (one of the Weberian ossicles), lower jaw, maxillary, palatine, pelvic girdle, frontal, and hyoniandibular (Pls. II-III). The fragments suggest that at least seven, and probably many more, individual fish are represented. The occurrence of several charred bones indicates beyond doubt that this fish was eaten by the aborigines. In 1950 I found reliable evidence along the river that both present-day Indians and whites eat this sucker whenever it is available.

The neural complex (Nelson, 1948: 226, fig. 1; 229; and pl. II, fig. 11), of which at least seven were secured, is an unpaired consolidated bone dorsal to the anterior end of the vertebral column (Pl. II*C*). In this species it is greatly thickened, elongated, and distally expanded and has the superior border curved downward anteriorly (broken in specimens illustrated). This complex, and its associated elements, supports the anterior part of the remarkable keel-like hump on the back (Pl. I). No other genus of sucker is known to have these bones so greatly modified (see X-ray photographs in Hubbs and Miller, 1953, pl. III). The length of the largest fish, as indicated by the neural complex, probably was 2-3 feet, and the fish may have weighed 10-12 pounds. Yet larger ones are known, for Ike Dowell, who took six tons of this species from Sahuaro Lake (east of Phoenix) in 1949, when he was a commercial fisherman, told me (in 1950) that specimens he handled weighed up to 14 pounds and were over 30 inches long.

A list of the identified bones referred to this species is given on page 131.

FAMILY CYPRINIDAE

Ptychocheilus lucius Girard

Colorado River Squawfish

(Pl. I*B*; Pls. IV-V)

This species, known locally as Colorado salmon or simply as salmon, is one of the largest minnows in the world. According to Ellis (1914: 55), it attains a length of 5 feet and a weight of nearly 100 pounds. Gilbert and Scofield (1898: 492) stated: "It is frequently taken reaching a length of from 4 to 5 feet . . . ." Testimony which I gathered during an ichthyological survey of the lower Colorado River in 1950 supports these claims and indicates that the maximum length approximates 6 feet.

The squawfish is said to have been the most highly prized of the native fishes of this region (Gilbert and Scofield, 1898: 492; Dill, 1944: 155), and formerly was abundant in the lower parts of the Colorado and Gila rivers. An unpublished report (on file at the Division of Fishes, USNM) by the late F. M. Chamberlain, who carried out a survey of Arizona fishes for the United States Bureau of Fisheries from January 15 to April 27, 1904, emphasizes that this species was prized both by the Indians and by white men. Grinnell (1914: 62) also states that the Indians ate this fish. They caught it either by using a sort of dipnet in the receding waters after sudden rises of the river (Chamberlain), or by shooting the salmon with bow and arrow (Rostlund, 1952: 32), or, more recently, by spearing the fish with pitchforks (Dill, 1944: 155). It can be taken with hooks at all seasons with almost any bait, as it is a voracious feeder. Typically, the salmon lie in deep holes, especially below riffles, but when the river rises it is said that they come in close to shore to feed on drift material (Chamberlain).

In his *Freshwater Fish and Fishing in Native North America*, Rostlund (1952: 32-33) minimizes the importance of the genus *Ptychocheilus* as food for the Indians. The three other species of the genus occur in the Sacramento and Columbia rivers and in certain coastal streams of Oregon, where excellent food fishes, such as sturgeon, herring, Pacific salmon, and eulachon are available in quantity. In those regions *Ptychocheilus* probably was little used for food. In much of the Colorado River, however, there are none of these more edible fishes, and here both *Xyrauchen* and *Ptychocheilus* assume an importance as food out of all proportion to that of such bony fishes elsewhere. Jordan (1891: 6, 26) noted that this is also true of these species in parts of Colorado.

Remains of this fish from Catclaw Cave are abundant and represent at least six individuals. Many of the bones that were found are highly diagnostic of the species, e.g., the pharyngeal arch and teeth hyomandibular, articular, symplectic, dentary, angular, maxillary operculum, branchiostegals, cleithrum, and pelvic girdle (Pls. IV-V). For comparative purposes, there is available a large, incomplete skull (USNM, No. 27408) and three sizable specimens preserved in alcohol (UMMZ, Nos. 117840, 136925, and 160649), the largest being about 20 inches in total length. By applying different proportional ratios to the biggest of the preserved specimens and to the skull, I obtained four estimates which indicated that the skull belonged to a fish about 4 feet long. Several bones found in the cave, in particular the hyomandibular, articular, and maxillary, are conspicuously larger than those of the fish represented by the skull. I therefore conclude that the size of the largest salmon was at least 5½ feet.

Gila cypha Miller

Humpback Chub

(Pl. 1*C*; Pl. III *C-D, F*)

The humpback chub, a minnow bizarre in appearance and highly streamlined for life in torrential waters, evidently is the third species that was eaten by the Indians at Catclaw Cave. Identification was made solely from two complete pharyngeal arches with teeth, each of which came from a different individual (Pl. III *D, F*). This extraordinary fish, described from a specimen taken in Grand Canyon (Miller, 1946b), has been discovered recently in other portions of the main river above Grand Canyon, and there is no obvious reason why it should not once have occurred below the Canyon, wherever the flow of the Colorado was consistently swift. Before the construction of dams, the river had sufficient gradient and flow to maintain a powerful current for at least 20 miles below Boulder Canyon (Hoover Dam), and there may have been a short stretch of swift water again through the canyon below Topock, Arizona, although Grinnel's report (1914: 57; pl. X, fig. 15) makes this seem unlikely. Below this section, the river broadened, losing much of its gradient, and probably did not harbor a permanent population of the humpback chub.

As noted in the original description, the pharyngeal arches of *Gila cypha* are much smaller than they are in its close relative, *G. robusta*. The shape and proportions of the arch appear to be diagnostic (Pl. III *C-D, F*). The lower limb is shorter than that in the bony tail, *Gila r. elegans*, and is neither markedly angular nor tapering at the tip; the upper limb is less sharply curved or is conspicuously broader, or both. In *Gila r. robusta*, which is found generally in major tributaries of the Colorado River, the lower limb of the arch is longer and more slender, somewhat approaching *Ptychocheilus lucius* in this feature. Measurements of the total length of each arch, 24.0 mm. and 26.3 mm., indicate, in the light of unpublished as well as published comparative data (Miller, 1946b: 411) for specimens of *G. cypha* and *G. robusta* of known length, that the total length of these fishes was between 17 and 18 inches.

Despite its remarkable appearance, recognition of the humpback chub as a fully distinct species is open to question, for it may well represent the extreme form of a series of subspecies of *Gila robusta*, briefly discussed and diagnosed by Miller (1946b: table 2, p. 414). The problem should be studied further, and more material is needed. The identification of both pharyngeal arches as those of the humpback chub seems reasonably certain, but little is known of the variation in these structures either in *G. cypha* or in *G. robusta*.

LIST OF BONES DETERMINED

The following fish bones or bone fragments from Catclaw Cave have been identified. The figures in parentheses indicate the number of remains of each structure.

XYRAUCHEN TEXANUS.—Dentary (4), maxillary (2), palatine (3), frontal (1), pterotic (1), quadrate (1), hyomandibular (1), tripus (1), neural complex (7), preoperculum (2), operculum (10), interoperculum (1), suboperculum (4), and pelvic girdle (2).

PTYCHOCHEILUS LUCIUS.—Dentary (4), maxillary (3), articular (3), quadrate (3), symplectic (1), hyomandibular (2), pharyngeal arch and teeth (3), preoperculum (1), operculum (6), interoperculum (2), suboperculum (1), lower branchiostegal (4), middle branchiostegal (3), upper branchiostegal (1), hypohyal (2), eeratohyal (6), pectoral girdle (3), posttemporal (1), supraclei thrum (2), and pelvic girdle (3).

GILA CYPHA.—Pharyngeal arch and teeth (2).

SNAKETOWN

Snaketown is the name given to a modern Indian site which was formerly occupied by a prehistoric people referred to by the Pimas as the Hohokam, "those who have gone" (Gladwin, Haury, Sayles, and Gladwin, 1937). It lies (Fig. 1) on the northern side of the Gila River (now a sandy wash), north of Casa Blanca, in the Gila River Indian Reservation. Tentative dates for the Hohokam civilization have been given as from 300 B.C. to A.D. 1400, during which time these people developed an elaborate irrigation system in southern Arizona (Haury, 1945) that enabled them to turn the desert soil into rich agricultural land, much as modern man has done in the Imperial Valley of California.

The only fish remains known to me from the Snaketown site are those recorded by Haury (in Gladwin, Haury, Sayles, and Gladwin, 1937: 157). They were identified as bones of the sturgeon (*Acipenser*) and vertebrae of unidentified species by the late Glover M. Allen, of Harvard University, who was Curator of Mammals and also an ornithologist. It is most regrettable that these bones were subsequently lost or discarded (letter of March 22, 1954, from William C. Schroeder), for I

believe that they were misidentified and that this led to an erroneous supposition concerning the nature of the Gila River in prehistoric times (Haury in Gladwin, Haury, Sayles, and Gladwin, 1937: 157).

The conclusion that the reference to sturgeon is erroneous is based primarily on zoogeographic grounds. The genus *Acipenser* is rare south of San Francisco Bay on the Pacific slope of North America, and is not known to enter fresh water south of the Sacramento River system. Although it was reported from Monterey by Jordan and Gilbert (1883: 86), the only actual record known to me of its presence south of San Francisco Bay is of a small specimen taken off the coast of southern California, between Huntington Beach and Newport (Roedel, 1941). Moreover, as Rostlund (1952: 18) pointed out, reports of sturgeon remains from archaeological sites are very rare, since their bones are essentially cartilaginous and normally would not be preserved long. I am confident that the bones in question were those of the Colorado salmon, *Ptychocheilus lucius*, and that the vertebrae may have represented this species as well as the humpback sucker, *Xyrauchen texanus*. Both of these fishes have occurred, within historic time, as far up the Gila River as Fort Thomas (Fig. 1; Kirsch, 1889: 556-558), and both were used as food by the Indians elsewhere in Arizona and in southeastern California.

QUIBURI

This site, occupied by the Sobaipuri Indians from approximately A.D. 1150 to A.D. 1760, lies about two miles north of Fairbank, Cochise County, on the west bank of the San Pedro River (Fig. 1). At that time the San Pedro was a large stream, which has since become intermittent. A comprehensive report on Quiburi is given by Di Peso (1953).

Fish remains recovered from trash heaps at Quiburi were submitted to me for identification, and the results of my preliminary study of the vertebrae were reported by Di Peso (1953: 236-237). These vertebrae are both charred and marked, which supports the view that fishes were used for food by the occupants of the ruin. The trash from which the fish bones were recovered belongs to the 1704-63 period of occupation by the Sobaipuris.

Ptychocheilus lucius

Thirty-one vertebrae, the largest 34.5 mm. in length, found at Quiburi are referred to the Colorado squawfish chiefly because of their size. Measurements of the average length of caudal vertebrae taken from a preserved specimen of *Ptychocheilus lucius* 174 mm. in standard length yielded an average ratio between these vertebrae and the standard length, and this ratio was then applied to the largest caudal vertebra from Quiburi. The rough estimate attained indicates that the biggest squawfish had a total length of about 5 feet (standard length about 53 inches).

To my knowledge, there are no preserved specimens of this species from the San Pedro River, originally the only major permanent southern tributary of the Gila River. However, “salmon trout” 3 feet long were reported in 1846 from the San Pedro at or near Fairbank (Cooke, Whiting, and Aubry, 1938: 144). Since *Gila robusta elegans* is not known to exceed a length of 1½ feet and since remains of *Ptychocheilus lucius* appear in the Quiburi site, we may be sure that this species occurred at or near Quiburi in 1846. It is doubtful whether the species has inhabited the San Pedro River .since about 1880, which is the approximate date when severe erosion began radically to alter the San Pedro and other southwestern streams (Bryan, 1925:341-342).

Xyrauchen texanus

The inclusion of the humpback sucker in the list of fishes eaten by the Indians at Quiburi is based solely upon a single vertebra. This bone, 10 mm. in greatest length, differs from the vertebrae referred to the Colorado squawfish in that it is notably flattened dorsoventrally (rather than evenly oval). The depth at the middle of the inner ring of the centrum is contained about 1.3 times in the maximum width of the centrum, whereas in *Ptychocheilus lucius* the depth is greater than or equal to the width. In shape and proportions, this vertebra agrees with the smaller ones of *Xyrauchen texanus* available to me. If properly identified, it belonged to a large individual (perhaps one nearly 3 feet long).

Reference of this bone to the humpback sucker finds support in the known distribution and utilization of this fish. According to notes made in 1904 by F. M. Chamberlain (see *supra*, p. 129), the species was formerly abundant (before 1885?) in the San Pedro River “. . . and was marketed at Tombstone as 'buffalo,' so called from the hump.” I know of no preserved specimens of the humpback sucker from the San Pedro basin.

ACKNOWLEDGMENTS

This paper was made possible through the splendid cooperation of several institutions, individuals, and organizations. For the loan of critical skeletal material, I am indebted to the authorities of the United States National Museum and E. A. Lachner, and to the California Academy of Sciences and W. I. Follett. Archaeological materials were loaned by the Amerind Foundation, through Charles C. Di Peso, and by the Department of Anthropology of the University of Arizona, the San Diego Museum of Man, and the United States National Park Service, through Barton A. Wright. William Ralph Taylor gave several valuable leads in the identification of some of the bones. Gilbert Sykes, District Forest Ranger of Nogales, Arizona, referred me to the early record of *Ptychocheilus* in the San Pedro River. William F. Sigler, of Utah State Agricultural College, collected and donated the specimens of *Catostomus latipinnis*, *Ptychocheilus lucius*, and *Gila cypha* used for comparison with the material from

Catclaw Cave. W. I. Follett pointed out the reference to sturgeon off southern California, and Volney H. Jones assisted with certain anthropological aspects of the manuscript. Field work in Arizona was supported by a research grant from the Horace H. Rackham School of Graduate Studies of the University of Michigan. William L. Rrudon, staff artist of the University of Michigan Museum of Zoology, photographed the bones and prepared the plates for publication. The drainage map was drafted by William L. Cristanelli and lettered by Mr. Brudon.

[1] Barton A. Wright, "Excavation of Catclaw Cave, Lower Colorado River" (unpublished master's thesis, University of Arizona, Tucson, Arizona, 1954; not seen).

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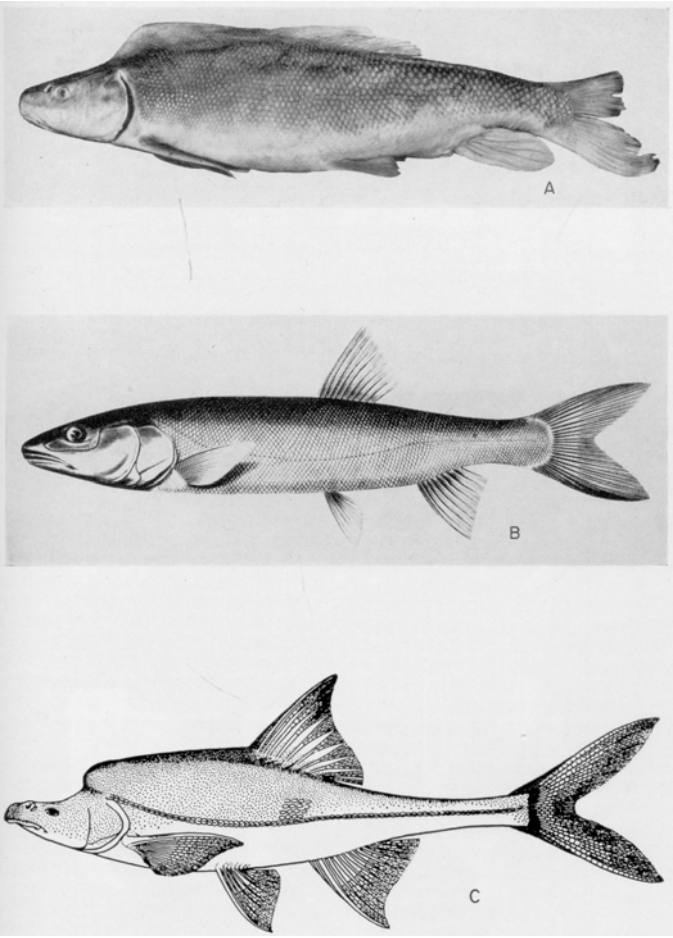
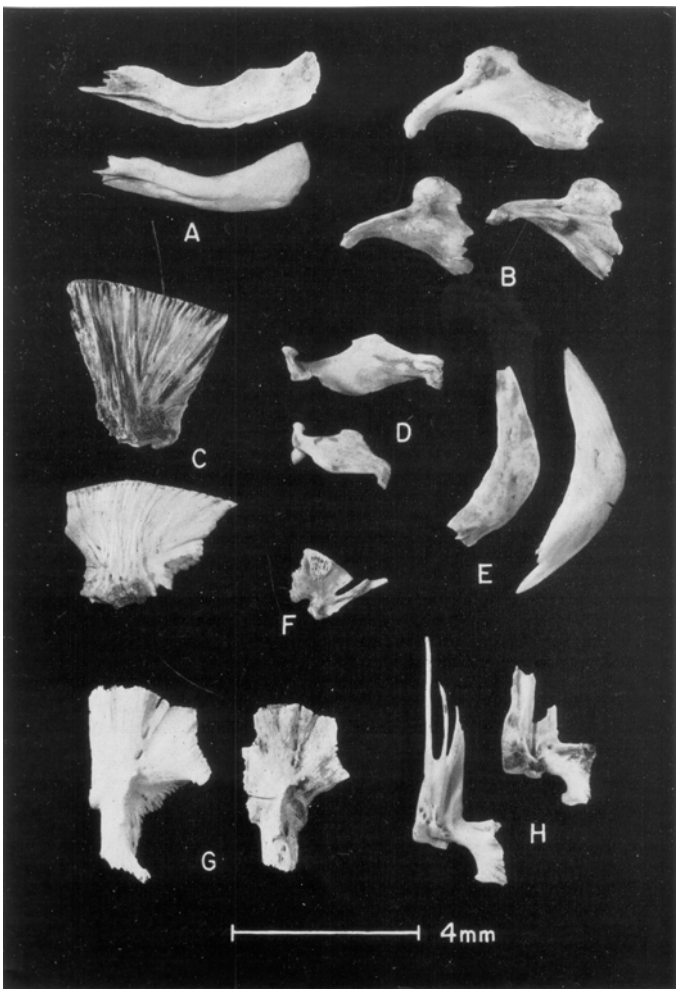


EXPLANATION OF PLATE I

Three fishes found in archaeological sites in Arizona

A, humpback sucker, *Xyrauchen texanus:* adult female, 291 mm. in standard length (UMMZ, No. 156798), from Gunnison River, Colorado (after Hubbs and Miller, 1953, pl. 1, fig. 3)
B, Colorado squawfish, *Ptychocheilus lucius:* holotype, about 195 mm. long (USNM, No. 203), from Colorado River, California (after Girard, 1859: 65, pl. 34, fig. l)
C, humpback chub, *Gila cypha:* holotype, 305 mm. long (USNM, No. 131839), from Grand Canyon, Arizona (after Miller, 1946b, fig. 1)



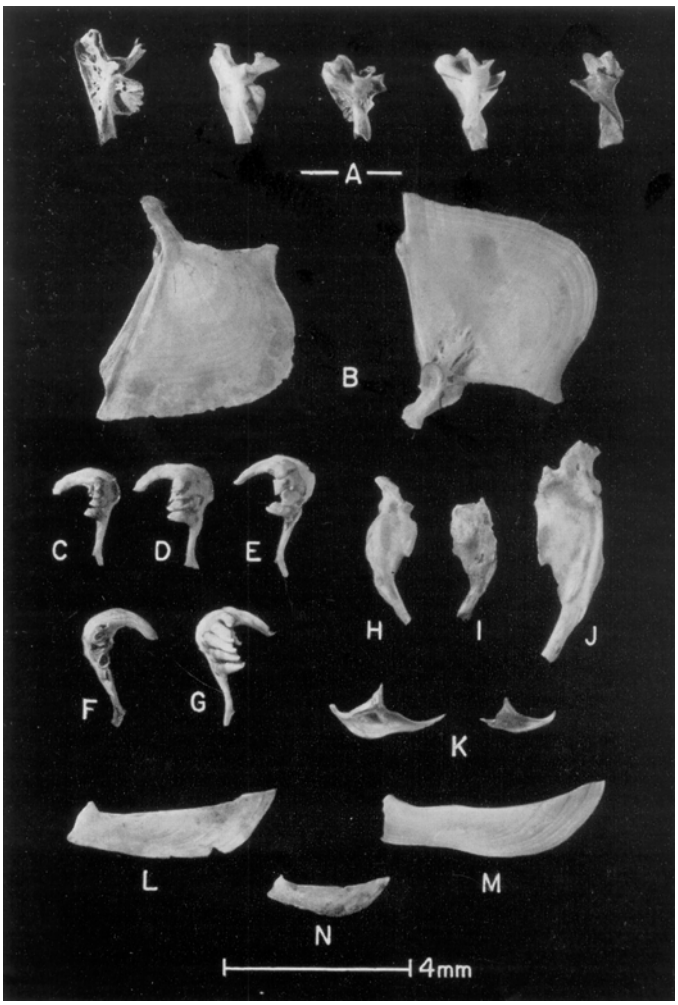
EXPLANATION OF PLATE II

Remains of the humpback sucker, *Xyrauchen texanus*

A, left interoperculum: top, from cave; bottom, from UMMZ, No. 94875
B, lower jaw: top, left dentary, angular, and articular from No. 94875; bottom, left dentaries from cave
C, neural complex: above, from cave; below, from No. 94875
D, maxillaries from cave
E, left preoperculum: left, from cave; right, from No. 94875
F, left quadrate from cave
G, left frontal: left, from No. 94875; right, from cave
H, right pelvic girdle: left, from UMMZ, No. 94876; right, from cave

(All bones are ¾ natural size; photographs by William L. Brudon.)

MILLER PLATE III



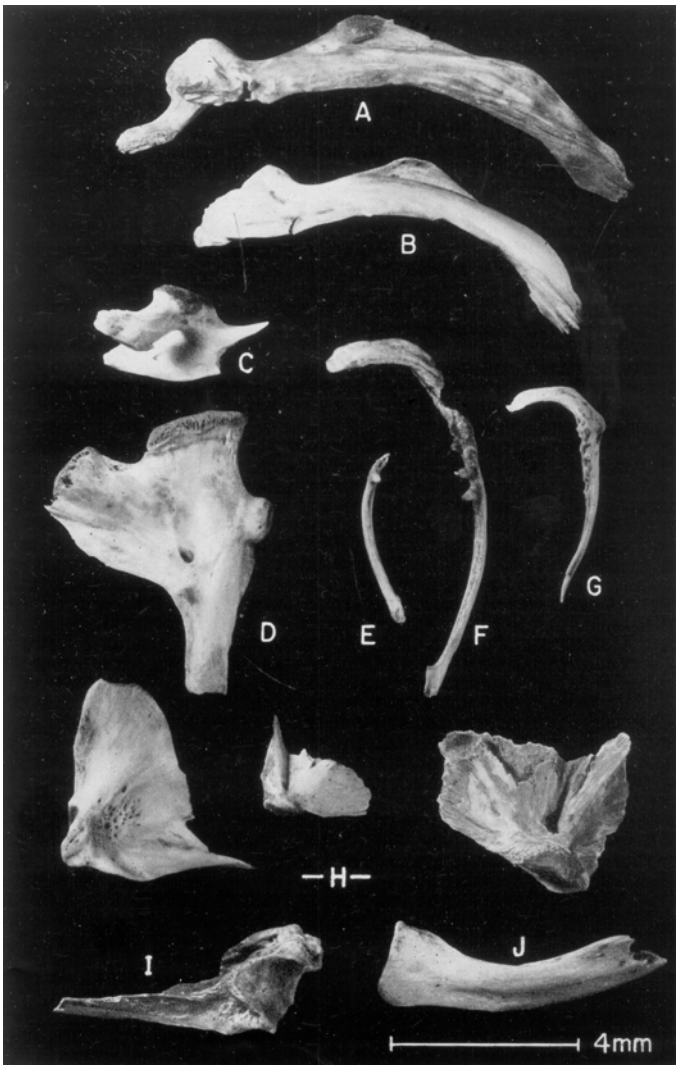
EXPLANATION OF PLATE III

Remains of the humpback sucker, *Xyrauchen texanus*, the flannel-mouth sucker, *Catostomus latipinnis*, the humpback chub, *Gila cypha*, and the bonytail, *Gila rohusta elegans*

A, palatine bones of *Xyrauchen texanus:* the three dark specimens from cave; the two light specimens from UMMZ, No. 94875
B, left operculum of *X. texanus:* left, outer view of cave bone; right, inner view of No. 94875
C, right pharyngeal arch and teeth of *Gila cypha* (290 mm. standard length), UMMZ, No. 160647, from Green River, Utah
D, right pharyngeal arch and teeth of *G. cypha*, from cave specimen
E, right pharyngeal arch and teeth of *G. robusta elegans* (about 390 mm. standard length), CAS, No. 25865, from the Nevada side of the Colorado River 2.1 miles below Davis Dam (Lake Mohave)
F, left pharyngeal arch of *G. cypha*, from cave
G, left pharyngeal arch of same individual from which right arch (*E*) was removed
H, right hyomandibular of *Catostomus latipinnis* (360 mm. standard length), UMMZ, No. 160646, from Green River, Utah
I, left hyomandibular of *Xyrauchen texanus*, from cave
J, left hyomandibular of *X. texanus*, from No. 94875
K, left tripus of *X. texanus:* left, from No. 94875; right, from cave
L, left suboperculum of *X. texanus*, from cave
M, left suboperculum of *X. texanus*, from No. 94875
N, left suboperculum of *X. texanus*, from cave

(All bones are ¾ natural size; photographs by William L. Brudon.)

MILLER PLATE IV

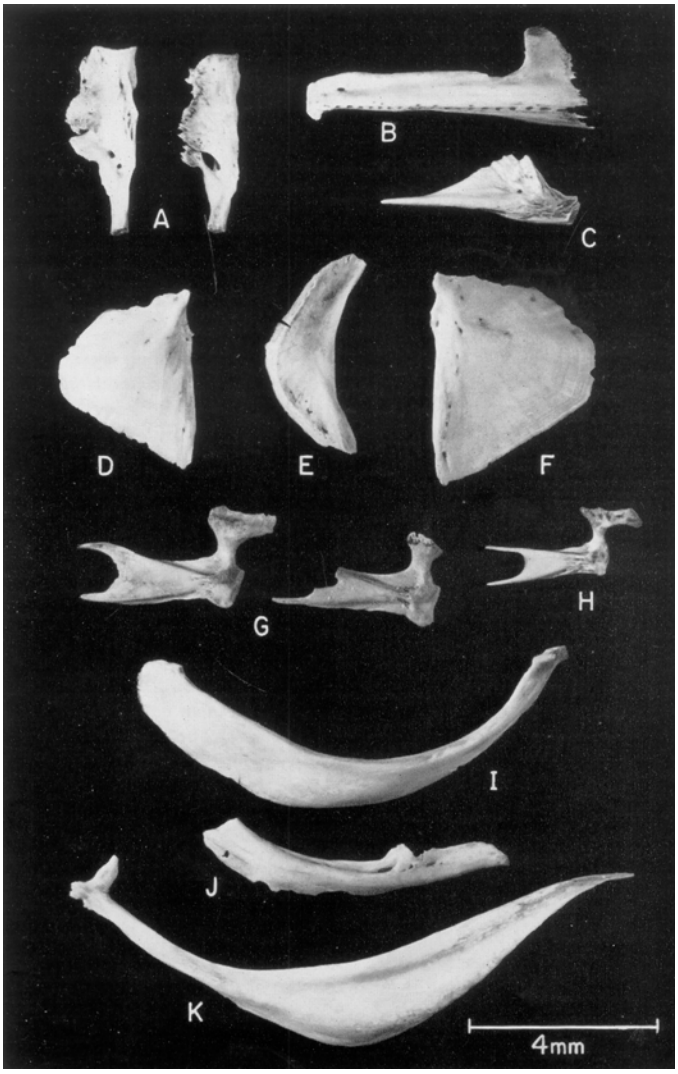


EXPLANATION OF PLATE IV

Remains of the Colorado squawfish, *Ptychocheilus lucius*

A, left maxillary from cave
B, left maxillary from USNM, No. 27408, a skull from a specimen estimated to have been 4 feet in total length
C, tip of right maxillary from cave
D, left hyomandibular from cave
E, portion of left pharyngeal arch and teeth from cave
F, right pharyngeal arch and portion of teeth from No. 27408
G, right pharyngeal arch from cave
H, quadrates (left and right) from cave
I, burned articular and angular from cave
J, right interoperculum from cave

(All bones are ¾ natural size; photographs by William L. Brudon.)



EXPLANATION OF PLATE V

Remains of the Colorado squawfish, *Ptychocheilus lucius*

A, right symplectic: left, from cave; right, from USNM, No. 27408, a skull from a specimen estimated to have been 4 feet in total length
B, left dentary from cave
C, left articular and angular (belongs to B) from cave
D, right operculum from cave
E, right preoperculum from cave
F, left operculum from cave
G, right pelvic girdles from cave
H, right pelvic girdle from UMMZ, No. 160649 (389 mm. standard length), from Groun River, Utah
I, right upper branchiostegal from cave
J, right middle branchiostegal (broken) from cave
K, left lower branchiostegal from cave

(All bones are ¾ natural size; photographs by William L. Brudon.)

SOME VALUES FROM RECREATIONAL LAND USE IN OGEMAW COUNTY, MICHIGAN

ROSS NORTON PEARSON

IT IS a well-established fact that recreation is of considerable economic significance to the people of the northern parts of Michigan and of other states in the upper Great Lakes region. The influx of nonresident visitors each year affects not only the persons who provide them with food, lodging, and entertainment, but also, in one way or another, practically all local inhabitants. Although it is clear that recreation is important in these areas, it is quite another matter to make a definite statement as to just how much it means to the people of a particular town or county. It is the purpose of this paper to describe the values received from one aspect of recreation—recreational land use—in one county of the northern part of lower Michigan.

Ogemaw County lies in the transition zone which separates the agricultural and manufacturing districts of southern Michigan from the less densely populated lands to the north (Fig. 1). It is roughly 160 miles north and west of Detroit and is, of course, much nearer cities like Flint, Bay City, and Saginaw. This proximity to the more heavily populated sections of the state has been an important factor in the development of recreational areas and pursuits. The problem of determining values derived from recreation is complicated by the existence of several significant economic activities in the county. Ogemaw not only has a strong interest in recreation, but it also has a healthy agricultural development, some manufacturing, and a number of oil fields, from which considerable income is derived.

RECREATION, LAND USE, AND LAND TYPES

There are two types of land use in Ogemaw County that are essentially recreational (Fig. 2). One, “resort land,” is solely, recreational and the other, “wild land,” is employed at present more for recreation than for any other purpose. The use of one of these types is intensive and of the other extensive. The intensive form occurs where clusters of cottages have been built for vacationing; this is the type referred to here as resort land. Many resort areas have retail business establishments, overnight cabins, permanent homes, or even commercial resorts interspersed among the cottages, but it is the single-family dwelling, occupied on weekends or for periods of a week or more, that characterizes resort land in Ogemaw County. With the exception of a small area along the Rifle River, near highway M55, all this resort land is adjacent to lakes. It occupies, however, only a small percentage of the surface of the county. In 1952 it made up only one half of one per cent of the area, and in only two townships (Hill and Mills) did it occupy more than one per cent of the total (Fig. 3).

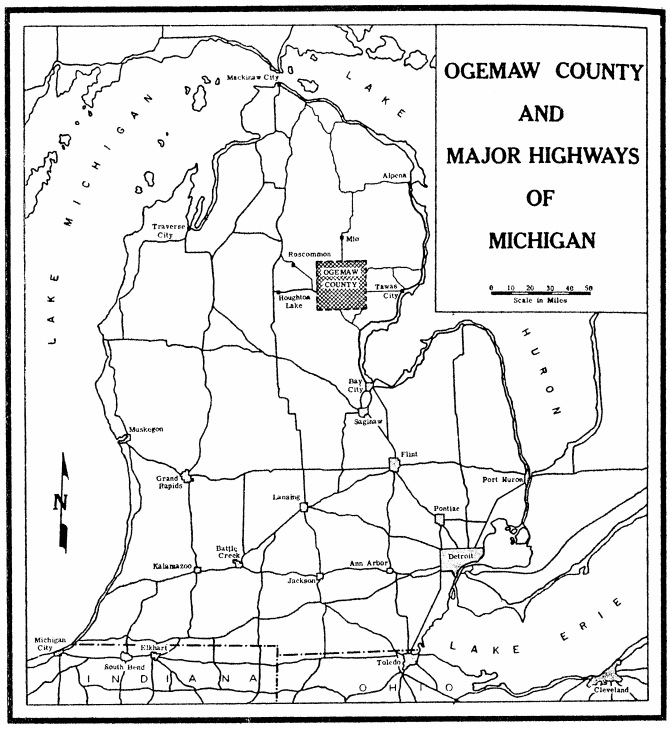


FIG. 1

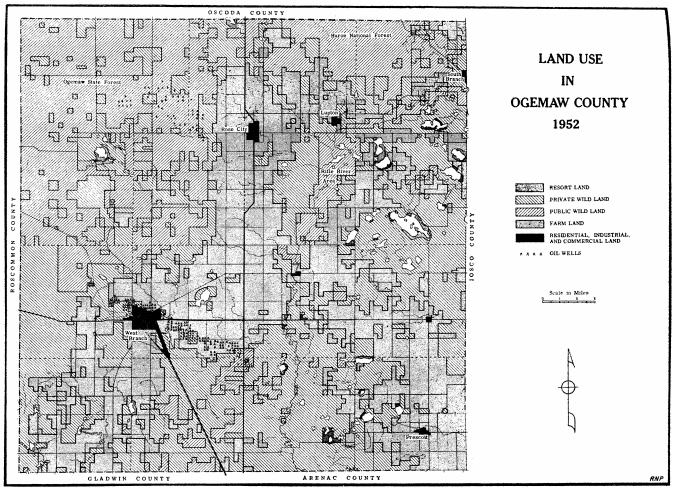


FIG. 2. Land use, with resort land chiefly edging the lakes

Almost two thirds of Ogemaw County is wild land, whose most important uses are recreational; this constitutes the extensive form of such land use. Wild land is the habitat of game; its lakes and streams support fish; scattered over it are cabins used by hunters and anglers, although it is common practice to classify all wooded, cutover, idle, or otherwise unproductive areas as recreational, it is more appropriate to refer to them as wild land. Some of this land belongs to farm units, and there are tracts of abandoned farm land, idle farm land, and farm wood lots that are essentially wild in nature. Other plots are being held for speculative purposes, for possible resort development, or for potential petroleum production, but, whatever the intent of ownership, the land is still most useful at present for recreation.

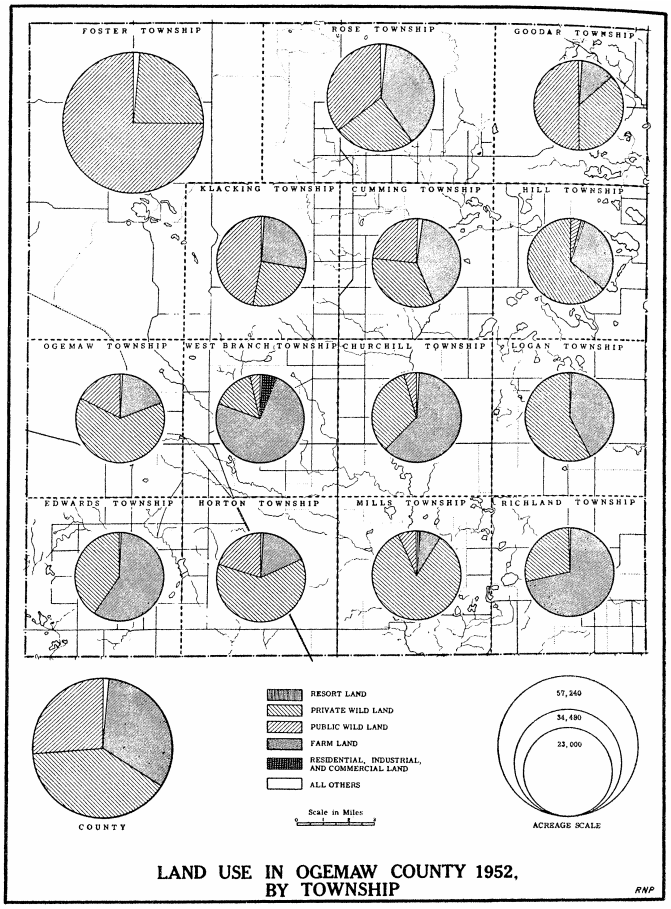


FIG. 3

A large part of the wild land (96,312 acres) is held by local, state, and national governments, and most of it is organized into the Huron National Forest, the Ogemaw State Forest, or the Rifle River Area. It is significant that small tracts of privately owned wild land in the vicinity of the state and national forests are devoted primarily to recreational purposes, having been bought chiefly because of their proximity to the forests. They commonly are the sites of one or more cabins, whose owners hunt and fish on the nearby public lands. Scattered holdings of 40, 80, or 160 acres in the farming districts have some recreational utility, although they are not held for that purpose.

Of the 66.3 per cent of Ogemaw County classified as wild land, 39.9 per cent is in private hands and 26.4 per cent in public ownership (Fig. 3). Five of the fourteen townships (Foster, Goodar, Ogemaw, Horton, and Mills) have over 80 per cent of their area in wild land, and three more have over 60 per cent.

The lands that are used for recreational purposes in this county are commonly those which are not suited to farming (Fig. 4). Lands indicated on the map as type A are sandy plains with dry, infertile soils; type B consists of swampy plains with wet, infertile soils; type C is hilly and sandy, with dry, infertile soils; and type E is made up of rolling plains which have extensive areas that are imperfectly drained. At one time or another attempts have been made to farm much of this wild land, hut

because of steep slopes, poor soils, or bad drainage, they have been unsuccessful. Some areas have always been recognized as useless for agriculture and have remained in a wild state. Most of the land now taken up by cottage clusters was previously wild. A few lakes in wild tracts have shorelines that are suitable for resort use; those which remain undeveloped either are inaccessible or have owners who will not permit a change.

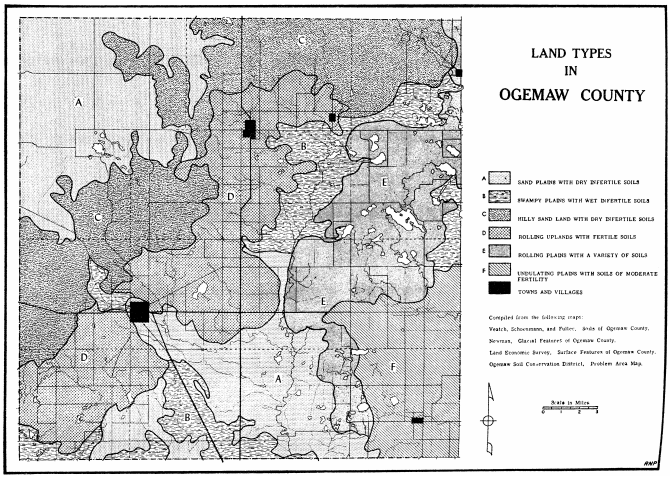


FIG. 4

RECREATION, PROPERTY VALUES, AND REAL-ESTATE TAXES

The relationship between land use and land types is reflected in the map showing the assessed valuation of land and buildings in 1950 (Fig. 5). The pattern displayed by the several groupings of land values[1] is similar to that of land use and land types. The principal effect of recreation upon property values is to raise assessments on lands which would otherwise have relatively low values to a point where they are among the highest in the county. Wild lands not suited to farming and having little utility for other purposes become valuable holdings when they are converted into resort subdivisions, or when cabins are built upon them. Resort land, which, as has been said, comprises only one half of one per cent of the total area of the county, accounts for 16.9 per cent of the assessed valuation. In the northwestern fourth of the county, which is almost exclusively wild land, there are a number of scattered parcels with higher valuations than the surrounding areas; these are tracts of privately owned land, in the sand plains, on which there are one or more hunting cabins.

The increase in the assessed valuation of land used for recreation results, of course, in an increase in real-estate tax payments. Since county taxes on land and buildings are directly proportional to assessed valuation, the percentages for valuation can be applied to the real-property tax. In 1950 resort land provided $11,858.47 in county taxes, and wild land yielded $13,377.14. In comparison with this total of $24,735.61, all other types of real-estate tax brought $42,147.50[2] into the county treasury. Recreational lands bore a particularly large part of the tax burden in three townships which have a high percentage of their total assessed valuation in resort and wild land (Fig. 6): in Foster Township recreational lands accounted for 97.7 per cent of the property tax; in Mills, 96.8 per cent; and in Hill, 86.5 per cent.

Taxes for the support of schools are levied at different rates in the several school districts. In 1950 the rate varied from .0001 in the Foster unit to a specially voted levy of .019 in School District No. 1, Fractional, in West Branch. Because of this variation it was not practical to compute the income from such taxes on as accurate a basis as was possible for county taxes. Estimates were arrived at by applying the percentage of the assessed valuation of property in recreational land in each township to the school taxes levied in that township; even so, the figures represent an approximation which should not be far from actuality. They reveal that revenue from recreational lands contributed an additional $20,038.55 to the public treasury, in this case for educational purposes. This is slightly more than one fifth of the $96,920.51 which was the local contribution to the cost of education. Since school taxes are somewhat higher in more heavily populated districts, the proportion derived from recreational lands is not so high as in county taxes. However, when it amounts to one fifth of the total it becomes important.

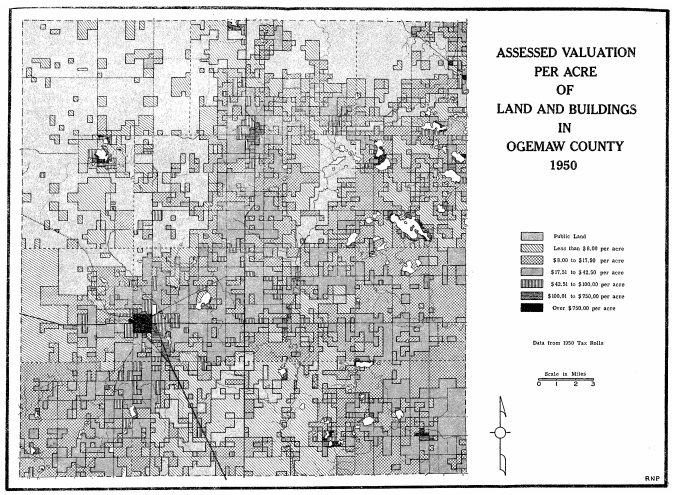


FIG. 5

Land in Ogemaw County owned by state and national governments is used primarily for recreation, and yields substantial payments to county funds each year. The state of Michigan pays a tax to the counties of 10 cents an acre annually on all state-owned lands, and the federal government returns 25 per cent of the income from its land to the local government. In 1950 the Ogemaw County treasurer received $7,578.48[3] from the state and $683.25[4] from the federal government for land held in public ownership. So, in 1950, the revenue the county received from lands in recreational uses was $24,735.61 from county taxes, $20,038.55 from school

taxes, and $8,261.73 from public lands, or a total of $53,035.89.

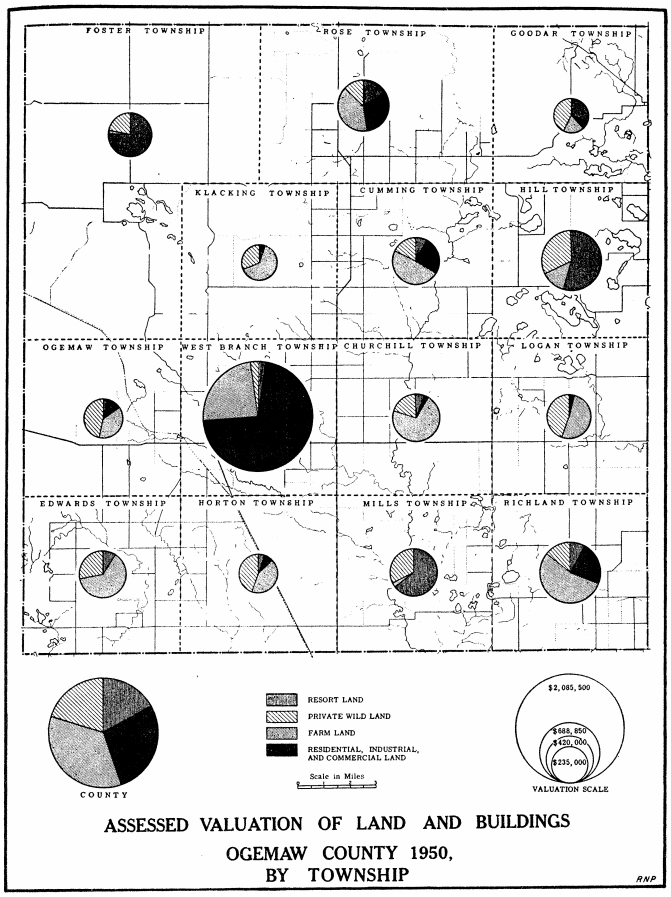


FIG. 6

VALUES ADDED BY RECREATION

Since all lands, except those held in public ownership, are given an assessed valuation and produce a tax income, it is unrealistic to infer that taxes paid on land in recreational use represent only income from recreation. Part of this land, being undesirable for other purposes, would probably revert to the state if not so employed, but that remaining in private ownership would yield some tax income. Nevertheless, the higher assessed valuations which result from recreational land use do add measurably to the tax base of the county.

Privately owned wild land has the lowest value per acre of any type of land in Ogemaw County. Most of it falls in the category "less than $8.00 an acre," although a large part is actually assessed at $5.00. If an assumption is made, however, that privately owned wild lands are normally assessed at $8.00 an acre, it is possible to estimate how much recreation adds to the tax base. Multiplying the total area of this privately owned wild land, 145,342 acres, by $8.00 gives $1,162,736.00, which represents the assessed valuation of the wild lands if no recreational use existed. The difference between this and the 1950 assessed valuation of wild land, $1,526,340.00, indicates the value that was added by recreation—$363,604.00. Thus recreational use of the wild lands added at least $3,272.44[5] to the county tax collections in 1950. By using the same procedure for land in resort subdivisions, we find that recreational use added $1,247,403.00 to the tax base, or $11,226.63 in one year in property taxes. Thus the total value added by recreation to real-estate taxes amounted to $14,499.07.

Another significant point in Ogemaw County is that a large part of the tax levy on recreational property is paid by people living outside the county. Tax money, however, is utilized by local governments to provide local services; nonresident taxpayers have no voice in the election of the officials who spend these funds and little say as to how the money will be spent. To be sure, some of it goes for the construction and maintenance of roads that are primarily of benefit to recreationalists, but nonresidents do pay a large share of the costs of government for services which benefit only the local population. It was not possible to make a complete survey of the proportion of the total tax burden that is borne by nonresident property owners, but a few examples will give some indication of the situation. A survey of the ownership of lots in the Rifle and George lakes resort area in 1951 shows that 71 per cent of them belong to persons who pay taxes in Ogemaw County but neither reside nor vote there. A sampling of the ownership of wild land in four sections of each standard township (i.e., one containing 36 square miles) indicates that 35 per cent of the assessed valuation is in the hands of persons who live outside of the county. If these two samples are representative of the whole, a very considerable portion of the taxes on both types of recreational land is paid by residents of counties other than Ogemaw.

SUMMARY

The values from recreational land use in Ogemaw County may be summarized as follows:

1. Recreation utilizes types of land that are not suitable for farming and that would otherwise have a low value. When cottages are built upon such land it becomes one of the most valuable types of real estate in the county.

2. The tax receipts from recreational lands represent an important part of the total taxes paid into the county treasury.

3. The taxes paid upon lands used for recreation are much higher than they would be if the lands were not so used.

4. A large part of the tax burden in the county is borne by persons who receive few benefits in return.

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[1]The map (Fig. 5) of assessed valuation of land and buildings does not give a true picture of the per-acre value of real estate in Ogemaw County. It seems customary for property to be assessed for from one fourth to one third of its market value, so maps showing property values should properly be employed only to illustrate the value of land in one type of use as compared with that in another.

[2] Figures for total assessed valuation, by township, were obtained from Ogemaw County Board of Supervisors, *Ogemaw County Supervisors Proceedings, 1950-1951* (West Branch, Mich., 1951); those for assessed valuation of property units, from Ogemaw County Treasurer's Tax Rolls, 1950; the area in resort land and in wild land is indicated in Figure 2.

[3] Michigan Department of Conservation, *Sixteenth Biennial Report, 1951-1952* (Lansing, Mich., 1952), p. 209.

[4] *Ogemaw County Supervisors Proceedings, 1950-1951*, p. 2.

[5] Based upon a tax rate of .009.

SARNIA—A GROWING INDUSTRIAL CENTER OF WESTERN ONTARIO*

ANDREW D. PEREJDA

INDUSTRIES along the St. Clair River in Canada are concentrated in Sarnia, Ontario (see Fig. 1), which is at the head of the St. Clair River, opposite Port Huron, Michigan. Their astonishing present-day development is described in this paper.

INDUSTRIES

Since the beginning of World War II, five major companies have located plants in Sarnia. They are the Polymer Corporation, Ltd., Dow Chemical Company, Ltd., Fiberglas Company of Canada, Ltd., Sun Oil Company, Ltd., and Cabot Carbon of Canada, Ltd. In 1952 alone, 80 million dollars were invested in new plants. These plants, together with the older Imperial Oil Company, Ltd., and the Dominion Salt Company, Ltd., are closely interdependent, and have created what is known as "Canada's chemical valley." Raw materials on which the chemical, synthetic rubber, and oil-refining industries are based are salt, locally produced, and crude oil, which is delivered by pipeline.

The refinery of the Imperial Oil Company is the oldest of Sarnia's industries, having been established in 1897. It is the largest refinery in the British Empire, with a crude-oil refining capacity of 55,000 barrels a day, and a tank-storage capacity of 4.5 million gallons. It is controlled by the Standard Oil Company of New Jersey—which owns over 69 per cent of the stock—and employs more than 2,300 people. The refinery occupies over 253 of the company's 510 acres of land.

Imperial Oil is just completing a 50-million-dollar expansion and modernization program, and has recently allocated another 6 million dollars to future development. A new crude-oil distillation unit with a capacity of 50,000 barrels a day and a fluid catalytic cracking plant processing 25,000 barrels a day will boost crude-oil refining capacity 30 per cent, or to 71,500 barrels daily. The company produces gasolines, greases, asphalt, crystalline waxes, and numerous other by-products. It also provides the Polymer Corporation with petroleum for the manufacture of synthetic rubber.

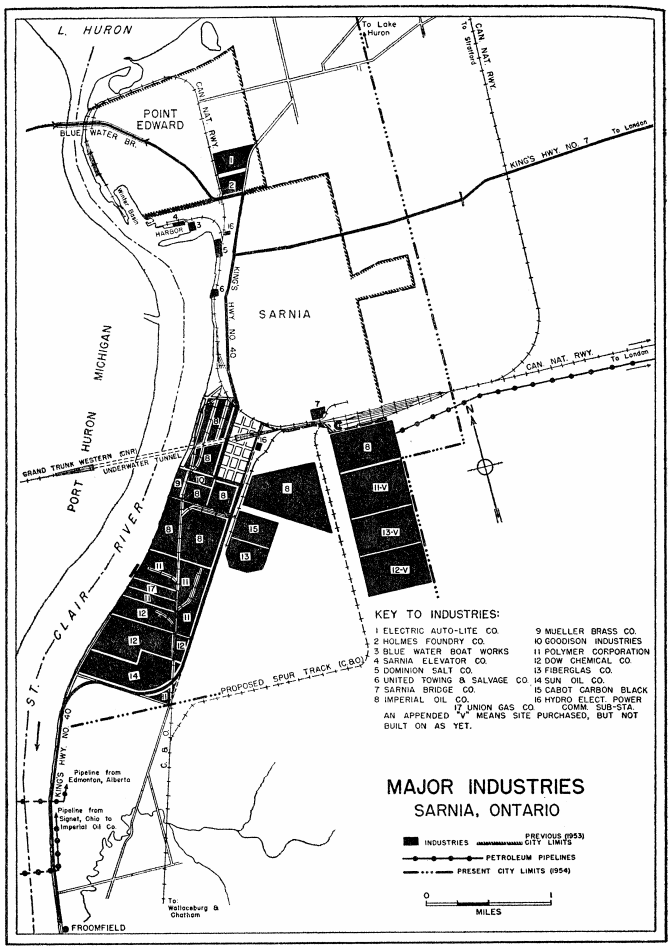

FIG. 1

In the fall of 1953 the Sun Oil Company, Ltd., of Sarnia, completed construction of a refinery having a capacity of 15,000 barrels a day and costing 15 million dollars. Sun Oil manufactures petroleum products and butylene feedstocks for Polymer Corporation's use in synthetic rubber.

In September 1953 the Canadian Oil Company, Ltd., after fifty years in Petrolia (17 miles southeast of Sarnia) transferred its plant to Corunna, 4 miles south of Sarnia. Here it operates a new 22-million-dollar refinery that produces petroleum products, feedstocks for Dow Chemical Company's new ethylene plant, and a propane by-product of the polymerizer for fuel or as a feedstock for chemical synthesis. There are four units in this refinery: a catalytic cracker, a platformer, a crude-oil distillation unit and visbreaker, and a catalytic polymerizer.

Increased investments of the Imperial Oil Company in new refining units and the establishment of another plant in Sarnia by the Sun Oil Company and one in Corunna by the Canadian Oil Company are attributed to the discovery of additional oil near Edmonton, Canada, in 1947. After this discovery a 30-inch, crude-oil pipeline costing 90 million dollars was built from Edmonton to Superior, Wisconsin, a distance of 1,126 miles. It was completed in the spring of 1951 and from then until 1953 delivered crude oil from the Edmonton fields to Superior.

From Superior the crude oil was transported to the refinery by Imperial Oil's fleet of tankers. Under these conditions a sufficient supply of crude oil had to be delivered to the storage tanks during the summer to take care of refinery operations during the winter season, when the St. Clair River is icebound. With the completion of an 80-million-dollar pipeline in the fall of 1953 between Superior and Sarnia via the Straits of Mackinac (a distance of 625 miles), Imperial Oil, Sun Oil, and Canadian Oil began to receive crude oil directly from the Edmonton fields. The delivery capacity of the pipeline is 300,000 barrels a day throughout the year. Since the refineries have a combined daily refining capacity of 100,000 barrels, the area has a daily excess of 200,000 barrels of crude petroleum. This excess will undoubtedly attract more refineries and chemical plants.

Before 1951, crude oils were transported to Imperial Oil Company by pipeline from the mid-continent and from the Texas oil fields. The pipeline, which is still intact, taps the main east-west oil line at Signet, Ohio, from which point oil is piped via Sylvania, Ohio, and Utica and Marysville, Michigan, to the Imperial Oil refinery, after crossing the St. Clair River between Marysville and Froomfield, Ontario. The line's capacity averages 30,000 barrels a day; the remainder of the crude oil formerly required to keep the refinery in full operation was delivered by tanker from the east coast of the United States and from Great Lakes ports.

In addition to employing tankers to transport its refined petroleum products, the Imperial Oil Company constructed in November 1952 an 11-million-dollar pipeline to carry gasoline and diesel, furnace, and stove oils the 188 miles to Toronto, via London and Hamilton. The capacity of this pipeline is from 40,000 to 50,000 barrels a day. Another pipeline covering the same route was completed in October 1953; it is owned by the Sun Oil Company (two thirds) and by the Canadian Oil Company (one third). These pipelines provide London, Hamilton, and Toronto with petroleum products throughout the year.

The establishment of the Polymer Corporation at Sarnia for the production of synthetic rubber was conceived in February 1942, while the western powers were still floundering from the shock of Pearl Harbor and the Japanese conquest of nine tenths of the rubber sources of the world. Construction started in August 1942, and by September 1943 the plant was producing GR-S (Government Regulation Standard) rubber at half capacity.

The corporation, now capitalized at 50 million dollars, began as the St. Clair Processing Corporation, Ltd., a subsidiary of the Standard Oil Company of New Jersey that was set up to operate eight of the ten units of Polymer Corporation. When the contracts of the subsidiary terminated on April 30, 1946, the organization and plant were absorbed by Polymer and came under government ownership.

The annual consumption of raw materials by Polymer Corporation includes 25 million imperial gallons of light petroleum, 5 billion cubic feet of petroleum gas, 300,000 tons of coal, 2.5 million imperial gallons of benzol, 5 million pounds of soap, enough brine to contain 11 million pounds of salt, 800,000 pounds of sulfuric acid, and many other modifiers and chemicals. Before 1951 light petroleum and petroleum gas were obtained chiefly from crude oils from the United States, and after that date, largely from crude oils of the Edmonton fields. Coal is imported from the United States, and salt is supplied by the local Dominion Salt Company.

The Polymer Corporation produces two types of synthetic rubber, also the chief components—butadiene and styrene—of GR-S rubber, and isobutylene for making butyl rubber. The GR-S output at the Sarnia plant varies from 7 million to 8 million pounds per month, or from 84 million to 96 million pounds per year. The production of GR-S rubber is slightly higher than the annual Canadian consumption of synthetic rubber, which in 1952 amounted to 75,260,000 pounds. In comparison, the Canadian consumption of natural rubber in 1952 was 75,042,000 pounds, and of reclaimed rubber 30,468,000 pounds. The total production of synthetic rubber for all of Canada in 1952 was 166,360,000 pounds. The location of the plant is an excellent one, since 90 per cent of the consuming market lies within a 350-mile radius of Sarnia.

From petroleum and petroleum gases the 1,900 employees on the 130-acre property turn out as much man-made rubber a year as 28,000 tappers tending 16 million natural rubber trees on 125,000 acres in Malaya. One Polymer employee produces as much as 15 native tappers. The Polymer Corporation is the only fully integrated rubber plant in the world. It has spent about 9 million dollars to boost its production 25 per cent, and 1 million dollars in 1953 to complete a new research and development laboratory.

The Dow Chemical Company of Sarnia is a subsidiary of the Midland, Michigan, organization. Originally, the Dow plant for this area was located in Marysville, Michigan, having been set up by the United States government during World War II as a National Defense Plant Corporation to manufacture magnesium, which was used in airplane parts and explosives. After the war, Dow closed the Marysville plant and moved to Sarnia, where its present plant occupies 163 acres.

The Polymer Corporation supplies Dow with styrene, the principal base in the manufacture of plastics, and ethylene, which is converted by Dow into glycol for antifreezes and explosives. Other Dow Chemical Company products are chlorine, caustic soda, hydrochloric acid, and ammonia. Dow Chemical Company products are essential to all the other industries of Sarnia.

The salt industry of Sarnia was operated from 1904 to 1940 under a charter granted to the Western Canada Salt Company. In 1940 its plant was purchased by the

Dominion Tar and Chemical Company, which controls the salt industry through its subsidiaries, the Dominion Salt Company and Sifto Company.

The salt, in the form of brine, is obtained from wells sunk into salt beds that are from 1,800 to 2,100 feet below the surface. Daily production is about 200 tons. This industry is an important adjunct to the Dow Chemical Company and the Polymer Corporation of Sarnia.

The 4-million-dollar plant of Cabot Carbon Black of Canada, Ltd., is the first oil-furnace, carbon-black plant in Canada. It is a subsidiary of Godfrey L. Cabot, Inc., of Boston, and produces 25 million pounds of carbon black annually, or one third of Canada's requirements. Carbon black is essential to the manufacture of synthetic-rubber tires and greatly increases the amount of wear. (One average-sized car tire—6.50-15—contains 4 pounds of carbon black.) The road wear of a modern tire reinforced with carbon black is from 25,000 to 30,000 miles. A tire with an equal volume of an inert filler in the tire tread instead of the carbon black would last for only about 3,000 miles.

Natural gases were first used in the manufacture of carbon black, but rising costs and the introduction of synthetic rubber led to a search for a substitute, and it was discovered that carbon blacks produced from liquid hydrocarbons were an excellent reinforcing medium for synthetic rubber. Thus the chief reason for locating the Cabot plant in Sarnia was the presence in the area of petroleum, from which the product is manufactured. Another factor was the presence of the Polymer Corporation plant. Even though carbon black is not used by Polymer, it is vital to Polymer's customers, the large Canadian rubber-tire manufacturers.

Canada's first plant to manufacture glass fiber was the Fiberglas Company of Canada, located in Sarnia. It was completed in 1949 at a cost of 1.5 million dollars and operates 24 hours a day, employing 200 people. The excellent rail and waterway facilities make it easy to obtain the fine sands and soda ash that are processed into glass fiber. Before the plant was built, glass wool, used for insulation and for glass textiles, and glass balls, from which glass yarn was drawn, were imported from the United States for the company's finishing plant at Oshawa, Ontario.

Mueller Brass, Ltd., of Sarnia, which has been in operation since 1912, is a subsidiary of the Decatur, Illinois, company. It produces pipes, brass rods, plumbing fixtures, and other brass articles. Raw materials used include brass ingots shipped by rail from the Canadian Metal Company of Toronto and the United Smelting Company of Hamilton, Ontario, molding sands imported from Zanesville, Ohio, and Ottawa, Illinois, copper from Aranda, Ontario, zinc from Tadnac, British Columbia, and tin from Malaya.

Electric Auto-Lite, Ltd., came to Sarnia from Port Huron, Michigan, in 1929. It employs 800 people, and future plans call for expansion and increased production to meet the growing demand of the Canadian automotive industry. Its products, which are sold to the Ford and Chrysler plants in Windsor, Ontario, include starters and lighting systems for automobiles, spark plugs, battery cables, and wiring.

The Holmes Foundry Company of Sarnia was built in 1919 as a subsidiary of the parent plant in Port Huron, which has since ceased operations. The foundry, which has 500 employees, manufactures automobile engine blocks for the Ford Motor Company of Windsor, Ontario, and rock-wool insulation. This insulation is produced from steel and cast-iron slag obtained from its own plant and from firms in Detroit and other Great Lakes ports. Molding and blasting sands are imported from Manistee and Port Huron, Michigan, Gary and Michigan City, Indiana, and Ottawa, Illinois.

The Canadian firm Goodison Industries, Ltd., was founded in Sarnia in 1882, and at present has over 100 employees. It produces threshers, feed mixers, steel grain bins, and marine engines. The company is also a distributing agent for the Oliver Products of America and the Page-Gordon Implements Company, both United States firms.

The Sarnia Elevator Company, Ltd. (45 employees), has a storage capacity of 3 million bushels of grain, as compared to the 3.5 million bushels and the 2.5 million bushels of the government and the BAWLF terminals at Port Arthur and Fort William, respectively. The Sarnia elevator receives wheat from Port Arthur and Fort William, and corn from the Chicago elevators, but not all the grain received is ground in Sarnia, since it is a transshipment point for wheat to the mills of eastern Canada and to ports for shipment abroad. The Sarnia mills grind feed grains for western Ontario.

There are a number of other important companies in Sarnia. The Sarnia Bridge Company, Ltd., assembles, welds, and rivets structural steel for construction purposes. The Blue Water Boat Works, at the head of the harbor, builds and repairs small lake craft. The United Towing and Salvage Company, Ltd. (Sin-Mac Lines), has machine shops and towing and salvage equipment and carries out repair work on the large lake steamers. Natural gas, which is used for industrial, commercial, and domestic purposes, is distributed in Sarnia by the Union Gas Company, whose main office is in Chatham, Ontario. The thermal value of the gas is 1,060 B.T.U.'s per cubic foot, which is twice the B.T.U. content of manufactured gas. The area's nearest natural-gas fields are seventeen miles to the east, within the county (Lambton), and those in adjoining Kent County. The natural-gas supply is almost gone, and 5.5 billion cubic feet are imported daily by pipeline from Texas fields.

Other industries include bottling works and servicing organizations, but they are in no way directly concerned with the major industries of Sarnia.

Factors Favoring Industrial Growth

Factors favoring the industrial growth of Sarnia are numerous. There are abundant salt deposits in the immediate vicinity. Crude oil is accessible, and is transported into the area by pipeline. The Great Lakes and their connecting channels provide excellent and cheap water transportation most of the year. The navigation season, which extends, on an average, from March 19 to November 30 each year, allows ample time for industries in Sarnia to stock-pile enough raw material to last through the three winter months, when the St. Clair channel is icebound.

The harbor and port facilities of Sarnia are excellent. Sarnia's natural harbor is formed by a sharp bend in the Canadian shoreline, and the spit shelters the harbor from river currents and winds. Within the harbor, extending eastward from Bay Point, is a dredged slip which has a mean depth of 23 feet and a width of 400 feet. On the north side of the harbor are rail facilities and the Sarnia Elevator wharf, which has a berthing length of 900 feet. On the south side of the harbor is the government wharf, with a berthing length of 500 feet. The port is an important shipping terminal of the Canadian National Railway. Sarnia also has a winter berthing basin, 23 feet deep, 1,900 feet long from north to south, and 250 feet wide. This basin and the harbor combined can accommodate 21 lake vessels during the winter. Six companies have their own wharves. There is the 1,100-foot-long Canadian National Railway wharf, the 400-foot wharf of the Dominion Salt Company, the 2,000-foot Imperial Oil wharf, the 600-foot Polymer Corporation wharf, the 218-foot Mueller Brass wharf, and the United Towing and Salvage Company wharf. Because of the excellence of these facilities and the cheapness of water transportation, coal, sand, copper, iron ore, steel, petroleum, and other raw materials can be imported from the United States and Canadian lake ports and brought directly to the plants without transshipping. Thus transportation costs are relatively low. The same is true for the finished products which are exported.

Sarnia also has excellent rail and highway facilities. The Grand Trunk Railroad (Canadian National Railway) at Sarnia connects the Michigan and the transcontinental railway systems of the United States with Ottawa and Montreal, via London and Toronto. This was made possible by an underwater railroad tunnel built between Port Huron and Sarnia in 1890. Sarnia is also the terminus of the Chesapeake and Ohio Railroad, which enters the city from the south and connects with the Canadian National Railway at Chatham, Ontario. Paralleling the southern shore of Lake Huron, the Canadian National Railroad joins Sarnia with Stratford, Ontario. In addition, Sarnia is the focus of two national highways that are linked to Michigan and the rest of the United States by the Blue Water Bridge between Sarnia and Port Huron.

Other advantages of the area include the clay soils, which do not require blasting for tank and building foundations, and unlimited amounts of flat land, which may be acquired cheaply, for the expansion of industry and the city. The city owns extensive tracts of land on the east and south, but expansion southward would encroach on the Chippewa Indian Reserve. Although approval of the Canadian government is required, the tribe has the right to sell its land if it chooses, but it is generally reluctant to do so unless an exceptionally high price is paid. The last sale by the tribe of a portion of its reserve was 195 acres of land to the Dow Chemical Company, for one thousand dollars an acre. Since its industrial boom, Sarnia has expanded from 2,000 to 11,000 acres (see Fig. 1) and has absorbed Point Edward. Its population increased by about 85 per cent between 1941 and 1950, or from 18,734 to approximately 42,000.

Factors affecting the movement of industry from the United States to Sarnia are the low taxation on property, unlimited markets in Canada, and the plentiful labor supply. There is also an abundant supply of water and of electrical power. Electricity is furnished chiefly by the Ontario Hydro Electric Commission, but some is produced locally by the Polymer Corporation. Since 1948 the commission has increased the amount available, and has converted power in the area from twenty-five cycles to sixty cycles. Another important factor in the development of industry in Sarnia is the ease with which United States plants can be established in Canada without legal restrictions on investments.

As a result of these advantages, Sarnia continues to grow industrially, and many more companies are looking for sites in or near it.

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* Based on field work carried on from 1950 to 1954.