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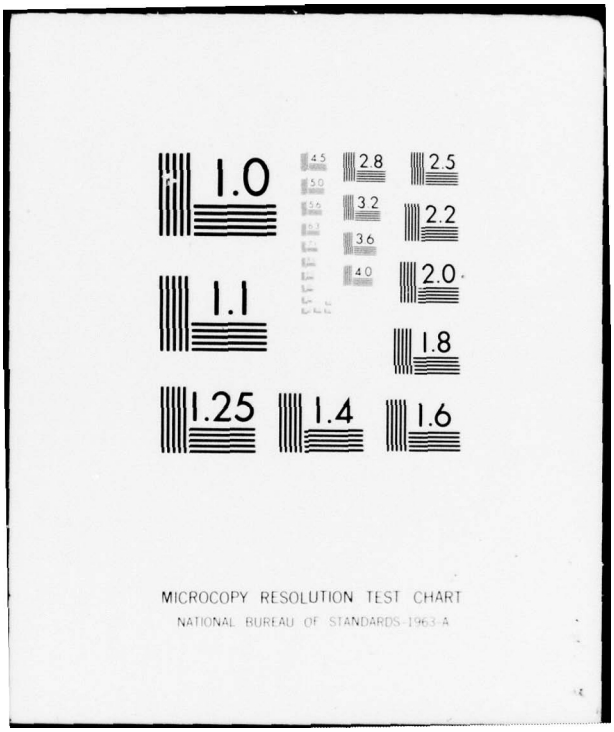
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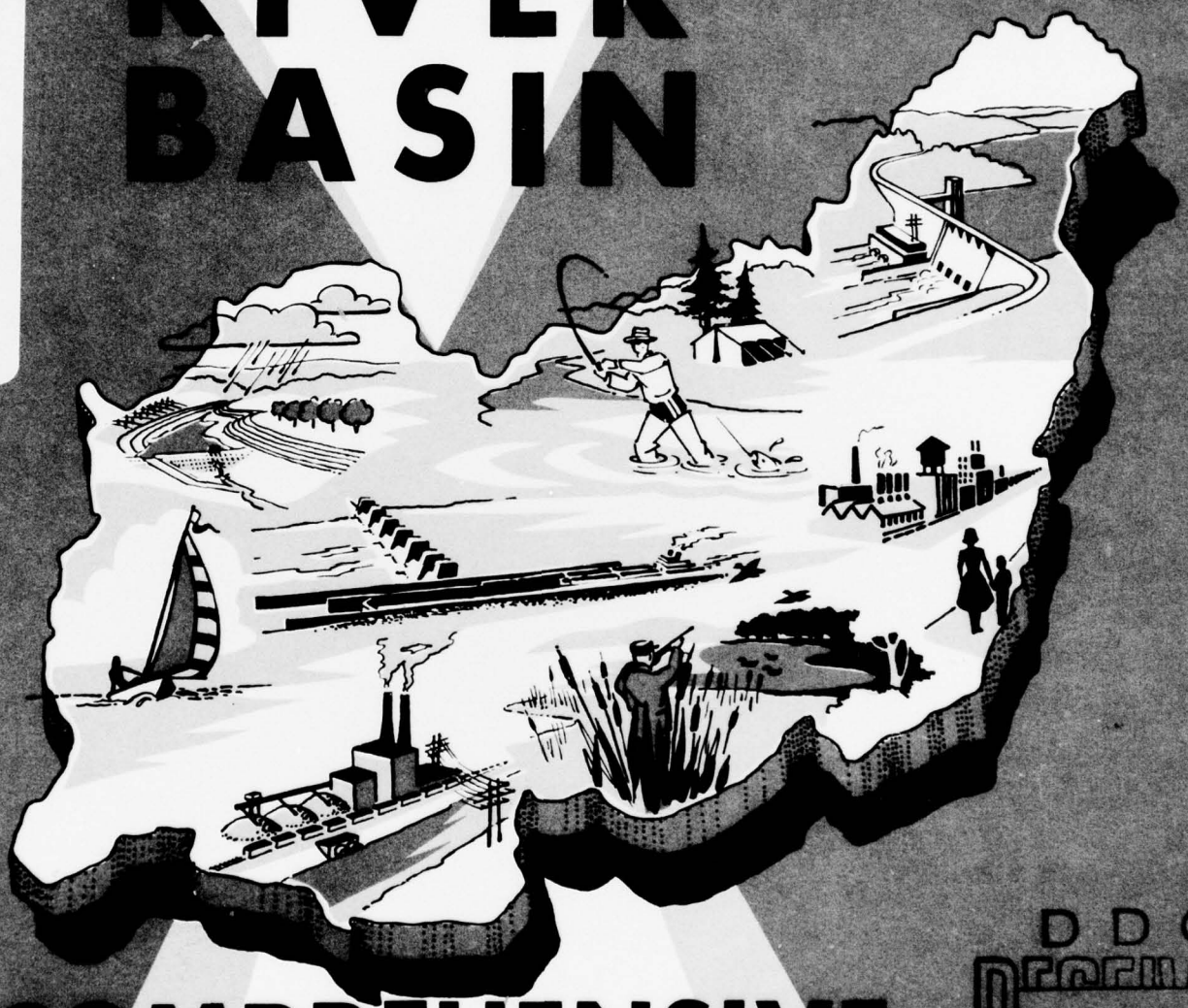


COMPREHENSIVE SURVEY

Appendix G

Prepared by Fish and Wildlife Service, Department of the Interior, in cooperation with Department of Agriculture; Army Corps of Engineers; Health, Education and Welfare; the Federal Power Commission; and participating states.

ORIGINAL CONTAINS COLOR PLATES: ALL DDC REPRODUCTIONS WILL BE IN BLACK AND WHITE

FISH AND WILDLIFE RESOURCES

U.S. ARMY ENGINEER DIVISION, OHIO RIVER-CINCINNATI, OHIO

(G) (1)

OHIO RIVER BASIN COMPREHENSIVE SURVEY.

Volume VIII.

APPENDIX G.
FISH AND WILDLIFE Resources.

(11) 1963

(12) 99p.

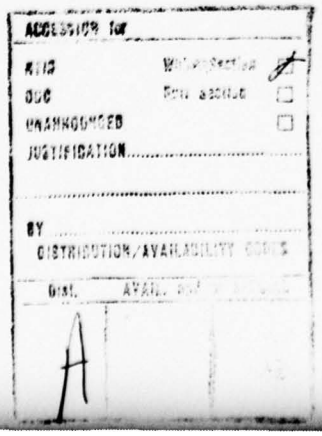
U. S. DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
BUREAU OF COMMERCIAL FISHERIES

REPORT OF THE REGIONAL DIRECTORS

Bureau of Sport Fisheries and Wildlife

and

Bureau of Commercial Fisheries



UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

Division Engineer
U. S. Army Engineer Division
Ohio River Division
P. O. Box 1159
Cincinnati, Ohio 45201

Dear Sir:

The U. S. Fish and Wildlife Service is pleased to present a report on the Fish and Wildlife Resources of the Ohio River Basin, to be included as Appendix "G" in the Ohio River Basin Comprehensive Survey. This report has been prepared, jointly, by the Bureau of Sport Fisheries and Wildlife and the Bureau of Commercial Fisheries, under the authority, and in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

The report is designed to analyze the fish and wildlife resource problems in the Ohio River Basin and to furnish general solutions, especially as related to potential water development projects.

This report was undertaken with the cooperation of each state fish and game agency within the basin. The study's findings and projections have been reviewed and generally concurred with by the heads of these various state agencies. Other Federal agencies involved in this study furnished basic data. The cooperation of your Basin Planning and Project Planning Branches was significant.

In 1960, approximately 2.6 million anglers fished 22 million days in the basin on 590,000 acres of ponded waters and 46,000 miles of fishable streams. Only slightly less hunters, 2.3 million, also spent approximately 22 million days afield in 1960 on 93 million acres of land in the basin.

In 1960, the Ohio Basin commercial fisheries catch was nearly 2.5 million pounds valued at $425,000. A potential demand of 7.9 million pounds of freshwater fish (exclusive of that produced in the Great Lakes) was estimated to exist in the basin that year, indicating potential deficit of 5.4 million pounds. The commercial catch originated almost entirely from the river fisheries which accounted for only 45 percent (191,000 acres) of the potentially available habitat (419,000). The average production rate was 12.6 pounds per acre. An average production rate of 19 pounds per acre on the potential habitat would have been required to meet 1960 demands. The commercial shellfish catch for the corresponding year was 2.25 million pounds valued at $95,000. Recent increases in demand for mussel shells has resulted in at least a doubling of the value of the catch since 1960.

Gross demand for sport fishing is projected to increase 62 percent by 1980, 88 percent by 2000 and 138 percent by 2020--over the 1960 actual basin use. Despite the assumption that much of this demand will be met by future habitat development programs, there will still be unfulfilled needs of 3.1 million angler-days by 1980 and 11.8 million by 2010.

The growth in hunter demand, while at a much slower rate than fisherman demand, nevertheless is projected to increase 18 percent by 1980, 23 percent by 2000, and 32 percent by 2020--over the 1960 actual basin use. Sufficient hunting opportunity, above that met by future habitat development programs, will be needed to sustain an additional 3.4 million man-days use by 1980 and 5.5 million by 2010.

This report lists several alternative measures for solving certain fish and game resource problems in each sub-basin of the Ohio Basin. Also, it provides a system of inter-sub-basin priorities based on net needs for sport fishing and hunting.

Future demands for inland commercial fishery products in the basin are estimated to total 14.2 million pounds in 1980 and 24.2 million pounds in 2010 based on projected increases in per capita consumption. Additional habitat created through reservoir construction and potentially available for commercial fishing will total 635,000 acres by 1980. A production rate of 22.3 and 38.0 pounds per acre from these waters will be required to meet 1980 and 2010 demands, respectively. Liberalization of legal restrictions and modernization and coordination of the fishery are necessary conditions for optimum utilization of the basin's commercial fishery resources.

There is every indication that demand for mussel shells will continue to increase. Unlike the commercial finfish resource, future shellfish production in the basin will likely be a function of a presently uncertain supply rather than demand. The Ohio Basin is one of the major quality shell-producing areas in the world and every effort should be taken to assure prudent utilization and appropriate habitat protection for this resource.

The reconnaissance nature of the data and the size of the areas being compared preclude its direct use in many specific future projects. A framework study such as this finds its value in inter-elemental comparisons rather than fixed indices for specific projects. We do not imply that the data for any specific area is particularly erroneous; just that certain elements of the reconnaissance-scope data may warrant additional analysis or eduction to more specific areas before they can be applied to a given project at a given location within a sub-area.

It has been a welcome opportunity to provide information on fish and wildlife resources of the Ohio River Basin. We hope our participation in this comprehensive study will result in the perpetuation and enhancement of these resources and that full consideration will be given to fish and wildlife

needs in the comprehensive plan for the solution of the water and associated land problems of the Ohio River Basin.

Sincerely yours,

R. W. Burwell, Regional Director
Bureau of Sport Fisheries & Wildlife
Region 3

Walter A. Gresh, Regional Director
Bureau of Sport Fisheries & Wildlife
Region 4

Acting for Richard E. Griffith, Regional Director
Bureau of Sport Fisheries & Wildlife
Region 5

William F. Carbine, Regional Director
Bureau of Commercial Fisheries

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INTRODUCTION

This is a report on the fish and wildlife resources of the Ohio River Basin, including the related needs of the present and future sportsmen of the area. The report has been prepared under the authority, and in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401 as amended; 16 U.S.C. 661 et seq.).

The Ohio River Basin Review of Reports was authorized by a resolution adopted May 16, 1955 by the Committee on Public Works of the United States Senate which requested a review of prior reports on the Ohio River with a view to determining whether any modification in the Corps of Engineers' comprehensive plan for flood control and other purposes in the Ohio River Basin was advisable.

Accordingly, the Division Engineer, Ohio River Division Corps of Engineers initiated studies in 1955. Participation by certain other Federal agencies started in Fiscal Year 1961; the Bureau of Sport Fisheries and Wildlife initiated basic studies that year.

The original scope of the investigation was changed in 1963 from a review of reports to a Type 1 (Framework), Basin Comprehensive Survey. The objectives of the present framework study are "the determinations in broad terms of overall basin requirements for water and related land resource development for municipal, industrial and agricultural water supply; water quality control; flood control and drainage; hydroelectric power; navigation; watershed protection and management; outdoor recreation; fish and wildlife conservation; and other purposes; the determination of the availability of water; the appraisal of the capability of the going program of resource development to meet indicated present and prospective needs; the formulation in general terms of a plan of development, including the indication of elements which would be required in the near future and the need for and priority of more detailed studies of tributary basin areas."

The area under study comprises the Ohio River Basin, exclusive of the Tennessee River Basin. It includes the major portions of the States of Ohio, Indiana, Kentucky and West Virginia; substantial parts of Pennsylvania, Illinois and Tennessee; and smaller areas of New York, Maryland, Virginia and North Carolina.

The fish and wildlife resources of the Ohio River Basin have been studied previously in connection with water and associated land development proposals. A total of 153 administrative reports on Corps of Engineer projects, 64 on Soil Conservation Service projects, and four on Federal Power Commission projects have been produced by the Bureau of Sport Fisheries and Wildlife prior to 1963.

ACKNOWLEDGEMENTS

The United States Fish and Wildlife Service wishes to acknowledge the valuable contributions made to this report by the Fish and Game agencies of each of the 11 states in the Ohio Basin. Information as to available habitat and indices of use on that habitat were secured from State resource files.

Additional information as to habitat and use was secured from Regional and Field Offices of the Soil Conservation Service, Economic Research Service, U. S. Department of Agriculture, U. S. Forest Services, Bureau of Outdoor Recreation, Geological Survey and the Water Supply and Pollution Control Division of the Department of Health, Education and Welfare.

The Project and Basin Planning Sections of the Ohio River Division, Corps of Engineers were especially helpful in developing the projective methodology and providing suggestions as to the development of the report.

Personnel of the Pittsburgh, Decatur and Ohio Area Offices of the Division of River Basin Studies, collected and analyzed the information on the status of the sport fishery and wildlife resources. The North Central Region, Bureau of Sport Fisheries and Wildlife, and the Ohio Area Office were responsible for the projective methodology and preparation of the report. The River Basins section of the Great Lakes and Central Regional Office, Bureau of Commercial Fisheries was responsible for preparing the portions of the report pertinent to the commercial fisheries of the basin.

DESCRIPTION OF THE AREA

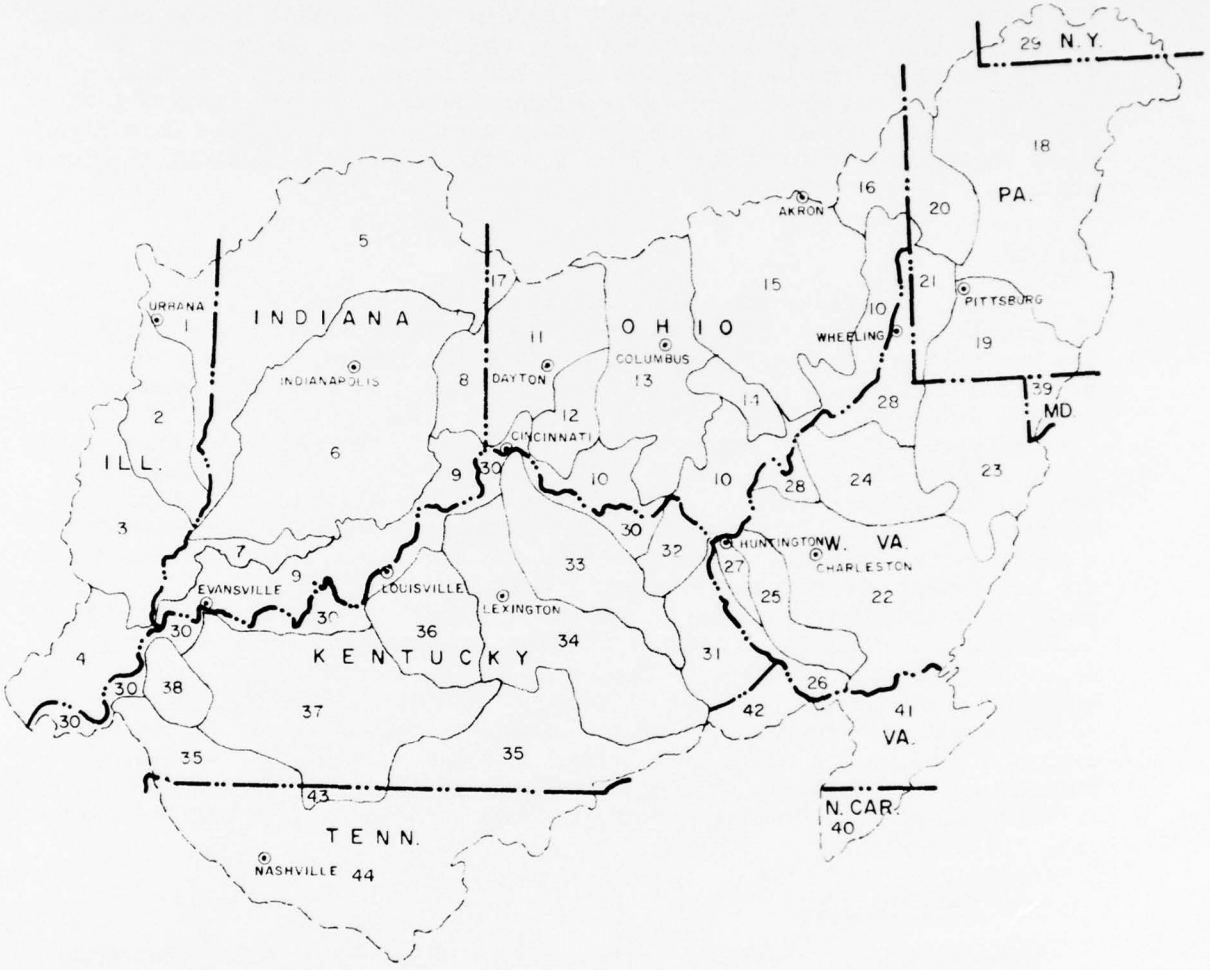
Geography

The Ohio River is formed by the confluence of the Allegheny and Monongahela Rivers at Pittsburgh, Pennsylvania. It flows 981 river-miles in a southwesterly direction and joins the Mississippi River at Cairo, Illinois. The river bounds Ohio, Indiana and Illinois (right bank); and West Virginia and Kentucky (left bank). Major Ohio River tributaries, in addition to the Allegheny and Monongahela Rivers, are the Beaver, Muskingum, Hocking, Scioto, Little Miami, Miami, and Wabash Rivers (right bank); and the Little Kanawha, Kanawha, Guyandotte, Big Sandy, Licking, Kentucky, Salt, Green, Cumberland, and Tennessee Rivers (left bank).

The area under study comprises that portion of the Ohio River Basin exclusive of the Tennessee River Basin and covers approximately 163,000 of the 203,900 square miles of the entire basin or 5.5 percent of the conterminous area of the United States (Plate 1).

Topography

The Ohio River Basin lies in four major physiographic divisions, namely:



Illinois

1 Vermillion
2 Embarrass
3 Little Wabash
4 Saline

Indiana

5 Wabash
6 White
7 Patoka
8 Whitewater
9 Ohio River Tribs

Ohio

10 Ohio River Tribs
11 Miami
12 Little Miami
13 Scioto
14 Hocking
15 Muskingum
16 Mahoning
17 Wabash

Pennsylvania

18 Allegheny
19 Monongahela
20 Beaver
21 Ohio R. Mainstem

West Virginia

22 Kanawha
23 Monongahela
24 Little Kanawha
25 Guyandot
26 Big Sandy
27 Twelvepole
28 Ohio Riv. Mainstem

New York

29 Allegheny

Kentucky

30 Ohio R. Valley
31 Big Sandy
32 Lt. Sandy Tygards
33 Licking
34 Kentucky
35 Cumberland
36 Salt
37 Green
38 Tradewater

Maryland

39 Monongahela

North Carolina

40 Kanawha

Virginia

41 Kanawha
42 Big Sandy

Tennessee

43 Green
44 Cumberland

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OHIO RIVER
COMPREHENSIVE BASIN STUDY

Fish and Wildlife Hydrologic Sub-basins

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF SPORT FISHERIES AND WILDLIFE
REGION 3 MINNEAPOLIS, MINNESOTA

PLATE 1

the Valley and Ridge Province, which borders the watershed on the east and is mountainous; the Appalachian Plateau, which lies to the west of the Valley and Ridge Province; the Interior Low Plateau, which lies south of the Ohio River and west of the Appalachian Plateau; and the Central Lowland, which includes virtually all of the basin north and west of the Ohio River below Portsmouth, Ohio, and which is a nearly level to undulating glaciated plain.

Geology

Broadly speaking, the Ohio River Basin is a region of slightly disturbed Paleozoic sedimentary rocks that range in age from Cambrian to Permian. On the basis of general lithology and economic importance, they are subject to two broad divisions: (1) the coal measures and, (2) a great series of calcareous sediments that extend from the base of the coal measures down through the Cambrian. The coal measures form the broad Appalachian plateaus of the eastern third of the basin in Pennsylvania, West Virginia, eastern Ohio, eastern Kentucky, eastern Tennessee, and underlie the central lowlands of western Indiana, western Kentucky, and eastern Illinois. They consist of a great series of sandstones and shales containing many important coal beds. The calcareous rocks underlie a broad belt extending through the central portion of the basin in central Tennessee, central Kentucky, western Ohio, and eastern Indiana, where they have been brought above major drainage by erosion and stream lowering on the crest of the Cincinnati anticline. The dominant rocks in this area are limestones and calcareous shales. The northern and western portions of the basin, including nearly all of the drainage area on the north side of the Ohio River, below Portsmouth, Ohio, have been glaciated. In this area, bedrock is generally buried beneath thick deposits of glacial drift and many profound changes in the preglacial drainage have taken place.

Climate and Hydrology

The climate of the basin is temperate. Mean temperatures vary from 50° F. on the northern boundary to 60° F. on the southern boundary. Daily temperatures range from about -30° F. to over 100° F.

The mean annual precipitation in the basin varies from 51 inches in the extreme southwestern portion to 43 inches in the extreme northeastern portion, and from 60 inches in the extreme southeastern portion to 37 inches in the extreme northwestern portion. Storms have occurred with a precipitation of 6.5 inches in 48 hours, over an area as large as 37,000 square miles. Conversely, minimum monthly rainfalls of as low as 1.7 inches have persisted for six months over a considerable portion of the basin. In general, rainfall and runoff are high in the late winter and in the spring, and are low in the summer.

Population

The study area has a population of about 20 million persons--ten percent of the national population. The majority of the people are located along a northeast-southwest axis through the basin.

Industry

Portions of the Ohio River are highly industrialized; agriculture, mining, and manufacturing also are extensive. Principal natural and manufactured products include coal; limestone; sandstone; gravel; petroleum; natural gas; salt; ores of iron, zinc, aluminum, and manganese; products of iron and steel plants, rolling mills, blast furnaces, foundries, and machine shops; motor vehicles, parts, and accessories; rubber goods; railroad equipment; electrical machinery; knit goods; furniture; electric power; lumber; cement; chemicals; farm products; and others.

STATUS OF FISH AND WILDLIFE RESOURCES - 1960

Basin Fish and Wildlife Populations

Basin fish and wildlife resources are limited by natural restrictions and by an expanding human population with its inevitable demands on land and water. Large populations not only limit the basin's habitat base, but also place extreme pressures on the basin's existing hunting and fishing facilities.

For the purposes of these resource discussions, the Ohio River Basin can be divided into three geographical regions: (1) Appalachian Region, to include the basin portions of New York, Pennsylvania, West Virginia, North Carolina, Maryland, Virginia, eastern Kentucky and southeastern Ohio; (2) the Central Lowland, to include the Ohio, Indiana and Illinois portions of the basin north and west of Portsmouth, Ohio; and (3) the Interior Plateau, to include western Kentucky and northwestern Tennessee. A more definitive inventory of available fish and game habitat on a sub-basin basis can be found in Appendix Table 1, Columns 5 through 12.

Stream Fisheries

Cold-water streams capable of producing or sustaining trout fishing are located, primarily, in the ridge section of the Appalachian Region and, generally, are associated with forested, mountainous areas.

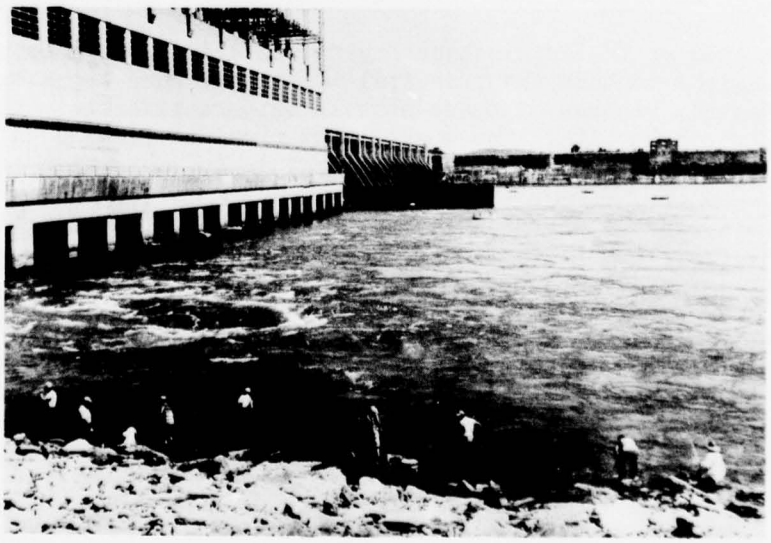
The balance of the Appalachian Region and upland portions of the two remaining regions contain the principal smallmouth bass--rock bass--sucker streams. Certain reaches of these streams support fishable populations of walleye and northern pike. The muskellunge provides fishing in certain Kentucky, New York, Pennsylvania, West Virginia and Ohio streams.

The lower reaches of the upland streams, plus streams in the lowlands or plateaus, are productive of carp, catfish, largemouth bass, spotted bass, sauger, crappies and suckers.

The basin's major tributary streams contain all the species mentioned, except trout. However, the normally inferior habitat in boundary streams and the lower reaches of large tributaries, inhibits the game fish populations

Photo 1. The Ohio River Basin contains many fine smallmouth bass streams. (Courtesy No. Car. Wildlife Resources Commission)

Photo 2. Tailwater fishing is popular and productive. (Courtesy Tennessee Game and Fish Comm.)



and promotes a higher ratio of non-game species. Species of game fish having restrictive habitat requirements occur rarely or as transients in many portions of these large rivers.

Pollution from many sources (industrial, municipal, agricultural and mining) seriously limit fish production in many basin streams. Presently, the most serious basin pollutant is acid mine drainage. This pollutant, and insufficiently treated industrial and municipal effluents, reduce potentially fishable basin streams by 47 percent in Pennsylvania, by nine percent in West Virginia, and to lesser degrees in other states. Stream pollution decreases in severity as one moves west across the basin; except below certain large municipalities or areas of industrial outfalls. Lack of seasonally sustained flows in many basin streams compounds pollution problems.

Reservoir, Lake, and Pond Fisheries

With the exception of the natural lakes, located principally in the Allegheny portion of New York and Pennsylvania and in the Wabash Basin of Indiana and Illinois, ponded-water fish populations are generally the result of artificial stocking.

Man-made reservoirs and farm ponds receive an initial stocking of various species combinations of largemouth bass, sunfish, crappies, white bass, walleye, perch, catfish and bullheads. Certain cold-water ponds in the Appalachian Region are stocked and managed for trout while certain reservoirs in the upland plateau region, especially in Ohio, are being managed for muskellunge. Northern pike also have been established in some reservoirs in Pennsylvania and Ohio, and in other basin states.

Indigenous fish populations in natural lakes have been augmented with stocked species; they now approximate the species composition of man-made lakes and ponds. Certain native species such as muskellunge, cisco, warmouth and yellow bass persist in natural lakes of the basin.

Commercial Fisheries

Although commercial catch statistics are not available for the inland waters of the U. S. prior to 1894, it appears that peak production in the Ohio Basin may have occurred earlier in the 19th century. The 1894 catch was 6.7 million pounds and the next year for which data are available, 1899, shows a drop to 3.1 million pounds. Between 1899 and 1963 the catch has remained relatively stable with the highest subsequent production, 3.6 million pounds, occurring in 1957 and the lowest, 1.2 million pounds, in 1963. The 1960 catch was 2.6 million pounds (Table 2).

Land-use changes, due to agricultural and lumbering activities early in the 19th century plus the rise of the Ohio Basin coal and steel industries in the mid 1800's caused substantial environmental changes prior to 1900. Acid mine drainage, slaughterhouse and pulp and papermill effluent, oil seepage, steel mill waste and municipal sewage all had begun to pollute the streams during this period.

Species of fish reportedly common to the Ohio River in the 1800's--mooneye, lake sturgeon, grass pickerel and walleye--already had declined in abundance by the turn of the century. In comparing species composition of the 1894 and 1922 commercial catches, largemouth bass, white bass, crappie, American eel, mooneye, northern pike, and lake sturgeon had practically disappeared by 1922 and after 1931, walleye and sauger also were absent. While they did not account for a large portion of the 1894 harvest, the persistence of these high-valued species in subsequent years would have aided in offsetting the low and often unstable prices of the more abundant carp and buffalo.

Sheepshead, or freshwater drum, which accounted for about 26 percent of the 1894 catch, has steadily declined to one or two percent of the catch in recent years, with the exception of 1959 and 1960.

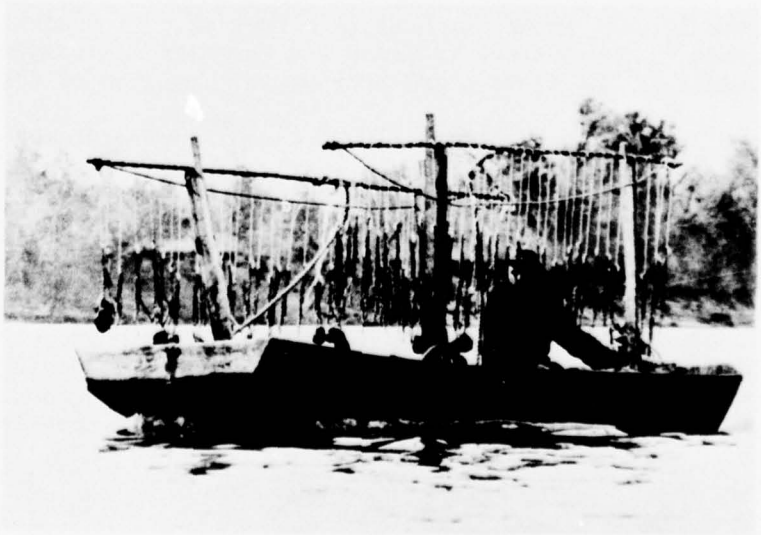
Carp, introduced into this country in the late 1800's, rose rapidly from 0.7 percent of the catch in 1894 to 21 percent in 1922 and currently averages around 25 percent. This species now exceeds the freshwater drum in poundage harvested. Catfish and buffalo, historically the more important food species, continue to average around 25 and 30 percent, respectively, of the total catch, although both are subject to fairly large fluctuations from year to year. Carp, buffalo and catfish combined comprised 70 percent of the catch in 1960, 88 percent in 1962 and 90 percent in 1963. The paddlefish has remained at between three and eight percent of the catch since 1931 while the shovel-nosed sturgeon reached a high of five percent in 1922 but has been below one percent since 1931. Table 3 shows species composition of the Ohio River Basin catch in the years of record to 1963. Species composition of the Ohio River main stem is essentially the same as that of the total basin catch.

The Ohio River Proper: The Ohio River continues to dominate the Ohio Basin fishery as it has historically. It accounted for 65 percent of the basin's production in 1894, 78 percent in 1899 and 67 percent in 1960. Kentucky continues to lead in volume of fish taken from the Ohio. The 1960 catch from the river in this state was 1.2 million pounds. However, the Ohio River fisheries industry of West Virginia and Ohio, accounting for 360,000 pounds in 1894, had disappeared entirely after 1931 partially due to changes in legislation. Catches in Indiana and Illinois also have undergone major declines. The Indiana harvest from the Ohio in 1894, over 1.3 million pounds, had declined to 52,000 pounds in 1963. The Illinois harvest of 940,000 pounds in 1894, declined to 357,000 pounds in 1960 and 120,000 pounds in 1963.

Tributary Streams: The Wabash River fishery industry, likewise, has decreased from 864,000 pounds in 1894 to 120,000 pounds in 1960 and 81,000 pounds in 1963. The Cumberland River catch has increased in recent years, from 193,000 pounds in 1894 and 81,000 pounds in 1903 to between 300,000 and 360,000 pounds currently. This same trend is apparent on the Kentucky River. In Kentucky, the Green, Barren, Big Sandy, Licking, and Rough Rivers have been utilized more extensively in recent years, although not making up a significant portion of the basin production.

Photo 3. The commercial fishery has remained relatively stable during the last 60 years. (Courtesy Illinois Department of Conservation)

Photo 4. Commercial shellfish fisheries are important in the Ohio, White and Wabash Rivers. (Courtesy Tennessee Game and Fish Commission)



Commercial shellfish catches are not recorded for the Ohio River Basin prior to 1908 (Table 4), although mussel fishing as a commercial enterprise dates back to 1891 with the establishment of a button factory at Muscatine, Iowa, on the Mississippi River. The decade following 1891 saw phenomenal growth in the mussel industry. In addition to supplying shells to the expanding button industry, many tons of shells were shipped to European markets. Large quantities of non-commercial species also were harvested to be "cooked-out" along with commercial species in the search for natural pearls and slugs. In many areas, virtually whole communities pursued the collecting and opening of mussels in the search for pearls; and, frequently, many small, shallow streams, where hand collecting was easy, were depleted.

During the decade preceding World War I, the pearl button industry flourished as a multi-million dollar enterprise. From the industry's inception on the Mississippi River, commercial mussel harvesting spread rapidly throughout the Upper Mississippi and Ohio River Basins. In the Ohio Basin between 1912 and 1922, production was recorded on some 25 of the basin's streams including the Muskingum, Scioto, Eel, Tippecanoe and Mississinewa Rivers, in addition to the major producing streams--the Ohio, Wabash and White Rivers. During the period 1908-1922, it is estimated that the basin supplied approximately one-third of the total U. S. production of mussel shells.

The post World War I years brought steady declines to the industry. Changing demands, increasing use of synthetic materials, depletion of high-yield beds, pollution of productive streams and other factors hastened this decline. Recent stabilization of demand, however, has permitted the industry to continue production. At the present time, approximately two percent of the commercial mussel harvest in the U. S. is utilized domestically with the balance being processed for export. Since at least 1950, the Tennessee River has been the major source of shells; although the Ohio, White and Wabash Rivers of the Ohio Basin also have provided significant quantities.

Farm Game

The most abundant game mammal in the basin is the cottontail rabbit. It supports the largest amount of hunting effort in most basin states. It is most numerous in the Central Lowlands and Interior Plateau Regions and is least abundant in the eastern and northeastern portion of the study area.

The range and abundance of the bobwhite quail approximates that of the cottontail. It is the basin's most widely spread and hunted gallinaceous game bird. Basin quail hunting is most prevalent in southern Illinois, southern Indiana and in central and western Kentucky.

The ring-necked pheasant is most abundant and subjected to the heaviest hunting pressure in central and western Ohio, northern Indiana and the northern part of the basin portion of Illinois. It is hunted in all basin states except Tennessee and Virginia, but absent or occurs only in limited numbers throughout most of the hill portion of the basin. Hunting is often supported by bird releases on managed areas in marginal pheasant country.

Photo 5. The cottontail rabbit is the most abundant game mammal in the basin. (Courtesy Ohio Department of Natural Resources)

Photo 6. The bobwhite quail is the most widely hunted game bird in the basin. (Courtesy Kentucky Department of Fish and Wildlife Resources)

Populations of Hungarian partridge reach huntable proportions in limited areas of Kentucky, Ohio and Indiana and, usually, are associated with premium pheasant range. Although both coturnix quail and chukar partridge have been established and are legally hunted in Kentucky, these exotics occur in limited numbers, even in areas where they are legal game.

Forest Game

Three big game mammals, white-tailed deer, European wild boar and black bear reach a level of abundance sufficient to sustain hunting in the basin. Deer are hunted in all basin states and reach their greatest abundance in Pennsylvania. Black bears are legal game in all the states comprising the Appalachian portion of the basin, except Kentucky, Maryland and Ohio. Wild boar are legal in Tennessee and North Carolina. Black bear and wild boar are scarce. They usually are found in remote, timbered areas.

Two species of squirrels are abundant over the basin. Gray squirrels are associated with larger forested areas, while fox squirrels are more common to farm woodlots and areas comprised of a mixture of timber and open lands. Squirrels usually rank first or second in the basin hunter's choice of game species.

Raccoons support a sizeable hunting effort in all basin states. In Indiana, it ranks third in the amount of hunting effort expended against a particular species.

The turkey is legal game in the basin's Appalachian states. Huntable populations are usually associated with large timbered acreages. Ruffed grouse are hunted in all basin states, except Illinois.

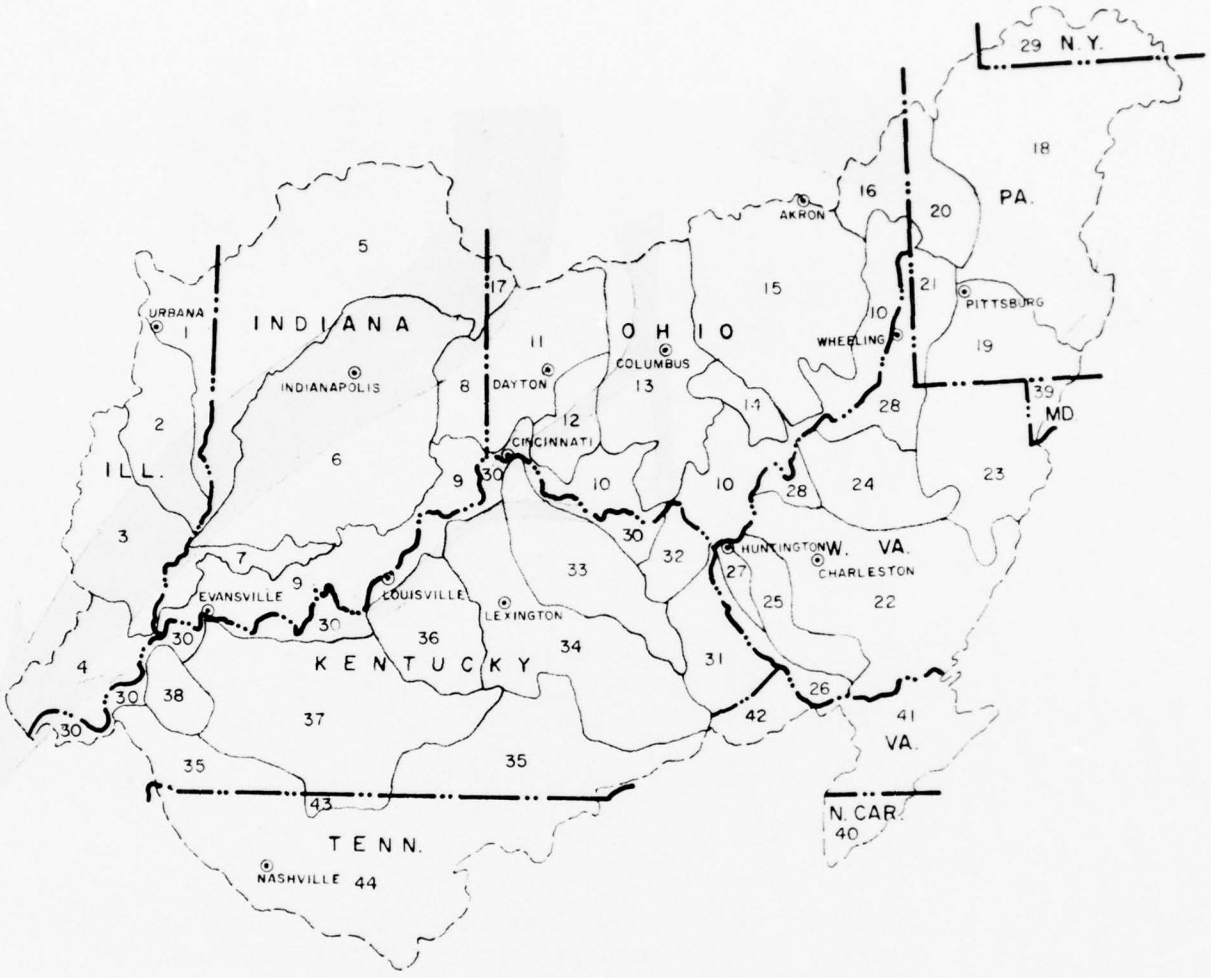
Furbearers

While not accorded game status by most fish and game agencies, the woodchuck, gray fox and, especially, the red fox receive considerable hunting effort in all basin states.

Other furbearers, with the exception of the raccoon, are hunted seldomly, with dog or gun. The status of trapping is a question of values. It is considered as a sport by some, and as a business by others. Furbearers vary in abundance according to the habitat. Muskrat populations are heaviest in the north-central lowlands with moderate populations in the Interior Plateau Region. Mink prefer small, rocky or gravelly streams and are common to most headwater areas in the basin. Mink harvest in Kentucky is the highest of any of the basin states. Except in the States of Maryland, New York, Pennsylvania and perhaps West Virginia, beaver populations are low. They are taken rarely.

Migratory Birds

There are two principal fall migration routes for waterfowl in the basin. The eastern route cuts across northern Ohio and Pennsylvania to the Atlantic



Illinois

1 Vermillion
2 Embarrass
3 Little Wabash
4 Saline

Indiana

5 Wabash
6 White
7 Patoka
8 Whitewater
9 Ohio River Tribs

Ohio

10 Ohio River Tribs
11 Miami
12 Little Miami
13 Scioto
14 Hocking
15 Muskingum
16 Mahoning
17 Wabash

Pennsylvania

18 Allegheny
19 Monongahela
20 Beaver
21 Ohio R. Mainstem

West Virginia

22 Kanawha
23 Monongahela
24 Little Kanawha
25 Guyandot
26 Big Sandy
27 Twelvepole
28 Ohio Riv. Mainstem

New York

29 Allegheny

Kentucky

30 Ohio R. Valley
31 Big Sandy
32 Lt. Sandy Tygards
33 Licking
34 Kentucky
35 Cumberland
36 Salt
37 Green
38 Tradewater

Maryland

39 Monongahela

North Carolina

40 Kanawha

Virginia

41 Kanawha
42 Big Sandy

Tennessee

43 Green
44 Cumberland

OHIO RIVER
COMPREHENSIVE BASIN STUDY

Waterfowl Migration Routes

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF SPORT FISHERIES AND WILDLIFE
REGION 3 MINNEAPOLIS, MINNESOTA

R.P.D. 660603

PLATE 2

Photo 7. White-tailed deer are legal game animals in all basin states. (Courtesy Pennsylvania Game Commission)

Photo 8. Waterfowl hunting is a popular sport throughout the basin. (Courtesy Indiana Department of Natural Resources)

coast. The western route enters the basin in northeastern Indiana and northwestern Ohio; follows the historic Kankakee marsh area in northern Indiana; and then proceeds down the Wabash River to wintering grounds in southern Indiana, Illinois, northwestern Kentucky, and farther south. There are minor flyways down other rivers such as the Scioto, White, and main stem of the Ohio. None of these afford more than local hunting opportunity (Plate 2).

The Lake Erie marshes; the wetland habitat adjacent to the tri-state junction of Kentucky, Indiana and Illinois; and the Pymatuning Area on the Pennsylvania-Ohio border are the major duck hunting areas in the basin. Goose hunting centers in the same general areas, with some of the most famous goose hunting areas in the nation lying just outside the basin in southern Illinois.

Other migratory game birds (snipe, rail and gallinules) are hunted in the basin's marsh areas. Woodcock provide upland-game hunting experiences through some of the northern and western portions of the basin. However, none of these species provide a major segment of hunting effort within any given basin state.

The mourning dove sustains a sizeable amount of the basin hunting effort, especially in the Interior Plateaus and Central Lowlands. Although this upland, migratory bird is plentiful throughout the basin, it is not legal game in Ohio, Indiana and New York.

Utilization of Fish and Wildlife Resources

Demand Indices

The need for fishing and hunting opportunity in the basin was determined through analyses of existing use and latent demand indices. These indices are a function of many factors: adequate time, desire to participate, availability and convenience of facilities, several standard socio-economic factors (age, health, social and economic status) and other less important factors.

Existing Pressures: After reviewing several methods of delineating geographical-use limits, the sub-basin within a given state was selected. It offered the most practical unit for basing estimates of existing pressure.

Collecting most resource data on a sub-basin basis was relatively uncomplicated. Basic county inventory data often was available in standard references. Direct estimates of hunting and fishing pressures, from game or creel censuses of sufficient coverage to allow for sub-area delineations were sometimes lacking, requiring the use of indirect methods.

These indirect approaches involved the use of regional or national statistics drawn from either the Bureau of Sport Fisheries and Wildlife publication, "1960 National Survey of Fishing and Hunting" or ORRRC Report No. 7 - "Sport Fishing - Today and Tomorrow." These statistics were applied

to either the area population or to the licensed portion of that population to determine use.

The methods used to derive these estimates of hunting or fishing pressure are discussed for each basin state in Supplement 1 to this report. Specific sub-basin estimates of hunting and fishing pressures are found in Table 1, Columns 13-19.

In 1960, stream fishing pressure in the basin states ranged from 497 anglers per mile per year in Indiana to 19 in the more remote streams in the basin portion of New York. The basin mean was 142 man-days per mile.

The range of estimates for impoundment fishing pressure, six man-days per acre per year in Maryland to 38 in Ohio, with a basin mean of 21, partially reflects the more stable ecological and access conditions attendant with reservoir fishing.

Only the basin states of Illinois, Indiana, Pennsylvania and New York have significant acreages of natural lakes. As in reservoirs, the range reflects stability of conditions: 14 man-days per acre per year in New York to 29 in Illinois, with a mean of 19.

Estimates of fishing pressure on farm ponds ranged from 94 man-days per acre per year in Ohio (with its many fee fishing ponds included) to 13 in Tennessee. The annual basin mean was 47 man-days per acre.

The 1960 commercial fish catch in the Ohio Basin was 2.5 million pounds valued at $426,000 (Table 5). Commercial fishing was confined almost entirely to the rivers and streams. Utilization of reservoirs was limited to two small impoundments in Kentucky, totalling 2,700 surface acres. The Ohio River proper provided 67 percent of the catch and three other rivers, the Wabash, Cumberland and Kentucky, together with the Ohio, accounted for 98 percent of the basin catch. There was no commercial fishing in the Ohio Basin portions of Ohio, Pennsylvania, New York, West Virginia, Virginia, Maryland and North Carolina.

In terms of volume and value, five species dominated the catch--buffalo, carp, catfish, freshwater drum and paddlefish. The average price per pound for all fish species was 17.3 cents.

Relatively, the average commercial fishery production (poundage) in the Ohio Basin has remained constant since the turn of the century, although there have been fluctuations by species and areas. The value of this production in terms of price per pound has tended to decline since 1950 with 1963 prices approaching those of the 1922-1931 period. The total value of the catch in 1963 was the lowest on record with the exception of 1903, 1908, and 1931.

The 1960 commercial shellfish catch in the Ohio Basin was 2.3 million pounds valued at $95,000. Mussel-shell production was recorded on the Wabash, White, Cumberland and Ohio Rivers, traditionally the major shell producing streams in the basin. Total pounds of shells produced have remained relatively constant since 1954 but have been considerably lower than the peak production years of 1908-1922. The average price per ton in 1960 was the highest on record, up to that time, and $22 higher than 1959, with

this price increase reflecting the recently developing export market stimulated by the Japanese cultured pearl industry.

In 1960, the estimated hunter-day use (21,700,000) was nearly equal to fisherman-day use (21,800,000) in the Ohio River Basin. Conversely the "1960 National Survey of Fishing and Hunting" indicates that nationwide, fresh-water-fishing use was nearly twice as great as hunter use. This disproportionate basin figure probably reflects a lack of fishing opportunity or desire rather than exceptional hunting opportunity. As evidence in support of this assumption, the basin ratio of resident hunting to fishing license sales, usually indicative of available opportunity, was 100:94; nationally, this ratio was 100:114. In 1960 in this relatively urban area, the basin participation was 10 annual-days use per hunter and nine per fisherman. The 1960 national participation was 13 annual-days use per hunter and 18 per fisherman. The disparity would have been larger than it actually is, had not the basin hunters and anglers approximated the national trends in which both the non-resident and non-licensed anglers exceeded the hunters by a significant margin.

Basin wide, the pressure directed against farm game was relatively homogeneous. Annual hunting pressure ranged from .11 days per acre in New York to .56 days per acre in Pennsylvania. The basin mean was .20 hunter-days use per acre.

Forest-game habitat in the basin annually sustains a somewhat greater hunter pressure than farm-game habitat, because access to timbered areas is usually less restricted and forest game generally support longer hunting seasons. The 1960 forest-game hunting pressure ranged from .09 days per acre in Tennessee to .58 in Pennsylvania, with a basin mean of .26.

Waterfowl hunting pressure estimates are considered less reliable than either of the two previous categories, because of the unstable character of waterfowl habitat. The estimates in this report are based on permanent-water habitat which tends to inflate the utilization estimate. Annual pressures ranged from 3.73 days per acre in Illinois to .17 in West Virginia, with a basin mean of .62.

Latent Demand: Estimations of present day hunting and fishing pressures represent a measure of existing participation in these recreational activities. Unfulfilled or latent demand is determined best through a survey of potential or actual users rather than use. A national survey of this character was undertaken in 1959-60 and the results were published in 1962.1/

The results of this survey indicated, on a national scale, that eight percent of the adults sampled would have liked to take up fishing and 13 percent would have liked to do more than they did. The study indicated that five percent of those sampled would have liked to hunt more than they did and an additional five percent would like to take up hunting as a form of recreation.

1/ Mueller, Eva and Gerald Gurin, Participation in Outdoor Recreation: Factors Affecting Demand Among American Adults, ORRRC Study Report 20 Washington, D. C., 1962.

Detailed discussions of latent demand, listing reasons why the respondent either did not hunt or fish or why he was not a more active participant (if he did), are given later in this report. These discussions also give estimates of the magnitude of this latent demand factor and its application to the demand features of future populations.

Role of Public Lands and Waters

There are numerous possibilities of increasing hunting and fishing opportunity by providing additional access to lands and waters. Many of these possibilities involve indirect approaches in which the attitude of the person controlling access must be altered. This is, at best, a temporary measure since a landowner's attitude to hunting or fishing access can change radically and quickly.

Long-term leases or fee-title purchase of access sites or blocks of land by public agencies represent a practical, direct approach to the problem of increasing hunting and fishing opportunity.

Public acquisition of land or water does not solve the problem completely since analyses of Ohio River Basin data does not indicate a direct relationship between public acreage per participant and its ability to provide hunting or fishing. For example, in 1960 in the Mahoning Sub-basin in Ohio, a pressure on public land of one licensed hunter per three acres amounts to 19 percent of the total hunting in the sub-basin. Conversely, 15 acres of public land per hunter in the Cumberland Sub-basin in Kentucky only sustain eight percent of the total sub-basin hunting effort. Similar circumstances can be listed for public fishing.

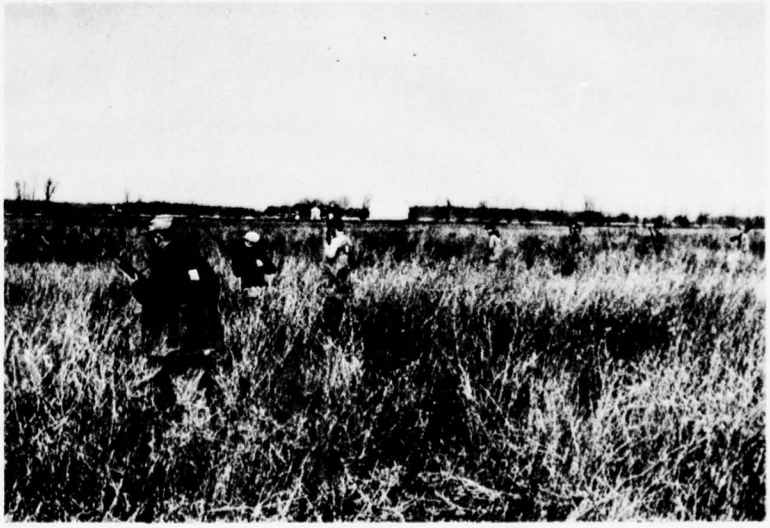
Public Fishing Areas: Public access to a state's inland rivers and streams usually is a question of legislative interpretation, which can only be settled conclusively by judicial determination.

In 1960 there were over 4,000 miles of navigable river in the basin, open to the public. These streams are the boundary rivers and the larger or downstream reaches of certain inland rivers. In addition, many stream miles are open to public access through state or territorial legislation. Public land bordering or underlying streams accounts for additional miles of access.

Public waters in the basin sustained 36 percent of the total fishing effort. Lakes with public access comprise a total of 95,000 acres and annually provided for 15 percent of the total fishing effort. Corps of Engineer reservoirs (including various Conservancy District waters in Ohio) total 302,000 acres and provided for 20 percent of the total basin fishing effort. Other agency lakes, totaling 10,300 acres and open to the public, provided less than one percent of the total basin fishing pressure. Considering only those states having a major portion of their land acreage in the drainage; 35 percent of Ohio's fishing took place in public waters, 27 percent of Kentucky's, 18 percent of Pennsylvania's, 17 percent of West Virginia's, and 12 percent of Indiana's (Table 1, Column 21).

Photo 9. Crowded stream sections indicate the need for additional public access. (Courtesy Pennsylvania Fish Commission)

Photo 10. Unlike most basins, hunting pressure approximates fishing pressure in the Basin.



Public Hunting Areas: Quality and location are more important than quantity in determining the utilization of public hunting areas. An 850-acre public hunting area lying within an hour's trip by car from Dayton and Cincinnati, Ohio, annually supports a use of 10-15 hunter days per acre per season. This is a pheasant release area. A unit of similar size, also within 30 miles of these two metropolitan centers, but with no pheasant stocking, annually supports less than three hunter-days use per acre. A remote public hunting unit in southeastern Indiana, also with daily pheasant releases, sustains an annual use of less than four hunter-days per acre on the release area and less than one trip per acre on the entire unit. Use is a function of people as well as operational procedures.

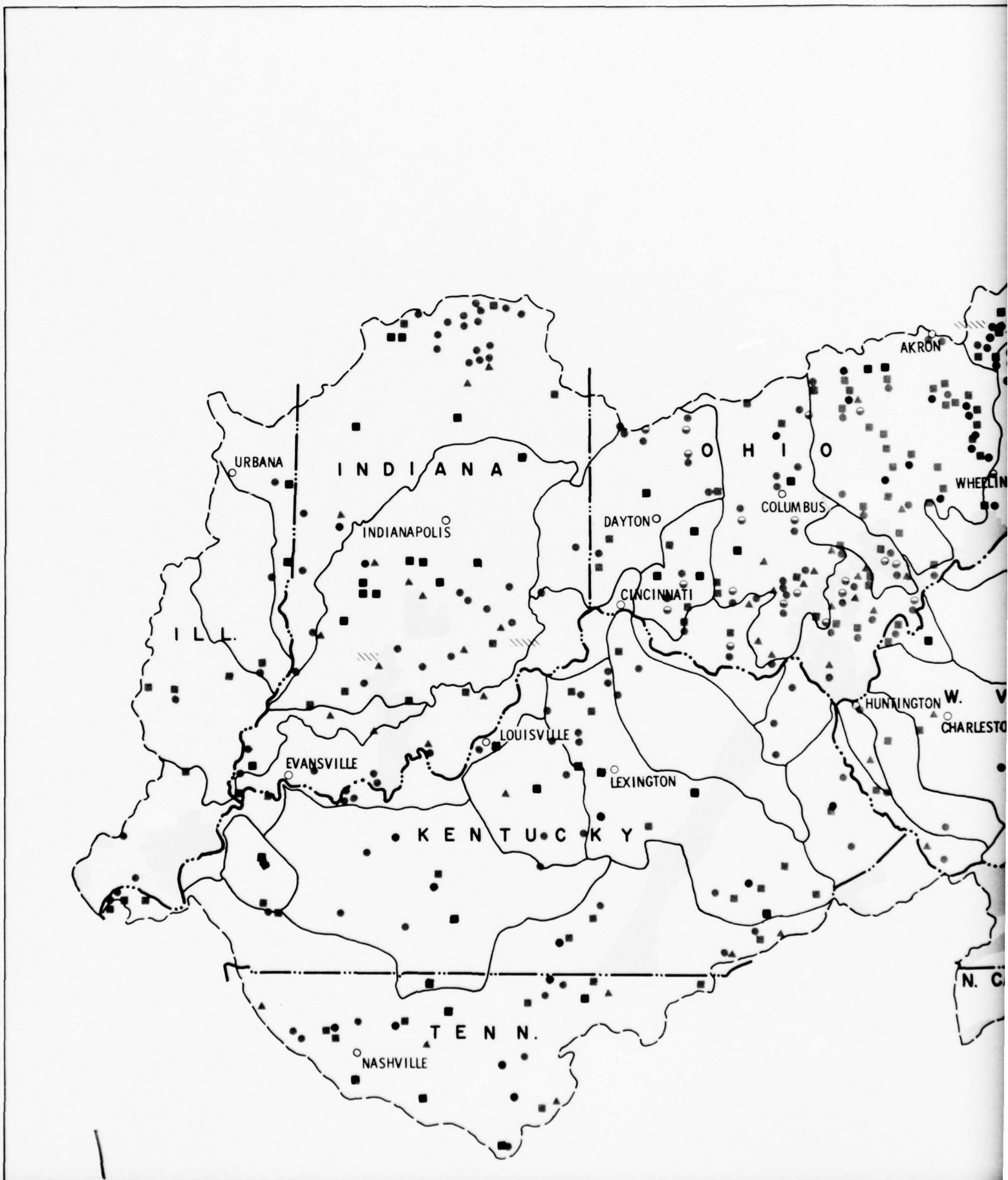
Considering hunting use on all types of public lands in the basin in 1960, 1.4 percent of all hunting took place on National forest land at the rate of .17 hunter-days per acre. Lands owned or leased by State fish and game agencies accounted for .8 percent of the total hunting use at a rate of .55 hunter-days per acre. State forests supplied .4 percent of total public use at .31 hunter-days per acre; Corps' land, also .4 percent at .14 hunter-days per acre; and State park land .2 percent at .62 hunter-days per acre. In 1960, public hunting areas in the basin contained approximately 2,700,000 acres and sustained 3.2 percent of the total basin use (Table 1, Column 24).

In most cases, while ownership rests with the various agencies mentioned above, the administration or actual management is the province of the State fish and game agency. Usually, the level of hunter use is directly dependent on the hunting area's level of management and its proximity to population centers.

Hunting on most state-owned areas in Illinois is on a reservation system. Based on a three-year study (1960-62) of three duck hunting areas, six pheasant release areas, and two goose hunting areas; 18 percent of those initially applying for permits to hunt were excluded due to lack of available facilities. Data on specific areas indicated that 29 percent of the hunters applying for a permit on a duck area were turned down, 18 percent on pheasant areas and nine percent on managed goose units. Whether the Illinois situation is indicative of basin conditions is a moot question. However, the data provides an index to present day unfulfilled demand for intensively managed public hunting areas for Illinois in particular and perhaps other areas in the basin.

It may be surprising to note the major use of many basin public hunting areas is not hunting, but rather various resource related uses. A 1965 survey of 14 intensively managed public hunting areas in Indiana showed the following activity breakdown: hunting and trapping--24 percent; wildlife associated, including target shooting, field trials, nutting, berrying and other consumptive uses of wildlife, bird watching and other nature studies--five percent; and general recreation pursuits including camping, picnicking, and sightseeing--58 percent. In the latter category over 60 percent of the people using the areas were sightseeing.

An earlier (1958) census of similar activities on Ohio public hunting areas indicated that 58 percent of the use was hunting and trapping; 26 percent wildlife associated; and 16 percent general recreation. In this study, sightseeing was not taken into consideration.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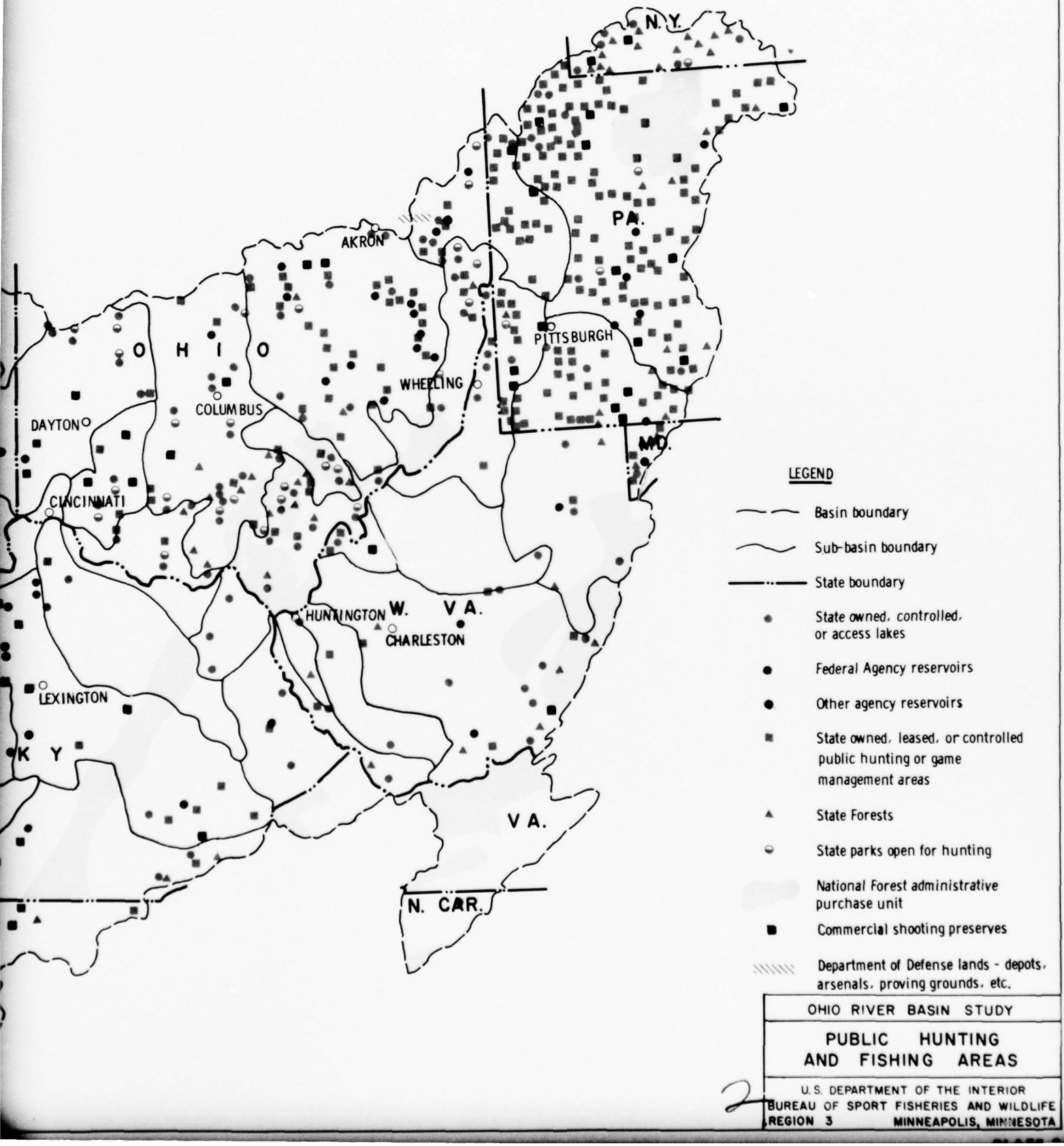

OHIO RIVER BASIN STUDY

PUBLIC HUNTING AND FISHING AREAS

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF SPORT FISHERIES AND WILDLIFE
REGION 3 MINNEAPOLIS, MINNESOTA

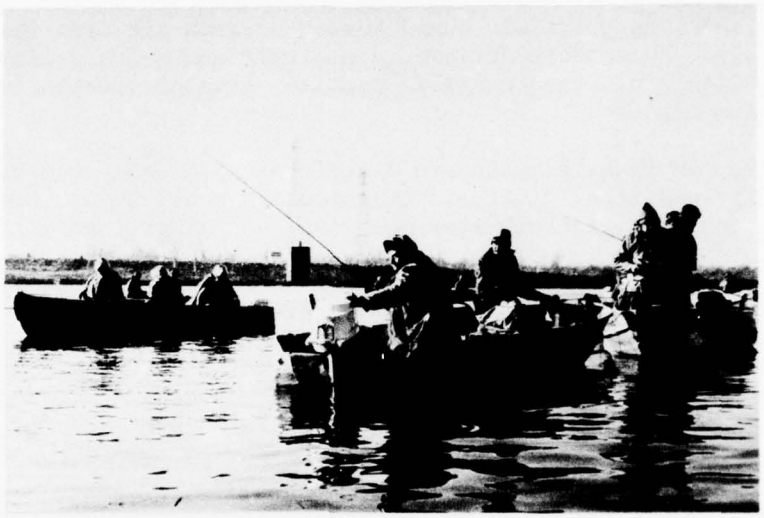

Photo 11. Over 20 per cent of the fishing in the basin is provided at reservoirs open to public use. (Courtesy Tennessee Game and Fish Comm.)

Photo 12. Only 3.2 per cent of the hunting in the basin is provided at public areas. (Courtesy Illinois Department of Conservation)

Role of Fee Hunting and Fishing Areas

An additional method of satisfying the demand for hunting and fishing opportunity involves privately owned acreages which are open to the public on a fee basis. These acreages are intensively managed and either heavily overstocked with adult (and usually "exotic") fish or stocked "under the gun" with game birds.

Usually, fee fishing ponds are associated with urban centers. The ponds are generally less than 20 acres. Overstocking small ponds tends to heighten competition for food, concentrates the fish, and makes them more susceptible to angling.

In many states in the Ohio River Basin, the number and acres of fee ponds are insignificant as an adjunct to the existing fisheries. However, in the heavily populated portions of Pennsylvania, Kentucky and Ohio, fee fishing constitutes a significant segment of each state's fishing pressure. The Pennsylvania portion of the basin has over 100 small fee ponds sustaining an estimated 20,000 man-days per year. In Kentucky, 413 acres of pay lakes provide an estimated 56,000 man-days of use annually. In Ohio in 1960 nearly 200 basin ponds, comprising 3,600 acres, provided an annual average use of 153 man-days per acre or a total fishing effort of 546,000 man-days. This amounted to eight percent of the state's total fishing pressure.

Number and type of fee hunting areas are related to the quality and quantity of local hunting habitat and local hunter demand. In many cases, access to private fee hunting areas is considered a status symbol. Therefore, these developments often cater to a clientele which would not normally be making use of other public or private hunting opportunity.

Information on utilization of private fee hunting areas in the Ohio Basin is rather scant. In the basin portion of Indiana, present commercial hunting effort on 4,200 acres amounts to approximately 3,200 hunter-days annually (.76 man-days per acre). While there are no commercial hunting areas in the basin portion of Illinois, the balance of the state has 134 licensed areas constituting 78,300 acres. The 1963 annual use of these areas was 23,500 man-days or .30 man-days per acre. This undoubtedly represents a minimum figure. Considering the low-utilization rates, coupled with the type of hunter these units cater to, it is doubtful that fee hunting could provide for the anticipated increase in hunter demand in the near future.

Private membership clubs, principally hunting clubs, cater to a restricted clientele. These clubs are usually socially oriented, self-governing within the framework of State or Federal regulations, and little is known of their importance to total basin hunting.

Existing (1960) Needs for Fishing and Hunting Opportunity

An inventory of 1960 opportunity and use serves two purposes in this report: (1) it reveals presently existing areas of insufficient hunting and fishing opportunity which could be benefited by immediate remedial management action; and (2) the inventory provides a base for projections of future needs.

The word "opportunity", as used in this report, is best defined as availability of lands or waters upon which the act of hunting or fishing is performed. Generally speaking, opportunity also implies: (1) availability of fish and game stocks; and (2) the seasons and limits governing take. These latter implications are equally important in the full development of the resources. However, it benefits the hunter and fisherman little if he is denied access to lands and waters abounding in game and fish. Opportunity is also a direct function of access.

If methods used to determine sub-basin hunting and fishing pressure per unit of habitat were consistent, comparative data analyses would provide an excellent index of 1960 sub-basin need. However, a general lack of method consistency between states restricted 1960 comparative sub-basin analyses to less quantitative indices; e.g. resident license sales per capita and acres of habitat per license (Table 1, Columns 3, 4, 22 and 25).

The ratio of licenses to a given population is considered an expression of recreational popularity and reflects the quality and availability of the resource. The relationship between the licensee and the actual and potential habitat open to him is a qualified expression of comparative sub-basin need for opportunity.

The medians of these state and sub-basin indices were used as an intra-basin comparison of 1960 needs. A median index is often more indicative of actual conditions than the mean. In states with few sub-basins, the mean could overemphasize an atypical sub-basin condition.

In the following state by state analysis, the sub-basin will be the unit of comparison. This analysis does not quantify future demands; it does represent a comparative inventory of 1960 opportunity and use. An analysis of future demand for fishing and hunting, and possible remedial programs, are discussed later in this report.

Sport Fishing

In the sales of resident licenses per capita, the sub-basin indices in 1960 ranged from .04 to .30 with a median of .09 and a mean for the 44 sub-basins of .11 (Table 1, Column 3).

The 1960 sub-basin average of acres of ponded water per licensed angler (resident and non-resident) ranged from .01 to 2.16 with a median of .16 acres and a mean of .36 acres (Table 1, Column 22).

Illinois: Only the Vermilion Sub-basin reflected a negative departure from the basin median of per capita license sales and amount of ponded water per licensee, thus indicating substandard conditions. Pollution, limiting fish production in the Illinois portion of the basin, is of a sporadic nature and usually confined to small streams. In 1960, it was not an acute fishery problem. Public access to streams is limited, under law, to navigable waters, so that inland flowing waters of the basin are all privately controlled. Creation of additional acres of fishing opportunity in the Vermilion Sub-basin could satisfy present day insufficiencies.

Indiana: Most sub-basins in Indiana, especially the Whitewater, indicate a need for additional ponded waters. Liberal attitudes and legislation on stream access do not compensate for these insufficiencies and, therefore, are not reflected in the quality index--i.e. a high licensed angler per capita figure. This latter index showed two of the state's five sub-basins below the basin median and the remaining three slightly above. Pollution affecting Indiana stream fisheries is primarily of a sporadic nature. Acid mine drainage is a chronic problem in the lower Patoka Sub-basin. Lack of sustained water levels in streams apparently compounds the pollutional problem in Indiana. Low-flow augmentation should be given consideration at all sizeable impounded water developments. This action could provide both a remedial for poor quality stream habitat as well as providing needed ponded water habitat.

Ohio: The Miami, Little Miami, Scioto, and Hocking Sub-basins need additional ponded water habitat. Localized problems of limited public access and serious pollution prevent stream-fishing opportunity from compensating for this deficiency. In addition to creating ponded water habitat, more leasing of stream access and more stringent control of agricultural, industrial and municipal pollution are needed.

The low per capita license sale may indicate that urbanization has decreased the desire to fish. In Ohio, as in other heavily urbanized states, the city fisherman usually needs some outstanding fishing experience, readily available, to draw him away from other urban recreational opportunities. The same angler, in a rural community, may have a better understanding of where fishing opportunity exists, be more accessible to these fishing waters, and be more inclined to fish as a recreational diversion.

Pennsylvania: With the exception of the Beaver River Sub-basin in Pennsylvania, all other drainages lack sufficient ponded waters, especially in the populated area adjacent to the Ohio River. Many streams in west-central Pennsylvania are polluted by acid mine waste and do not support a sport fishery. Other streams are so reduced in both attractiveness and production by both organic and inorganic pollution that they provide only minimum quality fishing. Although unique fishing experiences are available in the basin portion of Pennsylvania, a sub-average per capita sale of licenses in all sub-basins does exist. Providing the urban resident with convenient and attractive angling opportunity is also a challenge in Pennsylvania. There is an adequate amount of impoundment sites in the basin portion of Pennsylvania; however, consideration must be given the quality of the water sources if fishing is to be a project purpose. The Water Quality Act of 1965 should aid in combating stream pollution in Pennsylvania and other states with chronic pollutional problems.

West Virginia: West Virginia's lack of ponded water habitat is manifested in the exceedingly low ratio of these waters to its licensed anglers. Despite the acknowledged poor quality of certain of this state's flowing waters (over 50 percent acid mine polluted in some basins), most of the sub-basins indicate a high ratio of anglers per capita. This is probably a reflection of the rural fisherman's knowledge of where premium

fishing waters are, coupled with the ability of these waters to sustain heavy fishing pressure. Access is a problem in West Virginia due in part to remoteness of certain fishing habitat from an adequate road network. The problem of providing West Virginia with ponded fishing waters will be complicated not only by areas of poor water quality, but also by the topography of potential impoundment sites. Deep, narrow, steep-sided valleys usually are not capable of providing a quality impoundment fishery.

New York: The Allegheny Sub-basin in New York has sufficient ponded and flowing waters of a quality to sustain present (1960) angler demands.

Kentucky: Most Kentucky Sub-basins, like the Allegheny in New York, are well above both basin median and mean in the amount of ponded waters and flowing waters per licensee. Despite the fact that the number of resident license holders per capita was below the basin average, the attractiveness of Kentucky's aquatic resources was reflected by the extensive sale of non-resident fishing licenses--16 percent of the total license sales. Even though there are scattered acreages of ponded water, their remoteness from Kentucky's urban centers reduces their potential for fulfillment of resident needs. Several of the streams in this state, as well as those of other states, contain unique fisheries. Portions of the Green, Kentucky, Licking, Tygarts and Cumberland Rivers should be retained as vestiges of unaltered stream habitat due to their high quality fishery. In addition to these major rivers, the Little Kentucky River, Kinniconick, Herrods, Sinking, Blackfort and Humphries Creeks all contain high value sport fisheries which should not be altered. The principal areas of pollution are within the Ohio River Valley and various watersheds of the Big Sandy, Kentucky, Cumberland, Green and especially the Tradewater River Sub-basins. Poor distribution (remote from population centers) and inadequate access to existing waters limit certain aspects of Kentucky fishing.

Maryland: The predominately rural population, in the Ohio Basin portion of Maryland, requires little need for additional ponded waters at present. Acid mine waste limits productivity on certain streams, but does not seriously limit angling opportunity throughout this sub-basin.

North Carolina: Despite the lowest ratio of ponded water to licensed angler in the basin, the Kanawha Sub-basin in North Carolina has 22 percent of its total population as licensed fishermen. There were no reservoirs in this sub-basin in 1960. A major source of fishing habitat is represented by New River; one of the premium smallmouth bass streams in the state. The extensive cold-water streams in this sub-basin constitute good to excellent trout habitat and, together with New River, provide a high level of stream fishing opportunities.

Virginia: Even though there is an apparent lack of ponded water in the two Ohio River sub-basins in Virginia, the state has the highest basin per capita sale of fishing licenses. As in other Appalachian areas, there is need for a more adequate network of access roads and a more liberal attitude on trespass. Acid mine waste is a problem in certain areas of the Big Sandy Sub-basin. Creation of ponded water in this area would enhance the existing fisheries resources.

Tennessee: The highest basin ratio of ponded water per licensee was found in Tennessee. However, the apparent remoteness of these impoundments from population centers was reflected by the lowest per capita sale of fishing licenses in the basin. High quality smallmouth bass fisheries could be seriously damaged by certain flood control developments on Roaring River and South Harpeth River. Pollution is a serious problem in the Obey River drainage and on the Cumberland River below urban and industrial centers. A more homogeneous distribution of fishing habitat would increase the number of licensed fishermen.

Commercial Fishing

Some of the factors which have affected the past and current commercial fishery resource and its utilization are:

Market Conditions - Poor markets for edible fish products have been an important factor in the basin fishery.

The demand for food fish, nationally, has barely kept pace with population growth and, while food-fish production has increased slightly, per capita consumption has remained constant. However, per capita consumption of domestic food fish has declined while consumption of foreign food fish has increased. The present small demand for carp, once highly favored by European immigrants in eastern metropolitan areas, illustrates the change in consumer preferences toward certain of the domestic fresh-water species. Catfish, and buffalo to a lesser degree, continue to be in local demand; but major inroads into urban markets have never developed. Lack of quality control and tainting of fish taken in some polluted waters has caused adverse consumer attitudes. Present programs of the Bureau of Commercial Fisheries with industry cooperation are expected to improve this situation. These programs are aimed at improving methods of preparation and merchandising in order to increase consumer preferences for fresh-water products.

Fish production for industrial purposes, although increasing nationally and presently exceeding food-fish production, has not been an important part of the Ohio Basin fishery in past years. The potential for industrial production is significant. This will be discussed further in the analysis of future conditions.

Legal Restrictions - Legal restrictions have hindered full utilization of the commercial fishery resource in the Ohio Basin by (a) limitations on species, seasons and methods in those waters on which any commercial fishing is permitted (principally the main stem of the Ohio River and the lower portion of certain tributaries), and (b) complete prohibition of commercial fishing in many areas, including most inland lakes and reservoirs.

Both types of restrictions were developed and applied gradually and rather haphazardly and there is still considerable variation from state to state throughout the basin. Consequently, although legal restrictions, in general, have had a major influence on utilization and development of the

commercial fishery resource and enactment of specific regulations can be dated, there is no single, clear-cut point when this factor began exerting influence in a major way. However, it may be said that, generally, the present framework of restrictions solidified somewhere between 1900 and 1920. As of 1964, only four reservoirs, all in Kentucky, were open to commercial fishing. These comprise the total lake and reservoir habitat in the basin wherein commercial fishing is permitted. Optimum utilization of reservoirs and lakes in the other states within the basin, the key to future expansion of the fishery, would be predicated on liberalization of these restrictions. There is evidence that several reservoirs in the basin once supported significant fisheries. For example, in 1894, over one million pounds of fish were harvested from Grand, Licking, Lewiston, and Loramie Reservoirs in Ohio. Subsequently, sporadic rough fish removal projects on Lake St. Marys (Grand Reservoir) in Ohio have produced up to 38 pounds per acre from this 13,500-acre impoundment. One commercial fishing operation in 1963 on 2,060-acre Mansfield Reservoir in Indiana removed 59,860 pounds of buffalo and carp or approximately 30 pounds per acre.

Under proper state supervision and using an integrated approach to harvesting on an area or statewide basis, a rational program of coarse-species removal and food-fish production could be undertaken in many areas now closed, to benefit both the commercial and sport fishermen.

Water Quality - This factor influences the commercial fishery resource in two ways: (a) by direct or indirect effects upon the fish and their environment and (b) by effects upon marketability due to undesirable taste and odor qualities, described as of an oily, metallic or chemical nature. These qualities are caused by various chemical contaminants introduced into affected stream reaches. Precise evaluation of the influence of water quality factors is complicated by the simultaneous interaction of other factors such as markets and legal restrictions. Certain general conclusions and guidelines may be drawn from the existing evidence, however.

Water quality factors have had varying effects on different reaches of the Ohio River and its tributaries. The main stem and its tributaries may be divided into three segments: (a) upper section-upstream from Hannibal Locks and Dam (Ohio River Mile 125) and including the Allegheny and Monongahela Rivers, (b) middle section-from Hannibal Locks and Dam to Louisville, Kentucky (Ohio River Mile 607) and including such tributaries as the Miami, Licking and Kentucky Rivers and (c) lower section-from Louisville, Kentucky to its confluence with the Mississippi (Ohio River Mile 981) including the Green and Cumberland Rivers in Kentucky and the Wabash in Indiana and Illinois.

(a) Upper section - This reach contains the heaviest concentration of polluting sources including acid mine waste, steel and chemical industry pollutants and municipal effluent from some of the largest human population complexes in the basin. Dissolved oxygen and pH are lower here than in other sections while concentrations of copper, iron and other ions are high. Studies by the University of Louisville have estimated the standing fish crop at 76 pounds per acre. There has been no commercial fishery

harvest during the period of statistical record, although non-statistical accounts indicate the existence of such a harvest earlier in the nineteenth century. Water quality considerations were, and are, undoubtedly a major factor in the lack of commercial fishery development. It is significant, however, that even under these adverse environmental conditions, there is a measurable standing crop of fish present. Studies made during periods of temporary, industrial-pollution reduction during steel strikes have shown rapid positive response by these residual fishery populations.

(b) Middle section - This reach shows alternating zones of recovery and degradation but the general trend is one of water quality betterment as one proceeds downstream. Studies have estimated the standing fish crop at 180 pounds per acre. Commercial fishing had declined drastically by 1920--West Virginia production dropped about 75 percent between 1894 and 1922 while Ohio production ceased altogether in the decade of the thirties. Kentucky and Indiana still report commercial fishing harvest in this reach, but the catch comprises only a small portion of the total Ohio River and tributaries commercial fish harvest for these two states. Water quality changes, while contributing to the pattern of general, commercial fishery decline, appear to have been more involved with tainting and other influences upon the marketability of fish rather than direct effects upon fish populations and environment. The relative importance of economic and legal-restriction factors is greater in this reach than in the upper section.

(c) Lower section - This portion of the main stem Ohio River, together with its principal tributaries, has relatively few sources of municipal and industrial pollution. Some tainting due to oil pollution has been reported, particularly in the Wabash drainage, but, in general, the lower section exhibits relatively good water quality. The standing fish crop has been estimated at 480 pounds per acre. The bulk of the current Ohio Basin commercial fishery production comes from this reach. Economic and legal restrictions, rather than water quality, are more important in the present status of the commercial fishery in this reach.

The above description traces the broad outlines of the relationships between water quality and the current status of commercial fishery resources in the Ohio Basin. More detailed treatment of this aspect, including potential benefits to the resource from water-quality improvement is beyond the scope of this report. Detailed analysis of more subtle long range, historical effects of water-quality changes on fishery resources and commercial fishing catch also are not possible in this framework study. Sweeping changes in land use and water quality had taken place in the nineteenth century before quantitative catch records were kept. These included not only pollution but physical alteration in terms of increased turbidity and siltation, dam construction, channel deepening, and replacement of free-flowing streams with reservoirs and slack-water navigation pools. References in the scientific literature and old State Fish Commission Reports constantly cite these changes and allude to greater fishery production of an earlier day. Unfortunately, this early information is seldom of the quantitative nature which would permit solid comparisons that would take account of other factors such as market demand and legal restrictions. Nevertheless, analysis of the commercial catch for the period of record does permit some general, tentative conclusions to be drawn.

Certain species such as lake sturgeon, walleye, sauger, largemouth bass, smallmouth bass, white bass, crappie and yellow perch showed drastic declines or were completely eliminated from the commercial catch between 1894 and 1922. None of these species ever made up a large portion of the commercial catch even in the early records, but their loss limited the operational and marketing flexibility of the commercial fisherman. Currently, legal restrictions reduce or eliminate the commercial catch of these species. However, in some cases, the recorded decline preceded the imposition of restrictions. For example, prohibition of commercial fishing in the West Virginia waters of the Ohio River did not take place until 1923, yet the walleye, sauger and lake sturgeon had already disappeared from the catch between 1894 and 1922. The total explanation, therefore, would not appear to be legal restriction. Early, gradual changes of physical and water-quality conditions very likely had a selective influence particularly in the upper and middle sections.

Other species, such as the catfishes and paddlefish have continued to make substantial contributions to the commercial catch. In the case of catfishes, this has been combined with ready marketability and a consistently good price structure. This group of fishes is well adapted to the turbid, channelized conditions prevailing over much of the main stem Ohio and its major tributaries. Most of the production of even these tolerant species comes from the lower section of the river, which has the highest water quality. It may be concluded that water quality is one of the important factors affecting the commercial fishery resource, but it cannot be demonstrated to be the sole, or even the most important cause for the problems and ills of the commercial fishery.

Various factors have also been associated with the decline of the mussel industry from its once flourishing position during the years 1900-1925. Substitution of plastics and other materials in the manufacture of buttons was a major factor in reducing the demand for shells. Along with decreased demand, overexploitation of once productive beds and environmental changes affecting the specific ecological conditions necessary for survival of the mussel have been detrimental factors on certain streams. Such conditions as siltation, channelization, municipal and industrial pollution, and impoundment of producing streams are believed to harm the resource. Also, since the mussel strains large quantities of water through its system, it is particularly subject to the accumulation of toxicants in greater concentration than the surrounding aquatic habitat.

In recent years there is evidence that that introduced "Asiatic clam" (Corbicula fluminea) has become a serious habitat competitor with the mussel. It appears to physically take over available habitat to the exclusion of the desirable species of mussels. The clam is prevalent, at the present time, in the Tennessee and Cumberland drainages and extension of its range further into other Ohio Basin streams could lead to the dominance of available mussel habitat by this species. In addition to competing for habitat the young of this species clog water intake systems and reduces the quality of gravel dredged from its normal habitat.

Commercial Fishing Demand and Supply - In spite of declining demand for certain species and pollutional problems, output of the Ohio Basin commercial fishery has remained relatively constant since 1900 attesting to its viability. Although production since 1960 has declined, it remains to be seen whether this is a long-range trend or a normal-cyclic occurrence. On the other hand, the fishery has not expanded in relations to population growth and, in this respect, has undergone a relative decline in importance.

Data are lacking on which to estimate, directly, the demand for freshwater fish products originating within the Ohio Basin. However, working from National figures of 1.5 percent of the total National fish production originating from inland waters (exclusive of the Great Lakes), a demand of 7.9 million pounds is indicated in 1960--based on the basin population of 19,001,000 and a National per capita consumption (both edible and industrial domestic fish) of 27.9 pounds.

Since commercial fish production in the basin amounted to 2.5 million pounds in 1960, a potential deficit of 5.4 million pounds existed, presumably met by importing from other inland areas.

In 1960, about 191,000 surface acres of water, almost exclusively river habitat, were utilized for commercial fish production at an average rate of 12.8 pounds per acre. In the same year, a minimum of 228,000 additional acres were estimated to be physically available as commercial fishery habitat, primarily lakes and reservoirs over 1,000 acres in size (Table 6).

If the habitat physically available for production was utilized at the relatively low rate of 19 pounds per acre, present commercial fish demand could be met. While some of these waters could be harvested only intermittently and at low rates, others have a considerably higher potential for intensive harvesting and presently represent largely non-utilized resources.

The renewed interest in the mussel resources of the Ohio Basin already has been mentioned. The price per ton in 1963 was the highest on record and the total value of the catch exceeded that of the commercial fish catch for the same year. Prices received at the river for shells do not reflect current high export prices which have been in excess of $500 per ton in some cases.

The present high market price for shells has developed largely during the past decade in response to demands created by the Japanese cultured pearl industry. It was found that a high quality, lustrous, cultured pearl could be produced using as "seed" a sphere made from a slug cut out of the nacreous ("mother of pearl") layer of a freshwater mussel.

The Mississippi River system and its major tributaries, including the Ohio Basin, support the richest freshwater mussel fauna in the world, both

in terms of abundance and diversity of species. The shells which are presently most desired by Japanese interests are to be found nowhere else in the world, with the exception of several rivers in Asia, mainly Red China. While the Tennessee River has been the major source of shells in this country in recent years, current demand trends have prompted a renewed interest in mussel harvesting in the Ohio, Cumberland, Wabash and White Rivers.

Hunting

The sub-basin median was also used as the base for comparing intrabasin wildlife resources. In analyzing the amount of land available or potentially available to the 1960 licensed hunter (Table 1, Column 25), it was determined that only the state medians of Pennsylvania and Ohio fall much below the basin median of 56.5 acres per hunter (Range: 14.6-173.3). Available lands in Indiana, West Virginia, Maryland and Virginia all nearly approximate the basin median. The remainder of the basin states exceeded this amount by over 40 percent.

As an index of the degree of quality and access, the 1960 resident license per capita ratio is revealing. Only the State of Tennessee fell much below the basin median of .10 licensed hunters per capita (Range: .04-.26). Indiana, Ohio, Pennsylvania and Kentucky were at this median, indicating a quality or access equilibrium, at least in the states with a majority of land in the basin (Table 1, Column 4).

Illinois: Hunting opportunity in the predominantly rural basin portion of Illinois is not presently a subject of concern. All sub-basins significantly exceed the 1960 median basin ratio of acres per licensed hunter. While 25 percent above the basin median, the Vermilion Sub-basin offered the least amount of land to the local hunter. This lack of hunting opportunity in the Vermilion was reflected in the inter-subbasin comparison of licenses per capita, as was the sub-basins urban characteristics.

Indiana: Indiana statistics did not reflect a comparative need for additional hunting opportunity, since the state as a whole was above the basin median in acres per hunter. However, on a sub-basin basis, the White River drainage--the largest and most populous--was well below the comparative index in acres of habitat per hunter. This lack of available hunting areas in the White River Basin has not reduced the people's desire for hunting since the per capita license sale was nearly as high as any other of the Indiana sub-basins. Indications are that this demand was being met out of basin. Therefore, the White Sub-basin should receive priority consideration in the planning of public hunting areas at Water Resource projects.

Ohio: Only the State of Pennsylvania has less land available or potentially available to the licensed hunter than Ohio. When compared to the 44 sub-basins comprising the study area, only the rural Wabash Sub-basin, of the eight in Ohio, approached the basin's comparative average. The Mahoning and Miami Sub-basins are exceedingly limited in hunting opportunity, however, significant amounts of hunting opportunity are scheduled for completion prior to 1980 in these and other Ohio sub-basins. The urban character of this state, with the attendant lack of hunting access and hunter interest, is reflected somewhat by the small percentage of the total population buying hunting licenses. There is a favorable ratio of farm to forest habitat, implying that it is not a reduced assortment of game species which is limiting additional hunter activity. While access to this potential hunting habitat may be subject to owner restriction, this manifestation supports the basic assumption that urban populations often are less inclined to hunt than rural. If this "lost" tradition is to be rejuvenated, programs must be made very attractive to compete against other forms of urban recreation.

Pennsylvania: Hunting opportunity in all sub-basins in Pennsylvania was exceedingly low by the comparative standards. The state, and especially the Ohio Tributary Sub-basin, represents threshold values in their respective comparative ranges. Despite this low habitat per hunter ratio, one out of every 10 residents in the Ohio Basin portion of Pennsylvania bought a hunting license. The quality of hunting, or at least the hunter's opinion of the quality, seemingly, has not been impaired by crowding. Despite hunting restrictions in urbanized sub-basins which force city hunters to go far afield, a major portion of Pennsylvania hunters are doing just that. Pennsylvania's system of primary roads and expressways encourages hunter mobility.

West Virginia: The Little Kanawha and Twelvepole Creek Sub-basins were above the 1960 basin median in amount of land per licensed hunter, while all other sub-basins, except the Guyandotte, were close to this comparative average. However, all sub-basins were significantly above the established median for license sales per capita. It is possible that this phenomenon reflects the small amount of land posted against hunting.

New York: Hunting opportunity in the Allegheny Sub-basin in New York was of an adequate amount and quality to satisfy the requirements of both basin, and reportedly, out-of-basin hunters.

Kentucky: While Kentucky was slightly below the basin median on the sale of hunting license sales per capita, it apparently was not due to lack of available or potentially available land. The state as a whole exceeded the basin hunting opportunity index by nearly 60 percent. Limited access and inequitable distribution of hunting areas probably are among the factors restricting resident hunting activities. The effects of these limitations are apparent in the Ohio River Valley, the Big Sandy, the Licking and the Cumberland Sub-basins, where license sales are all significantly below the established basin median.

Maryland and Virginia: Both states fall into the same category as the other Appalachian States of Pennsylvania and West Virginia. The land per licensee ratio was below the 1960 basin median and yet the per capita license sales were above the median established by the study. This pattern is interesting because only in the ratio of forest to farm game (2:1) are these states similar to each other. An acre of forest-game habitat supports a heavier hunting pressure (in six of the 11 basin states) than an acre of farm-game habitat. This is probably related to longer hunting seasons and the more liberal access attitude that landowners have concerning timbered lands. To create farm-game hunting opportunity in mountainous states would require considerable expense by state fish and game departments.

North Carolina and Tennessee: The 1960 hunting acreages available per licensee in both North Carolina and Tennessee were greater than in all other Ohio Basin states. North Carolina was above the basin median in hunting license sales per capita. Surprisingly, Tennessee had the lowest basin ranking for this comparative factor. Licensed hunter use in Tennessee was not related simply to reduced population densities; Maryland and Virginia had similar densities but much higher hunter use. Licensed hunter use in Tennessee might be a reflection of inaccessible hunting lands, lack of hunting desire, or relaxed license enforcement and requirements.

FUTURE DEMANDS FOR HUNTING AND FISHING

Ohio River Basin requirements for future fishing and hunting will be influenced by greater populations, increased urbanization, and related socio-economic and demographic factors. These requirements are projected for the years 1980 and 2010 for 44 hydrologically delineated sub-basins occurring within portions of the 11 states involved.

The study indicates that the 1960 actual basin angler use will have increased 62 percent by 1980, 88 percent by 2000 and 138 percent by 2020. The 1960 basin-hunter use will have increased 18 percent by 1980, 23 percent by 2000 and 32 percent by 2020. These represent a 1960-2020 increase of 21.8 to 51.8 million angler days and 21.7 to 28.6 million hunter days.

Most fishery and some wildlife planning studies are based on natural hydrologic regions because data collection, presentation and ultimate value of the results relate well to this method. It is relatively easy to inventory both habitat and habitat use within hydrologic boundaries, and use these basic units for comparative purposes.

Hydrologic units crossing state lines were designated as separate sub-basins in each state because of legal considerations. An artificial division of a sub-basin bisected by state lines is implied by the non-resident license requirements and different regulations governing fish and game harvest.

Projecting Future Populations

Variations between the sampling areas established for the Projective Economic Study of the Ohio River Basin[2] and those chosen as best representing fish and wildlife considerations necessitated a reallocation of projected future populations.

A study by the U. S. Department of Health, Education and Welfare provided intermediate refinements in the disaggregation of population projections between the Projective Economic Study and this study. To better fit their needs the 19 Projective Economic Study subareas were divided into 61 smaller economic projection units.

Criteria for boundary delineations[3] were similar to those of the Projective Economic Study, with continued emphasis on economic factors and secondary emphasis on hydrologic factors.

The methodology using the projections was developed cooperatively with the staff of the Economics Section, Basin Planning Branch, Ohio River Division, Corps of Engineers.

The format for reconstituting population projections to 44 fish and wildlife sub-basins follows: (1) Projective areas were assigned to fish and wildlife sub-basins (Supplement 2). Seldom could boundaries of those areas be adjusted to correspond exactly with the boundaries of the sub-basins. A graphic representation of dissimilarities between boundaries is available by comparing the map[4] indicating economic subarea and the fish and wildlife sub-basins portrayed in Plate 1, this report. (2) Populations for 1960, 1980, and 2010 were determined by adding those given for the combination of projective areas making up any given fish and wildlife sub-basin. (3) Index factors denoting population change for each combination of economic projection areas were derived by dividing the projected 1980 and 2010 populations by the known 1960 populations. (The use of an index factor was necessitated by discrepancies between a fish and wildlife sub-basin's boundary and the boundary outlined by a particular combination of economic projection areas best approximating that sub-basin). (4) Each 1960 fish and wildlife sub-basin population (Table 6, Column 1) was multiplied by its respective index of population change factor to get 1980 and 2010 projections (Table 6, Columns 2 and 3).

2/ U. S. Army Corps of Engineers, Projective Economic Study of the Ohio River Basin, Appendix B, Ohio River Basin Comprehensive Study, 1964.

3/ Ibid., Appendix A-1, A-2, A-3.

4/ Public Health Service, Water Supply and Water Quality, Appendix D., Ohio River Basin Comprehensive Survey.

Projecting the future urban-rural population relationships was vital for estimating future demands for hunting and fishing. Fishing, and particularly hunting, long have been basic recreation to rural-oriented populations.5/

For example, adults (18 years of age and above) who live in Standard Metropolitan Statistical Areas with populations over one million, hunt an average of 0.25 trips per year, but adults living in rural, farm areas hunt 4.43 trips per year6/; a ratio, rural to urban, of about 18 to 1. It was evident that both the projected population and the urban-rural makeup of that population be considered to estimate future sub-basin hunting and fishing demands.

Rural population data were reconstituted from the original Projective Economic Study subarea figures7/ to fit the fish and wildlife sub-basins. Individual sub-basin deviations were determined by comparing the calculated percent rural to the known percent rural in the 1960 Status Report on each of the fish and wildlife sub-basins. The difference between known and calculated 1960 percent rural was determined and used as an adjustment factor for the calculated 1980 and 2010 percent rural figures for each sub-basin.

Methods of Estimating Future Demands

A projection is a forecast based on a number of assumptions, and as such, can be revised if future conditions should invalidate certain assumptions. To take full advantage of the flexible quality of projections, it is imperative to have a working knowledge of these assumptions and their effect on the developed methodology.

A sample sub-basin is taken through the appropriate calculation procedures to facilitate an understanding of the methodology in Supplement 3, this report.

License sales were considered as the best projective index of future hunting and fishing demand. Most people who hunt or fish buy licenses, and the act of buying a license expresses a definite desire to hunt or fish. License sales represent a quantitative measure. The states keep accurate records of sales, records are readily available and unlicensed participation is a known function of licensed participation.

Licensed-Resident Demand

For each fish and wildlife sub-basin, 1960 fishing and hunting resident license sales were totaled by adding together the license sales for all

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5/ Mueller and Gurin, op. cit., p. 13.

6/ Abbott, L. Ferris, National Recreation Survey, ORRRC Study Report 19, Washington, D. C., 1962, p. 36 - Table 7.

7/ Appendix B, op. cit., p. 130 - Table V-3.

counties entirely within that sub-basin. Where sub-basin geographic boundaries split a county, it was assumed that license sales within the county could be proportioned by the same ratio as the county's total population was proportioned. License sales per capita for each sub-basin were then determined by dividing the 1960 resident license sales by the 1960 total population of the sub-basin.

License sales in most sub-basins are indicative of related factors. Because licenses are bought and often used locally, their sale is related strongly to the origin of hunting and fishing demands and where pressure most likely will be exerted. In several states within the Ohio River Basin, approximately 85 percent of the hunting and fishing trips takes place within 50 miles of the sportsmen's residences.

The 1960 per capita sale of licenses in Ohio River sub-basins were found to reflect available opportunity. When studying the degree of association between fishing and hunting licenses per capita to acres of ponded water per capita or acres of potential hunting land per capita, the correlation coefficient was highly significant at the 99 percent level of probability for both experiences. Ponded water was chosen as the best denominator of future opportunity because this category represents the only clear-cut measure of man's influence on the aquatic habitat base.

A similar significant relationship existed in the correlation between resident license sales per capita and the percent of the total sub-basin population dwelling on farms or in communities of less than 2,500 people. The coefficient of correlation in this instance was even more significant than that determined between sales and opportunity to participate.

It became obvious that this interrelationship between resident license sales, areas of opportunity (ponded water and potential hunting acres), and rural populations provided the best method for determining future license sales as a function of projected populations.

An estimate of the number of future licensed-resident fishermen and hunters, by sub-basin, was determined by applying a per capita licensed-resident sales factor to sub-basin population projections. This factor was derived from a multiple-regression equation relating 1960 opportunity in acres and rural population characteristics to known license sales. Each computed 1960 sub-basin factor was adjusted as it deviated from the known 1960 per capita license sale. These adjustments were applied to the 1980 and 2010 determinations.

The formulas for the regressions are as follows:

Fishing

$$Y = 0.018 + 0.139\ X_1 + 0.225\ X_2$$

Where

Y=Resident fishing licenses as percent of population

X_1=Percent of population which is rural

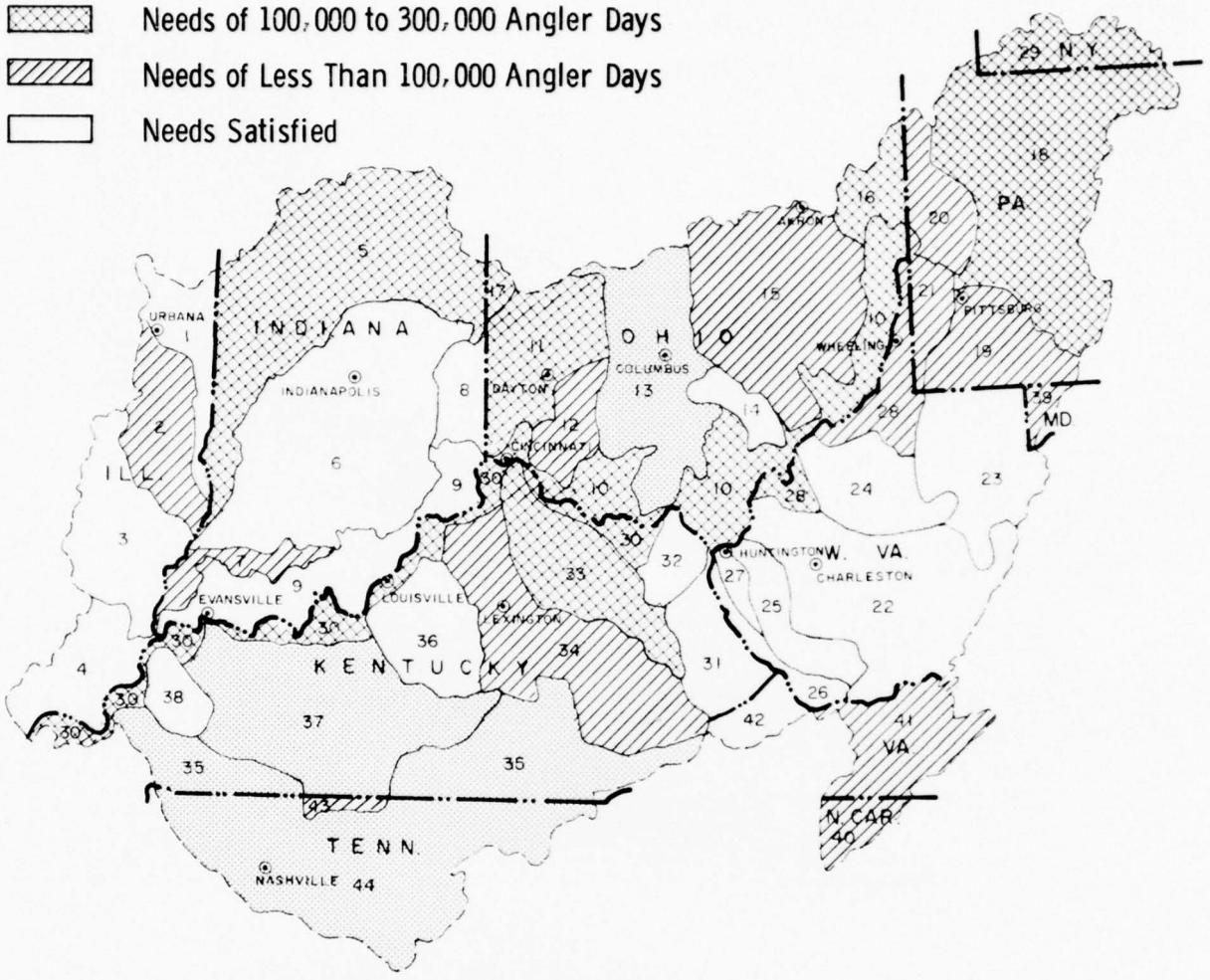
X_2=Acres of ponded waters per capita

Needs Exceeding 300,000 Angler Days

Needs of 100,000 to 300,000 Angler Days

Needs of Less Than 100,000 Angler Days

Needs Satisfied



Illinois

1 Vermillion
2 Embarrass
3 Little Wabash
4 Saline

Indiana

5 Wabash
6 White
7 Patoka
8 Whitewater
9 Ohio River Tribs

Ohio

10 Ohio River Tribs
11 Miami
12 Little Miami
13 Scioto
14 Hocking
15 Muskingum
16 Mahoning
17 Wabash

Pennsylvania

18 Allegheny
19 Monongahela
20 Beaver
21 Ohio R. Mainstem

West Virginia

22 Kanawha
23 Monongahela
24 Little Kanawha
25 Gyandot
26 Big Sandy
27 Twelvepole
28 Ohio Riv. Mainstem

New York

29 Allegheny

Kentucky

30 Ohio R. Valley
31 Big Sandy
32 Lt. Sandy Tygards
33 Licking
34 Kentucky
35 Cumberland
36 Salt
37 Green
38 Tradewater

Maryland

39 Monongahela

North Carolina

40 Kanawha

Virginia

41 Kanawha
42 Big Sandy

Tennessee

43 Green
44 Cumberland

OHIO RIVER
COMPREHENSIVE BASIN STUDY

Sport Fishery Needs--1980

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF SPORT FISHERIES AND WILDLIFE
REGION 3 MINNEAPOLIS, MINNESOTA

R.P.D. 660603

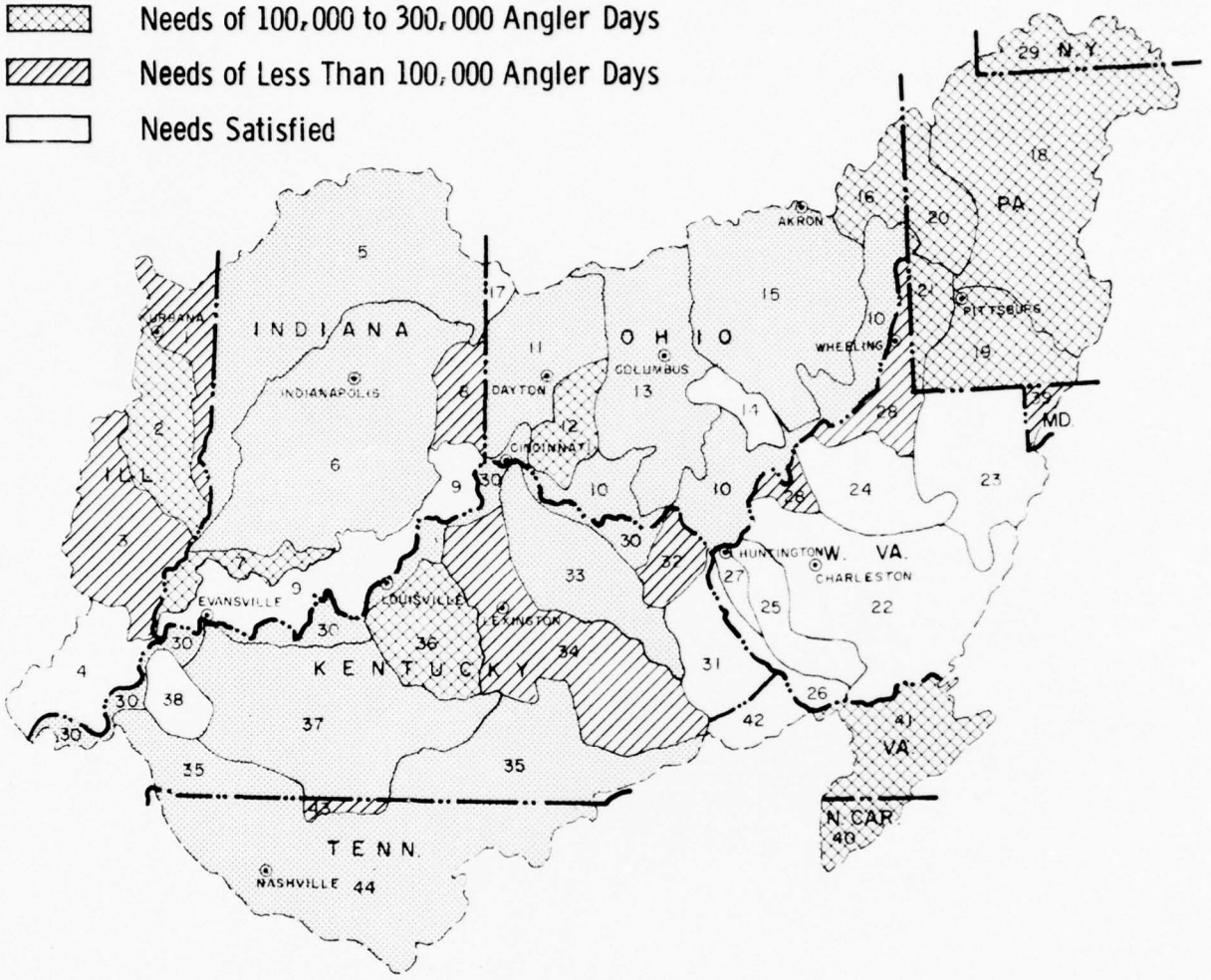
PLATE 4

Needs Exceeding 300,000 Angler Days

Needs of 100,000 to 300,000 Angler Days

Needs of Less Than 100,000 Angler Days

Needs Satisfied



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OHIO RIVER
COMPREHENSIVE BASIN STUDY

Sport Fishery Needs--2010

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF SPORT FISHERIES AND WILDLIFE
REGION 3 MINNEAPOLIS, MINNESOTA

R.P.D. 660603

PLATE 5

Hunting

$$Y = 0.027 + 0.108\ X_1 + 0.003\ X_2$$

Where

Y=Resident hunting licenses as percent of population

X_1=Percent of population which is rural

X_2=Acres of potential hunting land per capita

No correlation was found between acres of public hunting land within a 50-mile radius and license sales in the standard metropolitan sampling areas in the basin. The total potentially huntable land in the sub-basin, despite unknown access and quality factors, proved to be the best determinant of licensed hunter abundance.

Licensed Non-Resident Demand

Non-resident participation was derived from the 1960 ratio of non-resident to resident hunting and fishing license sales for each of the sub-basins. It was assumed that no significant changes would occur in this ratio during the projection years 1980 and 2010. Projecting a 1980 and 2010 total licensed hunter and sport fisherman demand for each sub-basin involved adding the resident and non-resident projections.

Unlicensed Demand

Adjustments for unlicensed participation were made from statistics developed in the 1960 Survey of Fishing and Hunting[8]. Approximately 33 percent of all fishermen and 20 percent of all hunters were not licensed. Some unlicensed fishermen and hunters did so in violation of existing laws requiring license. Other non-licensed participants are exempted from the license requirements by legislations, e.g. property owners on their own property; under or over aged; disabled or active servicemen; etc. No significant change in non-licensed participation is anticipated during this projection period. Total projected participation for 1980 and 2010 have been increased by 50 percent (i.e. one unlicensed for every two licensed anglers) of the projected resident licensed fishermen and 25 percent of the projected resident licensed hunters for each sub-basin, in consideration of this unlicensed demand.

Latent Demand

To this point in the report, all efforts have been directed at measuring and projecting fulfilled demand. Unfulfilled or latent demand is difficult to estimate and project. A National survey probing this problem was undertaken in 1959-60 and published in 1962.[9]

8/ Dept. of the Interior, 1960 National Survey of Fishing and Hunting, Cir. 120, Washington, D. C., 1961, p. 35.

9/ Mueller and Gurin, op. cit., pp. 6-9, 30-38.

In this study when asked, "What was it, mainly, that prevented you from participating (in a given outdoor activity) last year?", the respondents (18 years and older) answered [10]:

1.	Lack of leisure time	52%
2.	Cost, no car, no equipment	26%
3.	Ill health, old age, family ties	22%
4.	Miscellaneous (fear, lack of ability, etc.)	13%
5.	Lack of "available" facilities	9%[11]

The decision to remove items 2, 3, and 4 from consideration in developing a factor of latent demand was based on data presented in an Outdoor Recreation Resources Review Commission National Recreational Survey Report.[12] Items 1 and 5 were considered to be the more influential items in determining future latent hunting and fishing demands.

Increased leisure time (Item 1) was estimated by the Department of Labor in 1961.[13] Their 1960, 1976, and 2000 predictions for average weekly hours worked were 38.5, 35.4 and 30.7, respectively; average annual vacation weeks were 2.0, 2.8, and 3.9, respectively; and average annual holiday days were 6.3, 8.5 and 10.1, respectively. However, many persons gaining more leisure time will devote additional time to their present favorite recreational activities and may still not actively participate in fishing or hunting.

Lack of available facilities (Item 5) can be eliminated by providing additional hunting and fishing opportunities. Persons not participating, because of lack of available facilities, very likely would become participants if that opportunity could be provided. Since this factor is included in the projection formula for estimating future licensed participants, it has been eliminated from consideration in development of a latent demand factor.

Nationally, it has been estimated that eight percent of the adult population (18 years and older) would like to begin fishing and 13 percent would like to fish more.[14] The estimates for hunting were five percent to begin and five percent to do more. No reference was made to the number of times the respondent would like to do more hunting or fishing. Therefore, the percentile expressions in the following paragraph only apply to the number of non-participants and not to the marginal participant.

10/ Ibid., p. 7

11/ Multiple response from a single contact prevents total from summing to 100 percent.

12/ Ferris, op. cit., pp. 20-42.

13/ Anonymous, Projections to the Years 1976 and 2000: Economic Growth, Population, Labor Force and Leisure, and Transportation. ORRRC Study Report 23, Washington, D. C., 1962, pp. 67 and 72.

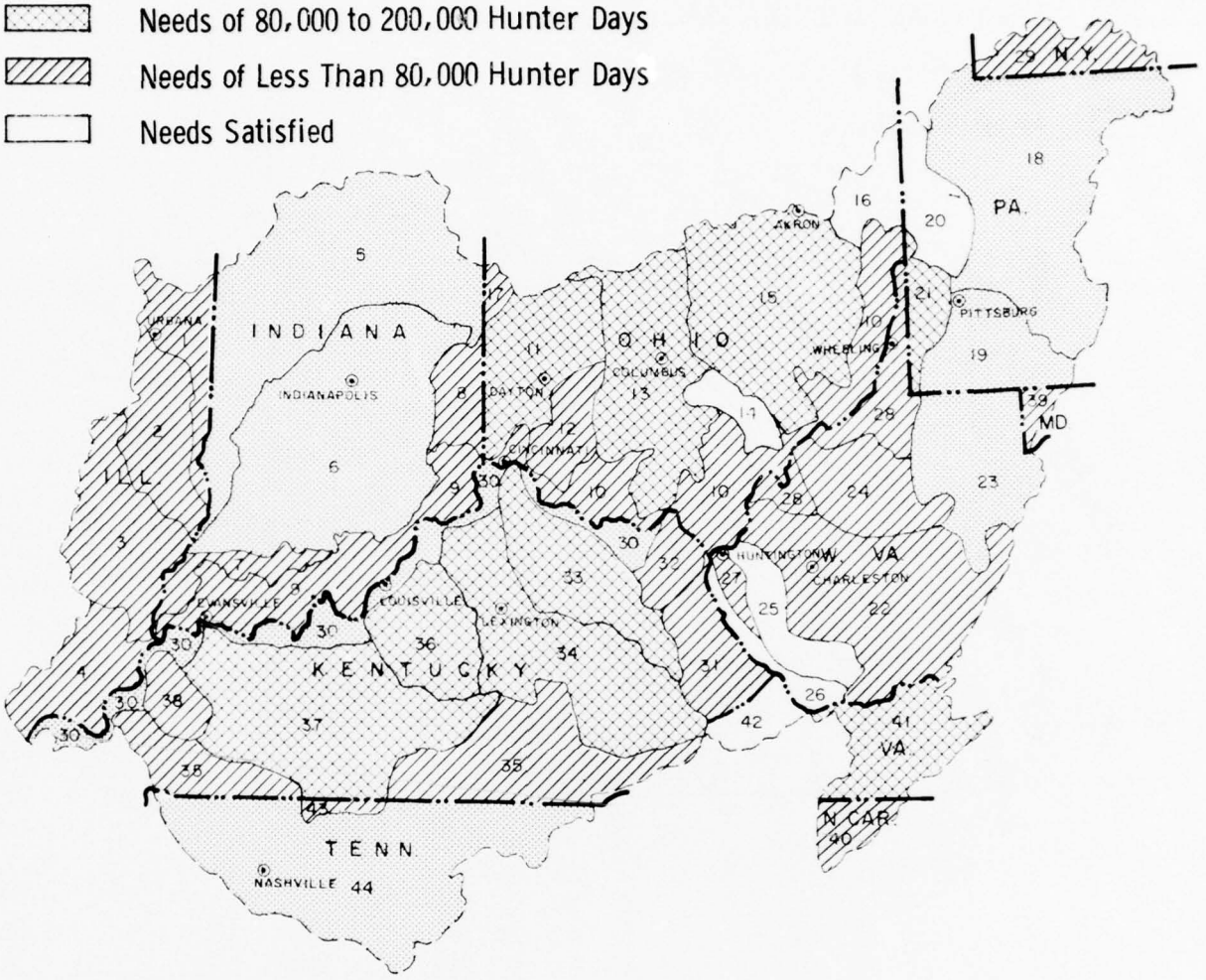
14/ Mueller and Gurin, op. cit., p. 7.

Needs Exceeding 200,000 Hunter Days

Needs of 80,000 to 200,000 Hunter Days

Needs of Less Than 80,000 Hunter Days

Needs Satisfied



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OHIO RIVER
COMPREHENSIVE BASIN STUDY

Hunting Needs--1980

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF SPORT FISHERIES AND WILDLIFE
REGION 3 MINNEAPOLIS, MINNESOTA

R.P.D. 660603

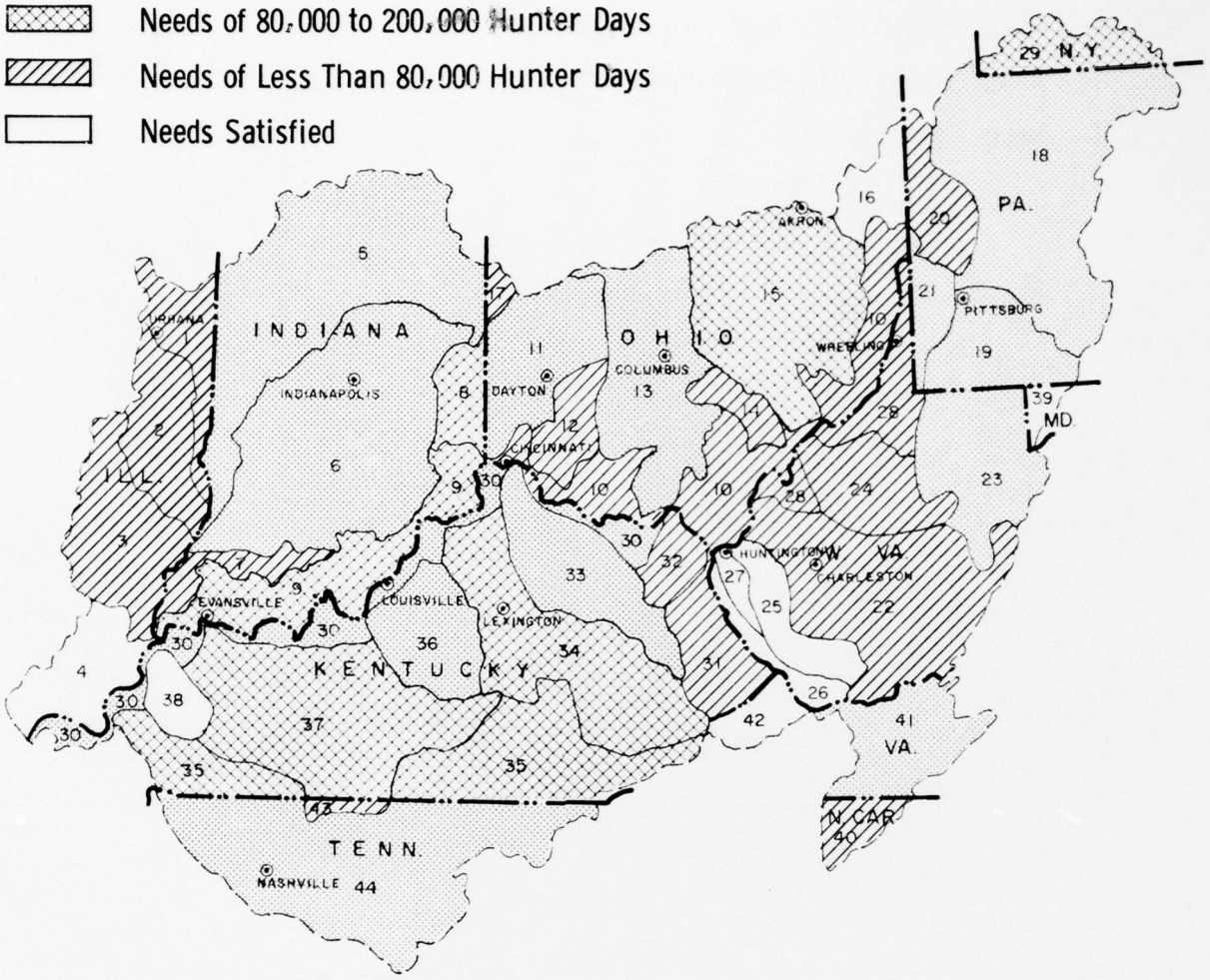
PLATE 6

Needs Exceeding 200,000 Hunter Days

Needs of 80,000 to 200,000 Hunter Days

Needs of Less Than 80,000 Hunter Days

Needs Satisfied



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9 Ohio River Tribs

Ohio

10 Ohio River Tribs
11 Miami
12 Little Miami
13 Scioto
14 Hocking
15 Muskingum
16 Mahoning
17 Wabash

Pennsylvania

18 Allegheny
19 Monongahela
20 Beaver
21 Ohio R. Mainstem

West Virginia

22 Kanawha
23 Monongahela
24 Little Kanawha
25 Guyandot
26 Big Sandy
27 Twelvepole
28 Ohio Riv. Mainstem

New York

29 Allegheny

Kentucky

30 Ohio R. Valley
31 Big Sandy
32 Lt. Sandy Tygards
33 Licking
34 Kentucky
35 Cumberland
36 Salt
37 Green
38 Tradewater

Maryland

39 Monongahela

North Carolina

40 Kanawha

Virginia

41 Kanawha
42 Big Sandy

Tennessee

43 Green
44 Cumberland

OHIO RIVER
COMPREHENSIVE BASIN STUDY

Hunting Needs--2010

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF SPORT FISHERIES AND WILDLIFE
REGION 3 MINNEAPOLIS, MINNESOTA

R.P.D. 660603

PLATE 7

Considering only lack of leisure time[15] as a reconcilable deterrent, and increasing the scope of coverage to make the factors adaptable to total population (not just those over 17), then 2.55 percent of the basin's population have unfulfilled demands for fishing and 1.62 percent for hunting.

Methods of Projecting Hunting and Sport Fishing Participation

Participation by hunters and sport fishermen was calculated and projected for each sub-basin because of extreme variations between sub-basins shown in the 1960 data. Sub-basin hunter participation ranged from four to 18 days per year, and fishing participation ranged from one to 32 days per year within the Ohio River Basin.

Angler participation, in the basin as a whole, was strongly correlated (significant at 99 percent probability level) with opportunity, represented by acres of ponded water. The correlation was not as strong for certain unique sub-basins dominated by stream habitat. "Ponded water" was chosen as the best denominator of future opportunity because this category represents man's future influence on the aquatic habitat base. Although predictable relationship between the number of licensed anglers and the sub-basin's urban-rural character does exist in the Ohio River Basin, a significant relationship between the number of times one fishes (participation) and the sub-basin urban-rural character does not exist.

The most accurate denominator of future angler participation in the Ohio River Basin is represented by a linear regression relating participation to an index of available opportunity and not to urban-rural characteristics. The 1960 data is best represented by the equation:

$$Y = 6.1 + 6.2X$$

Where

Y = Annual angler participation

X = Acres of ponded water per licensed angler

Adjustment factors for the above equation were based on the differences, by sub-basin, between the calculated and actual 1960 angler participation, and were applied to the projected sub-basin participation.

The fishing opportunity available in 1960, plus the opportunity programed for construction (described later in this report under "Methods of Projecting Net Needs for 1980 and 2010") by 1980, were summed and the result was applied to our regression to compute 1980 angler participation.

To arrive at a participation figure for 2010, an assumption was made in estimating the amount of fishing opportunity created from 1980 to 2010. It was obvious that the best designed plans for future expansion seldom

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15/ Restricted by lack of time due to work or family responsibilities.

are accurate or even conceived beyond a 10 to 15-year period. Therefore, it was assumed that sufficient opportunity will be created from 1980 to 2010, so that in 1980 and 2010 the acres of ponded water per licensed angler will be nearly equal, with resulting equality in 1980 and 2010 angler participation.

The factors which influenced the uncommitted person to buy a hunting license, also induce the hunter to spend additional days afield. Hunter participation depends strongly upon the sub-basin's rural makeup and opportunity, represented by acres of potential hunting land. A multiple regression, based on 1960 data, relating these factors is represented by the equation:

$$Y = 4.244 + 3.552\ X_1 + 0.066\ X_2$$

Where

Y = Annual hunter participation

X_1 = Percent of the population which is rural

X_2 = Acres of potential hunting land per licensed hunter

Individual sub-basin adjustment factors were applied to the sub-basin hunter participation, as they were for angler participation figures.

It was possible to estimate hunter participation for the projection years by using projected land use information for 1980 and 2010 provided by the Economic Research Service, United States Department of Agriculture, East Lansing, Michigan. Land use changes, which indicated a reduction or shifting in the land use base, then were incorporated into the above formula.

Method of Projecting Gross Demands for 1980 and 2010

To arrive at a projected instantaneous demand figure for the years 1980 and 2010, the projected participants of each sub-basin were multiplied by the angler and hunter participation derived from the respective regression, as adjusted for each sub-basin. Gross sub-basin demand in angler and hunter days for 1980 and 2010 are shown in Table 6, Columns 8 and 9 and Columns 18 and 19, respectively. Gross basin fishing demand will increase from 21.8 million angler days in 1960 to 35.2 in 1980, and ultimately 43.9 million angler days in 2010. Projected gross demands for hunting indicate figures for 1960, 1980, and 2010 in the amount of 21.7, 25.5 and 27.1 million hunter days, respectively.

Methods of Projecting Net Needs for 1980 and 2010

After projecting gross demand for the basin, it becomes necessary to estimate future changes in opportunity (supply) represented by acres of habitat. A comparison of supply and demand permits an evaluation of future net hunting and fishing needs or excesses.

The 1960 indices of pressure on given units of habitat (Table 6, Columns 7 and 17) are considered average; at least within the framework of known or foreseeable determinants. Indications are that over a period of years, pressure on a given area of habitat remains relatively stable, if the habitat and resources it sustains remains comparably stable. Thus, we assume that the habitat base present in 1960 should support hunting and fishing in the near future at a rate consistent with that occurring at present.

The angler finds greater acreages of ponded water to supply fishing needs with each succeeding year. Impoundments, however, are usually gained at the expense of stream fishing habitat. To compensate for losses of stream habitat it will be necessary to develop better fishery management methods, to develop more effective pollution abatement programs and to provide better access to existing waters. Extremely high 1960 stream use in Ohio and Indiana may indicate that stream-fishing opportunity is already critical in some Ohio River Sub-basins.

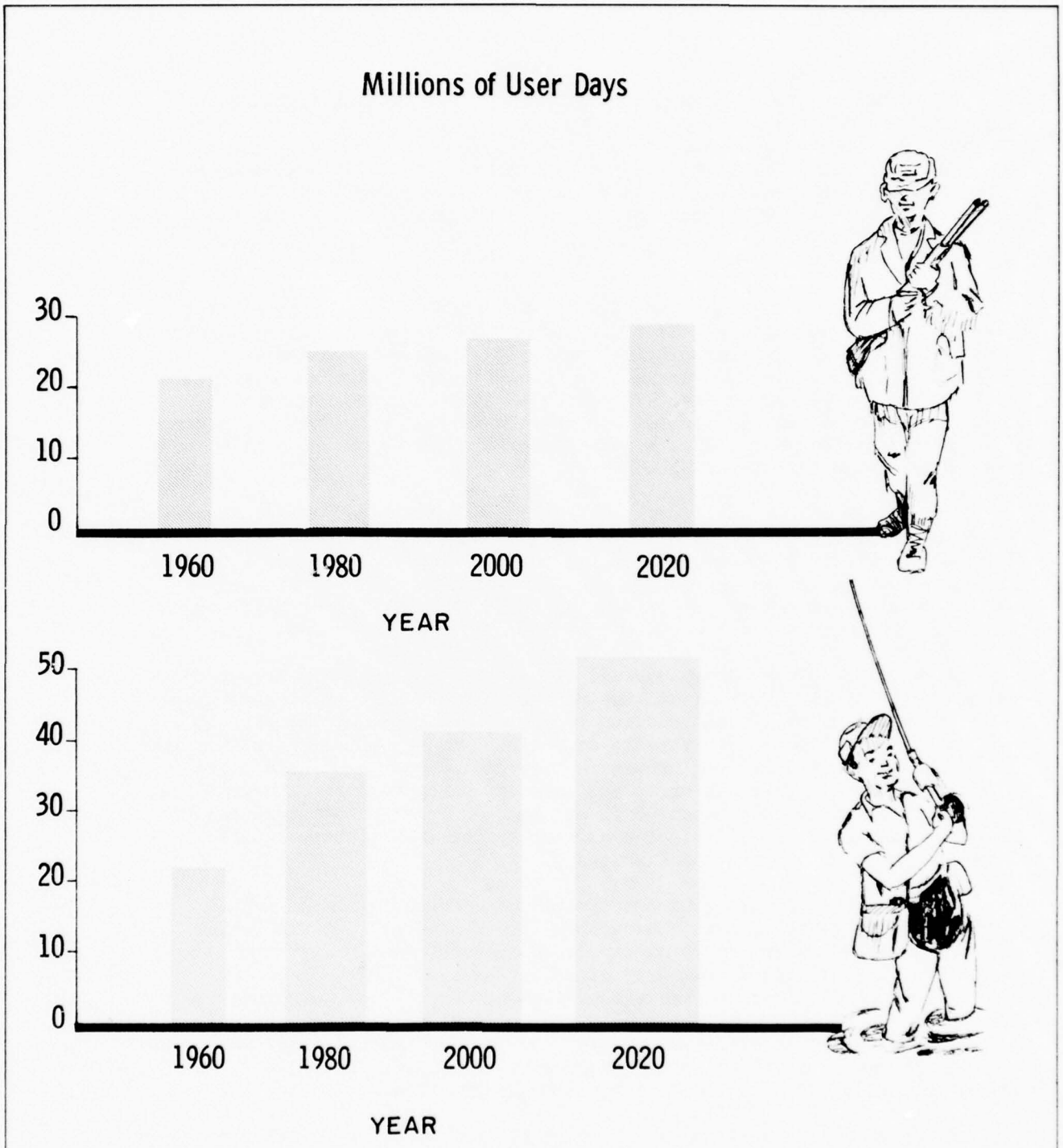
The hunter seldom realizes an increasing habitat base. More often, huntable habitat is consumed by urban sprawl, highways and other land-taking measures of a burgeoning population. Information on projected land-use changes in the years 1980 and 2010 was taken into consideration in all hunting projections since they indicated a reduction or shift in the land-use base.

Each agency, whose program could affect existing or could create future basin fish and wildlife habitat, was contacted and requested to project or give estimates of their construction or management plans to the year 1980. Most state conservation departments do not have master plans which take them 15-20 years into the future. However, they did furnish available plans and information on purchase units and intended management and construction programs. In addition to state fish and game agencies, state park and forestry units also were contacted as to that portion of their future program affecting hunting and fishing.

Annual rates of farm pond construction and developments of public multi-purpose fishing waters, under the U. S. Soil Conservation Service Small Watershed Program, were extrapolated from furnished historical data (1950-60), adjusted, and projected for the year 1980. The U. S. Forest Service provided similar projections of forest-land purchases which would be open to hunting. All Corps of Engineers' flood control projects authorized, under construction, or having fish and wildlife benefits formally ascribed to the project by this Bureau prior to January 1, 1965, were included in the 1980 habitat base.

Plans of other public agencies, such as Department of Defense, Conservancy Districts, and municipalities, considered as having an effect on hunting or fishing habitat were taken into consideration.

Plans for reservoir construction by private industry were considered when such information was available.



OHIO RIVER
COMPREHENSIVE BASIN STUDY

SPORTSMAN DEMAND
(Millions of user days)

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF SPORT FISHERIES AND WILDLIFE
REGION 3 MINNEAPOLIS, MINNESOTA

PLATE 8

With the reservoir construction programs contemplated for the period 1960-1980, it is estimated that the 1980 sport fisheries habitat will be capable of supporting approximately ten million more man days of fishing than in 1960. This newly created basin opportunity will be insufficient by 3.1 million man days in 1980 (Table 6, Column 10). If all the planned or programed hunting developments come into being by the year 1980, opportunity will be created to support an additional 800,000 man days of hunting. However, projected changes in land use and availability by 1980 will reduce the capabilities of the existing base to a degree that only about 60 percent of the increase, or approximately 500,000 man days of hunting opportunity will be realized. This increase is insufficient by 3.4 million man days to meet the 1980 requirements (Table 6, Column 20).

Projected Demands for Commercial Fishing

Future demand for fresh water commercial fish products in the basin is estimated to reach 14,200,000 pounds by 1980 and 24,200,000 pounds by 2010. In 1980 reservoir construction is expected to increase the potentially available habitat to over 635,000 acres. These waters, if harvested at 22.3 pounds per acre, would be able to meet the projected 1980 demand. Assuming no additional reservoir construction between 1980 and 2010, a 38.0 pounds per acre production rate would be required to meet 2010 demands.

Calculation of future demand is based on recent studies which indicate increased per capita consumption of fishery products in the future. Effects of increasing income in the future will not be offset to the extent they have been in the past by such factors as declining prices and increasing supplies of other animal proteins. Also, present and proposed programs in the area of product development marketing and consumer education are likely in themselves to increase demand.

The fishing industry (nationwide) has been slow to adopt new methods of harvesting, processing and marketing its products to increase demand and create new outlets. This has been particularly true of the inland commercial fishery where scattered operations, limited capital and restrictive regulations have been handicaps to modernization. Attempts by various levels of Government and the industry to remedy this situation through research, exploratory fishing, cooperative programs and market development are extremely recent and much remains to be done before an impact on overall demand can be expected. The basic ingredient is present, however, in the form of an abundant, nutritious and versatile resource, awaiting efficient management and development. For example, over 40 percent of the standing crop of 300 pounds per acre in the Ohio River is gizzard shad. This forage species is presently not harvested for commercial markets. Also, the large percentage of rough fish, usually present in

reservoirs, represent a sizeable source of fish supply. Studies by the State of Kentucky have indicated that the average standing crop of Kentucky reservoirs is 209 pounds per acre composed mainly of commercial and rough species. Other inland areas, notably Wisconsin and Minnesota, have provided large quantities of the so-called rough species to the mink ranching and pet food industries. Some of the areas that show promise in product development and in increasing the demand for Ohio Basin commercial fishery production include:

Fish meal production - Present and expected future demand for this high-quality ingredient of poultry and animal foods is brisk and prices are high. The chief problem in terms of the Ohio Basin commercial fishery resource, is the requirement for large poundages for economic operation. Modernization of harvest methods, coordination of operations on a basin basis and development of portable plants offer solutions.

Fish protein concentrate - This tasteless, odorless powder which is almost pure protein, can be cheaply produced from almost any species or size of fish or even from waste portions of fish primarily used for other purposes. It offers attractive possibilities, not only for domestic use but as a means of solving protein deficiencies prevalent in many areas of the world. There are still problems of process refinement to meet food and drug regulatory requirements, but continuing research is expected to solve them. Fish protein concentrate is included in the discussion to illustrate the relationship between technological development and potential demand for commercial fisheries products.

Increased consumption of fresh-water food fish - Although nationwide total consumption of fish has increased during the period of 1950-1960, consumption of domestic food fish has declined while industrial uses have risen. In part, at least, the food-fish decline may be traced to a failure to follow the pattern set by other segments of the food industry in active development of product forms geared to the tastes and convenience of the modern homemaker. Newer approaches are being taken by the industry and the Governmental agencies concerned with commercial fisheries. Related to this emphasis upon development of modernized technological and marketing methods is the more distant possibility of major shifts in the food habits of the American public. Past trends have shown a correlation between rising economic standards and the assimilation of ethnic groups on the one hand and increased consumption of animal protein over fish. Newer trends towards fortified, low calorie and cholesterol foods are likely to favor fish products which are naturally constituted to fulfill these requirements.

Fee ponds - A relatively new market for commercial fish production involves the supplying of live fish to fee ponds for sport fishing purposes. Little is known at present regarding the source or amount of fish utilized for this purpose, although it is believed that the supply originates largely from outside of the basin. As the number of fee ponds increases, it appears likely that this market will provide additional outlets for the

basin's commercial fishery. A related market potential exists in the utilization of certain species for sale as bait. The large populations of emerald shiner in the middle and upper reaches of the Ohio River indicate a profitable fishery could be developed for this valuable bait minnow.

In summary, the projected commercial fishery demands indicate a rising per capita consumption of fishery products. If additional incremental demand developed, a production rate of 50 pounds per acre (Table 7) could have been realized, thus providing 21 million pounds of fish in 1960. By 1980, new reservoir construction will increase this potential to 32 million pounds.

In addition, commercial utilization of lakes and reservoirs less than 1,000 acres in size, particularly in connection with rough fish removal programs, would expand the productive capacity of the basin. Several states including Illinois, Iowa, South Dakota, Minnesota and Wisconsin, presently have successful rough fish removal programs on smaller lakes and reservoirs. In terms of maximum, potential production capable of meeting critical future protein shortages, even farm ponds may provide significant additional increments of gross fish production. For example, studies have indicated the standing crop of 22 Kentucky farm ponds at 385 pounds per acre. In 1960, there were 41,900 acres of these impoundments in Kentucky alone with a calculated production potential of over 5 million pounds of fish.

Future demands for mussel shells - There is every indication that the demand for quality shell material will continue to increase and thus make the mussel resources of those yet productive areas in the Ohio Basin increasingly valuable. With the depletion of mussel beds in other areas, particularly the Tennessee Basin, streams of the Ohio Basin will be looked to, increasingly, for sources of supply to meet these demands.

At the same time, there is a serious lack of information concerning the extent of mussel resources in the basin and its ability to withstand increased exploitation. Research into the basin ecology and life history remains fragmentary. There is an immediate need to expand such investigations in order to evaluate the effects of such factors as reservoir construction, channelization and pollution.

In addition, regulations governing the harvesting of shells in several of the basin states were formulated many years ago and may not provide effective safeguards against depletion of the resource as future demands develop. For example, current development of dredging operations for the harvest of shells has caused great concern, in that dredging physically destroys the mussel bed. The destructive impact these operations may have is not known at the present time and, thus restrictions governing their use will be difficult to formulate without further study.

FUTURE PROGRAMS FOR HUNTING AND SPORT FISHING

Framework studies are designed to: (a) provide broad-scaled analyses of water and related land resource problems, and (b) furnish general appraisals of the nature, extent and timing of measures for their solution. Existing resource problems and brief discussions as to possible remedial actions are treated previously in this report. The problems of the future, at least as they pertain to deficiencies between supply and demand for fishing and hunting opportunity, are projected and displayed in Table 6.

Sub-basin priorities for solving near future water and related land problems are best determined by an inter-subbasin comparison of 1980 opportunity needs or excesses as given in Table 6, Columns 10 and 20.

In analyzing existing hunting and sport fishing facilities, certain relationships were observed which could influence methods of satisfying existing or projected deficiencies in hunting and fishing opportunity.

A paramount problem in the existing public facilities is not the lack of hunting and sport fishing opportunity rather the poor distribution of existing areas. Studies in many basin states have indicated that warm-water stream fishing is primarily a local pursuit. Approximately 75 percent of stream anglers come from less than 25 miles to fish. Reservoir and natural lake fishing presents a similar picture, with 85-90 percent of the anglers coming from less than 50 miles away.

Surveys in Illinois and Indiana indicate that hunting usually is done close to home. Over 50 percent of the hunters do all their hunting in their home county. The balance seldom hunt away from their home county more than once or twice during a season.

Information from the western portions of the basin indicate that public hunting grounds draw from a larger area than public fishing waters. Upland game units, without bird releases, primarily attract local hunters. Approximately 50 percent of the hunters using these areas come from less than 25 miles away. With pheasant releases, over 80 percent of the hunters come from more than 25 miles away.

Future areas of public hunting and fishing, therefore, should be planned within 50 miles of the areas of need. If this is impossible, attractive management procedures should be contemplated to increase the areas' drawing ability.

The theory of multiple purpose generally is sound; however, in practice, an occasional single-purpose unit merits consideration. Over-development can be as inexcusable as under development. A variety of recreational experiences can be provided by a group of single or dual-purpose developments on a less cluttered scale than trying to plan each unit of the group as, "all things to all people".

There never will be the large amounts of publicly owned land in this drainage as in the country's western river basins. Therefore, substantial future demands for hunting and certain categories of fishing must be met on private lands and waters.

The need for additional facts to guide the management of Ohio Basin fish and game resources is also imperative. The following areas are significantly important: (a) management of impounded waters for waterfowl and fish, particularly the large reservoirs; (b) new and precise techniques for the control of unwanted fish and game species or habitat manipulation to increase the production of desirable species; and (c) better understanding of the long-term effects of new pollutants, commercial poisons, detergents, and radioactivity on fish and game.

An analysis of future demands for fishing and hunting indicate the following conditions and possible remedial programs:

Fishing

Illinois - Demand generated by fishermen living within the basin portion of Illinois will be supplied better in 1980 than 1960 (Table 6, Column 10). Only the Embarrass Sub-basin indicates needs in 1980 for additional sport fishing opportunity. However, the Vermilion, Embarrass and Little Wabash Sub-basins must supply needs for many additional angler days (180,000) by 2010 (Table 6, Column 11). Undoubtedly, there will be greater intrastate demands for fishing opportunity in Illinois from the many nearby metropolitan areas lying outside of the Ohio River Basin; e.g., Chicago, East St. Louis, Decatur, Peoria, Springfield, etc. These potential sources of demand presently are not evaluated.

Indiana - The Wabash River Sub-basin shows extensive needs before 2010. The White, Patoka, and Whitewater Sub-basins also show considerable needs by this date. Only the Ohio River Sub-basin will keep pace with the existing conditions of 1960. The Patoka and, particularly, the Wabash Sub-basins have requirements for additional opportunity as early as 1980. In addition to creating impounded waters, stream fishing habitat can be improved through low-flow augmentation from reservoirs, resulting in increased opportunity on presently unproductive or under-utilized portions of existing streams.

Ohio - This state is faced with the challenge of providing for 790,000 unfulfilled angler days by 1980, and a tremendous total of 3,000,000 needed angler days before 2010. Only the small Wabash Sub-basin and the rural Hocking Sub-basin should continue to supply angler demand in comparison to opportunity available in 1960. The Scioto, Miami, Ohio River, and Mahoning Sub-basins indicate needs of more than 100,000 angler days by 1980, with the Little Miami and Muskingum Sub-basins far surpassing this figure by 2010. More facilities may have to be supplied by municipalities in future years, because projections indicate that approximately 81 percent of the state's population will reside in urban areas by 2010. This also points out the necessity of improving water quality by curbing pollution and providing proper zoning of the available water.

Pennsylvania - Needs for additional fishing opportunity will reach approximately 350,000 angler days by 1980, and should continue to increase until this figure nearly doubles by 2010. By 1980, the Allegheny Sub-basin will have the greatest needs followed closely by needs in the Monongahela, Ohio River, and Beaver Sub-basins.

It would be difficult to provide adequate opportunity for the future by employing any single remedial action. The means to reduce future acid-mine-drainage pollution has to be provided by legislation. Pollution abatement, in all forms, would help protect future impoundments and currently unpolluted waters, and allow existing polluted waters to gradually reach full fishery potential under a program of rehabilitation and reclamation. Future impoundments are needed in close proximity to large population centers. Present public fishing opportunity generally is located in rural areas. Continued acquisition of access and public fishing rights along quality streams also would help satisfy future angler needs.

West Virginia - Because projections indicate comparatively slower urbanization and industrial development in much of West Virginia, there are excellent opportunities to create attractive, well-planned, recreation areas. This state is unique in that existing opportunity (primarily streams) and estimates of construction (impounded waters) prior to 1980 should meet projected fishery needs by 1980. Challenges are faced in building water developments near areas needing additional opportunity and in a manner which will complement natural surroundings. Impoundments should have moderate water depths, permitting adequate development of the desired warm-water fishery, and water acreages best suited to other particular needs. Reservoirs also could provide low-flow augmentation to streams that presently only provide seasonal fisheries.

New York - The Allegheny Sub-basin, the only Ohio Basin drainage in New York, shows gross fishing demands doubling by the year 2010. The excellent cold-water and muskellunge fisheries, and the rural character of the sub-basin should continue to attract many Rochester, Buffalo, and non-resident anglers. Additional opportunity of nearly 50,000 angler days will be needed by 1980. Needs might best be met by opening or creating smaller lakes and ponds for public use. Also, the sustained construction of small, private ponds will serve to reduce fishing intensity on public fishing waters.

Kentucky - An excellent job of promoting its natural beauty in conjunction with state development of recreational facilities has, over the last two decades, established Kentucky as a recreational center for mid-eastern states. Improved road systems have facilitated travel for many anglers from large northern urban areas, particularly Ohio cities.

Although Kentucky presently possesses the greatest total ponded water acreage of any state within the basin, 50 percent of this opportunity is the marginal habitat of the Ohio River. Appropriate habitat must be provided by 1980 to meet the needs for 1.0 million angler days and by 2010, 3.4 million angler days. Some of the existing waters are isolated and

utilization is limited by lack of suitable access roads. Abatement of a broad spectrum of water pollutants would increase present utilization. A vigorous program to locate future manmade fishing waters in accordance with areas of specific need, and greater utilization of existing waters will be necessary to fulfill projected needs in the Cumberland, Green, Licking, Ohio River and Little Sandy-Tygarts Sub-basins.

Maryland - The Ohio River Basin (Monongahela drainage) in Maryland is expected to remain 100 percent rural through the year 2010. Presently, it has the highest acres of ponded water per capita and percent non-resident anglers of any Ohio River Sub-basin. Projections indicate needs for an additional two thousand angler days in 1980 and 16 thousand angler days in 2010. Opportunity to meet this additional fishing pressure might be created by small, strategically-placed impoundments.

North Carolina - Indications are that the North Carolina portion of the Kanawha River drainage will remain almost entirely rural through 2010. Anglers presently expend the majority of their efforts fishing high quality streams and farm ponds. The construction of several large impoundments in this area would provide the opportunity needed to satisfy demand projected to exist in 1980. However, some of this need could be satisfied by acquiring permanent access to certain existing trout streams. Consequently, reservoirs should be planned where the impoundments will not interfere with existing trout resources.

Virginia - The Kanawha and Big Sandy Sub-basins represent diverse fishery needs for the projection years. Anticipated losses of people in conjunction with an estimated increase of angler habitat before 1980 should result in adequate opportunity through 2010 in the Big Sandy Sub-basin. Conversely, the population in the Kanawha Sub-basin is expected to double and require opportunity for an additional one-quarter million angler days by 2010. These needs might best be met by the creation of impounded waters and better access roads to isolated streams.

Tennessee - Although Tennessee presently has the highest ratio of ponded water per licensee in the Ohio River Basin, a two-fold increase in the population prior to 2010 is expected to precipitate extensive increases in fishery demand. Either increased usage of existing waters or an extensive fishery-habitat construction program will be necessary to provide opportunity for a projected need of 2.9 million angler days. Because much of the future Cumberland Sub-basin's needs will be generated by the Nashville metropolitan area, additional opportunity should be provided near this municipality. Care must be taken not to degrade existing habitat through the channelization of outstanding smallmouth-bass streams or further pollution of quality water.

Hunting

Illinois - All Illinois sub-basins have been projected as being incapable of supplying 1980 hunter demands (Table 6, Column 18). At existing pressures on Illinois hunting areas, it would take approximately 60,000 acres of managed hunting land to provide the needed opportunity in the four sub-basins under study. With Illinois' hunting restrictions being the most relaxed of any state in the basin, the only foreseeable adjustments seem to be either increase the public hunting base, and the level of management on certain of these lands, or reduce the restrictions presently in force on intensively managed public hunting areas.

Indiana - Of all the states in the basin, with the exception of Kentucky, Indiana is projected to be faced with the most serious problem of providing hunting opportunity in 1980 (Table 6, Column 20). All sub-basins, except the Patoka, will have sizeable deficiencies in hunting opportunity comparable to the 1960 level.

Present utilization rates (1.5 man days per acre per year) on managed hunting areas will have to be increased considerably in order that it become economically feasible to provide sufficient additional public hunting lands to sustain the anticipated needs of 1980, much less 2010.

Short of increasing the quantity and quality of the public-hunting-land base, changes in hunting restrictions could increase the opportunity to hunt. By adding the mourning dove, and possibly the wild turkey and ruffed grouse to the game bird list, huntable resources would increase without a corresponding increase in hunting acreage. Participation could be increased by permitting Sunday hunting.

Ohio - While all basin states indicate a projected need for additional hunting opportunity, the future needs in Ohio are less critical than elsewhere. This is probably due to the low hunter-participation rate (lowest in the Ohio Basin) and the large amount of land which is planned for purchase or lease and which is to be opened to hunting during the period 1960 to 1980. The combinations of these two extremes actually cause a projection of excesses of hunting opportunity in the Hocking and Mahoning Sub-basins in 1980.

However, there is still considerable need for additional hunting opportunity projected for the Miami, Scioto and Muskingum Sub-basins in 1980. This need can be sustained by purchases or leases of additional public hunting areas. Short of additional land acquisition, adding the mourning dove and wild turkey to the game bird list; increasing the level of management on certain areas already in public ownership; or removing Sunday hunting restrictions would increase the hunting potential.

Based on the most recent Ohio averages, an acre of intensively managed (with pheasant releases) public hunting land is capable of supporting approximately five man days per acre per year. This use-per-acre figure could be increased through more liberal (and costly) bird releases. Public hunting areas without pheasant releases range in utilization from 0.5-1.5 trips per acre depending on location and level of management. Considerable expense would be required to purchase and manage the additional 50-125,000 acres needed to provide for the demands of the 1980 hunter.

Pennsylvania - The State of Pennsylvania ranks first in the basin in the projected demands for 1980 with the necessity of providing for nearly 6.3 million man days of hunting (Table 6, Column 18). Of the four Pennsylvania sub-basins, three will rank in the basin's top ten as to needs for hunting opportunity by 1980 (Table 6, Column 20). The Beaver Sub-basin projects an excess for the period. Per-acre hunting pressure in Pennsylvania is the heaviest in the basin. The State Game Department has an ambitious program of acquiring or leasing land for public hunting. It may be impractical to consider increasing the quantity or use of the public hunting sector to provide for anticipated future needs. Favoring under-utilized species or locations through selective legislation may provide an additional source of opportunity. Sunday hunting would increase the opportunity base. A third practical method would be to promote, through economic stimulation, if necessary, a more favorable access program to private lands for the purpose of hunting. The choices are limited but if hunting in the Keystone State is to be maintained at existing levels, the future problems of the game manager and administrator will be manifest. It is imperative that Federal water development programs and multiple-use programs of other Federal agencies take cognizance of this imminent shortage in hunting opportunity and hedge against it.

West Virginia - Of the seven sub-basins in West Virginia, four will have significant hunting needs by 1980. By 2010 (Table 6, Column 21) only three, the Monongahela, Little Kanawha and Ohio main stem, will have sizeable needs for hunting opportunity. The topography of a major portion of the state is not conducive to either increased utilization or management manipulations. There is a definite need for a larger hunting base; a factor to be considered in any multi-purpose recreational or water development program for the future. Removal of Sunday hunting restrictions would increase utilization opportunities without the necessity of a burdensome acquisition program.

New York - The present attractive state of wildlife resources in the Allegheny Sub-basin in New York should continue to provide a stimulus to use in the future. The need generated in the sub-basin will be considerable by 1980, and continue to grow in the distant future. Methods of sustaining this projected need are no different than for other eastern states; either increase the public-hunting acreage base through purchase or lease; or increase the resource base through a biologically sound program of reduction in restrictive legislation.

Kentucky - Of eight Kentucky sub-basins, five will have a serious shortage in hunting opportunity by 1980. In fact, the urban Ohio River Valley Sub-basin will have the greatest needs of any sub-basin in the study. With the Green, Salt, and Licking, the major sub-basins adjacent to this area of need, all indicating significant needs for hunting opportunity themselves, egress from the Ohio Valley, inland, will not relieve the situation. Since future projections are related to rural characteristics and hunting opportunity, it can be assumed that the strongly rural character and the large amounts of potentially huntable land in Kentucky sub-basins have influenced future projections of need. However, to approximate hunting opportunity and pressures as they existed in 1960, additional sources of hunting will be needed in 1980.

The sub-basins indicating the greatest need by 1980 are comparatively low in public hunting acreage. Purchases, leases or easements of huntable land, more intensive management programs on existing public hunting units will absorb some of the needs. The remoteness of the available habitat to centers of demand poses a problem in Kentucky, as in Pennsylvania and West Virginia. A wildlife management program coupled with a strong public relations program pointing out the attributes of these remote areas offer the possibility of increasing use.

Maryland - The basin portion of Maryland indicates a smaller per capita need for hunting opportunity in 1980 than do most other areas. Increased utilization on existing state-owned or controlled-hunting areas of one man per acre would balance out these projected needs.

North Carolina - As in Maryland, the small amount of the state in the Ohio basin imparts a questionable atmosphere to analyses. The projected lack of future hunting opportunity can be offset by increasing the hunting base through the establishment of a public hunting area in the Kanawha Sub-basin.

Virginia - Proposed wildlife developments in other river basins in Virginia may provide the potential to attract some of the man-days of hunting projected as being needed in the Kanawha Sub-basin. The excess opportunity in the adjacent Big Sandy may provide for certain of these needs. However, any water development planned in the future for the Ohio Basin portion of Virginia should give serious consideration to providing public opportunity to hunt. Consideration should be given to establishing a separate public hunting unit in the Kanawha Sub-basin.

Tennessee - Despite a seemingly abundant potential for hunting opportunity, the urban characteristics of the Cumberland Sub-basin in Tennessee were manifested in an extremely low per capita sale of hunting licenses. Since Nashville dominates the sub-basin's population, its urban influence is probably a major factor limiting sub-basin hunting license sales. It would seem, also, that the existing huntable lands in the basin are neither convenient nor attractive enough to appeal to the urban resident. To provide for future hunter demand, the focus still being the Nashville urban complex, existing hunting areas will have to offer special opportunities and new areas must be made more accessible. Future shortages in hunting opportunity can be reduced by gearing management programs and resource restrictions to benefit the urban hunter.

COST ESTIMATES-SPORT FISHERIES AND WILDLIFE DEVELOPMENTS

Fisheries

The gross sport fishing demand in the Ohio River Basin is projected to increase about 14 million man-days from 1960 to 1980; of which all but 3.1 million should be sustained by developments expected to be provided during this interim period.

By 1980, a total of about 10.4 million man-days of fishing opportunity is planned or projected for development by various public and private resource agencies, as well as private individuals.

Approximately 750,000 angler days should be sustained by state-owned developments at an estimated annual cost of between $190,000 - $350,000, chargeable to fisheries.

Planned or projected Federal developments should sustain an additional 7.1 million angler days use at a total cost ranging between $700,000 to $2.8 million annually. These costs allocated to fisheries will be equally divided between the Federal construction agency and the state managing agency and are based on annual equivalents of initial costs plus operation and maintenance costs.

Private interests have planned or are projected to provide for an additional 400,000 man-days of opportunity. The costs involved with this construction will be largely self-liquidating in purely commercial ventures or provided at no costs where a constructing agency accommodates the angler as a public service.

Approximately 2 million man-days of basin fishing opportunity will be created under the farm-pond program. Little or no costs can be allocated to fishing for this accommodation except the initial cost of stocking which is trivial.

The estimated total annual cost of this planned program, if put into operation, would range from $900,000 to $3.2 million depending on the scale of development and management.

It is reasonable to assume that the projected net need of 3.1 million man-days of fishing will either have to be satisfied by increasing the level of use on the habitat presumed to be available in 1980, or that additional habitat will have to be created to accommodate demand. If the latter course is deemed advisable, it is further presumed that opportunity will be created on the same inter-agency ratio as evidenced in the 1960-80 planned construction program.

If no extension of the habitat construction program is contemplated to satisfy the 1980 net needs, an increase of 3.5 man-days per acre of annual effort on the lake and impoundment habitat planned to be available in 1980 will suffice the demand. A 42 percent increase in use on presently fishable streams would also accommodate the demand. Similarly, an increase of 10 man-days of fishing per year on farm ponds projected to be available in 1980 would eliminate the opportunity differential. Any combination of the above intensified use on existing habitat would also provide for the increased demands. However, this heavier utilization probably would require changes in stream access attitudes or legislation, as well as angler's attitudes on crowding and creel quality; assuming that management techniques could not keep pace with increased use in the latter instance.

In order to satisfy the net needs of 1980 by increasing the scope of habitat construction, an additional 114,000 acres of "public" ponded waters would have to be created. By projecting present levels of construction in their existing relationship to one another, 105,000 acres would be constructed by Federal interests, and 6,900 acres by state agencies. Approximately 2,000 acres of privately constructed waters, which would be open to the public, would provide for the balance of the needed opportunity.

If the balance of the man days of unsatisfied needs are to be supported by increased farm-pond construction, there will be a need for an estimated additional 13,000 acres of farm ponds over that projected to be available in 1980.

The many combinations of the above elements which could satisfy projected net needs make the development of even general cost estimates on a basin basis a chancey procedure.

If the projected net needs for 3.1 million man days of fishing opportunity in 1980 could be entirely satisfied by increased use on available ponded-water habitat in the basin, the cost of this program is estimated to amount to less than $250,000 per year. This figure represents a 10 percent increase in the estimated, annual, operation and maintenance costs on the existing system.

To provide new acres of opportunity for the 3.1 million man days of net need projected to exist in the Basin in 1980 would involve an estimated expenditure of between $200,000 - $720,000 annually. This estimate includes both amortized initial costs and annual operation and maintenance costs.

To satisfy the total angler need projected for 1980 through agency developments, could cost between $1.1 million and $3.9 million annually. These are separable fisheries costs.

In the year 2000 these costs could conceivably be increased 42 percent and in 2020 by 123 percent.

Wildlife

A need for the creation of an additional 3.85 million man days of hunting opportunity is projected to exist in 1980. In addition to this projected need, there will be a loss of hunting habitat due to urbanization, etc. which will result in an additional need for 333,000 man days of hunting opportunity.

In 1980, a total of 773,000 man days of hunting could be supplied annually on the public developments planned to be open to hunting by that year.

Of this total, approximately 200,000 man days could be sustained on lands planned for state development at an estimated cost of $177,000 annually.

The balance of 573,000 man days of public hunting is planned to be supplied on Federally owned but state operated lands, at an estimated annual cost to Federal agencies of $6,000 and to state agencies of $567,000.

In order to provide for the remaining 3.4 million man days of hunter demand projected to exist in 1980, various options are available:

(a) A 15 percent increase in hunting pressures on private lands projected to be opened to hunting in 1980 would suffice the demand at no cost to resource agencies (assuming the wildlife resources could stand the 15 percent additional pressure).

(b) If the total demand were to be satisfied by purchase or lease of hunting land by public agencies, a total of 9 million acres would be required at a conceivable annual cost of $3,000,000. This is a maximum figure, assuming that no user fees are charged or share-cropping arrangements made, and that the entire need will be met by additional public acquisition and development. This capital outlay would be necessary even though 85 percent of the pressure will be supported on multiple-purpose public units, with a portion of the benefits being incidental and accruing at little or no cost.

(c) Liberalization of various state hunting regulations could provide additional man days of opportunity at little or no cost to the managing agency.

It is estimated that costs allocated to hunting to satisfy 1980 basin needs could range from $800,000 to $4.8 million annually. The low estimate would presume that all demands are to be satisfied through a combination of planned developments and increased utilization on available private lands. The high estimate assumes that all demands are to be sustained by newly created public developments. These are maximum estimates and assume no user fees or share cropping arrangements on public developments.

It is estimated that in the year 2000 these costs could be increased by 28 percent and in 2020 by 78 percent; due principally to increased demands for hunting.

FUTURE DEVELOPMENT OF COMMERCIAL FISHERY RESOURCES

Although the Ohio River Basin is not usually associated with significant commercial fishing values, a considerable potential for expanded production exists.

The Ohio River, historically the backbone of the fishery, has remained at a stable level of production since 1900, in spite of gross pollution in some reaches and channelization throughout its length. Other rivers, notably the Wabash, have declined in importance while the Cumberland and Kentucky have actually increased production in recent years. Recent advances in pollution abatement hold hope for continued improvement in water quality, eventually allowing utilization of food fish presently unfit for human consumption because of objectionable odor and flavor characteristics. The main stem of the Ohio, with its continuous series of slack-water, navigation pools, will remain the core of all future development of the commercial fishery resources of the basin. The large, total acreage involved, the established base of existing operations, the potential for rapid movement of modern gear from pool to pool, and the central location of the habitat--all would contribute to this central importance.

The second major, and as yet virtually untapped, supply-potential--to meet demands for fish products--lies in utilization of the lakes and reservoirs. A minimum of 228,000 additional acres of this type habitat were potentially available for commercial fishing in 1960 but remained unutilized. By 1980,

an additional 167,000 acres will be available. In addition to legal restrictions a major problem in utilization of lake and reservoir potentials lies in their inherent biological and economic limitations as scattered, individual production units.

The key to effective utilization of the entire commercial fishery habitat base in the Ohio Basin is coordinated management as a single system. The centrally-located, main stem, navigation pools are the logical core for such a system. Their sustained capacity would be the nucleus for investment in modern, efficient harvesting, processing and merchandising methods. From this base, intermittent utilization of scattered lakes and reservoirs in accordance with their biological and economic capacity would be feasible.

Implementation would require development of harvesting equipment specifically geared for lake and reservoir operations; portable, processing plants; biological studies to guide management on a sustained yield basis and liberalized, flexible restrictions on commercial fishing. The inherent economics of scale in this comprehensive approach would solve the central problem--how to combine the large-scale modernization and efficiency necessary for present day resource development with a resource base, large in aggregate, but geographically scattered.

Good management of a resource that involves diverse interests (as does the fishery of the Ohio Basin) requires controls and restrictions. Unfortunately, many of the commercial fishing regulations presently in force in many parts of the Ohio Basin are unnecessarily restrictive and outmoded. There is need for a flexible approach based on sound biological and economic information. Much of the existing pattern of commercial fishing regulation has evolved from a belief that almost any form of commercial fishing was necessarily detrimental to sport fishing. Biological studies and actual experiences have shown that, along with habitat productivity and deterioration, pre-emption of the waters of the Ohio and adjacent basins by species of little or no value to the sport fisherman constitutes the basic problem. Take-over of reservoirs by over population of gizzard shad has dramatized the situation in many areas. Even in waters occupied by species of interest to sportsmen, over population and subsequent stunting of prolific species may take place, and may require drastic reduction of numbers. Some sportsmen and conservation officials are beginning to recognize a properly regulated commercial fishery may be useful for a balanced approach to this problem and is not detrimental to sport fisheries.

Analyses of projected needs for sport fishing in this report indicates that quality of fishing opportunity may be a factor in influencing demand. The question of quality is often closely tied to imbalanced fish populations in certain of the basins aquatic habitat. With sound coordination of both programs, meeting the needs of the commercial fishery resource could benefit quality and, in effect, increase sport fishing opportunity.

With proper management and development, the estimated 1980 production potential of 32 million pounds annually would more than meet the projected demand for inland freshwater fish products (exclusive of that supplied by the Great Lakes) generated by the projected human populations within the

Ohio Basin. This does not include the production increment of smaller bodies of water under 1,000 acres in size. This 32 million pounds appears sufficient to meet projected demands and any reasonable increases over and above these projections that may be brought about by technological and marketing advances.

While it is not possible to forecast future demands exactly, it is expected that current high prices will increase mussel harvesting to levels approaching those of the 1920's. Unlike the commercial fin-fish resource, future commercial shellfish production in the Ohio Basin is more likely to be a function of limited supply rather than demand. The future of this industry will, in large measure, depend on the implementation of as yet embryonic research and development programs designed to provide sound scientific data upon which management programs can be structured.

Pre-impoundment surveys on the Wabash and White Rivers would be particularly useful in yielding basic information upon which to properly judge post-impoundment problems. The Indiana Department of Natural Resources is considering initiation of studies on its mussel resources under Public Law 88-309, "The Commercial Fisheries Research and Development Act".

Basic information concerning the spread of Corbicula, pollution effects, life history and ecological factors is lacking. Institutions with special competence such as the Mollusk Division, Museum of Zoology, University of Michigan, have made significant contributions; but much more is needed. There are, presently, no known controls for this organism.

In summary, the freshwater mussel has heretofore been typical of those natural resources which are of interest primarily to a small body of scientists and a relatively obscure industry. Without the benefit of appropriate social concern and/or significant economic values, the need for effective management becomes apparent only after the fact of impairment or depletion. It is hoped that an increased public and professional awareness of this valuable and unique resource will provide the impetus for initiating the investigations necessary for such effective management.

General Cost Estimates - Commercial Fisheries Program

Realization of the projected 9.9 million pounds of commercial fish demand by 1980 can be achieved by utilization of the then existing developments. No additional reservoir acreage other than that currently in authorized status will be required to meet foreseeable demands in 2010.

Development of the reservoir fisheries will be largely a function of technology and gear research and the integration of commercial fisheries into present reservoir fishery management programs. However, there are several opportunities for implementing full utilization by such methods as pre-construction clearing of seining and trawling areas and by periodic drawdowns during reservoir operation. Since the applicability of these features will vary with each project, no estimates of their costs and benefits as a function of meeting demands can be made with any degree of accuracy.

The river fisheries potential is presently limited by pollution, particularly the various chemical contaminants producing off-flavor characteristics in food fish. It is expected that pollution control or abatement measures under the Water Quality Act of 1965 will contribute to extending the quantity and quality of commercial fishery habitat in the basin's rivers.

Maintaining and increasing the supply of freshwater mussels to meet export demands and preserve the economic contribution of this industry to local communities will depend on the acquisition of basic knowledge of the various environmental factors influencing the organism. Not enough is known of these factors at this time to quantify the possible benefits or adverse effects resulting from water resource development projects.

SUMMARY AND CONCLUSIONS

General

The Ohio River Basin Review of Reports was authorized by a resolution adopted May 16, 1955 by the Committee on Public Works of the United States Senate. This resolution requested a review of prior reports on the Ohio River with a view to determining whether any modification of the comprehensive plan for flood control and other purposes in the Ohio River Basin was advisable. The original scope of the investigation was changed in 1963 from a review of reports to a Type 1, Comprehensive Basin Survey.

The extent of the area under study comprises the Ohio River Basin, exclusive of the Tennessee River Basin, and covers 163,000 of the 203,900 square miles of the entire basin, or 5.6 percent of the conterminous area of the United States.

The 20 million persons living in the study area, generally, are located along a northeast-southwest axis through the basin; they represent 10 percent of the 1960 national population.

Status of Fish and Wildlife Resources - 1960

Sport Fishing and Hunting

Basin fishing habitat was provided by 46,000 miles of stream and 591,000 acres of ponded water consisting of 19 percent farm ponds, 75 percent larger impoundments and six percent natural lakes.

Most cold-water streams and ponds capable of producing or sustaining trout fishing are located in the ridge section of the Ohio Basin's Appalachian Region.

The balance of Appalachian Region streams and upland portions of other basin streams usually contain smallmouth bass - sucker environments, with

fishable populations of walleye, northern pike, and muskellunge present in some areas.

Major tributary rivers and lower reaches of plateau and lowland streams are usually inhabited by species of fish which, though tolerant of a degraded habitat, are less desirable to sport fishermen.

Most ponded waters in the basin are periodically stocked with panfish, bass, perch, catfish, bullhead, walleye, and occasionally with trout, northern pike, and muskellunge.

Pollution in its many forms (acid mine drainage, agricultural, industrial and municipal) is a serious limiting factor to fisheries in many of the basin's streams and some of its ponded water.

Of the 93.3 million acres of potential hunting habitat available in 1960, 56 percent was designated as farm-game habitat, 43 percent forest-game habitat, and one percent waterfowl habitat.

The bobwhite quail is the most abundant and most hunted game bird within the basin; it is distributed throughout the majority of the basin's Central Lowland and Interior Plateau Regions.

The ring-necked pheasant is hunted in all but two of the basin's states. It is rare to moderate in natural abundance. Some pheasant hunting is supported by bird releases in conjunction with intensive management procedures on public hunting areas.

Cottontail rabbits and squirrels rank first or second as huntable small game mammals in all states within the basin.

The white-tailed deer is the only big game mammal hunted in all basin states; they reach greatest abundance in the northeastern portion of the basin.

Major duck or goose hunting areas lying in or just outside of the basin are the Lake Erie marshes; the Wabash and Ohio River lowlands in southern Illinois, Indiana, and northwestern Kentucky, and the Pymatuning area on the Pennsylvania-Ohio border.

The mourning dove, a migratory, upland-game bird, sustains sizeable basin hunting effort. The only basin states not having a dove season are Ohio, New York and Indiana, although they have adequate resident and migratory populations.

In 1960, available fishing habitat was used at mean basin rates of 142 angler days per stream mile, 21 angler days per impoundment acre, 19 angler days per natural-lake acre and 47 angler days per farm-pond acre.

Potential hunting opportunity was represented by the following mean basin rates: farm-game habitat - 0.20 hunter-days per acre, forest-game habitat - 0.26 hunter-days per acre and waterfowl habitat - 0.62 hunter-days per acre.

Approximately 2.6 million basin anglers fished 21.8 million days, expending 43 percent of their efforts on impoundments, 30 percent on streams, 24 percent on farm ponds and three percent on natural lakes. Public waters in the basin sustain 36 percent of the total fishing effort.

About 2.3 million basin hunters were afield 21.7 million days in 1960. Farm game and forest game each received over 49 percent of the effort, and waterfowl provided the remaining one percent of total hunting effort. Public-hunting areas satisfied only slightly over three percent of the total basin pressure.

An analysis of 1960 sport fishing and hunting resources and problems for the sub-basins of the 11 states located in the Ohio River Basin are presented in the report.

The 1960 opportunity to hunt or fish, as represented by available habitat, was frequently located far from basin population centers, and access to this habitat was often denied. It was further determined that the location of fishing and hunting habitat are more important than quantity in determining utilization.

Commercial Fishing

The Ohio Basin has supported an average annual commercial fishing production that has remained roughly constant in poundage since the turn of the century, although the value has declined in recent years.

This production has come largely from the main stem Ohio River, principally the lower third.

In 1960, the Ohio Basin supplied approximately 31 percent of the demand for inland fish (exclusive of that produced by the Great Lakes) estimated to originate in the basin.

The 1960 commercial catch was produced from 46 percent of the habitat estimated to be potentially available, including lakes or impoundments (1,000 acres or more in size), for production.

The primary factors over the entire basin bringing about the limited, low-intensity utilization of the available habitat have been economic and legal.

In the upper and middle portions of the basin, water quality and pollution have also been a factor - a major factor in the upper basin.

In the lower portion of the basin, water quality generally is good with little indication that pollution has affected the commercial fishery to any significant degree.

Environmental changes in aquatic habitat in the main stem Ohio and tributaries apparently have influenced species composition of fish populations which in turn have been reflected in the commercial catch. However, none of the major species in the historical, catch record have been influenced in this manner.

Since the early part of this century, the Ohio Basin has been an important source of supply for freshwater mussel shells used in the manufacture of pearl buttons. During the peak years of production between 1908 and 1922, the Ohio Basin supplied approximately one-third of the total United States catch. Following World War I, production declined as other raw materials replaced shells in the manufacture of pearl buttons and as various environmental factors and excessive harvesting adversely affected beds in many areas.

Up until the middle 1950's, demand for mussel shells was stabilized and production in the Ohio Basin averaged less than 10 percent of the peak production years. Since that time, new demands for shells created by the Japanese, cultured-pearl industry have created renewed interest in the mussel resources of the basin with 1963 price per ton being the highest on record.

Future Demand for Fish and Wildlife Resources - 1980 and 2010

Sport Fishing and Hunting

Procedures for projecting future basin hunting and sport fishing gross demands, net needs, and participation are presented, as well as procedures for projecting future populations in the basin.

Projected license sales are considered as the best indicator of future sport fishing and hunting demands. Present license sales (participants) in the Ohio River Basin are closely related to the urban-rural character of the population and the acres of opportunity in each of the 44 hydrologically delineated sub-basins. License sale projections, therefore, were based on these two factors.

Angler and hunter annual participation in the Ohio River Basin correlated with available habitat, but only hunter participation was related to the urban-rural composition of each sub-basin.

Future gross demand for sport fishing is estimated to increase 62 percent by 1980, 88 percent by 2000, and 138 percent by 2020, over the 1960 actual basin use.

Projected gross hunting demands will increase 18 percent by 1980, 23 percent by 2000 and 32 percent by 2020, over the 1960 actual basin use.

Despite much of the gross fishing demand being met by future habitat development programs, there will be significant unfulfilled needs for additional fishing opportunity projected in 25 sub-basins by 1980 and 31 of the 44 sub-basins by 2010. Unfulfilled basin needs are estimated to approach 3.1 million angler days by 1980 and 11.8 million angler days by 2010.

Projected sub-basin needs might be best satisfied by using combinations of the following remedial actions: (a) creating ponded waters by various private, municipal, county, state and Federal agencies; (b) improving water quality by curbing pollution, in all forms; (c) providing equitable zoning of use on available waters; (d) rehabilitating or reclaiming fishing waters that are now producing below their potential; (e) acquisition of additional public access to quality fishing waters; (f) prudent and immediate planning for the future; (g) avoiding the degradation of existing fishery habitat through unwise physical changes; and (h) providing facts, through research, which would produce better fishery management methods.

Considerable unsatisfied needs for more hunting opportunity, above that met by future habitat development programs, are projected in 38 sub-basins by 1980. Unfulfilled basin needs are estimated to amount to 3.4 million hunter days by 1980 and 5.7 million by 2010.

Possible remedial measures to meet future hunter needs are: (a) more intensive management of segments of the available public-hunting lands; (b) introduction of promising exotic species to bolster existing game or bird populations; (c) opening additional hunting lands to public use through purchase, lease or easement; (d) relaxation of overly stringent hunting regulations as to seasons, bag, or species to increase hunter participation; (e) prudent and immediate planning for the future; and (f) providing facts, through research, which would produce better wildlife management techniques.

Priorities for fulfilling near future basin hunting and sport fishing needs are represnted in Table 6, Columns 10 and 20.

To provide public fishing opportunity for the needs projected to exist in the basin in 1980 could involve estimated annual expenditures between $1,100,000 to $3,900,000.

To provide sufficient basin hunting habitat to sustain the 1980 projected needs could involve annual expenses between $800,000 and $4,800,000.

Commercial Fishing

Future demand for inland fish (exclusive of that produced in the Great Lakes) is estimated to total 14.2 million pounds in 1980 or 44 percent of the potential harvest the basin could supply, even without utilizing the smaller bodies of water. This demand is based on a projected 17 percent increase in per capita consumption of edible and industrial fishery products by 1980.

The commercial fishing potential of the Ohio Basin is capable of meeting the projected demand plus any incremental demand that can be reasonably foreseen for 1980 and 2010.

Neither realization of projected demand nor attaining the full commercial fishery production potential of Ohio Basin habitat will come about without extensive modernization of harvesting, processing and marketing techniques and organization. Existing programs of the Bureau of Commercial Fisheries and State agencies have made progress in this direction but much remains to be done.

Full realization of commercial fishery potentials also will require an up-dated, flexible system of regulations, reasonably uniform and consistent throughout the basin.

The key to management of commercial fisheries as part of total water resources management in the Ohio Basin is a system approach centered on the core of main-stem, navigation pools with intermittent utilization of the more scattered lake and reservoir network--the entire system being backed up by modern equipment and methods and made feasible by economies of scale.

The objective of increasing sport fishing demand by bettering the quality of sport fishing opportunity could, in many instances, be aided by continued, planned, commercial removal of rough fish stocks.

There are indications that the demand for mussel shells will continue to increase and rivers of the Ohio Basin will be subject to intensive harvesting approaching levels of the 1908-1922 period. Depletion of beds in other river basins will accentuate this trend. At the same time, basic information concerning the life history of the mussel and various environmental and ecological factors affecting the resource is greatly lacking. As a result, adequate management programs and effective regulations will be difficult to formulate.

Unlike the commercial fin-fish resource, future commercial shellfish production in the Ohio Basin likely will be a function of supply rather than demand. Little is known at the present time of the extent of the mussel resource and its ability to withstand the expected harvesting pressure resulting from increased demands. It is hoped that an increased public and professional awareness of this valuable and unique resource will serve to promote those studies necessary to insure proper management and regulation of the freshwater mussel in the Ohio Basin.

GLOSSARY OF REPORT TERMS

Angler Day - An individual partaking in a fishing experience during any part of a 24-hour period.

Catch - The annual harvest of fish, shellfish or game from any particular area.

Correlation - The degree of interdependence of two or more variables.

Farm-Game Habitat - Land usually associated with populations of cottontail rabbits, bobwhite quail or other comparable species; and listed in the Soil Conservation Service's "Conservation Needs Inventory" as Cropland, Pasture, Range, and appropriate acreages of Other Land categories.

Forest-Game Habitat - Land usually associated with populations of deer, bear, squirrels, raccoons, turkeys or other comparable species; and listed in the Soil Conservation Service's "Conservation Needs Inventory" as Forest and Woodland or appropriate Other Land categories.

Gross Demand - That demand generated by projected number of hunters and sport fishermen times their calculated annual hunting and fishing participation.

Harvest - (See Catch).

Hunter Day - An individual partaking in a hunting experience during any part of a 24-hour period.

Latent Demand - That desire to hunt or to fish, which is inherent in the total population, but is not fulfilled because of lack of facilities, leisure time or other pertinent factors.

Linear Regression - The degree in which one dependent variable changes with the changes of another independent variable, resulting in an association which does not differ significantly from a straight line when plotted.

Mean - An average; the sum of a given set of values divided by the number of values.

Median - A value in a given set of values below and above which there are an equal number of values.

Multiple Regression - The degree in which one dependent variable changes with the change of two or more independent variables, generally resulting in an association which is curvilinear when plotted.

Net Needs or Excesses - Net needs are projected when estimated gross demand exceeds projected opportunity. The reverse is true when net excesses are projected. Net needs and excesses are expressed in hunter and angler days.

Non-Resident - An individual residing in a state other than the particular state in which he occasionally hunts or fishes.

Opportunity - Lands or waters upon which the individual may gain access to, and expect to realize a hunting or fishing experience.

Participant - An individual who hunts or fishes.

Participation - The number of times an individual annually participates in a hunting or fishing experience.

Ponded Water - Waters which are not in a free-flowing state. These would include portions of rivers which are influenced by locks and/or dams.

Pressure - The number of user days a particular hunting or fishing area receives over a particular length of time.

Production - (See Catch).

Projection - A forecast based on certain assumptions.

Resident - An individual residing and hunting or fishing in the particular state being discussed.

Significant - This term is used for stating results of a rigorous statistical test. When the probability of the occurrence of a particular event is 19 in 20 or more ($P = 0.95$), the probability is termed significant. When the probability is 99 in 100 or more ($P = 0.99$), it is termed highly significant.

Streams - Water in a free-flowing state; it may locally be called a river, stream, brook or some other descriptive term.

Urban Area - Incorporated places of 2,500 inhabitants or more.

User Day - An individual partaking in a hunting or fishing experience during any part of a 24-hour period.

Utilization - (See Pressure).

SUPPLEMENT 1.

Sources and Methodology Data in Table 1.

Cols. 1 and 2	Reports - U.S. Bureau of the Census.
Cols. 3 and 4	License statistics from state records, on county license sales.
Cols. 5 thru 8	Data furnished by state fish and game agencies. Augmented in case of farm ponds from S.C.S. records-- and in cases of rivers and streams from U.S.G.S., C. of E. Reports, and map measurements.
Cols. 9 thru 11	Principal source of data was S.C.S. Land Use Reports augmented by U.S. Forest Service statistics.
Col. 12	Data secured from "Inventory of Permanent Water Habitat Significant to Waterfowl" and Wetland Habitat Reports produced by U.S. Fish and Wildlife Service, augmented by state statistics.
Cols. 13 thru 19	(a) Illinois Participation Statistics (E.S.C. Region) and median angler days from 1960 National Survey of Hunting and Fishing were used to determine fishing utilization figures by category. Sub-basin use indices developed from state-wide hunter survey, combined with adjusted 1/ license sales. Habitat inventories (Cols. 5-8) were used to calculate per unit hunting estimates. (b) Indiana Indices for fisherman use on streams, natural lakes, and reservoirs based on the state creel census data. Farm pond use data from "Survey of 1000 Ponds," 1959, U.S.Fish and Wildlife Circular 86. The use indices were then applied to the habitat base and expanded into sub-basin use estimates by category. Hunting statistics were developed in the same manner as in Illinois through use of the Indiana Sportsman' Questionnaire. (c) Ohio National fisherman use figures were applied to habitat base for farm ponds estimates while state data were used to determine use on fee ponds. River angling was determined by taking 27 percent (E.N.C. Division statistic-

1/ License sales figures adjusted for non-licensed hunters and fishermen.

National Survey Hunting and Fishing) of total angling determined by using the median trips (9.0) from National Survey X adjusted license sales. The above 3 category estimates were then subtracted from total angling estimate (National Survey X Licensed plus unlicensed anglers) to arrive at reservoir fishing estimate. Hunting statistics were developed using a similar procedure as outlined for Illinois.

(d) Pennsylvania-West Virginia, and New York Estimates of fishing pressure were obtained by using statistics developed in the ORRRC Study Report 7 "Sport Fishing-Today and Tomorrow." Production (to the angler) indices for various types of fisheries habitat are applied to the known acreages of existing habitat and the result divided by 1.2, the estimated poundage harvested per trip per angler, giving the total trip estimate per habitat category.

Hunting pressure was calculated from State Hunter Censuses which determined per cent of effort attributable to each species. Statistics from the National Survey of Hunting and Fishing were used to determine the average trips per species. These were combined with the adjusted hunting license sales giving the total hunter days by game category (farm game, etc.) and then applied to expressions of sub-basin habitat for the trips/acre estimate.

(e) Kentucky, Maryland, North Carolina, Virginia and Tennessee Estimates for fishing pressure were obtained using the same general procedures as outlined for Indiana except as indices to farm-pond use were obtained from State Departments of Fish and Game files.

Estimates of hunting pressure were based on resident license sales and data as to percentage of hunters seeking a particular species and the number of trips he expends against that particular species.

Col. 20 — Data furnished by state fish and game agencies.

Col. 21 — Data derived from actual quantitative creel censuses and from the application of statistics from a variable sampling pattern applied to different agency lakes according to size and location of the lake.

Col. 22 — These statistics include all ponded waters open to public fishing.

Cols. 23 thru 25 — Same methods and sources as for fishing statistics derived for Cols. 20-22 except as figures in Col. 25 are based on all potential hunting acres regardless of access restrictions.

SUPPLEMENT 1.

Sources and Methodology Data in Table 1.

Cols. 1 and 2	Reports - U.S. Bureau of the Census.
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Cols. 5 thru 8	Data furnished by state fish and game agencies. Augmented in case of farm ponds from S.C.S. records-- and in cases of rivers and streams from U.S.G.S., C. of E. Reports, and map measurements.
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Col. 12	Data secured from "Inventory of Permanent Water Habitat Significant to Waterfowl" and Wetland Habitat Reports produced by U.S. Fish and Wildlife Service, augmented by state statistics.
Cols. 13 thru 19	(a) Illinois Participation Statistics (E.S.C. Region) and median angler days from 1960 National Survey of Hunting and Fishing were used to determine fishing utilization figures by category. Sub-basin use indices developed from state-wide hunter survey, combined with adjusted 1/ license sales. Habitat inventories (Cols. 5-8) were used to calculate per unit hunting estimates. (b) Indiana Indices for fisherman use on streams, natural lakes, and reservoirs based on the state creel census data. Farm pond use data from "Survey of 1000 Ponds," 1959, U.S.Fish and Wildlife Circular 86. The use indices were then applied to the habitat base and expanded into sub-basin use estimates by category. Hunting statistics were developed in the same manner as in Illinois through use of the Indiana Sportsman' Questionnaire. (c) Ohio National fisherman use figures were applied to habitat base for farm ponds estimates while state data were used to determine use on fee ponds. River angling was determined by taking 27 percent (E.N.C. Division statistic-

1/ License sales figures adjusted for non-licensed hunters and fishermen.

SUPPLEMENT 2

CORRELATION OF FISH AND WILDLIFE AREAS
WITH HEW ECONOMIC PROJECTION AREAS

Pennsylvania

Number		
1	Allegheny	= A_1 + A_2 + Westmoreland and Allegheny Counties.
2	Mahoning	= D
3	Ohio River	= Beaver County
4	Monongahela	= B_1 + Washington County

West Virginia

5	Monongahela	= B_1 + B_2
6	Ohio River	= E_1 + E_2
7	Little Kanawha	= G_3
8	Kanawha	= G_1 + G_2 + G_4 + G_5 + G_6 + G_7
9	Guyandot	= J_3 + H_2
10	Big Sandy	= J_3 + H_2
11	Twelvepole Cr.	= J_3 + H_2

New York

12	Allegheny	= A_2

Maryland

13	Monongahela	= B_2

Virginia

14	Kanawha	= G_8
15	Big Sandy	= J_2

North Carolina

16	Kanawha	= G_9

Tennessee

17	Cumberland	= S_1 + S_2 + S_3 + S_4
18	Green	= S_3

Kentucky

19	Green	= $O_3 + P_1 + P_2 + P_3$
20	Cumberland	= $S_1 + S_4 + S_5$
21	Tradewater	= O_1
22	Salt	= M_1
23	Kentucky	= $M_2 + M_4$
24	Licking	= $K_2 + K_3 + M_3$
25	Big Sandy	= J_2
26	Lt.Sandy-Tygarts	= J_1 + Greenup County
27	Ohio River	= Lewis + Boyd + Gallatin + Boone + Hancock City's + $N_1 + N_2 + N_3 + O_1 + O_2$

Ohio

28	Mahoning	= D
29	Muskingum	= $F_1 + F_2 + F_3$
30	Hocking	= I_1 + Athens County
31	Scioto	= $H_1 + I_1 + I_2$
32	Little Miami	= L_2 + Clermont County
33	Miami	= L_2
34	Wabash	= L_2
35	Ohio River	= $E_1 + E_2 + H_3 + K_2 + K_3$ + Lawrence County

Indiana

36	Wabash	= $R_4 + R_5 + R_6$
37	Whitewater	= L_1
38	White	= $Q_1 + Q_2 + Q_3 + Q4$
39	Patoka	= Q_1
40	Ohio River	= $K_1 + N_1 + N_2 + N_3 + O_2 + O_3$

Illinois

41	Vermilion	= Edgar + Champaign + Vermilion Counties
42	Embarrass	= $R_1 + R_2$ + Coles + Douglas Counties
43	Little Wabash	= R_1
44	Saline-Ohio Rvr.	= O_1

SUPPLEMENT 3.

An example of appropriate calculation procedures for converting population projections into gross fishing demands and net needs.

Embarrass Sub-basin

Given:

1960 Resident Fishing License Sales	=	13,303
1960 Non-resident Fishing License Sales	=	394
1960 Sub-basin Population	=	121,000
1980 Projected Sub-basin Population	=	145,800
2010 Projected Sub-basin Population	=	207,000
1980 Percent Rural	=	46%
2010 Percent Rural	=	36%
1980 Estimated Acres of Ponded Water	=	12,314
2010 Extrapolated Acres of Ponded Water	=	17,388
Correction Factor for Resident Fishing Licenses/Capita	=	1.08 1/
Correction Factor for Angler Participation	=	1.25 1/
Angler Days of Opportunity Created 1960-1980	=	185,490
1960 Actual Angler Days	=	184,536

The Licensed Resident Sport Fishermen for 1980 and 2010:

Resident Fishing Licenses/capita = [0.018 + 0.139 (% Rural) + 0.225 (Acres Ponded Water/Capita)] X (Correction Factor)

1980

[0.018 + (0.139) (0.46) + (0.225) (0.084)] X (1.08) = 0.109

145,800 X 0.109 = 15,892 Licensed Resident Fishermen

2010

[0.018 + (0.139) (0.36) + (0.225) (0.084)] X (1.08) = 0.094

207,000 X 0.094 = 19,458 Licensed Resident Fishermen

1/ Sub-basin deviation from basin regression.

The Licensed Non-Resident Sport Fishermen for 1980 and 2010

1960

$$\frac{394}{13,303} = 2.96\%$$

1980

15,892 x 0.0296 = 470 Licensed Non-Resident Fishermen

2010

19,458 x 0.0296 = 576 Licensed Non-Resident Fishermen

The Unlicensed Fishermen for 1960, 1980, and 2010.

1960

13,303 x 0.50 = 6,652 Unlicensed Fishermen

1980

15,892 x 0.50 = 7,946 Unlicensed Fishermen

2010

19,458 x 0.50 = 9,729 Unlicensed Fishermen

The Latent Demand for 1980 and 2010

1980

145,800 x 0.0255 = 3,718 Fishermen

2010

207,000 x 0.0255 = 5,278 Fishermen

Total Sport Fishermen for 1960, 1980, and 2010

1960

Resident licenses + Non-resident licenses + Unlicensed Anglers

13,303 + 394 + 6,652 = 20,349 Actual Anglers

1980 and 2010

Include Latent Demand

15,892 + 470 + 7,946 + 3,718 = 28,026 (1980 Potential Anglers)

19,458 + 576 + 9,729 + 5,278 = 35,041 (2010 Potential Anglers)

Gross Demand for Sport Fishing in 1980 and 2010

Gross Demand = Total Anglers x Computed Participation

$$\text{Participation} = \left[6.1 + 6.2 \text{ (Acres Ponded Water per licensed Angler)}\right] \times \text{(Correction Factor)}$$

1980

$$\left[6.1 + 6.2\ (0.753)\right]\ (1.25) = 13.46 \text{ Angler Days per Year}$$

28,000 x 13.46 = 376,880 Angler Days (Gross Demand)

2010

35,000 x 13.46 = 471,100 Angler Days (Gross Demand)

Net Needs for Sport Fishing in 1980

Net Needs = 1980 Gross Demand - (1960 Actual Use + Angler Days of Opportunity Created from 1960 to 1980)

376,900 - (184,500 + 185,500) = 6,900 Angler Days (Net Needs)

TABLE 1. A COMPENDIUM OF FISH AND GAME RESOURCES INFORMATION - OHIO RIVER BASIN, 1960

Sub-Basin by State	1 1960 Tot. Pop. in 1,000's	2 % Rural	3 Licensed Fishermen /Capita	4 Licensed Hunters/ Capita	5 Miles of Stream 1/	6 Acres of Impounded Waters	7 Acres of Natural Lakes	8 Acres of Farm Ponds	9 Total Acres Land in 1,000's A's	10 % in Farm Game Habitat	11 % in Forest Game Habitat	1 % I Wate Habit
Illinois												
Vermilion	195.6	36%	.09	.10	314	1,699	31	593	1,525	85%	5%	
Embarrass	121.0	57%	.11	.12	272	1,540	62	1,070	1,592	76%	10%	
Lt.Wabash	133.1	65%	.12	.15	427	2,591	259	2,342	2,494	75%	7%	
Saline	95.6	73%	.14	.14	344	5,770	1,986	2,361	1,688	44%	30%	
STATE	545.3	54%	.11	.12	1,356	11,600	2,338	6,366	7,299	70%	13%	
Indiana												
Wabash	959.3	50%	.11	.11	1,167	2,960	13,336	2,182	7,146	83%	10%	
White	1,594.0	36%	.09	.10	1,263	10,131	3,319	6,992	7,191	67%	22%	
Patoka	124.7	43%	.11	.13	260	330	721	1,567	907	68%	22%	
Whitewater	135.3	47%	.08	.10	137	235	51	666	884	76%	17%	
Ohio R. Tribs.	387.7	45%	.08	.10	291	313	1,068	4,836	2,750	59%	31%	
STATE	3,201.0	42%	.09	.10	3,118	14,929	18,495	16,243	18,878	71%	19%	
Ohio												
Ohio R. Tribs.	1,080.0	34%	.07	.08	774	16,172	--	3,551	4,019	52%	39%	
Miami	1,361.1	22%	.08	.07	882	8,849	--	2,514	2,814	72%	9%	
Little Miami	328.7	43%	.07	.08	389	883	--	2,225	1,017	77%	14%	
Scioto	1,137.4	29%	.10	.08	1,380	8,770	--	3,120	3,943	73%	20%	
Hocking	118.0	59%	.12	.11	163	1,248	--	984	900	52%	38%	
Muskingum	1,230.9	43%	.09	.08	1,508	26,036	--	1,928	4,786	67%	23%	
Mahoning	496.8	25%	.07	.06	243	13,655	--	1,932	709	53%	17%	2.
Wabash	21.2	68%	.30	.13	774	13,500	--	32	189	86%	9%	5.
STATE	5,774.1	33%	.08	.08	5,386	89,113	--	15,286	18,377	65%	23%	
Pennsylvania												
Allegheny	1,538.0	38%	.11	.12	2,052	17,891	1,247	9,314	6,235	30%	59%	
Monongahela	962.0	34%	.06	.08	710	3,300	--	3,754	1,482	44%	43%	
Beaver	410.0	48%	.08	.12	491	19,782	--	1,736	1,113	51%	28%	
Ohio R.Mainstem	865.0	18%	.06	.06	284	361	--	2,583	1,037	46%	28%	
STATE	3,775.0	33%	.08	.10	3,537	41,334	1,247	17,387	9,867	36%	50%	
West Virginia												
Kanawha	660.4	63%	.11	.15	6,832	7,302	--	1,858	5,421	23%	74%	
Monongahela	318.3	62%	.12	.16	500	865	--	335	2,654	38%	59%	
Little Kanawha	119.7	91%	.12	.18	1,855	45	--	365	1,472	37%	58%	
Guyandotte	219.6	62%	.08	.12	1,017	--	--	122	1,080	13%	83%	
Big Sandy	114.8	85%	.07	.10	363	39	--	41	658	10%	85%	
Twelvepole	32.0	58%	.05	.09	338	--	--	10	285	26%	71%	
Ohio R.Mainstem	275.0	42%	.10	.12	472	125	--	325	1,606	41%	53%	2.
STATE	1,739.8	63%	.10	.14	11,339	8,376	--	3,056	13,176	29%	68%	.7
New York												
Allegheny	173.0	61%	.06	.08	1,779	609	14,024	367	1,273	52%	43%	1.5
Kentucky												
Ohio R. Valley	860.0	25%	.05	.05	1,732	12,400	--	6,000	2,752	43%	33%	1.8
Big Sandy	173.0	80%	.05	.07	800	1,100	--	100	1,463	8%	79%	.2
Lt.Sandy Tygarts	44.0	90%	.14	.18	400	300	--	200	692	21%	69%	--
Licking	269.0	40%	.06	.07	1,300	800	--	5,000	2,401	52%	39%	--
Kentucky	485.0	60%	.09	.08	2,400	6,000	--	7,000	4,489	40%	50%	--
Cumberland	368.0	75%	.10	.08	2,500	57,025	--	4,000	4,617	33%	56%	.5
Salt	212.0	75%	.16	.15	1,100	1,000	--	5,000	1,898	56%	36%	--
Green	415.0	70%	.09	.10	3,000	10,000	--	12,000	5,596	51%	40%	1.4
Tradewater	50.0	65%	.12	.15	300	2,200	--	1,600	612	54%	33%	1.9
STATE	2,876.0	55%	.08	.08	13,532	190,825	--	40,900	24,520	42%	47%	.7
Maryland												
Monongahela	16.4	100%	.20	.26	360	4,980	--	60	262	32%	63%	--
North Carolina												
Kanawha	39.2	91%	.22	.11	300	--	--	400	498	44%	47%	--
Virginia												
Kanawha	145.0	77%	.28	.24	1,250	5,600	--	700	2,013	43%	52%	--
Big Sandy	69.0	100%	.20	.21	370	--	--	100	642	13%	84%	--
STATE	214.0	84%	.26	.23	1,620	5,600	--	800	2,655	36%	60%	--
Tennessee												
Green	22.4	100%	.22	.20	210	40	--	300	263	52%	36%	--
Cumberland	833.0	44%	.04	.04	3,400	74,700	--	11,700	6,872	35%	51%	.1%
STATE	855.4	45%	.05	.04	3,610	74,740	--	12,000	7,135	35%	51%	--

1/ Habitat base includes "fishable" waters only.
2/ (--) means less than .1%, insignificant or lacking.
3/ Habitat base in Illinois, Indiana, and Ohio calculated on "permanent water" of significance to waterfowl.

TABLE 1 Cont. A COMPENDIUM OF FISH AND GAME RESOURCE INFORMATION - OHIO RIVER BASIN , 1960

Sub-Basin by State	13 Fisherman Days/Mile of Stream 4/	14 Fisherman Days/Acre Impoundment	15 Fisherman Days/Acre Nat. Lake	16 Fisherman Days/Acre Farm Pond 5/	17 Hunter Days/ Acre Farm Game Habitat	18 Hunter Days/ Acre Forest Game Habitat	19 Hunter Days/ Acres Water-fowl Habitat	20 Acres Public Fishing Waters (Ponded)	21 % in Total Fishing on Public Waters
Illinois									
Vermilion	221	49	612	102	.20	1.11	21.20	971	21%
Embarrass	203	43	244	45	.13	.35	17.00	1,242	29%
Lt. Wabash	157	31	71	25	.16	.71	2.50	1,953	30%
Saline	163	12	8	21	.20	.24	.80	3,881	13%
STATE	182	26	29	34	.17	.42	3.73	8,047	23%
Indiana									
Wabash	578	21	21	72	.11	.36	1.40	7,911	14%
White	482	21	21	72	.18	.50	2.67	10,342	15%
Patoka	385	21	21	72	.15	.42	.69	302	3%
Whitewater	385	21	21	72	.11	.46	12.97	200	4%
Ohio R.Tribs.	385	21	21	72	.14	.24	4.53	749	3%
STATE	497	21	21	72	.14	.39	1.90	19,504	12%
Ohio									
Ohio R.Tribs.	552	32	--	72	.10	.15	14.31	1,655	5%
Miami	427	65	--	175	.22	.22	1.11	8,560	40%
Little Miami	213	13	--	95	.12	.29	2.87	955	4%
Scioto	298	101	--	73	.12	.20	.87	4,102	27%
Hocking	330	61	--	71	.16	.11	1.38	1,272	39%
Muskingum	274	38	--	68	.17	.20	.27	29,588	57%
Mahoning	526	18	--	52	.41	.37	.16	15,100	57%
Wabash	371	5	--	57	.08	.03	.22	13,500	70%
STATE	431	38	--	94	.13	.18	.57	74,732	35%
Pennsylvania									
Allegheny	373	12	15	51	.60	.62	.77	4,681	5%
Monongahela	28	15	--	51	.66	.57	.49	2,109	27%
Beaver	108	15	--	51	.29	.39	.49	17,124	62%
Ohio R.Mainstem	63	17	--	49	.53	.26	.11	299	6%
STATE	217	13	15	51	.56	.58	.65	24,213	18%
West Virginia									
Kanawha	28	15	--	34	.35	.22	.17	4,047	25%
Monongahela	34	28	--	18	.33	.31	.17	1,887	23%
Little Kanawha	31	65	--	31	.32	.23	.17	--	--
Guyandotte	31	--	--	32	.44	.20	.17	12	4%
Big Sandy	31	43	--	20	.66	.21	.17	49	40%
Twelvepole	31	--	--	25	.37	.20	.15	--	--
Ohio R.Mainstem	324	63	--	22	.31	.24	.15	101	7%
STATE	41	26	--	31	.25	.24	.17	6,096	17%
New York									
Allegheny	19	14	14	40	.11	.35	.39	13,959	78%
Kentucky									
Ohio R.Valley	144	3	--	32	.47	.34	.21	110,639	23%
Big Sandy	68	22	--	32	.75	.14	.45	1,125	32%
Lt.Sandy Tygarts	56	192	--	32	.41	.22	--	279	62%
Licking	84	64	--	32	.75	.14	--	383	8%
Kentucky	75	51	--	32	.18	.13	--	3,416	7%
Cumberland	71	21	--	32	.17	.13	.46	56,055	65%
Salt	77	84	--	32	.24	.21	--	366	9%
Green	63	52	--	32	.12	.12	.31	5,842	15%
Tradewater	0	33	--	32	.29	.33	.64	--	--
STATE	79	14	--	32	.21	.16	.32	178,105	27%
Maryland									
Monongahela	33	6	--	50	.21	.20	--	4,847	12%
North Carolina									
Kanawha	202	--	--	62	.12	.12	--	--	--
Virginia									
Kanawha	107	30	--	50	.14	.26	--	--	--
Big Sandy	120	--	--	50	.58	.22	--	--	--
STATE	110	30	--	50	.18	.26	--	--	--
Tennessee									
Green	147	53	--	47	.24	.36	--	--	--
Cumberland	93	21	--	12	.13	.08	.83	73,869	69%
STATE	96	21	--	13	.14	.09	.83	73,869	68%

4/ Calculated as adjusted by conditions set out in footnote 1/
5/ Includes fee ponds where present.

TABLE 1 Cont. A COMPENDIUM OF FISH AND GAME RESOURCE INFORMATION - OHIO RIVER BASIN, 1960

Sub-Basin by State	22 Acres Ponded Waters/Licensed Angler	23 Acres (In 1000's) Public Hunting Land	24 % of Total Hunting on Public Lands	25 Acres Hunting Land/Licensed Hunter
Illinois				
Vermilion	.13	--	--	70.7
Embarrass	.20	--	--	88.5
Lt. Wabash	.31	--	--	101.6
Saline	.73	145.5	12%	89.8
STATE	.33	145.5	3%	87.6
Indiana				
Wabash	.17	10.7	2%	63.4
White	.15	120.4	2%	43.3
Patoka	.19	11.8	2%	52.0
Whitewater	.08	--	--	63.7
Ohio R. Tribs.	.18	100.6	5%	63.8
STATE	.16	243.6	2%	53.7
Ohio				
Ohio R. Tribs.	.25	114.7	10%	48.9
Miami	.11	6.1	3%	23.7
Little Miami	.14	4.4	13%	36.5
Scioto	.11	119.0	10%	38.7
Hocking	.15	16.5	11%	59.8
Muskingum	.25	169.7	11%	42.1
Mahoning	.44	9.0	19%	18.8
Wabash	1.91	--	--	69.9
STATE	.22	439.4	10%	37.6
Pennsylvania				
Allegheny	.16	1,034.0	20%	28.5
Monongahela	.12	160.0	7%	16.5
Beaver	.61	95.0	2%	17.0
Ohio R. Mainstem	.06	22.0	3%	14.6
STATE	.19	1,311.0	12%	22.5
West Virginia				
Kanawha	.12	561.5	9%	53.4
Monongahela	.03	284.9	2%	48.7
Little Kanawha	.03	--	--	71.9
Guyandotte	.01	6.2	3%	39.2
Big Sandy	.01	.9	1%	54.0
Twelvepole	.01	7.2	3%	95.4
Ohio R. Mainstem	.01	21.4	3%	46.0
STATE	.06	901.1	5%	51.4
New York				
Allegheny	1.06	93.8	11%	84.6
Kentucky				
Ohio R. Valley	2.16	12.5	1%	42.8
Big Sandy	.12	12.0	--	104.3
Lt. Sandy Tygarts	.08	--	--	73.0
Licking	.29	80.0	4%	103.4
Kentucky	.28	110.5	2%	109.1
Cumberland	1.11	422.6	8%	141.6
Salt	.17	18.5	--	56.5
Green	.56	9.2	--	121.5
Tradewater	.53	15.8	3%	70.5
STATE	.85	681.2	2%	91.6
Maryland				
Monongahela	.88	27.8	11%	56.5
North Carolina				
Kanawha	.05	--	--	99.2
Virginia				
Kanawha	.14	156.0	11%	53.4
Big Sandy	.01	19.0	3%	43.2
STATE	.11	175.0	8%	50.5
Tennessee				
Green	.03	--	--	51.3
Cumberland	1.89	215.4	4%	173.3
STATE	1.60	215.4	4%	159.0

TABLE 2. OHIO RIVER BASIN COMMERCIAL CATCH (FISH ONLY) - 1894-1963
(Thousands of pounds-thousands of dollars)

	Ohio R.& Tribs.	Inland Lakes	Wabash R. & Tribs.	Cumberland River	Total Lbs.	Total Value	Av.Price Per Lb. (Cents)
1894	4,509	1,028	985	194	6,716	299	4.4
1899	2,553	---	344	245	3,142	185	5.9
1903	1,499	---	315	81	1,895	99	5.2
1908	*	---	*	*	2,446[1/]	127	5.2
1922	2,433	---	846	72	3,351	395	11.8
1931	1,067	---	221	106	1,394	139	10.0
1950	*	---	270	*	1,812	372	20.5
1954	2,060	---	106	507	2,673	377	14.1
1955	1,928	---	442	445	2,815	351	12.5
1956	2,540	---	125	516	3,181	490	15.4
1957	2,948	---	176	480	3,604	613	17.0
1958	918	---	192	509	1,619	263	16.2
1959	1,916	---	151	234	2,301	408	17.7
1960	2,004	12	143	299	2,459	426	17.3
1962	1,314	---	60	315	1,689	231	13.7
1963	785	---	84	366	1,235	149	12.0

*Not available.
1/ Excludes Tennessee portion of the Cumberland River.

Table 3--Species Composition-Ohio River Basin Commercial Catch
(Fish Only) 1894-1963
(Figures in Percent)

	1894	1899	1903	1908	1922	1931	1950	1954
Bass, black	1.3	0.8	0.3	0.3	T	-	-	-
Bass, other	1.1	0.4	T	0.1	T	T	-	-
Buffalo	19.4	16.1	28.6	23.1	13.8	24.8	30.0	29.3
Carp	0.7	3.5	5.7	22.4	21.6	29.9	25.0	21.4
Catfish	30.7	29.0	25.9	21.3	20.2	18.3	27.7	28.0
Crappie	0.4	0.3	T	0.3	T	0.1	-	T
Drum	23.6	22.9	17.6	20.5	15.9	11.3	9.7	9.9
Eel	0.3	0.4	0.2	T	-	T	T	-
Mooneye	0.7	0.3	0.3	-	-	T	-	-
Paddlefish	2.0	4.1	2.1	2.7	0.2	7.1	3.3	8.1
Pike, Pickerel	T	T	-	-	-	-	-	-
Quillback	-	-	-	-	12.2	3.2	1.2	2.4
Sauger	T	0.2	0.3	-	T	0.2	-	-
Sturgeon, Lake	0.5	0.6	T	-	T	-	-	-
Strugeon, Shovel-nose	2.9	2.6	5.0	4.1	2.9	1.6	0.7	0.3
Sucker	13.2	15.4	13.1	4.2	12.9	2.8	2.3	0.8
Sunfish	T	0.5	T	0.2	T	-	-	-
Walleye	2.6	0.7	0.3	0.6	0.2	0.3	-	-
Yellow Perch	-	1.1	T	-	-	-	-	-
Other	0.6	0.8	T	-	-	T	T	-

T-less than 0.1%

	1955	1956	1957	1958	1959	1960	1962	1963
Bass, black	-	-	-	-	-	-	-	-
Bass, other	-	-	-	-	-	-	-	-
Buffalo	26.6	30.2	30.0	22.5	16.5	21.1	31.1	31.4
Carp	30.7	28.1	27.7	21.3	16.6	23.0	25.5	35.4
Catfish	25.3	26.0	26.9	39.7	27.4	25.5	31.4	23.1
Crappie	-	-	-	-	-	-	-	-
Drum	6.6	8.8	9.2	7.3	28.4	21.0	3.6	2.5
Eel	-	-	-	-	-	-	-	-
Mooneye	-	-	-	-	-	-	-	-
Paddlefish	7.1	3.2	3.4	3.0	3.4	4.1	3.9	3.7
Pike, Pickeral	-	-	-	-	-	-	-	-
Quillback	2.7	2.1	1.6	2.9	3.7	1.3	1.5	1.0
Sauger	-	-	-	-	-	-	-	-
Sturgeon, Lake	-	-	-	-	-	-	-	-
Sturgeon, Shovel-nose	0.2	0.4	0.3	0.6	0.2	0.5	0.7	0.7
Sucker	0.9	1.1	0.8	2.7	3.0	3.4	2.3	2.2
Sunfish	-	-	-	-	-	-	-	-
Walleye	-	-	-	-	-	-	-	-
Yellow Perch	-	-	-	-	-	-	-	-
Other	-	T	-	T	T	-	T	T

T-less than 0.1%

TABLE 4. OHIO RIVER BASIN COMMERCIAL SHELLFISH CATCH - 1894-1963
(Thousands of pounds - thousands of dollars)

	Total Pounds	Total Value	Av. Price Per Ton (Dollars)
1894	----	---	---
1899	----	---	---
1903	----	---	---
1908	26,263	289	22
1912-13	31,482	283	18
1922	16,837	356	42
1931	8,318	122	29
1950	553	10	34
1954	2,812	59	42
1955	3,956	94	48
1956	4,264	109	51
1957	3,383	83	49
1958	1,144	29	51
1959	708	22	62
1960	2,260	95	84
1962	1,150	47	82
1963	2,762	160	116

TABLE 5. 1960 COMMERCIAL CATCH (FISH AND SHELLFISH) - OHIO RIVER BASIN

	FISH		SHELLFISH	
	Pounds	Value	Pounds	Value
Ohio River	1,638,315	279,269	660,000	27,000
Kentucky River	203,453	56,045	------	-----
Green River	100,395	20,700*	------	-----
Licking River	32,168	5,123	------	-----
Rough River	560	110	------	------
Big Sandy River	1,897	445	------	-----
Barren River	27,555	10,863	------	-----
Cumberland River	299,500	48,366	400,000	16,000
Wabash River	120,000	11,720	1,200,000	52,000
Little Wabash River	23,000	2,766	------	-----
Misc. Kentucky Lakes	12,305	1,043	------	------
	2,459,148	$425,702	2,260,000	$95,000

*Estimated

AD-A041 276 ARMY ENGINEER DIV OHIO RIVER CINCINNATI F/G 8/6
OHIO RIVER BASIN COMPREHENSIVE SURVEY. VOLUME VIII. APPENDIX G.--ETC(U)
1963

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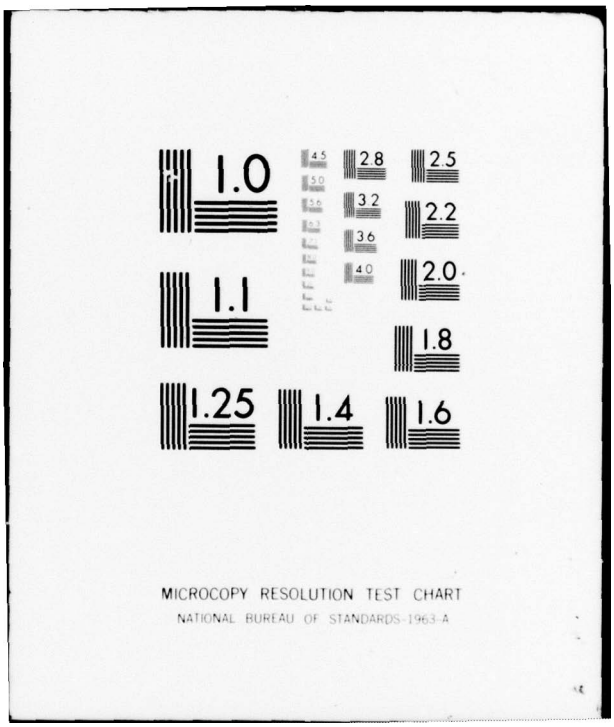
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE 6 - A COMPENDIUM OF PROJECTION DATA RELATIVE TO FUTURE FISHING AND HUNTING DEMAND IN THE OHIO RIVER BASIN - 1960-2010

and basin	1 1960 Pop. (1000's)	2 1980 Pop. (1000's)	3 2010 Pop. (1000's)	4 1960 Tot. Ang. (1000's)	5 1980 Est. Ang. (1000's)	6 2010 Est. Ang. (1000's)	Estimated Man Days of Fishing: 7 Actual Use 1960 (1000's)	8 1980 Gross Demand (1000's)	9 2010 Gross Demand (1000's)	10 1980 Net Needs (1000's)	11 2010 Net Needs 1/ 2/ (1000's)
ois											
rmilion	195.6	257.4	373.4	25.6	23.8	30.0	231.5	258.7	326.1	E 40.4	N 27.0
barrass	121.0	145.8	207.0	20.3	28.0	35.0	184.5	376.9	471.1	N 6.9	N 101.1
ttle Wabash	133.1	152.3	213.1	24.6	30.7	39.4	223.6	319.9	410.5	E 40.0	N 50.6
line	95.6	101.8	109.5	20.4	23.8	19.3	187.2	265.1	215.0	E 88.2	E 138.3
STATE TOTAL	545.3	657.3	903.0	90.9	106.3	123.7	826.8	1,220.6	1,422.7	E 161.7	N 40.4
na											
bash	959.3	1,267.2	1,847.6	163.7	261.7	338.3	1,185.4	2,067.4	2,672.6	N 153.5	N 758.7
ite	1,594.0	2,115.2	3,146.6	208.5	285.3	361.3	1,440.0	2,293.8	2,904.9	E 77.6	N 533.5
toka	124.7	138.9	194.4	20.2	28.6	38.6	234.5	514.2	694.0	N 27.9	N 207.7
itewater	135.3	177.8	253.8	17.6	33.8	47.9	106.6	274.1	388.5	E 27.2	N 87.2
io Riv. Tribs	387.7	525.7	758.7	49.7	73.5	94.4	488.6	848.9	1,090.3	E 317.8	E 76.4
STATE TOTAL	3,201.0	4,224.8	6,201.1	459.7	682.9	880.5	3,455.1	5,998.4	7,750.3	E 241.2	N 1,510.7
io Riv. Tribs	1,080.0	1,418.0	1,723.7	113.9	162.3	183.6	1,064.0	1,567.8	1,773.6	N 141.7	N 347.5
ami	1,361.1	1,739.5	2,533.0	153.3	201.5	255.3	1,396.7	1,871.9	2,371.7	N 236.3	N 736.1
ttle Miami	328.7	440.8	607.1	33.7	54.5	70.5	306.7	556.4	719.8	N 43.0	N 206.4
ioto	1,137.4	1,565.1	2,347.6	167.0	231.3	308.0	1,523.3	2,248.2	2,993.8	N 369.7	N 1,115.3
cking	118.0	151.7	183.8	21.8	35.6	41.7	193.3	403.3	472.5	E 135.2	E 66.0
skingum	1,230.9	1,569.4	2,186.0	166.4	213.6	253.9	1,520.6	2,071.9	2,462.8	N 22.1	N 413.0
honing	496.8	558.4	743.7	52.1	66.8	81.1	476.9	660.7	802.1	N 112.2	N 253.6
bash	21.2	27.1	26.7	10.3	11.7	10.8	96.2	99.8	92.1	N 0.2	E 7.5
STATE TOTAL	5,774.1	7,470.0	10,351.6	718.5	977.3	1,204.9	6,577.7	9,480.0	11,688.4	N 790.0	N 2,998.4
sylvania											
llegheny	1,538.0	1,711.8	2,131.7	258.8	321.2	341.3	1,459.2	1,975.4	2,099.0	N 115.2	N 238.8
onongahela	962.0	1,034.2	1,236.2	87.1	123.2	141.7	258.2	362.2	416.6	N 95.5	N 149.9
eaver	410.0	460.8	613.8	51.5	62.4	74.4	433.3	604.0	720.2	N 50.6	N 166.8
hio R. Mainstem	865.0	1,020.7	1,272.4	78.2	124.4	149.3	150.1	238.8	286.7	N 86.5	N 134.4
STATE TOTAL	3,775.0	4,227.5	5,254.1	475.6	631.2	706.7	2,300.8	3,180.4	3,522.5	N 347.8	N 689.9
Virginia											
anawha	660.4	752.9	923.9	110.4	146.3	147.2	370.0	596.9	600.6	E 87.6	E 83.9
onongahela	318.3	495.9	605.1	59.9	109.8	121.7	67.0	142.7	158.2	E 58.7	E 43.2
ittle Kanawha	119.7	159.8	159.8	22.2	34.6	34.6	72.0	133.9	133.9	E 25.1	E 25.1
uyandotte	219.6	210.4	217.4	26.6	28.9	24.9	36.0	42.8	36.9	E 29.5	E 35.4
ig Sandy	114.8	110.0	113.7	12.0	12.9	10.9	14.0	16.1	13.6	E 17.5	E 20.0
elvepole	32.0	30.6	31.7	2.4	3.2	2.8	11.0	34.9	30.6	E 17.5	E 21.8
hio Riv. Mainstem	275.0	292.6	361.9	42.2	50.5	54.7	170.0	209.6	227.0	N 29.5	N 46.9
STATE TOTAL	1,739.8	2,052.2	2,413.5	275.7	386.2	396.8	740.0	1,176.9	1,200.8	E 206.4	E 182.5
York											
llegheny	173.0	224.9	295.5	19.4	31.3	38.4	263.9	452.0	554.5	N 44.6	N 147.1
ucky											
hio R. Valley	860.0	1,101.7	1,492.1	77.1	109.7	130.6	770.4	1,075.1	1,279.9	N 134.1	N 338.9
ig Sandy	173.0	150.9	142.2	14.4	16.8	16.1	81.7	117.8	112.9	E 31.2	E 36.1
t. Sandy-Tygarts	44.0	51.0	65.0	9.5	12.8	16.0	86.3	146.6	183.2	E 16.3	N 20.3
icking	269.0	400.5	525.3	28.3	57.4	75.3	320.1	1,124.5	1,475.1	N 204.5	N 555.1
entucky	485.0	517.5	729.9	67.9	81.6	80.2	709.1	984.1	967.2	N 18.0	N 1.1
umberland	368.0	315.0	453.7	72.6	82.5	112.3	1,491.9	2,480.0	3,375.7	N 333.1	N 1,288.8
alt	212.0	275.6	431.4	52.7	81.8	119.5	328.7	580.0	847.3	E 89.7	N 177.6
reen	415.0	491.8	713.8	57.1	85.0	112.0	1,094.6	2,135.2	2,813.4	N 421.9	N 1,100.1
radewater	50.0	53.3	57.3	10.3	11.6	9.3	123.8	150.2	120.4	E 3.5	E 33.3
STATE TOTAL	2,876.0	3,357.3	4,610.7	389.9	539.2	671.3	5,006.6	8,793.5	11,175.1	N 970.9	N 3,352.5
yland											
Monongahela	16.4	18.2	23.6	7.3	8.4	10.8	43.2	48.0	61.8	N 2.0	N 15.8
th Carolina											
Kanawha	39.2	51.8	89.0	13.0	18.7	32.2	85.4	124.2	213.8	N 24.4	N 114.0
ginia											
Kanawha	145.0	186.8	271.6	64.1	88.0	124.1	337.2	452.3	637.9	N 83.2	N 268.8
Big Sandy	69.0	60.2	56.7	20.6	20.2	19.0	49.5	54.1	50.9	E 81.9	E 85.1
STATE TOTAL	214.0	247.0	328.3	84.7	108.2	143.1	386.7	506.4	688.8	N 1.3	N 183.7
nessee											
Green	22.4	31.8	50.2	11.1	17.6	27.8	47.1	82.7	130.7	N 14.9	N 62.9
Cumberland	833.0	1,136.2	1,717.6	62.5	115.0	151.7	2,021.8	4,167.6	5,497.6	N 1,532.2	N 2,862.2
STATE TOTAL	855.4	1,168.0	1,767.8	73.6	132.6	179.5	2,068.9	4,250.3	5,628.3	N 1,547.1	N 2,925.1
-Basin Mean											
-Basin Median											
TOTAL OF BASIN	19,209.2	23,699.0	32,238.2	2,608.3	3,622.3	4,387.9	21,755.1	35,230.7	43,907.0	N 3,118.8	N11,795.1

"N" indicates a projected need or insufficiency. "E" indicates a projected excess or surplus.

based on 1980-2010 incremental gross demand, plus needs or minus excesses present in 1980

TABLE 6. Cont. A COMPENDIUM OF PROJECTION DATA RELATIVE TO FUTURE FISHING AND HUNTING DEMAND IN THE OHIO RIVER BASIN - 1960-2010

State and Sub-basin	12 A's Ponded Water/Lic. Ang. 1960	13 A's Ponded Water/Lic. Ang. 1980	14 1960 Tot. Hunters (1,000's)	15 1980 Est. Hunters (1,000's)	16 2010 Est. Hunters (1,000's)	Estimated Man Days of Hunting: 17 Actual Use 1960 (1,000's)	18 1980 Gross Demand (1,000's)	19 2010 Gross Demand (1,000's)	20 1980 1/ Net Needs (1,000's)	21 Additional Needs-2010 2/ (1,000's)	22 1960 Acres/Lic. Hunter	23 1980 Acres/Lic. Hunter
Illinois												
Vermilion	.13	.36	24.0	23.3	28.5	351.8	347.2	374.2	N 2.4	N 44.9	70.7	87.1
Embarrass	.20	.75	19.2	22.1	25.8	222.9	242.7	252.3	N 26.9	N 46.1	88.5	84.3
Little Wabash	.31	.49	25.2	28.4	33.4	429.8	463.5	485.0	N 37.2	N 77.8	101.6	96.2
Saline	.73	1.08	17.5	18.6	15.7	280.7	294.3	254.8	N 3.6	E 33.8	89.8	92.0
STATE TOTAL	.33	.68	85.9	92.4	103.4	1,285.2	1,347.7	1,366.3	N 70.1	N 135.0	87.6	90.3
Indiana												
Wabash	.17	.28	131.5	185.7	231.4	950.7	1,233.0	1,367.6	N 254.6	N 428.3	63.4	49.3
White	.15	.33	182.9	228.7	284.7	1,658.9	1,932.5	2,152.3	N 270.7	N 561.0	43.3	40.3
Patoka	.19	.84	19.7	21.8	27.5	183.1	196.9	223.6	N 8.3	N 42.4	52.0	51.3
Whitewater	.08	.44	16.0	24.6	33.3	149.4	209.8	255.1	N 64.3	N 118.8	63.7	45.5
Ohio R. Trib.	.18	.38	47.9	62.3	78.1	433.2	517.7	577.2	N 78.4	N 151.6	63.8	56.2
STATE TOTAL	.16	.34	398.0	523.1	655.0	3,375.3	4,089.9	4,575.8	N 676.3	N1,302.1	53.7	46.2
Ohio												
Ohio R. Tribs.	.25	.29	102.3	136.4	152.7	455.8	540.1	569.6	N 30.6	N 75.3	48.9	39.5
Miami	.11	.13	119.5	156.6	199.6	532.0	659.3	770.5	N 125.5	N 269.2	23.7	21.5
Little Miami	.14	.28	31.7	45.8	58.5	142.3	190.1	222.3	N 24.4	N 65.2	36.5	28.9
Scioto	.11	.19	119.3	162.7	214.6	531.2	662.2	781.1	N 81.2	N 226.9	38.7	32.6
Hocking	.15	.46	17.1	24.1	27.6	75.9	98.1	105.4	E 1.8	N 10.4	59.8	45.8
Muskingum	.25	.33	128.6	160.9	191.3	572.9	667.7	719.3	N 80.6	N 161.6	42.1	39.3
Mahoning	.44	.55	34.8	44.0	53.9	154.8	189.2	216.1	E 58.5	E 18.0	18.8	17.9
Wabash	1.91	1.66	3.4	4.3	3.8	15.1	17.5	15.4	N 2.7	N 1.2	69.9	61.2
STATE TOTAL	.22	.29	556.7	734.8	902.0	2,480.0	3,024.2	3,399.7	N 284.7	N 791.8	37.6	32.6
Pennsylvania												
Allegheny	.16	.27	243.3	275.9	293.0	3,898.3	4,171.6	4,157.7	N 263.5	N 347.3	28.5	24.4
Monongahela	.12	.12	98.2	122.3	141.5	963.1	1,191.2	1,328.7	N 230.7	N 393.8	16.5	15.2
Beaver	.61	.85	66.5	71.6	83.8	353.6	360.9	390.5	E 16.3	N 32.9	17.0	17.0
Ohio R. Mainstem	.06	.05	65.9	96.9	117.5	363.1	522.3	612.2	N 160.2	N 262.7	14.6	11.9
STATE TOTAL	.19	.26	473.9	566.7	635.8	5,578.1	6,246.0	6,489.1	N 638.1	N1,036.7	22.5	19.5
West Virginia												
Kanawha	.12	.36	125.0	147.0	147.8	1,313.0	1,492.0	1,410.0	N 74.7	N 6.2	52.4	48.5
Monongahela	.03	.18	65.6	102.0	111.2	783.5	1,098.5	1,126.5	N 276.3	N 318.7	48.7	34.0
Little Kanawha	.03	.22	25.0	33.4	33.4	372.5	454.9	453.2	N 72.4	N 74.5	71.9	56.4
Guyandotte	.01	.10	33.1	33.0	29.4	237.9	239.9	211.1	E 1.6	E 29.0	39.2	43.7
Big Sandy	.01	.08	14.5	14.4	12.6	150.4	150.3	131.5	E .7	E 18.2	54.0	61.8
Twelvepole	.01	1.40	3.6	3.8	3.4	63.5	68.9	62.9	N 3.1	E 1.8	95.4	104.9
Ohio R. Mainstem	.01	.03	42.0	47.2	50.6	395.9	434.2	439.2	N 41.9	N 55.3	46.0	45.0
STATE TOTAL	.06	.23	308.8	380.8	388.4	3,316.7	3,938.7	3,834.4	N 466.1	N 405.6	51.5	45.4
New York												
Allegheny	1.06	1.17	18.0	25.8	30.1	270.0	350.9	373.5	N 78.2	N 108.8	84.6	67.8
Kentucky												
Ohio R. Valley	2.16	2.11	59.5	83.3	95.1	864.8	1,140.4	1,205.9	N 286.1	N 377.0	42.8	38.8
Big Sandy	.12	.38	15.1	16.1	15.3	250.2	282.1	274.6	N 30.4	N 23.9	104.3	115.8
Lt.Sandy-Tygarts	.08	.36	10.6	12.4	14.7	166.7	185.8	205.2	N 17.6	N 38.3	73.0	65.6
Licking	.29	.90	26.3	40.8	51.4	275.3	365.2	408.1	N 112.5	N 203.8	103.4	76.7
Kentucky	.28	.47	46.2	53.4	54.1	631.3	720.4	685.4	N 99.3	N 91.7	109.1	109.5
Cumberland	1.11	2.07	36.2	34.8	43.3	595.7	626.7	675.0	N 33.7	N 91.5	141.6	170.9
Salt	.17	.33	38.6	52.7	73.9	400.6	511.2	634.1	N 118.3	N 252.2	56.5	44.3
Green	.56	1.03	52.3	65.6	81.8	634.7	745.9	816.4	N 107.3	N 182.9	121.5	109.7
Tradewater	.53	.65	9.5	10.2	8.6	170.2	178.8	152.1	N 9.1	E 16.2	70.5	71.0
STATE TOTAL	.85	1.16	294.3	369.3	438.2	3,989.5	4,756.5	5,056.8	N 814.3	N1,245.1	91.6	84.5
Maryland												
Monongahela	.88	.83	5.4	6.2	7.5	50.7	56.5	64.3	N 5.8	N 14.5	56.5	52.3
North Carolina												
Kanawha	.05	.06	5.6	7.8	12.4	52.5	66.4	89.7	N 14.1	N 38.0	99.1	79.2
Virginia												
Kanawha	.14	.12	44.6	57.5	75.9	417.9	507.2	614.8	N 88.7	N 200.3	53.4	43.4
Big Sandy	.01	.12	18.0	17.2	16.3	171.1	167.5	160.9	E 3.3	E 9.2	43.2	47.7
STATE TOTAL	.11	.12	62.6	74.7	92.2	589.0	674.7	775.7	N 85.4	N 191.1	50.5	44.4
Tennessee												
Green	.03	.15	5.6	8.0	12.0	65.8	86.7	119.3	N 11.8	N 45.5	51.3	38.3
Cumberland	1.89	2.21	42.2	69.8	89.9	604.1	871.1	960.1	N 262.3	N 360.8	173.3	141.5
STATE TOTAL	1.60	1.86	47.8	77.8	101.9	669.9	957.8	1,079.4	N 274.1	N 406.3	159.0	128.4
Sub-Basin Mean	.36	.58									64.6	59.6
Sub-Basin Median	.16	.36									56.5	48.9
TOTAL OF BASIN			2,257.0	2,859.4	3,366.9	21,656.9	25,509.3	27,104.7	N3,407.2	N5,675.0		

1/ "N" indicates projected need or insufficiency. "E" indicates projected excess or surplus.
3/ Based on 1980-2010 incremental gross demand and depleted opportunity, plus needs or minus excesses present in 1980.

TABLE 7 - ACTUAL AND POTENTIAL COMMERCIAL FISHERY HABITAT - OHIO RIVER BASIN - 1960

Actual Habitat (Acres)	
Ohio River (to Louisville)	99,986
Kentucky River	13,063
Green River	6,900
Licking River	2,000
Rough River	1,400
Big Sandy River	1,300
Barren River	560
Cumberland River	46,690
Wabash River	15,374
Little Wabash River	1,182
Dewey Reservoir	1,100
Herrington Reservoir	1,600
	191,155

Potential Habitat (Acres)	
Rivers, free flowing:	
Cumberland River	16,740
Barren River	105
Rough River	1,400
Big Sandy River	1,300
Licking River	2,000
Eagle Creek River	780
Tradewater River	240
Pond River	150
Mud River	70
Wabash River	15,374
Little Wabash River	1,182
Embarrass River	226
Saline River	104
White River	1,000
	40,761
Rivers, Impounded (Locks & Dams)	
Ohio River	99,986
Kentucky River	13,063
Green River	6,900
Barren River	455
Cumberland River	29,950
	150,354
Reservoirs	
*Corps of Engineers over 1,000 acres at seasonal or conservation pool	143,865
*Other reservoirs over 1,000 acres	66,517
	210,382
Natural lakes, over 1,000 acres	13,376
	414,873

*Non-polluted waters only.

TABLE 8 - POTENTIAL COMMERCIAL FISHERY HABITAT - OHIO RIVER BASIN - 1980

Potential Habitat (acres) - 1960		Additional Acres to be available by 1980	Total Potential Habitat in 1980
Rivers, free-moving	40,761	-11,740	29,021
Rivers, Impounded (Locks & Dams)	150,354	69,860	220,214
Reservoirs (over 1,000 acres at seasonal or conservation pool)			
Corp of Engineers	143,865	151,425	295,290
Other Reservoirs	66,517	11,215	77,732
Natural Lakes (over 1,000 acres)	13,376	-	13,376
	414,873 acres	220,760 acres	635,633 acres