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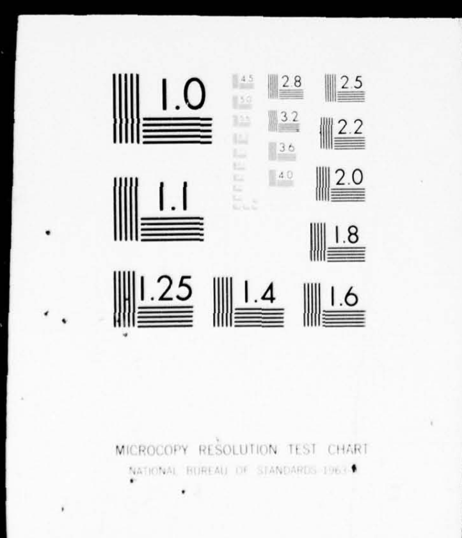
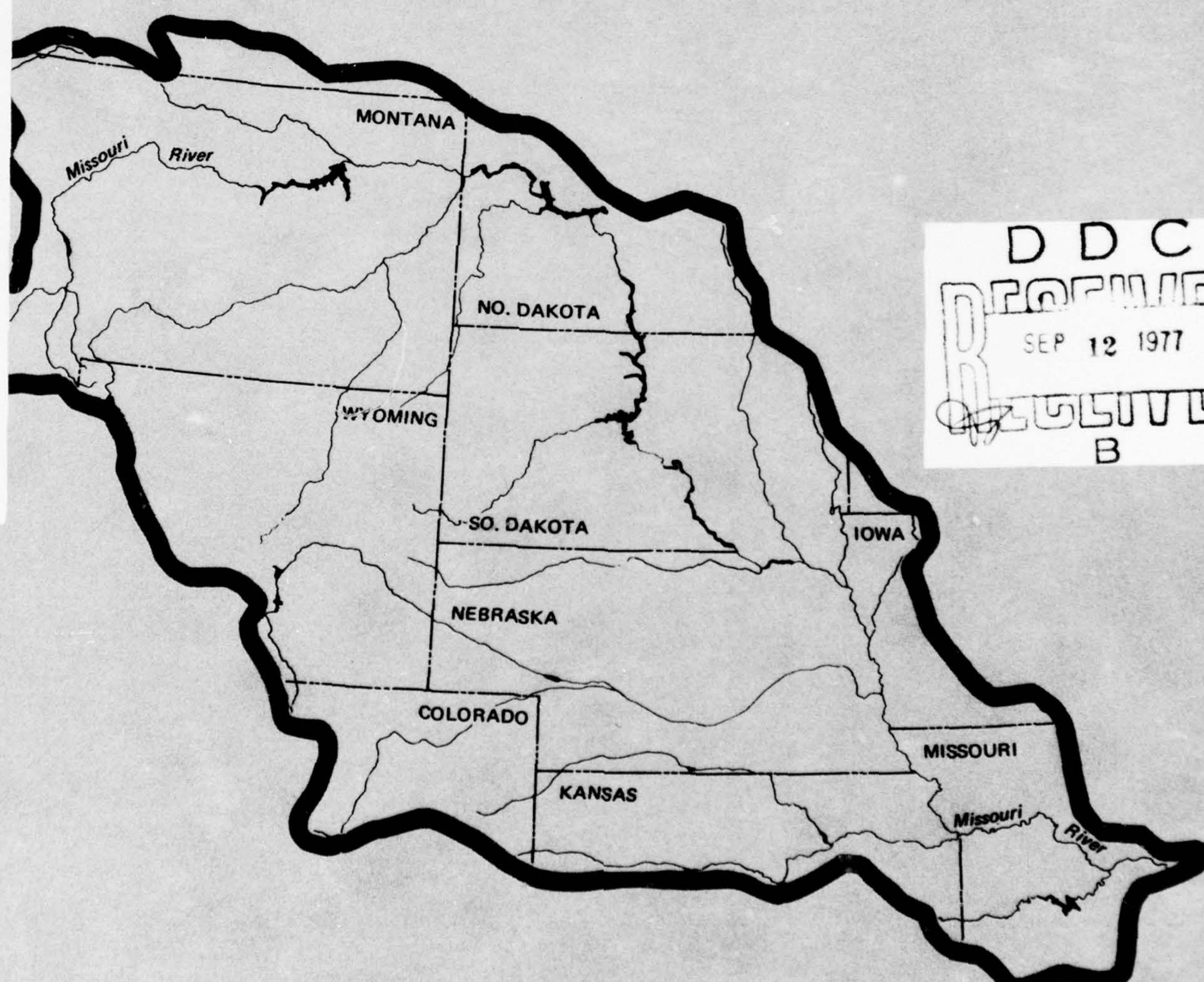


The Missouri River Basin Comprehensive Framework Study

• Present and Future Needs

Volume 5 **Appendix**



Missouri Basin Inter-Agency Committee
Standing Committee
June 1969

Published December 1971

COMPREHENSIVE FRAMEWORK STUDY
MISSOURI RIVER BASIN.

VOLUME 5.

APPENDIX.

PRESENT AND FUTURE NEEDS.

MISSOURI BASIN INTER-AGENCY COMMITTEE

June 1969

294 p.

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

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MISSOURI RIVER BASIN

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APPENDICES

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History of the Framework Study

Existing Water and Land Resources Development

Volume 3 – Laws, Policies, and Administration Related to Water Resources Development

Volume 4 – Economic Analysis and Projections

*Volume 5 – Present and Future Needs

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Hydrologic Analyses and Projections

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FIGURE 1

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FOREWORD

The task of assembling information and preparing this appendix was assigned to the "Work Group on Present and Future Needs". The "work group" acted as a guiding and reviewing body. Seven "task forces", organized along functional lines, provided the special skills and talents required in making the studies. Chairmen of these task forces were selected from Federal agencies having expertise in each function. Task force members were selected from both Federal and State agencies having a planning or regulatory responsibility involving water and land resources.

Figure 1 shows the organization adopted by the Missouri Basin Inter-Agency Committee to conduct the study and personnel assigned to the work group and task forces.

SUMMARY

At the threshold of America's 200th birthday, our leaders are properly concerned with the status of our natural resources, and particularly water. In directing this report, the Congress used the term "Comprehensive" – having a wide scope. The many writers and technical people who have put together the material for this specialized appendix have tried to make it also "Comprehensible" – capable of being understood.

Those readers who seek the detail contained in the appendices are entitled to the easiest possible communication with those who have studied the basin. Although the backgrounds of those who read may vary greatly, this appendix attempts to state the problems as simply as feasible and to set forth needs that are realistic. The basin problems are necessarily complex. Possible solutions usually contain a time factor which is not precise.

Recognizing these complexities in advance, but understanding the sincere concern of the specialists in facing them, the reader may share the difficulties and also the gratification in trying to use the basin's resources to the optimum.

That part of the basin within the United States comprises 519,300 square miles, or one-sixth of the area of the 48 contiguous states. It is an area of physical as well as climatic extremes. Natural resources available for development are abundant, but vary from place to place within the basin. Population density ranges from one person for 2 square miles in Garfield County, Montana, to high concentrations in the larger metropolitan areas of Denver, Colo., and Kansas City, Mo.

Despite the size and extremes of the basin, the needs and desires to control and use the water resources are remarkably similar throughout the basin. Overall, they involve the use of water and related lands to create a balanced living environment for the next 50 years. In this they involve the use of water for drinking, industry, sanitation, agriculture, navigation, recreation, and fish and wildlife; and for the control of floodwaters.

Purpose

It is the purpose of this appendix (1) to present facts and findings of extensive studies on existing needs and uses of water, (2) to analyze and project the needs for water in the years 1980, 2000, and 2020, and (3) to set forth needs for associated changes in land use.

The basin needs have been expressed in a wide variety of positive terms such as pounds of meat, kilowatt-hours, recreation-days, etc., which are convenient and necessary units by which to express the needs for water and related changes in land use. Since the desired end-product is an evaluation of such needs for water and related land-use changes, these terms have been used to the extent possible. Inasmuch as needs in the field of flood control and erosion prevention do not lend themselves to the use of these terms, they are defined and evaluated in average annual damages.

In general, the needs for water are expressed in diversion requirements, and in consumptive use. In most instances, much of the water diverted is returned to streams and is available for reuse; therefore, diversion or farm-delivery requirements cannot be added in order to obtain any meaningful total figure. Also, some uses are complementary, or overlapping in effect. As an example, water supplied to meet navigation requirements is also available to help fulfill the requirements of municipalities, industry, quality control, fish and wildlife, and for recreation. Return flows from irrigation developments can be used to meet or serve other functions.

A need associated with the general well-being of people is the prevention and control of vectors and vector-borne diseases that constitute public health hazards. Mosquitoes, horseflies, and deerflies are the more serious vectors associated with the management and control of the basin's water resources. Prevalent habitat for these vectors are inundated floodplains, ponded and seeped areas associated with improper irrigation practices, and ponded areas in open treeless prairie regions which are largely under cultivation. Specific needs for vector control have not been developed in this study, although fulfillment of the needs for flood control, irrigation system rehabilitation, agricultural drainage, and soil and water conservation will be an improvement in vector control. Further, it is assumed that vector controls will be included in the design, construction, and operation of the potential water resource developments.

The need for changes in land use are summarized for specific or primary purposes, and for ancillary uses. Land devoted to ancillary use for one purpose, can also readily serve in complementary fashion for other purposes, such as fish and wildlife and recreation. Agricultural croplands can frequently be used in a dual role to meet recreation and wildlife needs.

AGRICULTURE

Agriculture is the largest industry in the Missouri Basin. The basin's production is an important part of the Nation's agricultural production. About 312 million acres of the basin's land is used for some kind of agriculture, including forestry. Cropland is estimated at 104 million acres, of which 6.9 million acres are irrigated. An additional 189 million acres are used for grazing, of which about 0.5 million acres are fully or partially irrigated.

With 25 percent of the Nation's cropland, the Missouri Basin regularly produces a third or more of the Nation's wheat, 40 percent of the rye, 30 percent of the sugar beets, 50 percent of the flaxseed, and 25 percent of the Nation's cattle, hogs, and sheep. It also produces between 20 and 30 percent of the feed grains such as corn, barley, and sorghums. The current normal crop production capability exceeds demand placed on the basin by about 7 percent.

The number of farms has decreased from 528,000 in 1949 to 380,000 in 1964, and this trend is expected to continue, but at a lesser rate. The decline in the number of farms results in an increasing size of farm and a decreasing rural population; however, gross farm income is projected to increase from $5.3 billion in 1960 to over $14 billion in 2020.

Food and fiber requirements for the basin are projected to exceed current normal production levels approximately 2.2 times by 2020. Commodity requirements by time periods are indicated below and are summarized in chapter 2.

AGRICULTURAL PRODUCTION IN TERMS OF CROP AND FORAGE PRODUCTION REQUIREMENTS FOR THE MISSOURI RIVER BASIN

Year	***Production Index***
Current Normal	100
1980	134
2000	164
2020	207

The projected capability of the agricultural resources, considering only technological improvements, land conservation, and improved livestock feeding efficiencies, is estimated to be able to meet the projected food and fiber requirement of the basin through the year 2000. Increased production of approximately 5 to 10 percent by means other than those specified will be required by 2020 to meet the basin's production requirements. This additional production will be provided by some combination of alternative means. Irrigation of 7.6 million acres of cropland now dry farmed is the only single method that could meet all the increased needs by 2020. Conversion of 20 million acres of pasture and rangeland to cropland could meet about 80 percent of the increased needs; flood protection of agricultural lands about 15 percent; drainage of croplands less than 10 percent; and rehabilitation of existing irrigation systems less than 5 percent. A combination of these methods will undoubtedly be used to satisfy the increased needs of the basin beyond 2000.

Most of the 7.4 million acres of land now irrigated is in the western and central or more arid parts of the basin. However, residents of the more humid parts of the basin are beginning to recognize the value of diversity and stability afforded by irrigated agriculture. A foreseeable potential exists for additional irrigation development on 10,855,000 acres although 64 million acres are physically suitable for irrigation.

Average annual crop yields from lands can be increased substantially through irrigation for all parts of the basin. In addition, the variation of annual yields from the normal average, with irrigation, would be reduced two to two-and-one-half times. Irrigation permits a diversity of crops to be grown and to plan farming operations well in advance, thereby reducing hazards associated with the one- or two-crop economy and achieving greater economic and social stability.

The desire of the basin's farmers to attain local and regional stability plus the basic profit motive can be expected to encourage large-scale irrigation developments and to improve the existing irrigation systems long before a need for increased agricultural production is reached at a national level. Increased agricultural production may be attainable through improvements to existing irrigation systems or through combinations of systems as indicated by the following tabulation:

POTENTIAL FOR EXISTING IRRIGATION SYSTEMS

Ditch Consolidation	3,369 miles
Ditch Lining	5,392 miles
Drainage Ditches (service area)	717,000 acres
Storage Requirements	1,180,000 acre-feet
Total New Water Available	1,415,000 acre-feet
Storage Water and Saving in Transportation Losses	269,000 acre-feet
Increased Net Future Water Depletion	196,000 acre-feet
Equivalent Irrigated Area	(499,000 acres for production only)

Much of the flood control which would benefit croplands will be needed for other purposes before 2020. Consequently, it is thought that many of these potentials will proceed at a fairly uniform rate from the present time. If the anticipated increase in production of the basin's existing agricultural plant materializes, agricultural production somewhat above the basin's share of national needs can be expected.

An estimate of the probable irrigation development in the basin by 2020 would require a complex coordination with the needs for agricultural products, for regional stability, and availability of water. Such a determination is beyond the scope of this part of the study and, consequently, no estimate is given of the amount of water required for irrigation. Water used by livestock, including evaporation of water from stockponds, is expected to increase from 1.1 million acre-feet per year in 1965 to 2.3 million acre-feet per year in 2020. The increased water consumption expressed in million gallons per day, and other data, are summarized in the following tabulation:

LIVESTOCK WATER REQUIREMENTS

	1980	*2000*	*2020*
		(Cumulative)	
Increased Consumption			
(million gallons per day)	195	414	708
New Farm Ponds			
(number in thousands)	58	95	116
Source of Water (percent)			
Ground	54	53	52
Surface	46	47	48

Agricultural land in the basin with a drainage problem and considered potentially suitable to drain for agricultural purposes totals 5.1 million acres. Of the total, it is estimated that 2 million acres will require group action for effective results and about 3 million acres can be accommodated through individual action.

POTENTIAL AGRICULTURAL DRAINAGE

	(Thousand Acres)
Cropland	1,908.8
Pasture and Range	2,593.2
Forest and Woodland	605.3
Total	5,107.3

Agricultural land areas subject to flood damages total 14.1 million acres and land areas subject to gully erosion amount to 2 million acres.

Land conservation treatment is needed to maintain past accomplishments and to increase the amount of adequately treated cropland and other agricultural land.

AGRICULTURAL AND OTHER LAND NEEDING CONSERVATION TREATMENT

Item	Proper Management Practices Only	Proper Management & Vegetative and/or Mechanical Practices	Total
	(Thousand Acres)		
Private Land			
Cropland	31,660	34,227	65,887
Pasture and Range	65,496	25,032	90,528
Forest and Woodland	5,356	1,419	6,775
Other (Ag. and Non-Ag.)	885	1,062	1,947
Total	103,397	61,740	165,137
Federal Land			
Pasture and Range	6,781	3,602	10,383
Forest and Woodland	1,729	1,126	2,855
Other (Ag. and Non-Ag.)	174	267	441
Total	8,684	4,995	13,679

Annual timber growth in the basin is about double the cut. This relationship is expected to continue through 2020, and will result in a large inventory of commercial timber by 2020. There appear to be prospects for increasing water production from some of the higher mountain drainage areas by application of appropriate forest management practices.

MUNICIPAL, RURAL DOMESTIC, AND INDUSTRIAL WATER SUPPLY

The population of the Missouri Basin is expected to grow from a 1965 total of 8,560,000 to 20,100,000 by 2020. Most of these people reside in 2,120 municipalities. In 1965, some 1,773 of these places, with 73 percent of the basin population, were served by central water systems. By year 2020 it is expected that 18,800,000 persons or 94 percent of the basin population will be served by central water systems. The population requiring central water system service in 2020 will demand 3,118,000 acre-feet of water, up from the 976,000 acre-feet being used in 1965.

People in the rural-domestic classification with individual water supplies number 2,280,000 and use 87,000 acre-feet annually. By the year 2020, demand is expected to decline to 79,000 acre-feet for the 1,300,000 people then on individual water systems.

The projected 2020 water demand for mineral production will be 192,000 acre-feet, up from 82,000 acre-feet in 1965. All other industrial users, exclusive of thermal-electric demand and industries supplied by municipal systems, diverting 405,000 acre-feet in 1965, will need diversions in the magnitude of 1,862,000 acre-feet by year 2020.

The demands for water for thermal-electric power production are projected to grow from 1,724,000 acre-feet in 1965 to 4,878,000 acre-feet in 2020.

Total municipal, domestic, and industrial demand will grow from the present diversion rate of 3,274,000 acre-feet per year to a 2020 diversion of 10,129,000 acre-feet if all projected demands are to be met.

INCREASED MUNICIPAL AND INDUSTRIAL WATER NEEDS

	1980	*2000*	*2020*
	(Cumulative Above Current 1,000 AF)		
Withdrawal Requirements	2,485	4,624	6,855

At the present time, 18 percent of the municipal, domestic, and industrial total demand is met from ground water and 82 percent from surface water diversions. Approximately 60 percent of the municipal, domestic, and industrial water demands are met by diversions of flow which in some part have returned to a river from a previous upstream municipal or industrial use. The percentages of surface and ground-water utilization are considered to remain about the same in the future. Reuse of return flow may increase in the future, but the current level of technology suggests that, with an increasing degree of waste treatment, consumptive use of water may also increase.

Of the present 1,773 municipal water systems, 140 are inadequate when compared with framework planning criteria adopted for this study. Six of the systems rated inadequate require additional capacity and 134 have poor water quality. In addition, improvements would be desirable for 435 other communities.

ELECTRIC POWER

In 1965, electric power installations and production in the Missouri Basin were 10.2 million kilowatts and 39.0 billion kilowatt-hours, respectively. Installation capacity exceeded peak basin demands by 2.4 million kilowatts. Energy production exceeded the demand by 2.1 billion kilowatt-hours, the net export from the basin. By the year 2020, basin power demands will increase to 125.9 million kilowatts and 637.0 billion kilowatt-hours. The power supply and production by 2020 will exceed that of 1965 by 135.0 million kilowatts and 615.9 billion kilowatt-hours. About 97 percent of the 2020 capacity will be supplied by thermal generation, and the remainder by hydro-generation. About 41 percent of the thermal installations in 2020 will be nuclear plants, which are expected to show a marked increase in installed capacity after 1980. Most of these plants will be located near population centers in the lower portion of the basin. Many of the remaining thermal installations will be fossil-fuel plants, most of which will be located in the Yellowstone and Western Dakota subbasins because of the availability of coal and potentially adequate water supplies.

Cooling water needs for thermal generation will increase from a diversion rate of 1,724,000 acre-feet per year with an associated consumptive use of 36,800 acre-feet in 1965, to a diversion of 4,878,000 acre-feet per year with an associated consumptive use of 590,100 acre-feet by 2020. An estimated 14 percent of the increase in consumptive use of water will occur by 1980 and 56 percent by 2000.

ELECTRIC POWER PRODUCTION NEEDS

Feature	Unit	1980	2000	2020
		(Cumulative Above Current)		
Installed Capacity				
Hydro	MW	3,267	3,267	3,267
Thermal	MW	12,934	62,730	131,790
Total	MW	16,201	65,997	135,057

ELECTRIC POWER WATER REQUIREMENTS

Feature	Unit	1980	2000	2020
		(Cumulative Above Current)		
Condenser Cooling	AF/year	6,119,800	23,063,000	40,652,300
Streamflow Diversions	AF/year	1,398,400	2,576,500	3,154,000
Cooling Water Consumption	AF/year	78,700	308,900	553,300

FISH AND WILDLIFE

About 97 percent of the entire basin area is used to some extent by fish or wildlife; however, only 0.3 percent of the area is totally devoted to this use. An additional 2.7 percent of the basin area serves a primary use for fish and wildlife.

The basin provides 43,500 miles of streams and 1.4 million acres of ponded waters. Streams and lakes of the mountainous west and Black Hills provide excellent trout fishing. Some of these streams, such as the Upper North Platte, Madison, and Yellowstone rivers, are known nationally and support a substantial non-resident demand. Pike and bass and various other warm-water species provide fishing in the streams and lakes of the plains area. Put-and-take trout fishing is maintained at a few favorable locations. Bass and several other warm-water species are of primary importance in the warm-water areas of the basin. The basin supports a small commercial fishery, principally at the larger impoundments.

The total Missouri Basin demand for sport fishing of about 28 million fisherman-days is presently less than the capacity of the habitat that will sustain good fishing, but demand will exceed that capacity shortly before 1990. In the Middle Missouri and Lower Missouri, demand now exceeds the supply and it will do so in the Platte-Niobrara and Kansas subbasins by 1980. Fishing demand in the upper four subbasins is well below total capacity now and, while demand will increase significantly, the capacity will not be exceeded by 2020.

The basin supports a wide variety of wild game. Deer are most numerous and the most important big game in all parts of the basin. In 1960, the deer supply exceeded the demand in the Upper Missouri, Yellowstone, Western Dakota, and Platte-Niobrara subbasins. However, in 2020 the demand will exceed the supply in all subbasins. Many areas in the western subbasins carry important populations of antelope, elk, moose, Bighorn sheep, Rocky Mountain goat, and bear, but the demand for hunting these animals far exceeds the available supply. Hunting is well controlled, and with continuing management a substantial harvest can be sustained for all big-game species through the foreseeable future.

Small game, including upland game birds, is found in all areas, the species varying considerably in number and importance throughout the basin. Substantially more upland-game hunting could be provided if mourning doves were hunted in all states. In 1960, the supply of small game exceeded the hunting in all subbasins, with the largest surplus in the Eastern Dakota and Lower Missouri subbasins. By 2020 the supply will be deficient in all subbasins.

Waterfowl are found in all parts of the basin with the largest numbers in the Eastern Dakota, Platte-Niobrara, and Middle Missouri subbasins. In 1960 waterfowl hunting of 1.7 million hunter-days was in excess of the supply for the basin. The 2020 demand for waterfowl hunting will far exceed the supply.

Although the demand and supply varies with the type of hunting and location, the 1960 demand of about 17 million hunter-days was about equal to the basin's capacity to provide hunting. This demand will more than double by 2020. The capacity of the basin to supply the added hunting will gradually decrease by a small amount through 2020.

Realization of the land and water use changes, together with maintenance of streamflow in 4,600 miles of the basin streams now dewatered periodically by diversions, and restoration of about 2,400 miles of the basin's polluted streams would materially enhance the fish and wildlife resources. However, even with these changes, the basin's projected needs could not be met.

INCREASED LANDS NEEDED FOR FISH AND WILDLIFE

Purpose	1,000 Acres	Use From	Use To
Wildlife Habitat Enhancement	11,600	Various uses	Primary use
Wildlife Wetland Preservation	1,329	Various uses	Wildlife use
Wildlife Upland Preservation	35	Various uses	Wildlife use
Wildlife Habitat Development	2,119	Various uses	Wildlife use
Fishing Access	49	Various uses	Fishing use
Fishing Reservoirs	70	Various uses	Fishing use

FISHING- AND HUNTING-DAY NEEDS

Feature	Unit	1980	2000	2020
		(Cumulative Above Current)		
Fishing	1,000 F.D.	(-5,510)[1]	8,306	28,163
Hunting	1,000 H.D.	5,659	14,834	26,120

[1] Excess capacity available for meeting needs in the basin; however, some subbasins are short of capacity to meet needs.

OUTDOOR RECREATION

Portions of the basin, such as the Rocky Mountains, Black Hills, and the Ozarks have a Nationwide reputation as being desirable recreation areas. The reputation of the Rocky Mountain area is further enhanced by Glacier, Yellowstone, and Rocky Mountain National Parks. The nationally known recreation areas attract many nonbasin residents and also residents from other parts of the basin.

About 50.2 million acres of the basin's land and water surface areas are used currently to some extent for recreation. Of this area, about 174,000 acres have been developed to various degrees. Less than 1,500 acres are highly developed. Of the 50.2 million acres, 6 percent is associated with scenic, historic, and natural areas, 11 percent with water-oriented recreation areas, and 83 percent with land-oriented recreation areas.

The 1965 demand for recreation was estimated to be 286 million activity-days, exclusive of hunting and fishing. Of this demand 95 million activity-days were for nonbasin residents.

Although there are local recreation land and facility surpluses in some areas, all subregions show overall deficits between 11 and 28 percent. The greatest shortages are in the four subregions representing the populous southern part of the basin. In general, the greatest shortages are for adequate camping, boating, and water-skiing facilities.

Projected demands for recreation activities total 1.14 billion activity-days in 2020, exclusive of hunting and fishing. Of this total demand, about 380 million activity-days are for nonbasin residents. The Platte-Niobrara and Lower Missouri subregions' projected demand greatly exceeds that of the other subregions. To provide for the recreation demands in 2020 will require changes in land use to that shown below:

RECREATION WATER AND LAND NEEDS

Type of Recreation	*1980*	*2000*	*2020*
	(Cumulative Above Current – Millions)		
Recreation Water (acre)	0.23	0.72	1.50
Recreation Land			
Developed (acre)	0.15	0.37	0.60
Primary Use but			
Undeveloped (acre)	1.19	2.81	4.43
Activity Days	174	484	854
Recreation Days	68	186	343

FLOOD CONTROL AND EROSION PREVENTION

Highly destructive floods have occurred in all eight subbasins and along the mainstem of the Missouri River. In general, floods are caused by snowmelt, heavy rainfalls, or ice jams; or a combination of any of these factors. Flood damages occur much more frequently in the lower portion of the basin because of a higher development of flood plains and a higher susceptibility of the area to intense rainfalls over broad areas. Devastating floods have also originated in the western mountain areas, such as on the Sun and Marias rivers in 1964, and on the South Platte River in 1965. Ice jams can occur on most of the perennial streams in the basin. Small tributaries have produced destructive floods in all parts of the basin.

Based on the 1965 level of development, average annual flood damages for the entire basin are estimated to be $95.5 million. Thirty-five percent of these damages are associated with the Lower Missouri Subbasin. Average annual damages to other subbasins are progressively less upstream, with only 1.6 percent being assigned to the Upper Missouri Subbasin. With a 2020 level of development, average annual flood damages for the basin are estimated to be $392.3 million. Average annual benefits (flood damages prevented) associated with existing flood control work at the 1965 and 2020 levels of development are $105.5 million, and $579.1 million, respectively.

Streambank erosion is causing serious damage to about 11,200 bank-miles of the basin's rivers. This represents about 1 percent of the total length of all channels not classified as gullies. Based on the current level of economic development, average annual damages due to streambank erosion are estimated to be $5.1 million. However, with projected economic development, these damages will increase to about $13.6 million annually by 2020 if no additional protection is provided. About one-half of these damages will occur in the Middle Missouri and Kansas subbasins, with the remaining one-half spread evenly among the six other subbasins.

About 40,000 acres of land are damaged each year by gullies which would require project-type action to correct. Current average annual damages are estimated to be $15.4 million and, unless corrective measures are implemented, damages are estimated to increase to $50.4 million by 2020. About 83 percent of these damages will occur in the Lower Missouri and Middle Missouri subbasins.

AVERAGE ANNUAL FLOOD AND EROSION DAMAGES

Feature	Unit	1980	2000	2020
Flood Damages	$1,000/year	152,535	241,270	392,260
Gully Erosion	$1,000/year	23,411	33,849	50,366
	1,000/acre	2,041	2,041	2,041
Streambank Erosion	$1,000/year	7,300	10,000	13,600
	Miles	11,200	11,200	11,200

NAVIGATION

Commercial navigation is confined to the lower portion of the main stem of the Missouri River. The authorized navigation channel is from Sioux City, Iowa, to the mouth of the river near St. Louis. The effective season usually comprises about 8 months from April to December.

Commercial barge traffic can be expected to increase from 1,078 million ton-miles in 1964 to 3,300 million ton-miles in 2020, an increase of 200 percent in 56 years. About 70 percent of this increase can be expected by 1980 and over 95 percent by 2000. Water requirements to maintain the authorized navigation channel are estimated to be 30,000 c.f.s. at Sioux City and 32,500 c.f.s. at Kansas City. Flow during an 8-month period at 30,000 c.f.s. amounts to a total volume of 14.5 million acre-feet.

WATER QUALITY CONTROL NEEDS

The principal elements of water pollution in the Missouri Basin are bacterial agents, organic waste matter, undissolved solids, dissolved solids, and temperature. The sources of bacterial and organic pollutants considered in this study were municipal and industrial waste discharges and animal wastes from major confined feeding operations. Undissolved solids pollutants include sediments, oils, and refuse from manufacturing processes. Natural runoff contributes practically all of the dissolved solids in the basin's waters. A small fraction of the total dissolved solids is contributed in municipal and industrial wastes and irrigation return flows, but may add undesirable or toxic constituents. Most uses deplete the water and return or leave the dissolved solids. The resulting increase in dissolved solids concentration is included among the pollution or water quality problems. Stream temperatures normally vary with the average air temperature. However, the temperature of a stream can be raised locally by warm effluents from industrial processes and irrigation return flows. Conversely, stream temperatures may be lowered for short reaches by reservoir releases. The resultant changes in temperature may affect the biologic regimen of the stream and the fishery habitat.

Water quality criteria applicable to streams adapted for this study are as follows:

1. A dissolved-oxygen concentration of 7 milligrams per liter (7 mg/l) for cold-water fisheries and 5 mg/l for warm-water fisheries and other surface waters.
2. A total dissolved-solids concentration of 500 mg/l average as desirable, and 1,500 mg/l as usable.
3. A limit of 5° F. for temperature increase resulting from thermal discharges.

These criteria are equal to or compatible with the present State water quality standards developed in harmony with the Federal Water Quality Act of 1965 and the Clean Water Restoration Act of 1966. To meet the criteria, treatment of all municipal and associated industrial wastes with a B.O.D. removal of 85 percent by 1980, 90 percent by 2000, and 95 percent by the year 2020 was assumed.

In 1965 there were 1,773 municipalities or places in the basin which had public water supplies. Only 1,308 had public sewerage systems, 101 had no waste-water treatment, 198 provided primary treatment, and 1,009 provided secondary treatment of waste discharges. Treatment by these plants reduces the pollution load to the basin's streams from a population equivalent of 16.8 million to just over 9.0 million.

To meet the indicated criteria will require the enlargement of 1,009 secondary treatment facilities, the addition of 198 secondary treatment to existing primary facilities, and construction of 731 new secondary treatment facilities throughout the basin by 1980. Upgrading of facilities will continue and new facilities will be added until by 2020 there will be 3,870 tertiary treatment plants throughout the basin. The municipal waste loading, treatment objectives, and residual waste discharged to the basin's streams are summarized in the following table.

MUNICIPAL WASTE TREATMENT REQUIREMENTS

Year	Waste Load Domestic	Waste Load Industrial	Waste Load Total	B.O.D. Removal	Waste Load of Effluent Discharged
		(1,000 P.E.)		(Percent)	(1,000 P.E.)
1980	8,982	15,588	24,570	85	3,686
2000	13,363	23,152	36,515	90	3,652
2020	18,840	32,905	51,745	95	2,588

It will be noted that after treatment needs are met, there still will be a residual B.O.D. to be assimilated by streamflow. This will require sufficient streamflow to maintain a satisfactory dissolved-oxygen level in accordance with accepted standards. In addition to the treatment needs, the streamflow required at each waste outfall was estimated and furnished to the planners as a "need to be met."

In 1965 the Industrial Directories list 3,409 water-using industries in the basin. Limited data were made available for only 602 industries with separate waste systems. Some industries are connected to municipal systems but the exact number is unknown. Many of the existing and potential industrial plants are expected to connect with municipal sanitary systems and their waste treatment needs have been included in the municipal treatment needs; others are expected to maintain separate waste treatment facilities and outfalls. To the extent possible, these separate needs were estimated and the streamflow requirements to maintain satisfactory dissolved oxygen levels after 85, 90, and 95 percent treatment were furnished the planners as "needs to be met." However, treatment plant costs were not estimated as it was assumed these would be private costs to be met in compliance with state water quality standards.

Cattle feeding in commercial lots is a major industry in the basin and is projected to expand. While the amount of waste loading contributed to streams from feedlots is unknown, the potential as a contributing source of pollution is recognized. Current trends and State and Federal statutes indicate that any feedlot operation which is an identified source of pollution will have waste-handling facilities installed by 1980 or sooner which will achieve nearly 100 percent control. Both control and treatment requirements were assumed as private production costs and were not included as needs to be met by framework plan facilities, nor were streamflow requirements estimated to assimilate potential B.O.D. residuals.

In addition to feedlot waste problems, agricultural operations can result in pollution due to leaching and washing of fertilizers and pesticides, soil erosion, and the concentration of dissolved solids in irrigation return flows. The extent and impact of some of these problems are much more difficult to assess than with municipal and industrial wastes; hence, no evaluation has been made in these studies. The potential impact of irrigation return flows has been evaluated in future dissolved solids levels in the surface waters. However, it is recognized that current technology does not offer an economical method for reducing the dissolved solids content of these flows.

Currently about 12.9 billion kwh of electric power is generated in the basin by thermal-electric plants utilizing flow-through cooling water. These plants divert about 1.7 million acre-feet of water annually. Gross diversion demands for flow-through cooling are projected to be 3.0 million acre-feet by 1980, 4.0 million acre-feet by 2000, and 4.3 million acre-feet by 2020. The general location and diversion demands for assumed individual thermal plant locations were estimated and these data furnished the planners as water quality needs to comply with streamflow temperature standards.

Currently the average total dissolved-solids concentration of the Missouri River flow at the mouth is about 390 mg/l. The maximum average annual main stem concentration is about 470 mg/l at Sioux City, Ia., and Omaha, Nebr. Several tributary stream reaches have high concentrations of dissolved solids such as the South Platte River at Julesburg, Colo., with 1,480 mg/l, and the Cheyenne River at Eagle Butte, S. Dak., with 1,005 mg/l. Any further basin development that uses and further depletes the existing water supply will increase the average concentration of dissolved solids. Without some kind of technological breakthrough, this form of degradation of water quality is inevitable. Maintenance of desirable and acceptable dissolved-solids quality is one need to be considered in connection with the planning of all potential water resource developments.

The water-quality degradation of surface and ground waters and the degree and sources of pollution are not well known. Data are available which have yet to be analyzed, and there is a need for additional data. A solid technical base is a prerequisite to implementation of the actions necessary for improving water quality. To achieve this objective there must be continued effort to identify and quantify waste sources; there should be obtained better quantity and quality data on the basin's streams and ground waters; and the economic effects of water quality must be evaluated.

* * * * * *

AFTERWORD

Such is the kaleidoscope of people, land, and water called the Missouri River Basin. In the chapters ahead, these basic elements are examined to determine trends and capabilities which will contribute toward a balanced resource development in the basin during the next 50 years.

The "needs" set forth in this appendix are estimated requirements which, if met, will guide planners in attaining a balanced basin development through the year 2020. It is emphasized that they are requirements only. Discussion as to the prospect of providing appropriate works and other methods to meet these requirements is beyond the scope of this particular appendix.

CHAPTER 1

BASIN DESCRIPTION

PHYSIOGRAPHY

Geographically, the Missouri River Basin is a large central sample of the United States. Without it, the Nation would lose 8 million people, much of its food and forests, far-flung natural resources, and wealth of every description. To better understand this large segment of America, with its problems and potential, a few boundaries should be described.

Lying diagonally within a huge quadrangle enclosed by the 90th and 114th Meridians and the 37th and 49th Parallels, the basin extends from the Continental Divide formed by the Rocky Mountains on the west to the Mississippi drainage on the east. Nebraska, most of Montana, North and South Dakota, and Wyoming, about half of Kansas and Missouri, and smaller parts of Colorado, Iowa, and Minnesota make up the basin.

Although similarities are common from locality to locality, diversity of physiographic features exists over broad areas. The basin is accordingly separated into major physiographic divisions and provinces as follows:

Major Division	*Province*
Rocky Mountain System	Northern Rocky Mountains Middle Rocky Mountains Wyoming Basin Southern Rocky Mountains
Interior Highlands	Ozark Plateaus
Interior Plains	Great Plains Central Lowlands

Figure 2 shows the location of each of the provinces listed.

The Rocky Mountain System consists of the mountainous area that forms the western boundary of the watershed in Montana, Wyoming, and Colorado. This division is characterized by alternating prominent mountain ranges, intermountain basins, and relatively wide valleys of major subdrainages. Elevations range from about 4,000 feet to more than 14,000 feet above sea level. Minor tributaries have steep gradients and generally V-shaped channels. The streams frequently flow through steep canyons before they enter the plains where the stream gradients are considerably flatter.

The Ozark Plateaus province of the Interior Highlands division within the watershed consists of maturely dissected plateaus in south-central Missouri. The topography varies from undulating to hilly and broken land. In the hilly and broken section, the streams are deeply entrenched meanders.

The Interior Plains division is separated into the Central Lowlands and Great Plains provinces according to physical features and geographic location. The Central Lowlands province includes the gently rolling and rolling plains in southeastern South Dakota, eastern Nebraska, northeastern Kansas, northeastern Missouri, western Iowa, and southwestern Minnesota. Adjacent to the Missouri River in Nebraska, Iowa, and northwestern Missouri, there is a large area of long rolling slopes deeply mantled with loess. In east-central Kansas and west-central Missouri, there is an extensive area consisting of nearly level to rolling plains with wide, gently sloping valleys. Along the watershed boundary in Missouri and Iowa and in northeastern Kansas and southeastern Nebraska, there are rolling areas which are dissected with well entrenched drainages.

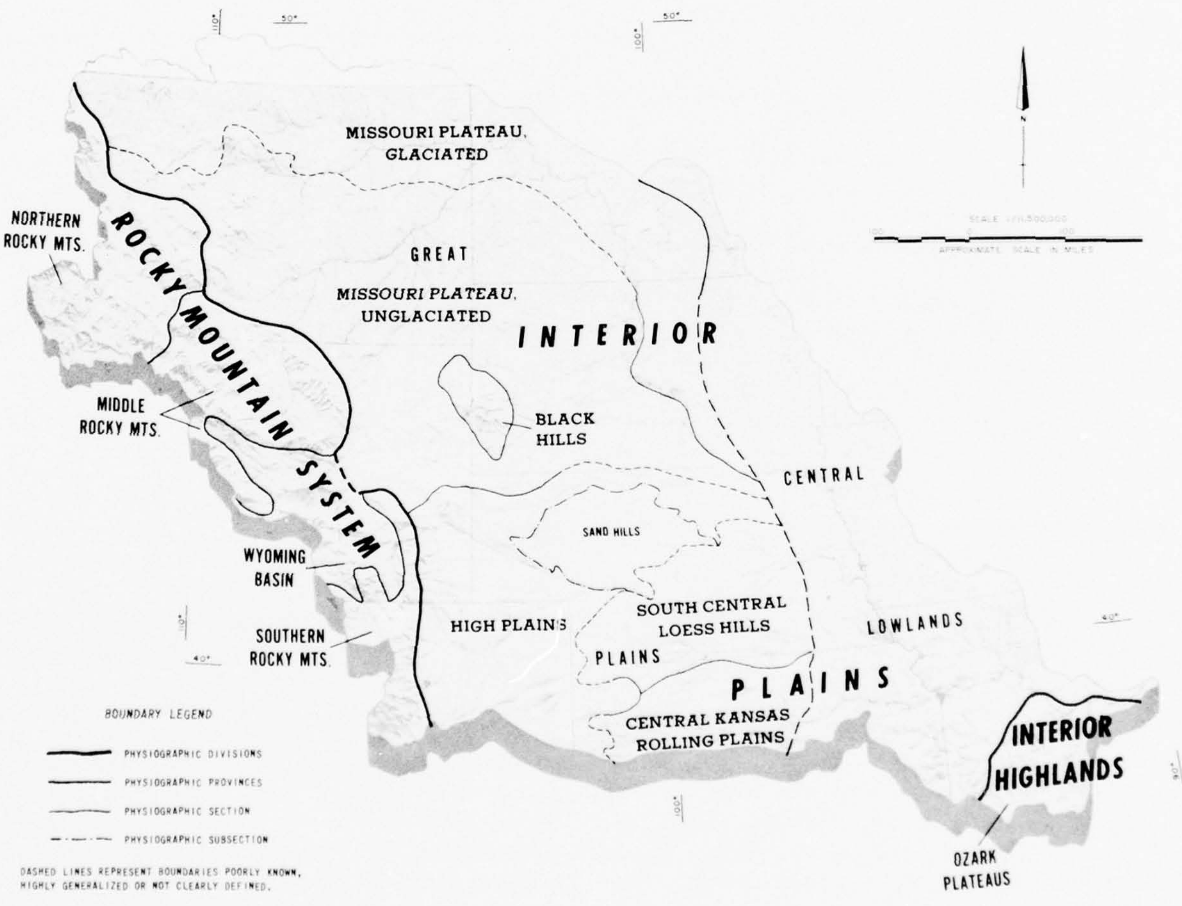
The Great Plains province of the Interior Plains is the large area between the Rocky Mountains on the west and the Central Lowlands on the east. A further subdivision of the Great Plains province has been made for the purpose of describing the area: (1) Glaciated Plains, (2) Unglaciated Northern Plains, (3) Northern High Plains, (4) South Central Nebraska Loess section, and (5) Central Kansas Rolling Plains.

The Glaciated Plains section is a broad expanse of gently rolling topography extending eastward from the Rocky Mountains across northern Montana and including those portions of North Dakota and South Dakota lying north and east of the Missouri River. Stream dissection and drainage are not well established except in areas adjacent to the Missouri River and along some of its larger tributaries. Local drainage is chiefly into pot holes, small intermittent lakes, and a few larger permanent lakes.

The Unglaciated Northern Plains section comprises the broad rolling area west of the Missouri River in North and South Dakota. It also includes most of the eastern half of Montana and northeastern Wyoming. Numerous small hilly areas, buttes, and hogbacks reach

FIGURE 2

PHYSIOGRAPHIC FEATURES



elevations higher than the general level of the plains. Although the area as a whole is rolling and rather thoroughly dissected by streams, there are small, nearly level areas on the stream divides and a few relatively large areas of gently rolling relief are scattered throughout the section. Badlands and canyon areas occur along the White River in South Dakota, Little Missouri River in North Dakota, and in the plains adjacent to the Missouri, Yellowstone, and Powder rivers in Montana and Wyoming. The Black Hills area is mountainous and has varied soil conditions. Slopes are steep to precipitous and are typically covered with stands of ponderosa pine, native grass in treeless areas, and bare, craggy rocks.

The Northern High Plains section slopes gently eastward from the Rocky Mountain front in north-central Colorado and south-central Wyoming. One part of this section extends eastward across north-central Nebraska and south-central South Dakota. The plains are characterized by nearly level to rolling tablelands with hilly to rough broken areas along the valley sides. Stream dissection is well established with broad smooth divides between the larger drainages. A distinct subdivision in the Northern High Plains section is a large area of sandhills in north-central Nebraska.

The South Central Nebraska Loess section includes a small area in northwestern Kansas. It is an area with nearly level plains, rolling land, and long narrow undissected plains remnants that form divides between a rather complete pattern of drainages.

The Central Kansas Rolling Plains section occupies a large area in north-central Kansas. Strongly rolling relief predominates over the northern and western parts of the area, with deeply entrenched drainages and occasional smooth divides between major streams. Smoother plains occur in the southern and southeastern parts.

Study Areas

Because of the immense size of the Missouri River Basin, the diversity of its climate and resources, and distribution of the population, the material and findings in this appendix are presented by subbasins or subregions, as follows:

Subbasin	*Adopted Subbasin Abbreviation*
Upper Missouri River Tributaries	Upper Missouri
Yellowstone River	Yellowstone
Western Dakota Tributaries	Western Dakota
Eastern Dakota Tributaries	Eastern Dakota
Platte-Niobrara Rivers	Platte-Niobrara
Middle Missouri River Tributaries	Middle Missouri
Kansas River	Kansas
Lower Missouri River Tributaries	Lower Missouri

Subbasins correspond to the drainage area of the stream or streams as named and as illustrated by figure 3. Subregion boundaries generally conform to the subbasin boundaries, but are delineated by county lines selected for statistical availability and economic analysis. The Missouri River which comprises only the water area of the Missouri River (and main-stem reservoirs) from Three Forks, Mont., to its confluence with the Mississippi River, will receive special consideration for hydrological analysis and the special services that it provides.

As a general rule, information herein will be designated as to whether it is by subbasin or by subregion.

SOCIO-ECONOMIC CHARACTERISTICS

During the basin's development, water and space (or land) have been the prime movers of growth. Water served as the primary means of transportation in the early years of development, as is still apparent from the present-day location of the major population centers in the basin. Today, as in yesteryears, water for agriculture, industry, and recreation, as well as space (or land), is still the dominant factor in the development or expansion of an area economy. These resources vary from place to place, as does the population density in the Missouri Basin, so that the basin could well be described as an area of transition because of the wide variation in the natural environment. Despite the size and extremes of the basin, the problems and desires of the people are remarkably similar.

Historically, the pioneers faced many problems such as transportation, water, Indians, building materials, and fencing, some of which they failed to solve fully. A determined effort to live on the plains and face the many problems was not made until after the Civil War. A century later many of the early-day problems still confront the people, such as political boundaries, climate conditions, density of population, and distance to service centers.

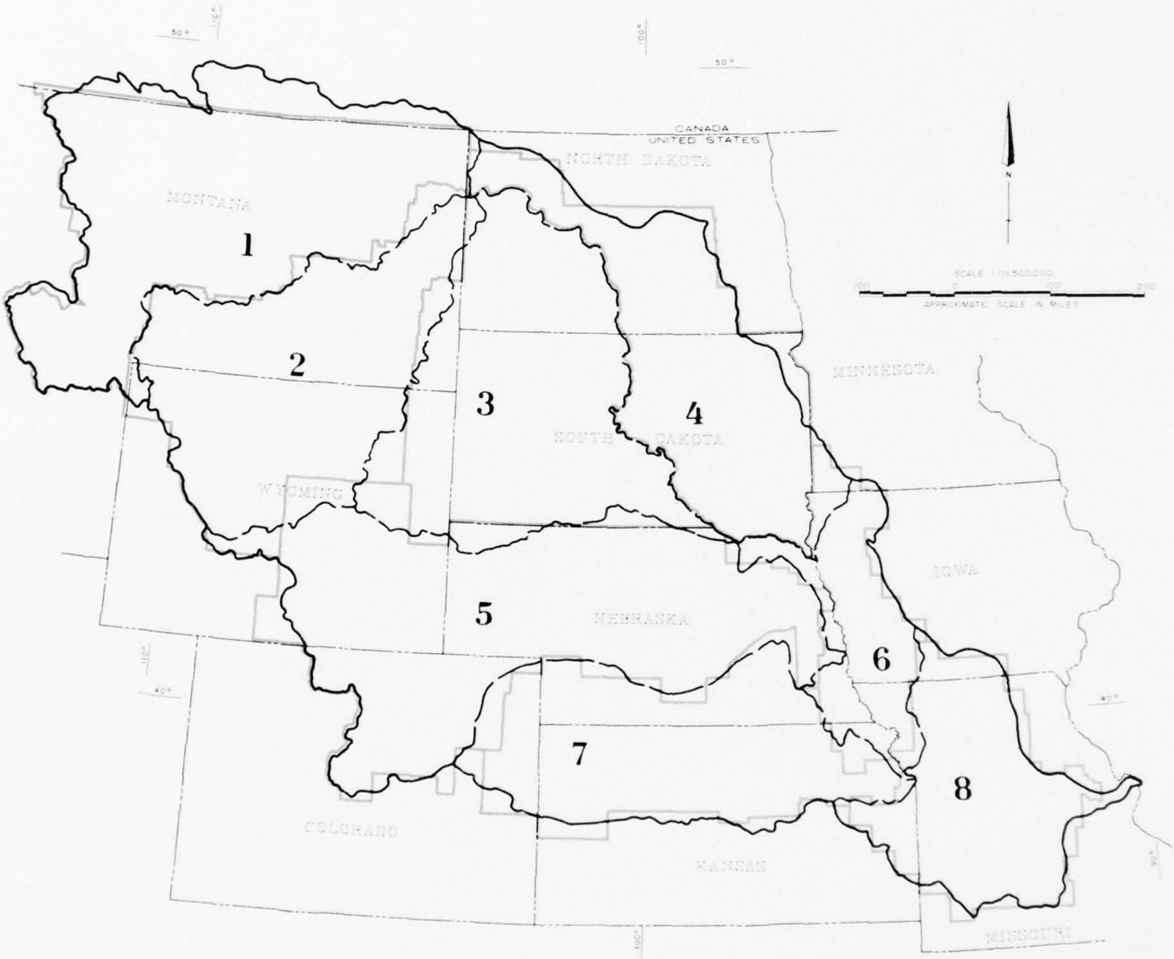
It is interesting to note that the cities along the Missouri River, and some of the mining cities, grew to regional importance; but by-and-large, the cattle centers did not.

Railroads caused the eastern gateway cities to dominate the commerce of the basin. Primarily because of the east-west alignment of the main railroads, the original economic areas developed along them. Today, the major economic regions are a series of east-west strips across the basin with one of the gateway cities at the eastern edge. Most of the "inner" towns still persist, and many perform almost the same functions, but none has attracted the institutions and industry necessary for regional domination.

The farmers and ranchers, to a great extent, have been able (with technological improvements) to adjust to an economic and social system more adapted to the

FIGURE 3

SUBBASINS AND SUBREGIONS



LEGEND

BASIN BOUNDARY

SUBBASIN BOUNDARY

STATE OR NATIONAL BOUNDARY

SUBREGION BOUNDARY

SUBBASINS AND SUBREGIONS

1 UPPER MISSOURI RIVER TRIBUTARIES
2 YELLOWSTONE RIVER
3 WESTERN DAKOTA TRIBUTARIES
4 EASTERN DAKOTA TRIBUTARIES
5 PLATTE-NIOBRARA RIVERS
6 MIDDLE MISSOURI RIVER TRIBUTARIES
7 KANSAS RIVER
8 LOWER MISSOURI RIVER TRIBUTARIES

environment of the plains. Much of the land is still best suited to the grazing of livestock in practically the same manner as was done during the late 1800's. A higher economic use of this land has not yet materialized.

Political regionalism that was apparent during the early settlement days has developed into some rather basic political philosophies. There has long been a feeling within the basin that the individual should be able to control his destiny without major interference from the rest of society or from government. However, there is also a feeling that the problems which individuals face justify assistance from this same society and government. Thus, there has been a concurrent (but somewhat paradoxical) drive by many basin residents to reduce the influence of government in their decisions while agitating for more government help to solve their problems.

The agricultural economy, most important in the basin, is composed of many thousand firms. Farming is dependent upon imports for tools and supplies. The products to a large degree are exported to outside markets. Individually, the farmer has little control over industry conditions; collectively, efforts to determine a common policy have found little success. The laws which settled the lands of the basin and the structure of local governments, communities, and services were based upon concepts and ideas used in the development of more humid regions of the Nation. All of these factors have contributed to many of the problems found in the basin today.

One significant phase of the occupation of the plains was the dispossession of the Indians. After the final struggle, the Indians were largely contained upon their various reservations. The Dawes Act of 1887 sought to hasten the integration of the Indian into society by abolishing the tribal ownership of land and allotting it to the individuals. This did not solve the problem of the Indian, but it was instrumental in making land available to the white settler.

The apparent paradox in attitudes of people in the basin toward innovation also can be found in the settlement period. There was a tendency to accept innovations which would facilitate the physical conquest of the land and climate. For example, machinery, dry farming methods, and irrigation found ready acceptance within the basin. On the other hand, innovations in social and economic institutions often were accepted reluctantly, and only after the older forms had become entirely unworkable.

This is not to say that the entire mosaic of social and economic traits to be found in the basin was established during the settlement era, for much of the character of the region is uniquely the result of events which followed. However, many of the basic economic and social characteristics have their roots in the manner by which the frontier was settled. These traits probably will continue to be characteristic of the people for some time to come and will have a bearing upon many of their future decisions.

The socio-economic aspects of this basin are considered more specifically and further discussed in relationship to population, employment, and income.

CLIMATE

The climate within the basin is determined largely by the interaction of three great air masses which have their origins over the Gulf of Mexico, the North Pacific, and over the northern polar regions. The air masses regularly invade and pass over the basin throughout the year, with the gulf air tending to dominate the weather in summer and the polar air dominating in winter. It is this seasonal domination of the air masses and the frontal activity caused by their colliding with each other which produces the general weather regimens within the basin.

Perhaps the most significant climatic factor is the remoteness of the basin from the source areas of the air masses. This means that the air masses have to cross wide land areas before they reach the basin. In crossing these areas, the air masses lose much of their available precipitation, and their air temperatures are changed considerably through contact with the land surface.

Primarily because of its midcontinental location, the basin experiences weather that is known for its fluctuations and extremes. Also there are variations between areas within the basin. Winters are relatively long and cold over much of the basin, while summers are sunny and hot. Spring is cool, moist and windy; and autumn is cool, dry and sunny. Averages are misleading for seldom does "average" weather actually occur. Instead, weather tends to fluctuate widely around the averages, with the occurrence and the degree of the fluctuations being annually unpredictable. Thus, the climatic averages have to be thought of as generalizations of the more common occurrences over a period of time.

Figure 4 shows normal annual total precipitation for the entire basin. Generally, about 80 percent of the annual precipitation occurs during the growing season. Figure 5 shows mean length of the freeze-free period, which exclusive of mountainous areas varies from about 90 to 180 days. Table 1 shows the mean relative humidity in percent for 20 locations, and figure 6 shows the mean total hours of sunshine.

POPULATION

The basin is not necessarily over or under-populated. It is the population makeup and movement and environment that result in numerous problems.

Although basin population showed an increase from 1940 to 1960, the increase was less rapid than the national average. The increase was about 34 percent

FIGURE 4

NORMAL ANNUAL TOTAL PRECIPITATION

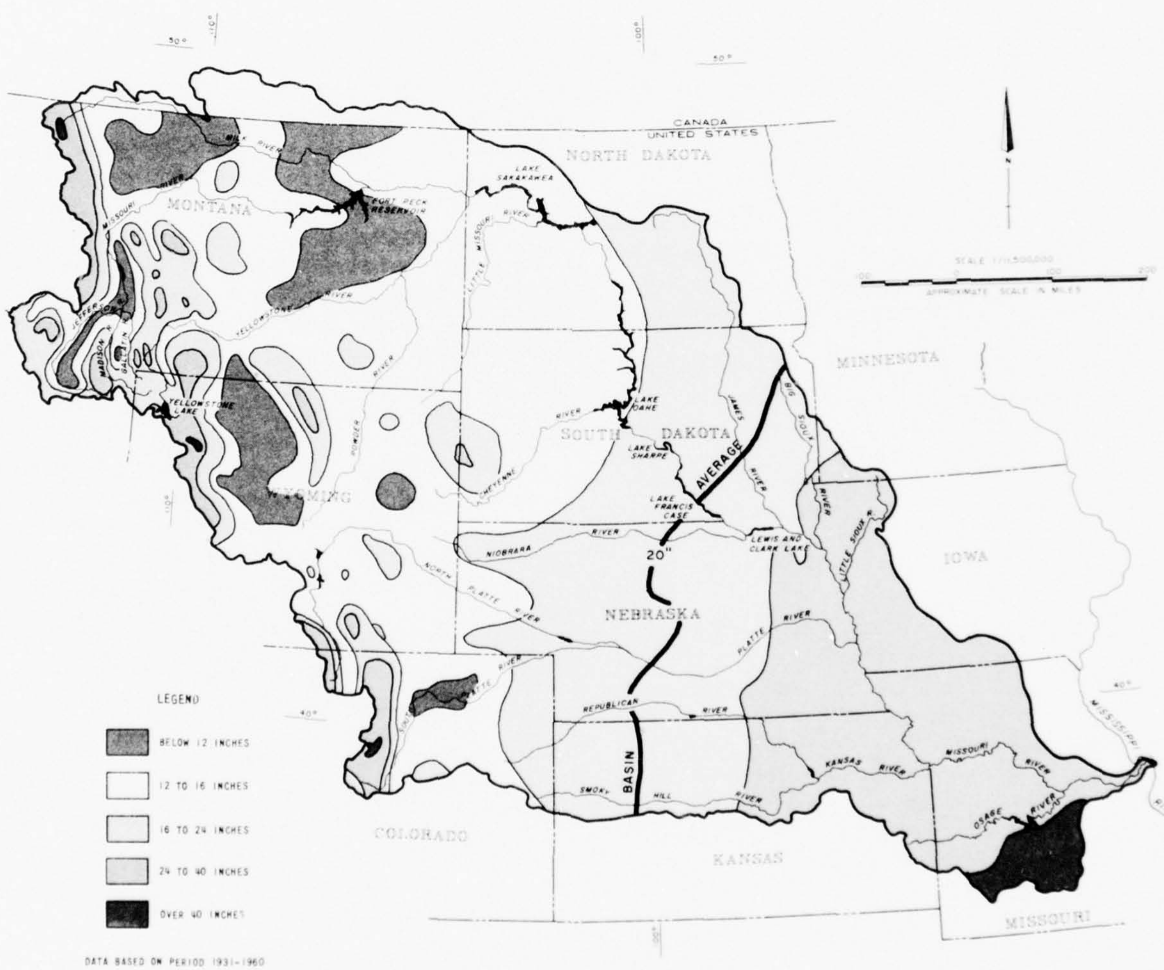


FIGURE 5

MEAN LENGTH OF FREEZE-FREE PERIOD (DAYS)

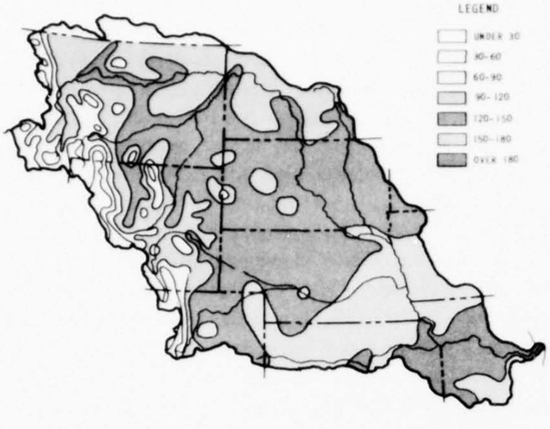


FIGURE 6

MEAN TOTAL HOURS OF SUNSHINE (ANNUAL)

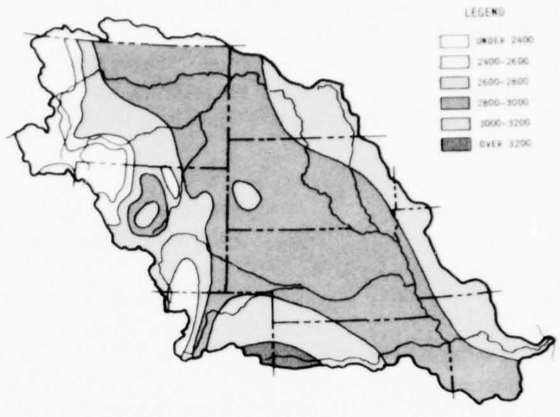


Table 1 – MEAN RELATIVE HUMIDITY (%)

STATE	Station	Year	JANUARY 1 A.M.	JANUARY 7 A.M.	JANUARY 1 P.M.	JANUARY 7 P.M.	APRIL 1 A.M.	APRIL 7 A.M.	APRIL 1 P.M.	APRIL 7 P.M.	JULY 1 A.M.	JULY 7 A.M.	JULY 1 P.M.	JULY 7 P.M.	OCTOBER 1 A.M.	OCTOBER 7 A.M.	OCTOBER 1 P.M.	OCTOBER 7 P.M.	ANNUAL 1 A.M.	ANNUAL 7 A.M.	ANNUAL 1 P.M.	ANNUAL 7 P.M.
COLORADO	Denver	20	60	60	44	49	60	67	40	39	57	67	32	34	56	62	34	35	59	64	38	40
IOWA	Des Moines	19	78	79	71	73	71	79	54	54	78	85	56	56	71	80	52	55	77	82	61	62
	Sioux City	66	76	77	68	71	74	77	52	52	79	80	52	51	74	79	52	56	77	79	58	60
KANSAS	Concordia	72	73	78	63	68	68	77	50	50	68	77	47	48	67	78	48	56	70	78	54	57
	Dodge City	67	74	79	56	62	69	76	47	47	67	76	41	44	69	78	46	52	71	78	48	52
	Topeka	18	75	78	64	67	72	79	53	53	76	81	51	50	73	80	50	54	75	81	56	58
MISSOURI	Kansas City	66	74	66	37	66	68	74	53	54	72	76	49	53	67	76	51	55	71	77	55	59
	St. Louis	65	77	77	65	68	72	73	54	58	74	73	50	55	74	76	52	58	75	76	57	61
	Springfield	68	80	82	68	72	74	77	56	57	84	82	57	60	78	82	54	61	80	81	60	63
MONTANA	Havre	50	76	82	71	78	65	79	47	44	57	74	38	35	67	79	50	54	69	79	54	55
	Helena	66	70	68	64	64	64	69	48	43	56	64	37	33	68	71	53	51	67	69	52	49
NEBRASKA	Lincoln	14	78	79	67	72	75	81	54	54	76	82	50	50	72	78	47	56	77	81	57	61
	North Platte	15	80	83	61	62	73	82	50	47	74	84	50	47	75	84	47	51	77	84	54	54
NO. DAK.	Bismarck	55	76	74	67	70	76	79	50	51	79	81	48	48	74	81	51	57	77	79	56	59
	Devils Lake	22	--	76	72	75	--	82	56	54	--	86	53	53	--	83	57	60	--	82	62	63
	Williston	43	74	74	67	69	68	76	49	47	71	77	45	41	70	79	53	53	73	77	55	55
SO. DAK.	Huron	67	78	76	72	72	76	80	54	51	79	81	52	49	75	81	52	56	79	80	60	59
	Rapid City	9	71	71	60	66	66	71	48	47	64	70	42	40	60	64	42	46	67	70	50	52
WYOMING	Cheyenne	67	61	58	48	52	68	72	47	49	65	70	36	41	64	65	39	47	65	66	44	48
	Sheridan	18	70	73	61	65	70	77	48	46	63	73	37	35	66	72	44	47	69	75	50	51

Time is Eastern Standard (75th Meridian), subtract 1 hour for Central (90th M.), 2 hours for Mountain (105th M.)
Based on records through 1959, except in a few instances, taken from "Normals, Means, and Extremes" table in U.S. Weather Bureau Publication, Local Climatological Data.

nationally and only 17 percent for the basin. While the population increased in absolute terms, the increase was less than the national population increase due to migration from the basin.

In 1960, the population of Missouri Basin was 7.9 million, or 4.5 percent of the population of the United States. Of the 7.9 million, 3.4 million or 43 percent were classified as rural. Of the rural population, 56 percent were classified as nonfarm and 44 percent as farm.

During the period 1940 to 1960 the rural population declined 17 percent. However, the overall population of parts of the basin, especially the Great Plains portion which is primarily dependent on agriculture, declined sharply in the 1930's. The depression of the early 1930's, coupled with a severe basin-wide drought during the same period, dealt the agricultural economy a devastating blow and resulted in mass movement out of the basin. General prosperity of the World War II and post-war years, with accompanying industrial development, tended to enhance the urban population.

The rural farm population decreased 40 percent between 1940 and 1960, while the rural nonfarm population increased 20 percent for the same period.

The urban population, comprising people living in cities with a population of 2,500 or more, was about 4.6 million in 1960. A summary of urban places by number and size follows:

	Urban Places in 1960	
Item	*No.*	*Percent of Population*
Total urban places	207	100.0
SMSA's[1]	11	64.8
Other urban places by number of people:		
25,000–50,000	11	8.1
10,000–25,000	34	11.0
5,000–10,000	51	8.2
2,500–5,000	100	7.9

[1] A standard metropolitan statistical area (SMSA) comprises a county or group of counties containing at least one city of 50,000 inhabitants or contiguous cities with a combined population of 50,000 or more. At least 75 percent of the labor force in a county must be nonagricultural, and the county must have a density of 150 persons per square mile.

Plate 1 shows metropolitan areas and urban places of the basin. On plate 2, population projections for the basin (and subbasins) indicate a steady basin growth to about 2½ times the 1960 population by 2020.

Prior to 1900, the basin served as a safety valve by providing the eastern population a place to move if congestion became excessive. The vast majority of people who left the basin's farms have migrated to the cities, both within and outside of the basin. Even though untrained for off-farm employment, most of these migrants have been provided with a better standard of living and greater livelihood opportunities. This has been especially true for the young, who are just beginning their productive lives. Some of the Missouri Basin States have experienced out-migration of the most productive age group (20-34). During the period of 1950-60, South Dakota, for example, lost some 94,000 persons of whom 38 percent were of this most-productive age group. These are the people in which the states have made great capital investments in education and training. This constitutes a loss of the human resource; for South Dakota it represented 23 percent of the population in the 20-34 year age group. Out-migration for the total state population amounted to about 14 percent. This is the part of the region's population that is best able to pay taxes and is most willing to make the capital improvements to stimulate permanent growth.

Agriculture has experienced a revolution or at least some drastic changes in the last decade. Modern technology has made agricultural land and labor vastly more productive. The vast production capacity of the agricultural industry has created economic conditions which make efficient use of land, labor, and capital. Ever increasing sizes of farms, either through physical expansion or intensification, have resulted. Both contribute to further problems. Intensification increases the total output of the industry and adds further to economic woes. Expansion in size eliminates employment and intensifies the migration to industries in urban areas, usually in other regions since this region is essentially agriculturally oriented. The number of farms in the Missouri Basin decreased by nearly 150,000 between 1949 and 1964, or nearly 30 percent of the 1949 level. Since 1954, about one out of every five farm operators has changed occupation or retired without being replaced. This out-migration results in repercussions both in the area of departure and the new area of arrival. The out-migration seriously affects the social and economic base of the community, county, and state. The churches, school districts, and the many community businesses and services find it difficult to continue their operations in the presence of a shrinking economic base.

Concomitant with the out-migration of rural population has been a rather dramatic increase in urban populations; however, the urban growth has been very selective. Urban centers whose business has remained that of serving agriculture have not grown. Most small towns and hamlets have actually lost population. The exceptions are the county seats or towns which have been able to retain other governmental functions, develop tourist services, or become "bedroom communities" for larger urban neighbors.

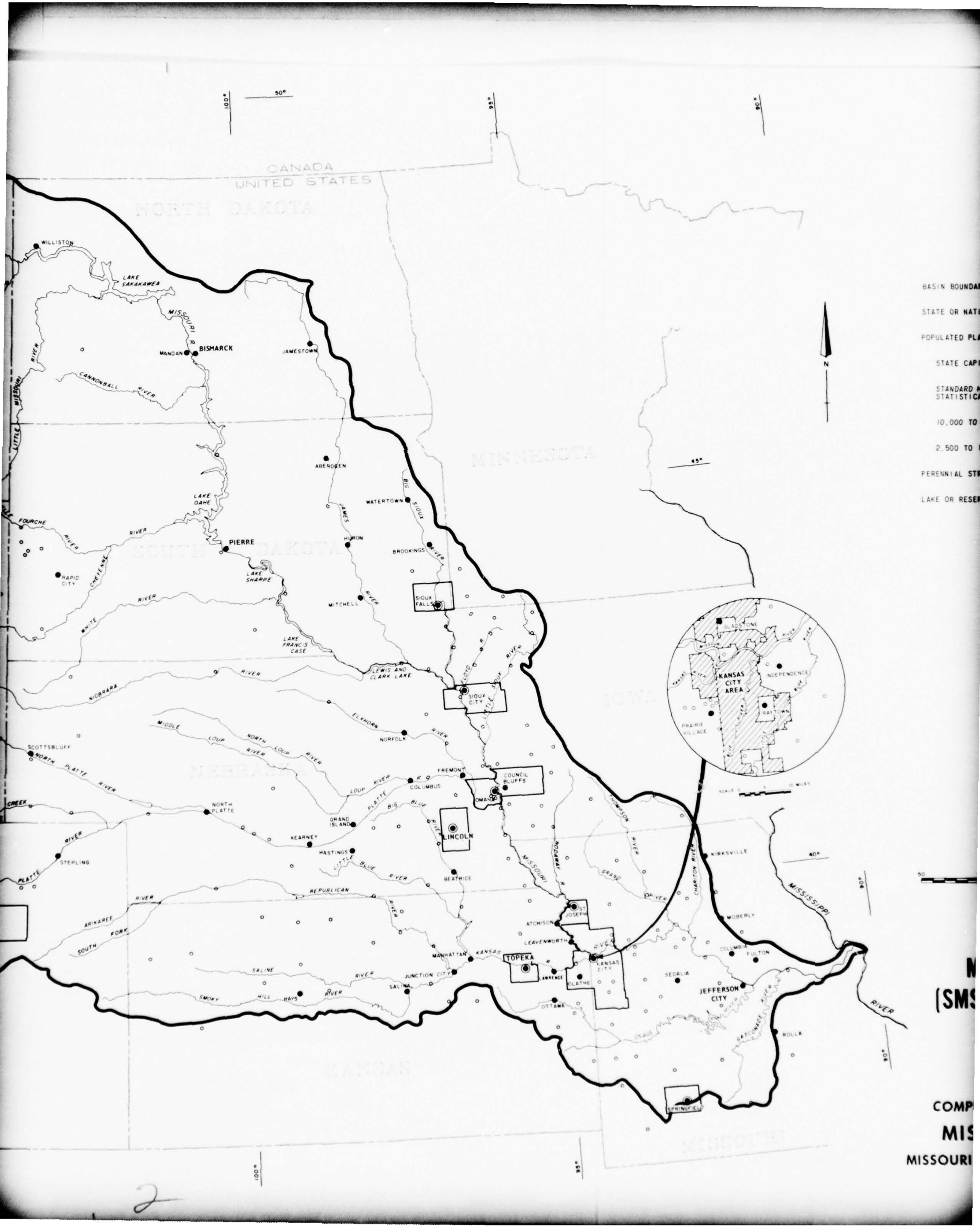
With the decline of the small towns, larger cities have tended to take over their service functions. Consequently, travel distances have become greater as the rural population turns to the "distant" city to satisfy most of the rural needs.

The large metropolitan areas have experienced the highest percent of growth since the 1930's. These centers have continued to function as the gateways to commerce within the basin. In addition, their bases have become diversified with manufacturing, food processing, professional services, and governmental functions being important segments of their economies.

One of the very striking characteristics of the basin is the absence of large urban centers on the plains. By far the largest concentration of population is along the eastern edge of the basin, with a secondary concentration along the foot of the mountains in the west. Between these two there are virtually no urban places of material significance.

Metal refining, oil, governmental institutions, education facilities, and tourism have provided most of the economic growth for the few larger towns and cities in the plains. Only a few cities in the vicinity of large

MONTANA
WYOMING
COLORADO
HAVRE
MILK RIVER
MARIAS RIVER
RIVER
SUN RIVER
MISSOURI
GREAT FALLS
FORT PECK RESERVOIR
WILLISTON
HELENA
MUSSELSHELL RIVER
BIG HOLE RIVER
JEFFERSON RIVER
MADISON RIVER
GALLATIN RIVER
BOZEMAN
YELLOWSTONE
BILLINGS
RED ROCK RIVER
YELLOWSTONE LAKE
SHOSHONE RIVER
SHERIDAN
TONGUE RIVER
POWDER
N. FORK
BIGHORN
WIND RIVER
S. FORK
CASPER
SWEETWATER RIVER
NORTH PLATTE R
LARAMIE RIVER
LARAMIE
LODGEPOLE CREEK
CHEYENNE
SCOTTSBLUFF
NORTH PLATTE
LITTLE MISSOURI RIVER
BELLE FOURCHE RIVER
RAPID CITY
WHITE
FORT COLLINS
GREELEY
STERLING
PLATTE
BOULDER
LONGMONT
DENVER
WESTMINISTER
THORNTON
ARVADA
WHEAT RIDGE
LAKEWOOD
DENVER AREA
AURORA
ENGLEWOOD
LITTLETON
SCALE 0 5 10 MILES
LOCATION MAP
MISSOURI RIVER BASIN
115°
110°
105°
45°
40°
ALBERS EQUAL-AREA PROJECTION



CANADA
UNITED STATES
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
MINNESOTA
IOWA
MISSOURI
WILLISTON
LAKE SAKAKAWEA
MISSOURI R.
MANDAN
BISMARCK
JAMESTOWN
CANNONBALL RIVER
LAKE OAHE
PIERRE
LAKE SHARPE
RAPID CITY
ABERDEEN
WATERTOWN
HURON
BROOKINGS
MITCHELL
SIOUX FALLS
LAKE FRANCIS CASE
LEWIS AND CLARK LAKE
SIOUX CITY
NIOBRARA RIVER
ELKHORN RIVER
NORFOLK
SCOTTSBLUFF
NORTH PLATTE RIVER
NORTH PLATTE
FREMONT
COLUMBUS
COUNCIL BLUFFS
OMAHA
GRAND ISLAND
KEARNEY
HASTINGS
LINCOLN
BEATRICE
STERLING
REPUBLICAN RIVER
SOUTH FORK
MANHATTAN
KANSAS R.
JUNCTION CITY
SALINA
SMOKY HILL RIVER
SALINE RIVER
HAYS
TOPEKA
LAWRENCE
OLATHE
OTTAWA
ATCHISON
LEAVENWORTH
ST. JOSEPH
KANSAS CITY
SEDALIA
JEFFERSON CITY
COLUMBIA
FULTON
MOBERLY
KIRKSVILLE
ROLLA
SPRINGFIELD
MISSISSIPPI RIVER
GRAND RIVER
CHARITON RIVER
GASCONADE RIVER
OSAGE
GLADSTONE
KANSAS CITY AREA
INDEPENDENCE
RAYTOWN
PRAIRIE VILLAGE
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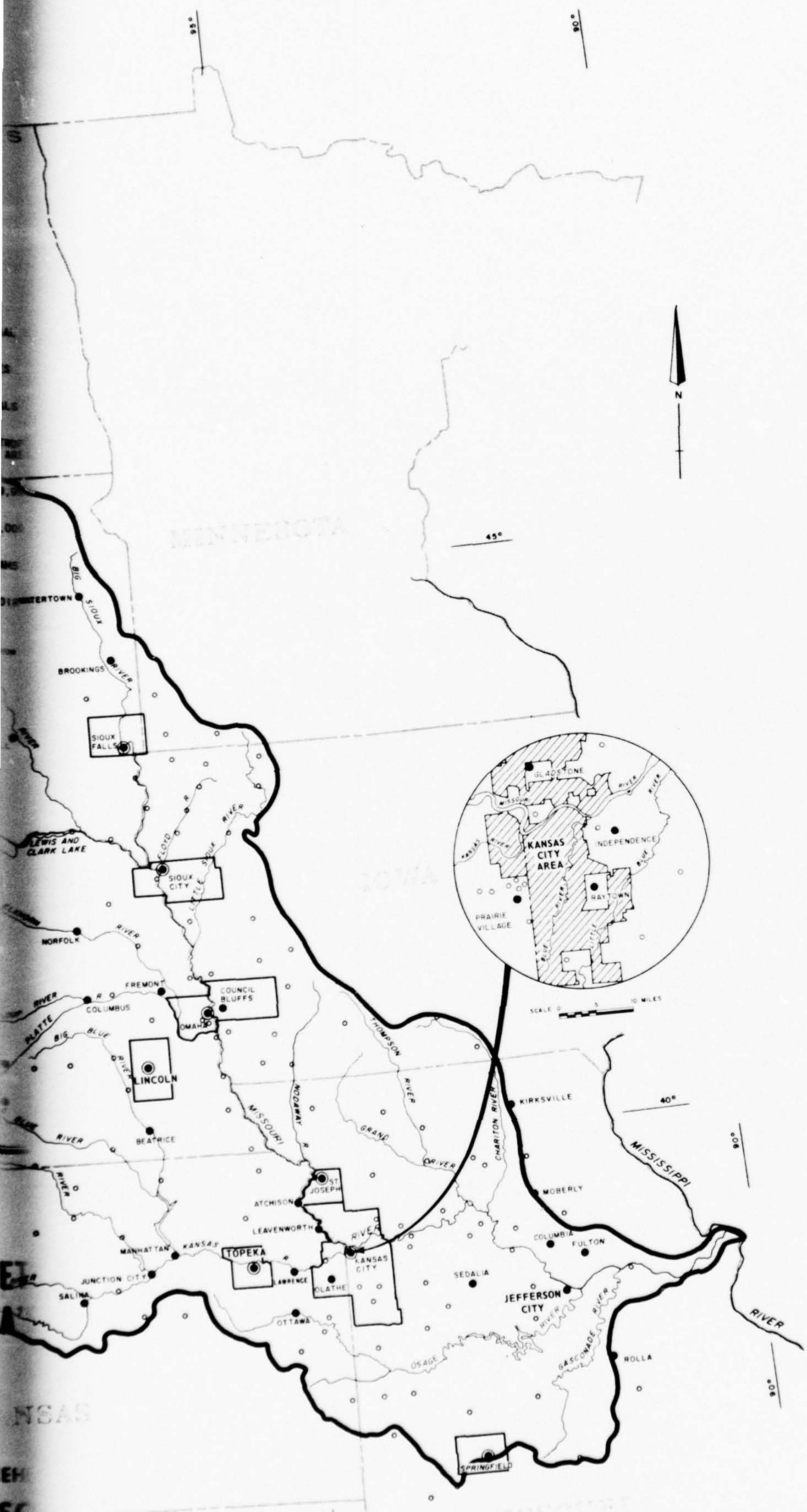


METROPOLITAN AREAS (SMSA'S) AND URBAN AREAS

1960 POPULATION

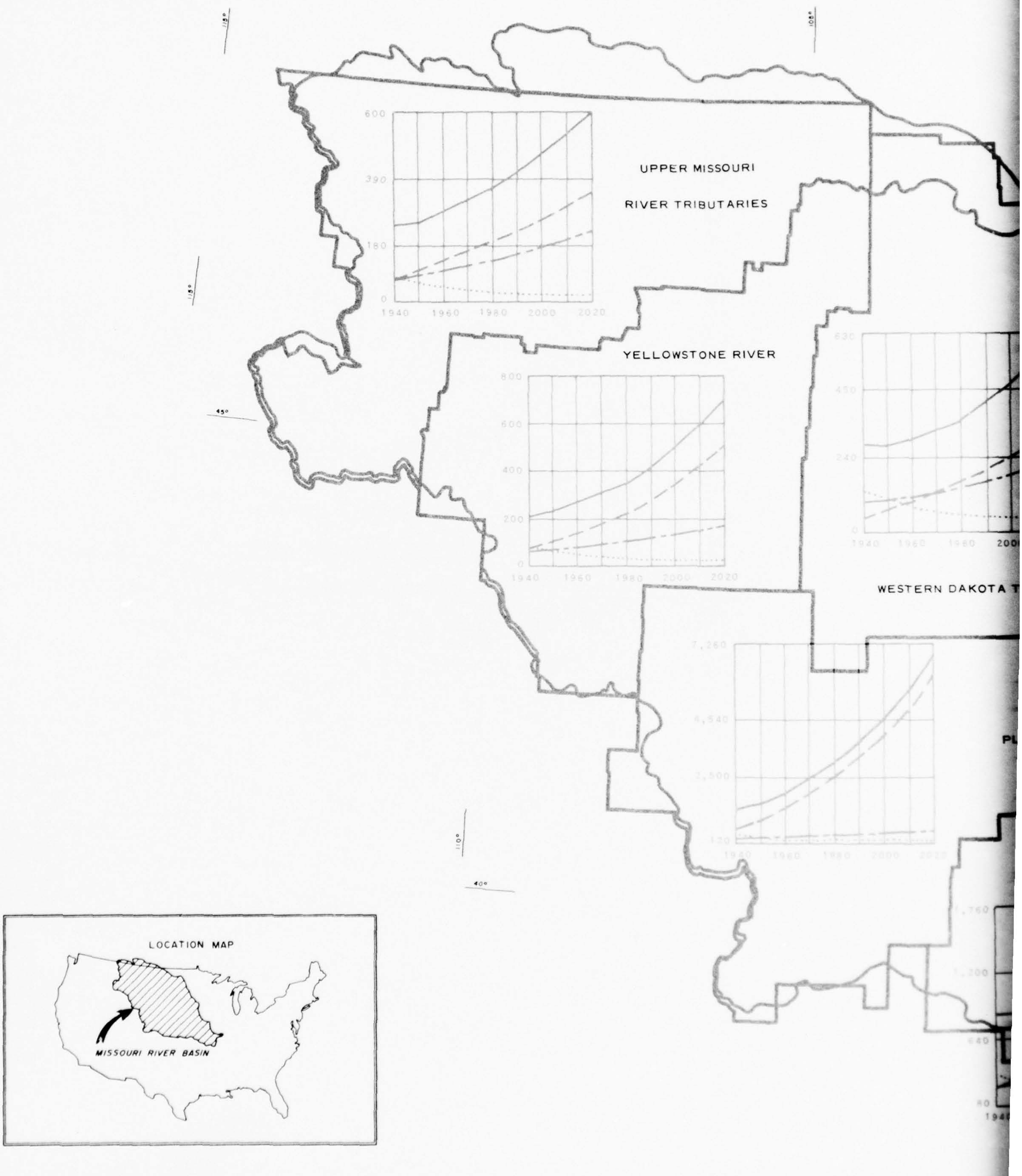
COMPREHENSIVE FRAMEWORK STUDY

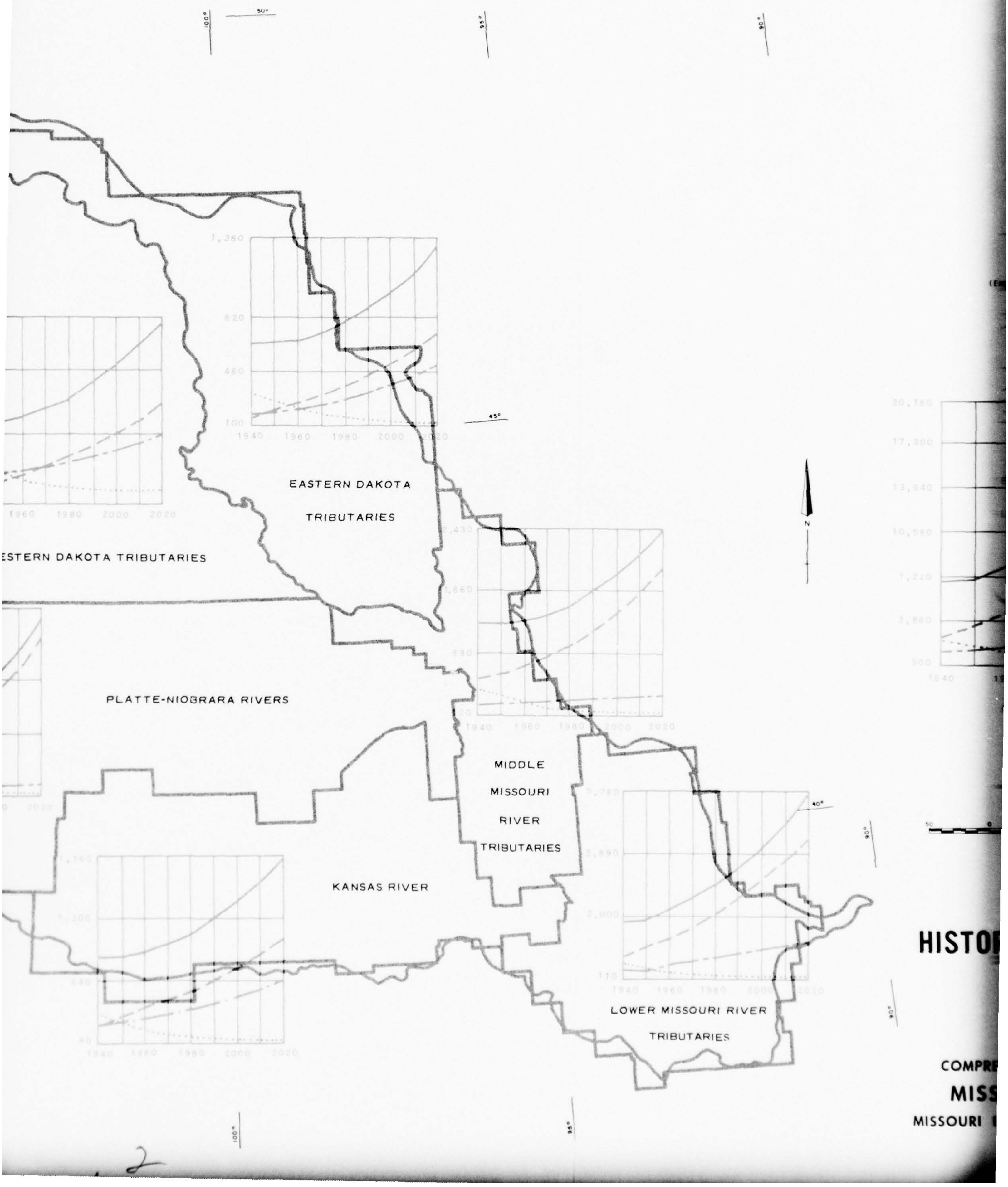
MISSOURI RIVER BASIN

MISSOURI BASIN INTER-AGENCY COMMITTEE

PLATE 1

3


UPPER MISSOURI
RIVER TRIBUTARIES
YELLOWSTONE RIVER
WESTERN DAKOTA T
PL
LOCATION MAP
MISSOURI RIVER BASIN
ALBERS EQUAL-AREA PROJECTION
45°
40°
110°
105°
600
390
180
0
800
600
400
200
450
240
1940
1960
1980
2000
2020



EASTERN DAKOTA
TRIBUTARIES
ESTERN DAKOTA TRIBUTARIES
PLATTE-NIOBRARA RIVERS
MIDDLE
MISSOURI
RIVER
TRIBUTARIES
KANSAS RIVER
LOWER MISSOURI RIVER
TRIBUTARIES
1,360
820
460
100
1940
1960
1980
2000
2020
2,430
1,660
890
5,780
3,890
2,000
110
20,180
17,300
13,940
10,580
7,220
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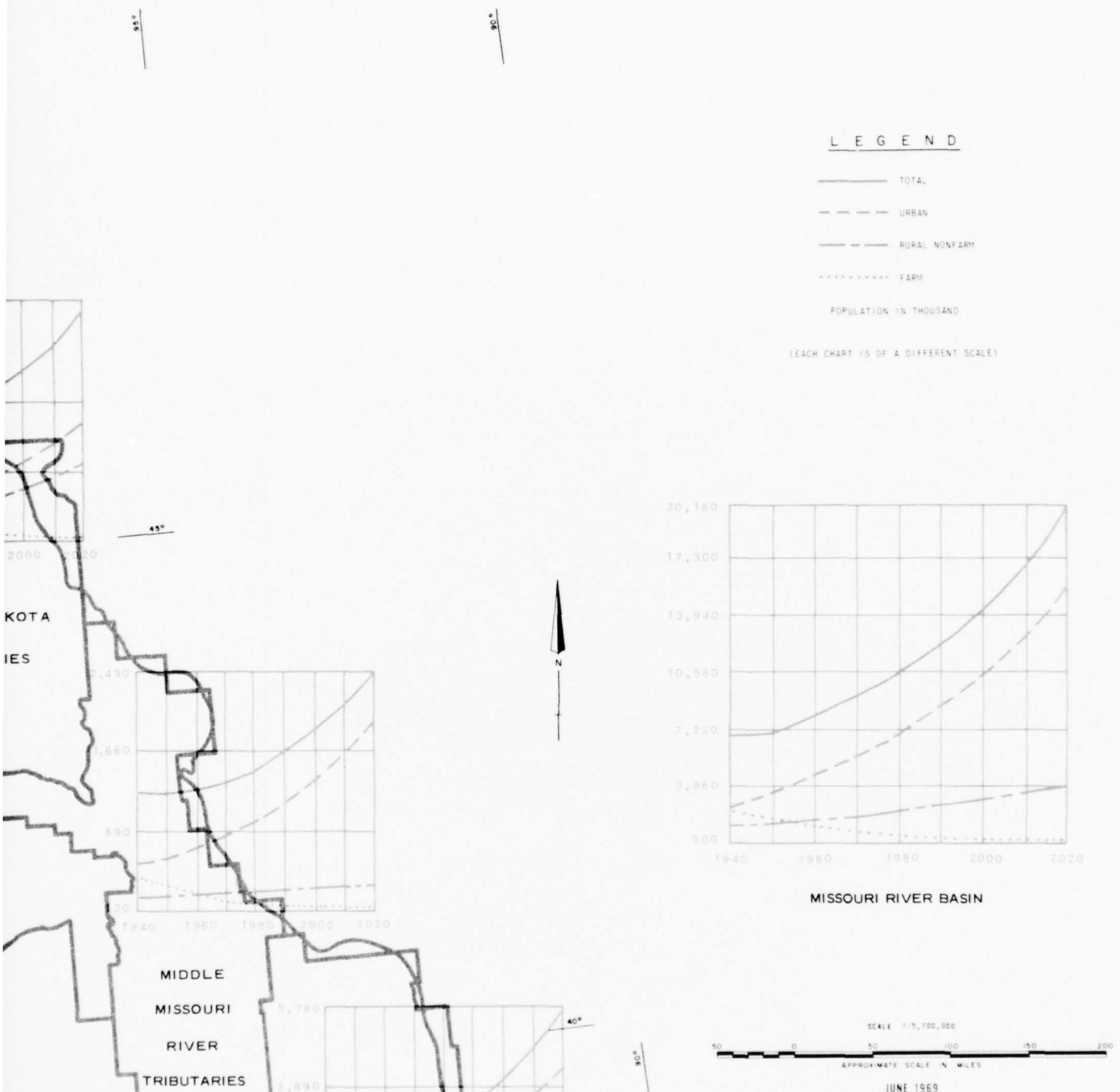


HISTORIC AND PROJECTED POPULATION

COMPREHENSIVE FRAMEWORK STUDY

MISSOURI RIVER BASIN

MISSOURI BASIN INTER-AGENCY COMMITTEE

PLATE 2

irrigated areas derive a significant amount of their income from agriculture. The ranching industry and dryland farming have not been able to generate the economic conditions needed to support large urban populations.

There is no inherent merit in having an increasing population nor is there necessarily an inherent disadvantage in a decreasing population. However, the sparse rural population within much of the basin has been, and is now, at a point where it is too small to support many of the commonly accepted institutional patterns. The decreasing rural population has meant substantial financial losses to such services as churches, medical facilities, schools, and local government. Today, many of the counties, particularly those within the plains, do not have sufficient populations to justify or adequately maintain their existence as separate governmental units. The continuing and growing problems of school district reorganization show no sign of abatement. Since the 1950's, all of the States have faced agonizing battles over this subject. With constantly declining populations in the rural areas, complete and satisfactory reorganization can never be finished. In addition, there has been a continuing consolidation of more and more service functions within the larger urban areas at the expense of the small town. Generally, the hamlet and the small town are doomed to extinction. One major result of increasingly lower population densities has been the imposition of higher social costs — the costs that result from open space and travel distance.

It is not easy to measure the total extent of the social cost of space, but there is no doubt that it is large. Many of the costs occur in the form of subsidies made by the local, State, and Federal Governments. Rural electrification and the R.F.D. are examples of other segments of the population providing a subsidy for operations in the sparsely settled areas. Certain other social costs may not be apparent at once, but become evident at some later date. Inadequate schooling may not show up until the college entrance exams are taken. The expense of maintaining a two-dwelling household for school purposes, one on the farm and the other in town, represents a higher social cost of space which a more densely settled area would not require. The enforced lower quality of many services found in the scattered plains areas also represents a social cost. These include inadequate facilities for religion, medical attention, care for the aged, the mentally ill and retarded, prisoners, and juvenile offenders. All these "costs" exist and are significant throughout the rural areas.

A critical question resulting from the continued loss in rural population and the increasing social costs is: "At what point will the social costs become greater than the tax revenues of the area?" As this point approaches, an area ceases to fully support its public institutions and requires an increasing subsidy from other areas to maintain desired standards. This condition currently exists in some areas of the basin. If present trends continue, it will become increasingly widespread throughout all the rural areas. In contrast with rural problems of decreasing population are the urban problems arising from over-crowding. While resource developments will certainly exert an influence on the cities, the resulting socio-economic relationships are not explored in depth for purposes of this study.

People who settled the basin created a large number of distinctive ethnic areas; however, most of these boundaries have since blurred because of the population shifts and the general social mobility of the people in the basin. Today, most of the population is fully assimilated and has become cosmopolitan.

The remnant ethnic groups which have been able to maintain their identity exhibit some special social traits. They have strong kinship and religious ties, and resist cultural change not originating within their group. As an interesting example, the Hutterites is one of the groups that has been most successful in maintaining its identity. These people generally have proven themselves to be excellent farmers and are a hard-working group intent on practicing their religion in private and remaining apart from the population that surrounds them.

One of the more unique ethnic concentrations, however, is the Indians — some 58,000 of them, or less than one percent of the basin's population. The Indians are concentrated on 23 different reservations scattered throughout the basin. The paternalistic concepts inherent in the reservation system, the physical isolation of many of the reservations, and the inability of both whites and the Indians to accept certain of the cultural traits of the other have pretty much insured the continuance of the Indian as a separate entity within the basin.

The Indians are basically poor. The annual incomes for Indian families are often below $1,000, and the basin average is under $3,000. The basic economy for the reservations has been ranching, some farming, and the leasing of land to whites. Traditionally, unemployment has been high on the reservations, ranging from 24 to 69 percent of the employable work force in 1966. In many instances, the standard of living on the reservations has not been rising as fast as in the rest of the basin's society. Consequently, some reservations are actually becoming poorer in relation to other areas.

Indian tribes of the basin have governmental institutions patterned on non-Indian principles but which have a peculiar autonomy set forth in treaties and subsequent legislation. Tribal and allotted Indian land, which is held in trust by the United States Government, is subject to tribal and Federal jurisdiction but not to State, county, nor city jurisdiction. Thus, this land is subject neither to taxation or other assessment by the State and local or county governments, nor to State and county laws governing land use and development. Indian tribes and individuals, when on trust land, are likewise subject to tribal and Federal jurisdiction, but not to State or county jurisdiction.

The autonomy of the Indian tribes (which seems peculiar to the non-Indian) enables them to appeal directly to the Congress of the United States for special legislation. This explains why certain Federal legislation is applicable to only one specific tribe – the tribe which obtained it for its own purposes.

The Indians, with their differing economic and social situations, must be considered as separate entities in the planning of resource development. They have different values and social philosophies that are not commonly subscribed to by the white communities within the basin.

ECONOMY

The basin's or region's economic growth, as indicated by the projections of income, employment, and population, will nearly parallel that for the Nation.

Table 2 – POPULATION AND ECONOMIC INDICATORS: UNITED STATES AND MISSOURI RIVER REGION, 1960; WITH PROJECTIONS TO 2020[1]

Item and Area	Unit	1960	1980	2000	2020
Population:[2]	*Million*				
United States		176.3	243.9	336.8	467.7
Missouri Region		7.9	10.4	14.3	20.1
Employment:[3]	Million				
Total					
United States		66.4	94.8	130.6	181.2
Missouri Region		3.0	4.1	5.6	7.8
Agriculture:	Thousand				
United States		4,528	2,500	1,900	1,750
Missouri Region		512	336	272	249
Gross National Product:[4]	$ Billion	440	1,001	2,144	4,686
Personal Income:[4]	$ Billion				
United States		352	785	1,680	3,630
Missouri Region		14.4	32.4	69.4	151.4
Per Capita Income:[4]	$ Billion				
United States		1,994	3,200	5,000	7,750
Missouri Region		1,813	3,106	4,838	7,549

[1]Preliminary economic projections for the Missouri River Region (Basin), Office of Business Economics, U.S. Department of Commerce and Economic Research Service, U.S. Department of Agriculture.
[2]Includes Armed Forces abroad.
[3]Census of Population concept; excludes those stationed overseas.
[4]In terms of 1954 dollars.

Population is expected to increase 2½ times the 1960 figure by 2020, and employment is expected to show a similar growth. Personal income in the basin is expected to increase tenfold by 2020 and, on a per capita basis, personal income is expected to show a fourfold gain by that year.

In absolute terms, population in the basin is expected to increase from 7.9 million in 1960 to 20.1 million in 2020; employment will go from about 3.0 million to over 7.8 million, a gain of 160 percent for the same period; and per capita personal income in 1954 dollars will increase from $1,813 in 1959 to $7,549 in 2020, a gain of 316 percent.

Employment composition in the Missouri Region for 1950, 1960, and future projections are as follows:

Table 3 – EMPLOYMENT COMPOSITION BY INDUSTRIAL SECTORS, MISSOURI REGION, 1950 AND 1960; WITH PROJECTIONS TO 2020

Sector	1950	1960	1980	2000	2020
	(Percent)				
Agriculture	27.3	17.2	8.3	4.9	3.2
Manufacturing	10.6	13.8	16.0	15.7	15.3
Other Commodity-Producing	7.5	7.2	7.5	7.4	7.4
Noncommodity-Producing	54.6	61.8	68.2	72.0	74.1
Total Employment	100.0	100.0	100.0	100.0	100.0

The traditionally basic industries of agriculture, manufacturing, mining, and construction essentially represent the commodity-producing industries which provided 38 percent of the region's employment in 1960. This percentage is projected to decrease to 26 by 2020.

The noncommodity-producing industries involve some overlap with basic industries, especially in trade and service activities which cater to tourists. Employment in the noncommodity-producing sector has shown significant gains historically, and as projected will provide about 74 percent of the employment in the region by 2020.

Agriculture, the basic industry of the basin, in 1960 provided 34 percent of the direct employment in the Eastern Dakota Subbasin, the highest percentage of the basin. The subbasin continues to rank highest in the projection for the year 2020, with only 9 percent of the employment coming from agriculture. The Platte-Niobrara Subbasin provided the smallest percentage employment from agriculture, about 12 percent in 1960 and about 2 percent in 2020.

Manufacturing employment ranked highest in the Lower Missouri Subbasin, both in 1960 and in 2020, providing 20 percent of the employment in each year. In the Western Dakota Subbasin, manufacturing ranked lowest, with only 5 percent being employed in 1960 and 7 percent in 2020.

Other commodity-producing industries provided about the same percentage of employment in all subbasins, ranging from 6 percent in the Lower Missouri to 12 percent in the Yellowstone Subbasin.

In the noncommodity-producing sector, the Platte-Niobrara Subbasin in 1960 provided the top percentage employment of 65 percent, while the Upper Missouri is projected to provide 83 percent in 2020. The noncommodity-producing sector provided over 50 percent of all employment in the various subbasins in 1960 and for the year 2020.

Even though the projection of agricultural employment indicates large decreases, it is anticipated that agricultural production in 2020 will be approximately three times that of 1960. Almost all other economic sectors are expected to expand similarly.

The principal economic activities in the basin are agriculture and agriculture-oriented industries. Manufacturing is one segment that could show greater increase if other factors should become more favorable. Other industrial developments have failed to show significant growth because of the high cost of transporting goods to the principal centers of population in the east and on the west coast. Low product-tonnage, distance from and to markets, and high transportation rates combine to discourage investments in the development of the manufacturing industry which would utilize some of the raw materials available in the basin. The prospects of the upper part of the basin ever becoming highly industrialized as a manufacturer of many finished products are remote. However, it is expected that the basin's vast coal resources will be utilized to provide thermal power, oil, gasoline, and petrochemicals. The extensive gypsum deposits are a potential source of sulphuric acid.

Hunting, fishing, and outdoor recreation use of nature's scenic and water resources, especially in the mountains, and the growth in related service functions have become important economic activities in several of the basin states.

The per capita personal income and earnings per employee for the various subbasins are shown in table 4. The Platte-Niobrara Subbasin had the highest per capita personal income of $2,010 in 1960, and the Eastern Dakota Subbasin the lowest, $1,332. Earnings per employee in 1960 ranged from $4,103 in the Platte-Niobrara to $2,959 in the Eastern Dakota. The projected per capita personal income for the year 2020 ranges from $7,050 in the Eastern Dakota to $7,769 in the Upper Missouri Subbasin. Earnings per employee projected for 2020 range from $13,848 in the Kansas Subbasin to $17,040 in the Western Dakota Subbasin.

Table 4 – AVERAGE ANNUAL INCOME AND EARNINGS, BY SUBBASINS – 1960 AND PROJECTIONS TO 2020

Subbasin	Per Capita Personal Income		Earnings Per Employee	
	1960	2020	1960	2020
Upper Missouri	$1,844	$7,769	$3,879	$14,912
Yellowstone	1,812	7,556	4,070	15,769
Western Dakota	1,449	7,680	3,183	17,040
Eastern Dakota	1,332	7,050	2,959	15,011
Platte-Niobrara	2,010	7,661	4,103	15,080
Middle Missouri	1,830	7,626	3,878	15,091
Kansas	1,775	7,403	3,360	13,848
Lower Missouri	1,835	7,502	3,763	15,157
Missouri Basin	1,813	7,549	3,751	15,065

EMPLOYMENT

Overall employment in the Missouri Basin increased less than in the Unites States as a whole during the 1940 to 1960 period. In the basin, employment gained about 33 percent for the 20-year period, while the Nation's employment was increasing about 46 percent. Consequently, the basin's share of total national employment declined over this period from 4.9 percent to 4.5 percent. Employment composition in the basin has definitely reflected this fact during the past two decades. Workers in agriculture decreased from 35 percent of the total employment in 1940 to only 17 percent in 1960. This sector of employment showed the greatest percentage change, and in absolute numbers amounted to about 280,000 jobs. Employment changes in other sectors over this period varied from 9 to 14 percent for manufacturing; 5 to 7 percent for other commodity-producing; and 51 to 62 percent for noncommodity-producing.

One might conclude that while agricultural employment was declining, its workers were being absorbed in the increasing manufacturing employment during this period; however, the rate of absorption was not sufficient to allow the total employment in the basin to keep pace with the total increase in the Nation.

The noncommodity-producing group has shown a significant gain historically and is projected to grow to about 75 percent of the total employment in the basin by 2020. While this industrial sector contains some industries which are basic to particular local economies and are generative in that they support local employment, the majority of employment in this sector is of the trade-in-service variety, and typically "labor-intensive." They depend upon commodity-producing or export-based industry in the local area, or may be categorized as linked to these basic type industries. Growth of employment in these industries is therefore explained by and depends upon growth in the local export base. Because of their "labor-intensive" character, employment increases in these industries over a period tend to be more than proportional to employment increases in the basic type industries, which are generally highly "capital-intensive." It may be concluded that noncommodity-producing industries which show increasing shares of total employment are reasonable, and to be expected.

Without a like increase in the other commodity-producing sectors to offset the continued decline in agricultural employment, one cannot expect the basin's employment to keep pace with that of the Nation. The shift out of agricultural employment and the pattern of "little farms becoming big ones" create many problems such as the formation of ghost towns. These, in turn, increase the influx of the basin's population to the larger cities.

INCOME

Agriculture, the predominant source of income or means of livelihood has historically held average personal income per capita to the lower brackets. What portion of the total economy that is dependent, either directly or indirectly, on agriculture is difficult to estimate precisely. A large portion of the noncommodity-producing industries is made up of segments such as machinery maintenance, feed grinding, fuel delivery, electric power service, and similar services of inputs to agriculture, which depend upon the farmer's income. In the manufacturing sector, the largest component is that of the food-processing industry directly related to agriculture. Likewise, the large livestock markets and numerous meat packing plants are the basics of agricultural economy.

Of the basic industries, agriculture is the major employer. This is true even with the decreases in agricultural employment due to the interrelated rural out-migration and the technological advancements, including mechanization of the farm.

The products of agriculture sold in the basin were worth approximately 4.6 billion dollars in 1959 and 5.1 billion in 1964, with the average value per farm being $13,444 in the latter year. In 1964, livestock and livestock products accounted for 70.6 percent of the total sales from farms.

Manufacturing, a basic type industry, has enjoyed a rapid growth during the last two decades; however, it is located primarily in the larger metropolitan areas. The smaller urban places in the basin, where alternative sources of employment and income are needed to offset the loss resulting from changes in agriculture, are still virtually without manufacturing. Cities of 10,000 to 50,000 population have experienced some success in attracting manufacturing in recent years, due largely to the trend of decentralization in the food-processing industries. A small amount of light industry, such as machinery fabrication and electronics, has moved into the basin. Even with this influx of manufacturing, the plains portion of the basin has been largely void of any material gain.

The most rapidly expanding sector of the economy is the noncommodity-producing group which has the largest proportion of employment and exerts the greatest influence on the average earnings per employee. In 1960, about 62 percent of the basin workers were employed in this sector. Even though the noncommodity sector contains some industries which are basic to particular local economies (and are generative in that they support local employment), the majority of the employment is generated in the trades or services. It must be noted that this employment is dependent largely upon the wealth produced by the more basic sectors of agriculture and manufacturing. Only when these industries are supported by income from outside of the basin do they add to the basin's economic growth or economy. Otherwise, they simply represent the reexpenditures of wealth created by some other industry within the basin. This is not always a desirable situation, i.e., to be wholly dependent upon the economic health of the rest of the basin.

An increase in the tourist business has played a large part in the increase in employment in the trades-and-services segment. Throughout the basin, greater emphasis is being placed upon attracting the tourist because tourism is an alternative to agriculture in the economic base. This "new industry" has probably the most potential for growth, and is expected to become increasingly important.

A dependence of the majority of the people in the basin on the non-commodity sector has not been a total blessing. Historically, their wages have been below the Nation's average, and generally, the level of earnings per employee in the Missouri River Basin for 1960 and projected years is following the same pattern. The basin level of personal income per capita was 90.9 percent of the national level in 1960; however, the basin average earnings per employee were only 88.7 percent of the national average.

The lower salaries, as shown by the earnings-per-employee figures in table 5 paid in the basin clearly indicate the difficulty in effectively competing with other areas of the Nation for the trained worker.

When the earnings of the most rural areas or subbasins are examined, it is readily noted that the employee earnings and per capita incomes are the lowest of the basin. The more highly skilled industrial jobs and the better paying professional services are located in the larger cities.

Table 5 – INCOME AND EARNINGS MISSOURI BASIN – 1940, 1950, AND 1960

	1940	1950	1960
Total Personal Income ($000,000)	6,270	11,144	14,381 [1]
Percent of U.S.	3.97%	4.44%	4.09%
Per Capita Personal Income ($)	927	1,575	1,829
Percent of U.S.	77.30%	95.17%	90.92%
Total Earnings ($000,000)	5,209	9,108	11,196
Percent of U.S.	4.12%	4.53%	3.99%
Earnings Per Employee($)	2,329	3,354	3,751
Percent of U.S.	83.48%	95.80%	88.72%

[1] 1960 employment and 1959 earnings (1954 dollars)

NATURAL RESOURCES

Land

Each element of the basin may well claim high importance, but the basal fact of 329 million acres of land and water must be considered first. On what kind of land is the Missouri Basin founded? The answer is varied.

The plains portion of the basin consists of areas which are underlain by sedimentary formations ranging in character from hard rocks to unconsolidated sediments, mostly clays, shales, silts, sands, and sandstones. Large areas are covered by more recent deposits of glacial till, sand, gravel, silts, and clays that were laid down by water, wind, and ice.

Soils have been developed under grass cover, with the exception of those in the Ozark Plateaus and Rocky Mountains. Many types of soils, with wide variations in profile characteristics and use capabilities, are found. Zonal soils include the Prairie soils in eastern Kansas and Nebraska, Iowa, Missouri, Minnesota, and extreme southeastern South Dakota; the Chernozem soils in a zone that extends from eastern North and South Dakota through central Nebraska and Kansas; the Chestnut soils in northern Montana, western North and South Dakota and Nebraska and northwestern Kansas; the Brown soils in eastern Montana and Wyoming and northeastern Colorado; the Sierozem soils in the intermountain basin and high, dry plateaus in northwestern Wyoming; and Podzolic soils in the forested areas of the Rocky Mountains in western Montana, Wyoming, and Colorado, the Black Hills in South Dakota and Wyoming, and the Ozark Plateaus in Missouri.

About 312 million acres, or 95 percent of the land area in the basin, is used for some agricultural purpose. Grasslands used for grazing comprise about 54 percent of the total agricultural area. About 31 percent of the land is cultivated. The remainder of the area is in forest or is devoted to miscellaneous agricultural uses.

The basin contains 7.4 million acres of irrigated cropland, principally in the Platte-Niobrara, Kansas, Upper Missouri, and Yellowstone subbasins. About 38.6 million acres of the agricultural land area are in Federal ownership. These lands occur largely in the mountains and western plains area and are used for grazing and production of forest products.

About 2.8 million acres of land in the basin, most of which is publicly owned, is devoted primarily to recreational use. Nearly all land in the basin is used by some form of wildlife, but only 0.7 million acres is inventoried as land dedicated primarily to fish and wildlife uses. This area excludes any water area, which is inventoried separately with no attempt to delineate use.

Transportation, urban, and built-up uses of land are estimated at 7.7 million acres; military use, at 0.6 million; and use by mineral industries, at 33,000 acres.

Approximately 3.8 million acres of the Missouri Basin is covered by water, including water areas under 40 acres and streams less than one-eighth mile in width.

The following table presents a summary of the primary uses of land and the water area:

Coordination in management of primary and ancillary uses of land and water is recognized. For the Missouri Basin, the 328,508,000 acres of primary land and water now furnish an equivalent of 714,291,000 acres of multiple resource use. This multiple-use aspect is summarized in table 7.

Water

The recorded average annual runoff of the Missouri River at Hermann, Mo., from 1898 through 1966 is 56.7 million acre-feet. Considering the 1970 level of development in the basin, consumptive use of water in various subbasins would reduce their contribution to the main stem to 55.5 million acre-feet per year. Subbasin flow contributions are as shown in table 8.

Considering Missouri River reservoir evaporation, consumptive use of diversions from the Missouri River of water used within the basin and diversions out of the basin, the average annual flow of the Missouri River at

Table 6 – PRIMARY USES OF LAND AND WATER AREA

Subbasin	Agriculture[2]	Recreation[3]	Fish and Wildlife[3]	Transp. Urban & Built-Up	Water Area[4]	Mineral Industry	Military	Total
				(Thousand Acres)				
Upper Missouri	50,382	519	182	1,200	670	3	7	52,963
Yellowstone	43,152	1,408	34	243	345	9	9	45,200
Western Dakota	47,289	334	101	898	472	3	269	49,356
Eastern Dakota	34,399	38	427	1,536	902	1	1	37,303
Platte-Niobrara	60,787	377	254	1,474	654	6	123	63,675
Middle Missouri	14,901	37	60	565	174	2	6	15,745
Kansas	37,182	36	21	1,189	336	6	106	38,876
Lower Missouri	24,300	65	69	585	266	3	102	25,390
Missouri Basin	312,392	2,814	1,148	7,680	3,819	33	622	328,508

[1]Less than 500 acres.
[2]Includes cropland, pasture & range, forest, and other agricultural lands.
[3]Figures shown are for single-purpose lands, but an additional 8,764,000 acres are included in other categories that are jointly used and have primary value for fish and wildlife.
[4]Includes primary water area of recreation and fish and wildlife.

Table 7 – SUMMARY OF PRIMARY AND ANCILLARY USES OF LAND AND WATER AREA

Subbasin	Agriculture[1]	Recreation	Fish and Wildlife	Transp. Urban & Built-Up	Water Area	Mineral Industry	Military	Total[2]
				(Thousand Acres)				
Upper Missouri	53,710	14,774	51,687	1,200	670	3	7	122,051
Yellowstone	45,742	13,311	44,914	327	346	9	9	104,658
Western Dakota	51,055	10,708	48,316	1,508	500	3	345	112,435
Eastern Dakota	34,520	1,490	35,615	1,536	902	1	0	74,064
Platte-Niobrara	64,054	8,380	61,985	1,474	743	6	358	137,000
Middle Missouri	15,580	209	15,057	566	174	2	6	31,594
Kansas	37,680	431	37,508	1,202	646	6	127	77,600
Lower Missouri	28,019	949	24,566	984	266	3	102	54,889
Missouri Basin	330,360	50,252	319,648	8,797	4,247	33	954	714,291

[1]Agriculture includes cropland, pasture and range, forest, and other agricultural lands.
[2]Includes both primary and secondary uses of land and water.

Table 8 – ORIGIN OF MEAN ANNUAL FLOW OF MISSOURI RIVER

Subbasin	Million Acre-Feet Per Year (1970)
Upper Missouri	7.7
Yellowstone	8.8
Western Dakota	2.4
Eastern Dakota	3.2
Platte-Niobrara	4.2
Middle Missouri	7.7
Kansas	4.2
Lower Missouri	17.3
Subtotal	55.5
Main Stem Reservoir Evaporation	-1.9
Total	53.6

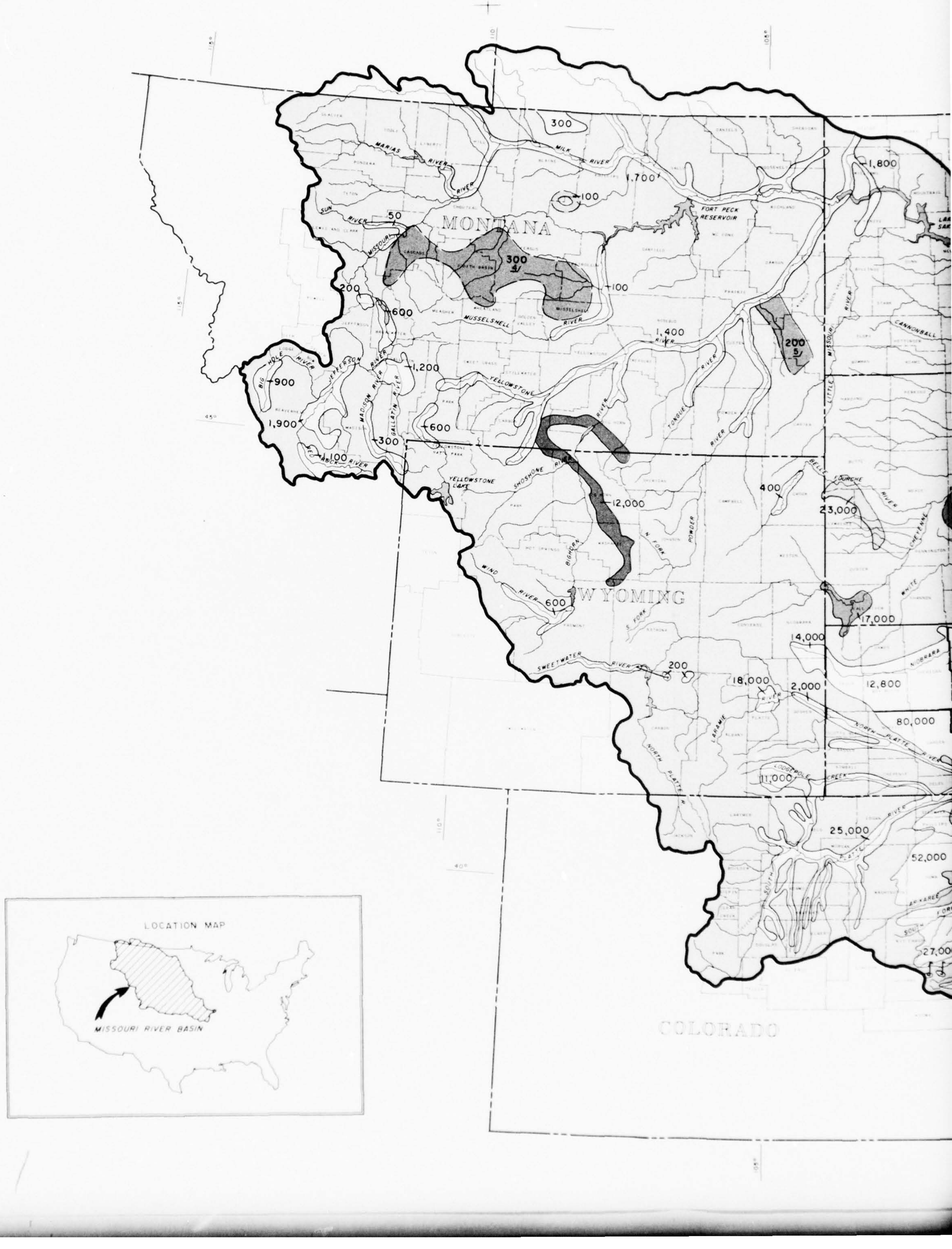
Hermann reflecting the 1970 level of upstream development is 53.6 million acre-feet.

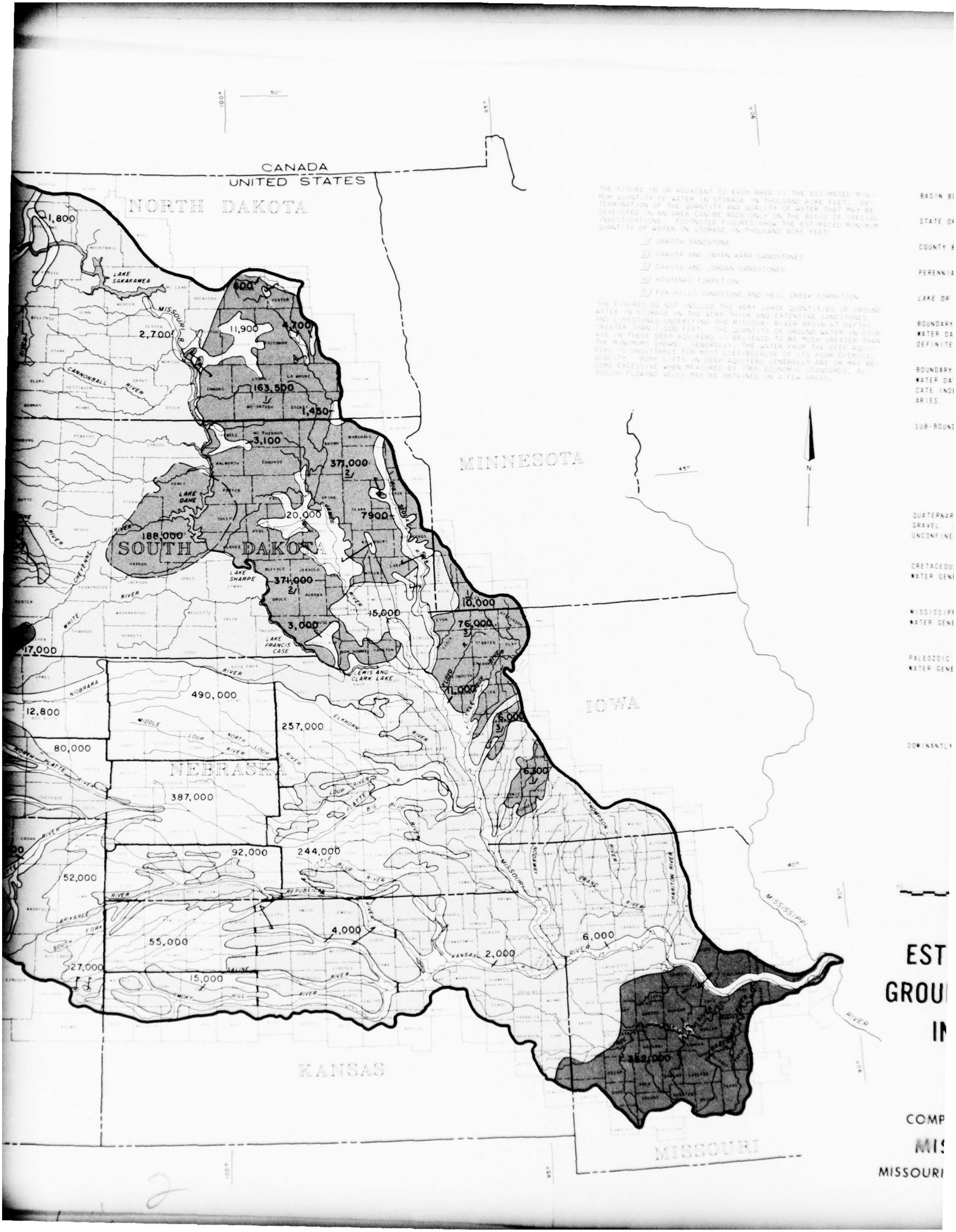
There is a huge amount of ground water in storage in principal aquifers of the Missouri Basin. Plate 3 shows the estimated amount of ground water in storage in selected areas in each of the eight subbasins. Characteristics of some of the aquifers are fairly well known. However, development of much of the ground water and determination of its quality awaits further investigation. There is some intermingling of surface water and ground water, the full extent of which has not yet been investigated.

Minerals

Mineral resources of the basin are most conveniently described by grouping the many mineral commodities into three categories – metallics, nonmetallics, and fuels.

Metallic mineral resources in the basin are generally associated with orogenic provinces – mountainous areas – and their peripheral outwash plains. Metallic ores are produced in significant quantities from the mountainous areas of central Montana, central Wyoming, and north-central Colorado, and from the Black Hills of South Dakota.


MONTANA
WYOMING
COLORADO
MARIAS RIVER
MILK RIVER
SUN RIVER
MISSOURI RIVER
FORT PECK RESERVOIR
MUSSELSHELL RIVER
YELLOWSTONE RIVER
BIG HOLE RIVER
JEFFERSON RIVER
MADISON RIVER
GALLATIN RIVER
RED ROCK RIVER
YELLOWSTONE LAKE
SHOSHONE RIVER
BIGHORN RIVER
WIND RIVER
TONGUE RIVER
POWDER RIVER
N. FORK
S. FORK
SWEETWATER RIVER
NORTH PLATTE RIVER
LARAMIE
LODGEPOLE CREEK
SOUTH PLATTE
LITTLE MISSOURI RIVER
CANNONBALL
BELLE FOURCHE RIVER
CHEYENNE
WHITE
NIOBRARA
300
1,700
100
50
300 4/
100
200
600
1,400
200 5/
1,800
1,200
900
1,900
600
300
1,100
12,000
400
23,000
600
17,000
14,000
200
18,000
2,000
12,800
80,000
11,000
25,000
52,000
27,000
LOCATION MAP
MISSOURI RIVER BASIN



CANADA
UNITED STATES
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
MINNESOTA
IOWA
MISSOURI
LAKE SAKAKAWEA
MISSOURI R.
CANNONBALL RIVER
LAKE OAHE
LAKE SHARPE
LAKE FRANCIS CASE
LEWIS AND CLARK LAKE
CHEYENNE RIVER
WHITE RIVER
NIOBRARA RIVER
NORTH PLATTE RIVER
MIDDLE LOUP
NORTH LOUP RIVER
LOUP RIVER
PLATTE
ELKHORN RIVER
BIG BLUE RIVER
LITTLE BLUE RIVER
REPUBLICAN RIVER
ARIKAREE RIVER
SOUTH FORK
SALINE RIVER
SMOKY HILL RIVER
KANSAS RIVER
GRAND RIVER
CHARITON RIVER
NODAWAY
THOMPSON RIVER
MISSISSIPPI RIVER
1,800
2,700
11,900
4,700
600
163,500
1,450
3,100
371,000
7900
20,000
188,000
371,000
10,000
15,000
76,000
3,000
17,000
11,000
6,000
6,300
12,800
490,000
257,000
80,000
387,000
92,000
244,000
52,000
4,000
55,000
2,000
6,000
27,000
15,000
352,000
THE FIGURE IN OR ADJACENT TO EACH AREA IS THE ESTIMATED MINIMUM QUANTITY OF WATER IN STORAGE IN THOUSAND ACRE FEET. DETERMINATION OF THE QUANTITY AND QUALITY OF WATER THAT MAY BE DEVELOPED IN AN AREA CAN BE MADE ONLY ON THE BASIS OF SPECIAL INVESTIGATIONS. FOOTNOTED FIGURES SHOW THE ESTIMATED MINIMUM QUANTITY OF WATER IN STORAGE IN THOUSAND ACRE FEET:
1/ DAKOTA SANDSTONE
2/ DAKOTA AND INYAN KARA SANDSTONES
3/ DAKOTA AND JORDAN SANDSTONES
4/ KOOTENAI FORMATION
5/ FOX HILLS SANDSTONE AND HELL CREEK FORMATION
THE FIGURES DO NOT INCLUDE THE VERY LARGE QUANTITIES OF GROUND WATER IN STORAGE IN THE VERY THICK AND EXTENSIVE SANDSTONES AND LIMESTONES UNDERLYING THE MISSOURI RIVER BASIN AT DEPTHS GREATER THAN 1,000 FEET. THE QUANTITY OF GROUND WATER IN STORAGE IN THESE DEEP AQUIFERS IS BELIEVED TO BE MUCH GREATER THAN THE MINIMUMS SHOWN. GENERALLY, THE WATER FROM THE DEEP AQUIFERS IS UNSUITABLE FOR MOST USES BECAUSE OF ITS POOR CHEMICAL QUALITY. PUMP LIFTS IN DEEP AQUIFERS GENERALLY ARE OR MAY BECOME EXCESSIVE WHEN MEASURED BY 1966 ECONOMIC STANDARDS, ALTHOUGH FLOWING WELLS MAY BE OBTAINED IN A FEW AREAS.
BASIN B
STATE O
COUNTY B
PERENNIA
LAKE OR
BOUNDARY
WATER DA
DEFINITE
BOUNDARY
WATER DA
CATE IND
ARIES.
SUB-BOUND
QUATERNAR
GRAVEL.
UNCONFINE
CRETACEOU
WATER GEN
MISSISSIPP
WATER GEN
PALEOZOIC
WATER GEN
DOMINANTLY
N
EST
GROU
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COMP
MIS
MISSOURI

THE FIGURE IN OR ADJACENT TO EACH AREA IS THE ESTIMATED MINIMUM QUANTITY OF WATER IN STORAGE IN *THOUSAND ACRE FEET*. DETERMINATION OF THE QUANTITY AND QUALITY OF WATER THAT MAY BE DEVELOPED IN AN AREA CAN BE MADE ONLY ON THE BASIS OF SPECIAL INVESTIGATIONS. FOOTNOTED FIGURES SHOW THE ESTIMATED MINIMUM QUANTITY OF WATER IN STORAGE IN THOUSAND ACRE FEET:

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3/ DAKOTA AND JORDAN SANDSTONES

4/ KOOTENAI FORMATION

5/ FOX HILLS SANDSTONE AND HELL CREEK FORMATION

THE FIGURES DO NOT INCLUDE THE VERY LARGE QUANTITIES OF GROUND WATER IN STORAGE IN THE VERY THICK AND EXTENSIVE SANDSTONES AND LIMESTONES UNDERLYING THE MISSOURI RIVER BASIN AT DEPTHS GREATER THAN 1,000 FEET. THE QUANTITY OF GROUND WATER IN STORAGE IN THESE DEEP AQUIFERS IS BELIEVED TO BE MUCH GREATER THAN THE MINIMUMS SHOWN. GENERALLY, THE WATER FROM THE DEEP AQUIFERS IS UNSUITABLE FOR MOST USES BECAUSE OF ITS POOR CHEMICAL QUALITY. PUMP LIFTS IN DEEP AQUIFERS GENERALLY ARE OR MAY BECOME EXCESSIVE WHEN MEASURED BY 1966 ECONOMIC STANDARDS, ALTHOUGH FLOWING WELLS MAY BE OBTAINED IN A FEW AREAS.

LEGEND

BASIN BOUNDARY

STATE OR NATIONAL BOUNDARY

COUNTY BOUNDARY

PERENNIAL STREAMS

LAKE OR RESERVOIR

BOUNDARY OF STORAGE UNIT, GROUND WATER DATA ARE ADEQUATE TO INDICATE DEFINITE BOUNDARIES.

BOUNDARY OF STORAGE UNIT, GROUND WATER DATA ARE INADEQUATE AND INDICATE *INDEFINITE OR ESTIMATED BOUNDARIES*.

SUB-BOUNDARY OF STORAGE UNIT

AREAS WHERE PROPERLY CONSTRUCTED AND LOCATED WELLS, LESS THAN 1000 FEET DEEP, *GENERALLY ARE CAPABLE OF YIELDING MORE* THAN 300 GALLONS PER MINUTE

QUATERNARY AND TERTIARY SAND AND/OR GRAVEL. WATER MAY BE CONFINED OR UNCONFINED.

CRETACEOUS SANDSTONE. WATER GENERALLY CONFINED.

MISSISSIPPIAN LIMESTONE. WATER GENERALLY CONFINED.

PALEOZOIC ROCKS, UNDIFFERENTIATED. WATER GENERALLY CONFINED.

AREAS WHERE WELLS LESS THAN 1000 FEET DEEP GENERALLY WILL YIELD LESS THAN 300 GALLONS PER MINUTE.

DOMINANTLY SILT, CLAY AND SHALE.

SCALE 1/5,700,000

50 0 50 100 150 200

APPROXIMATE SCALE IN MILES

JUNE 1969

ESTIMATED QUANTITY OF GROUND WATER IN STORAGE IN SELECTED AREAS

COMPREHENSIVE FRAMEWORK STUDY

MISSOURI RIVER BASIN

MISSOURI BASIN INTER-AGENCY COMMITTEE

PLATE 3

3

The principal minerals include gold, silver, copper, lead, zinc, tungsten, vanadium, chromium, beryllium, and low-grade iron ore. The general locations of areas producing metallic ores are shown in figure 7.

Nonmetallic minerals include construction materials; a number of fertilizer minerals such as phosphate, potash and gypsum; minerals for chemicals such as fluorspar, lime, mica, salt, etc.; and bentonite clays. Counties producing nonmetallic minerals other than sand and gravel are shown in figure 8. Mineral fuels consisting of crude oil and coal reserves comprise much of the basin's mineral wealth. Production of crude oil is expected to increase moderately through the year 2000 and to decline thereafter. General locations of crude-oil reserves are shown in figure 9.

Recoverable reserves of coal are estimated to be 450 billion tons, or about 55 percent of the Nation's total. The states of North Dakota, Montana, and Wyoming possess about 80 percent of the basin's supply. General locations of the coal fields and reserves are shown in figure 10.

Coal's long-range future will be influenced by results of current research in chemistry, in specialized fields of synthetic liquid fuels, manufactured gases, and coal chemicals. A sharp increase is anticipated in use of the basin's coal for generation of thermal-electric power.

FIGURE 7

COUNTIES PRODUCING METALLIC ORES, 1910-1963

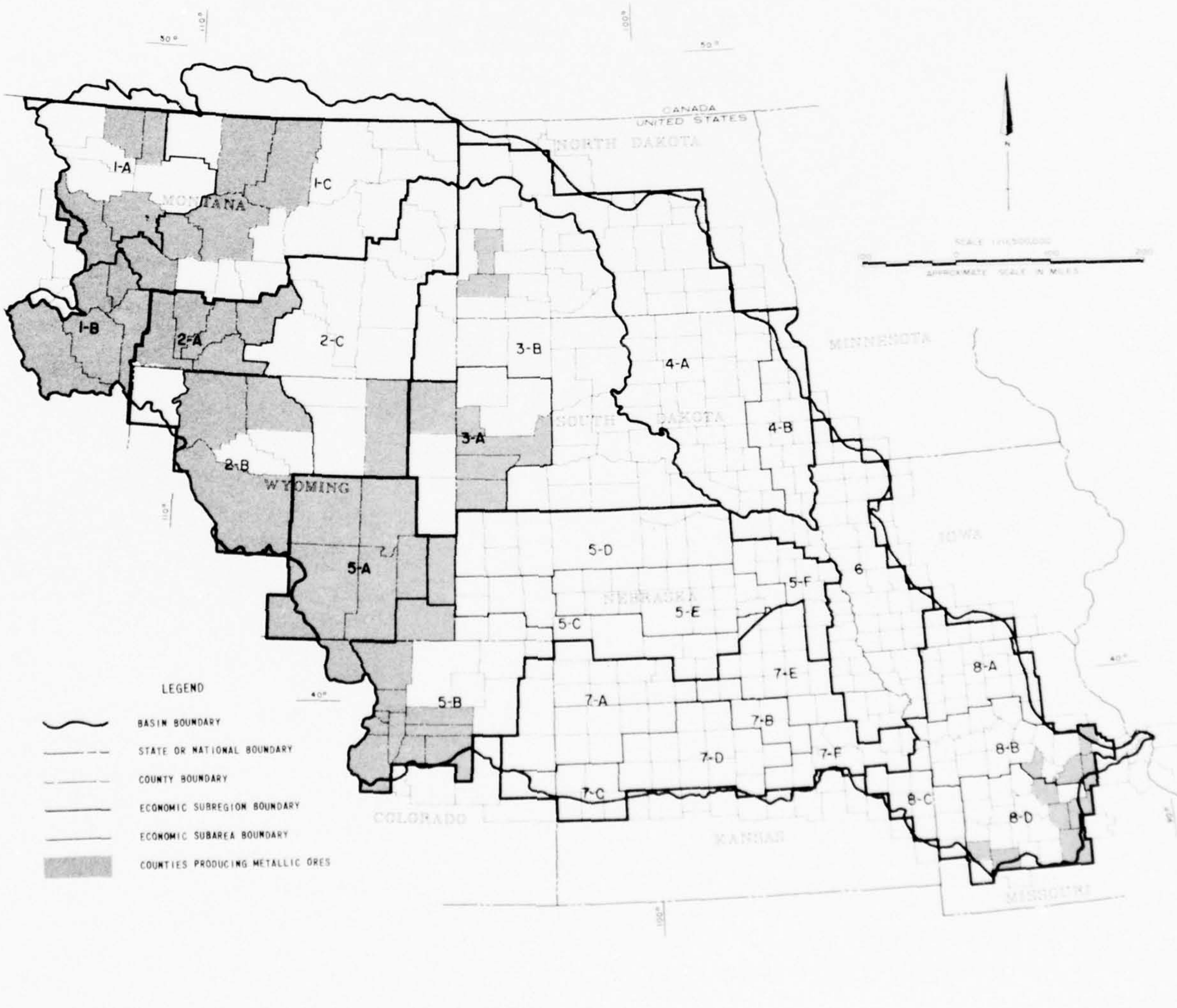
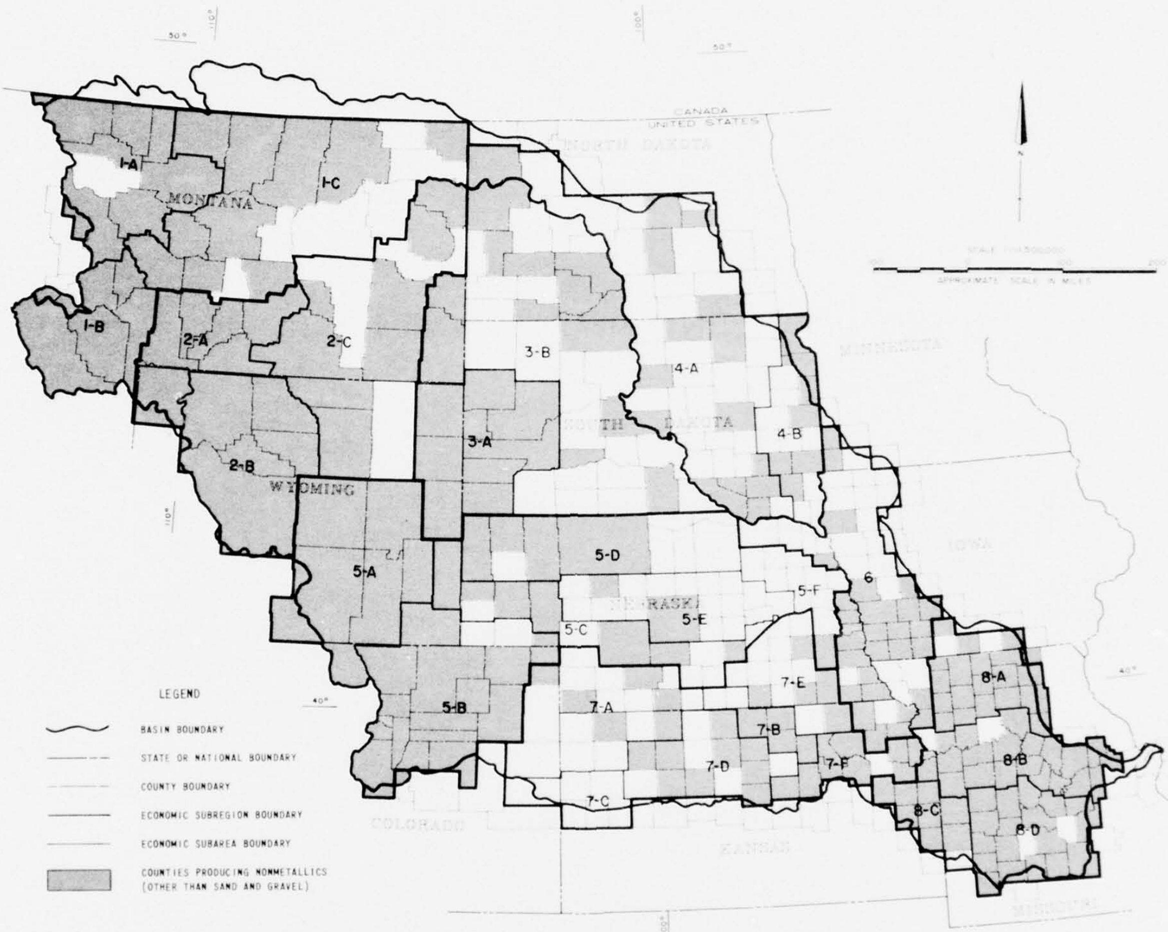


FIGURE 8

COUNTIES PRODUCING NONMETALLICS OTHER THAN SAND AND GRAVEL 1910-1963



Fish and Wildlife

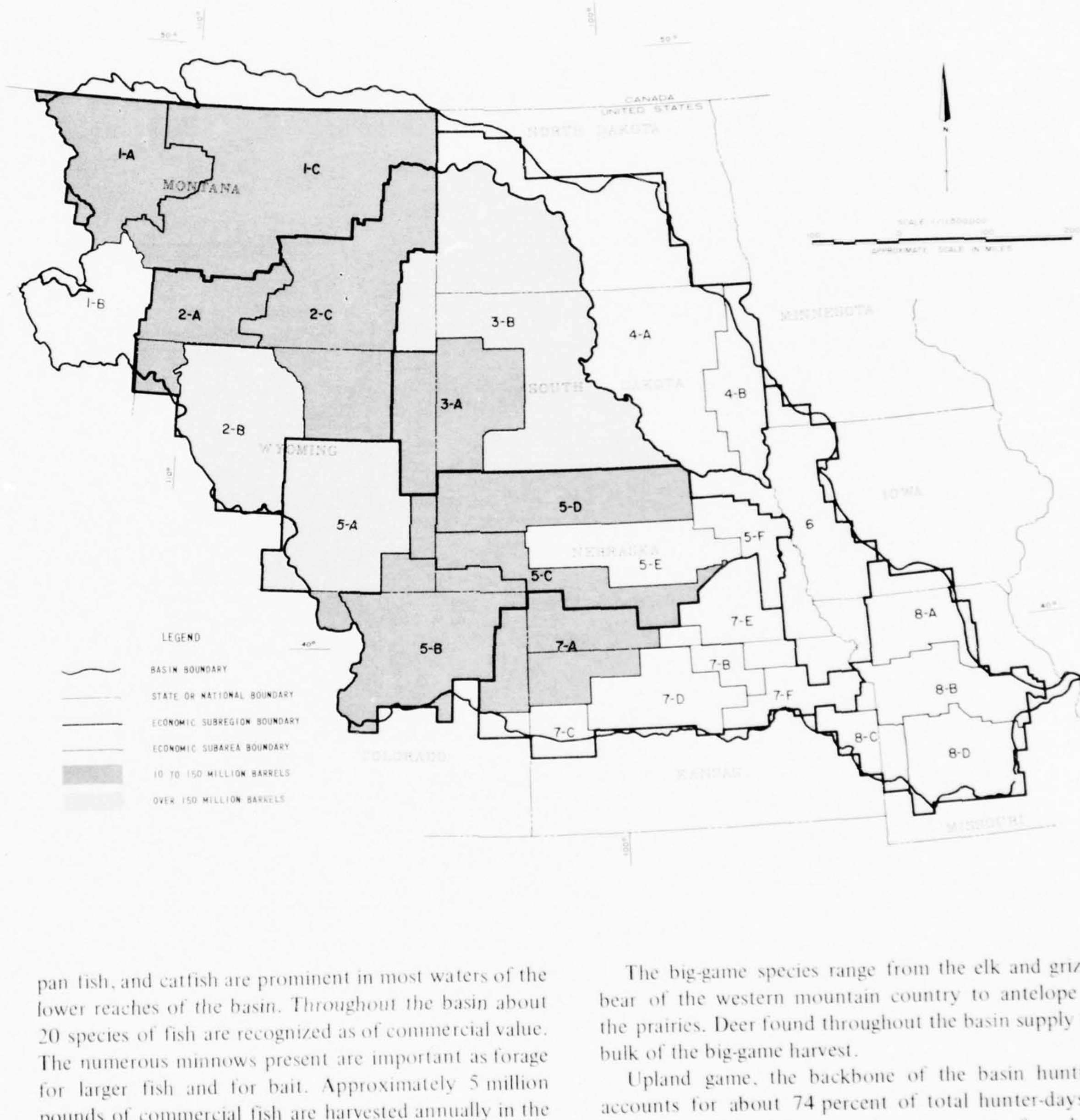
The fish and wildlife resources of the Missouri Basin are among the most outstanding in the Nation. Much of the Nation's best big game, upland game and waterfowl hunting, and coldwater fishing is found in the basin. Each year these resources attract large numbers of fisherman and hunters from all parts of the Nation. Also the basin contributes to hunting and other recreation outside the basin as large numbers of migratory birds are produced here.

In the western part of the basin, fish and wildlife are heavily dependent for habitat on public lands, while in the eastern portion they are almost entirely dependent for habitat located on private lands. Over the basin, less than one-half of 1 percent of all lands is devoted to fish and wildlife as a single-purpose use.

The great variety of fishing waters supports about 40 species important to the sport fishery, including the rare grayling and several species of trout that inhabit the clear mountain streams and lakes, and the prized northern pike and walleye of the prairie waters. Bass,

FIGURE 9

ESTIMATED CRUDE-OIL RESERVES BY SUBAREAS, 1965



pan fish, and catfish are prominent in most waters of the lower reaches of the basin. Throughout the basin about 20 species of fish are recognized as of commercial value. The numerous minnows present are important as forage for larger fish and for bait. Approximately 5 million pounds of commercial fish are harvested annually in the Missouri Basin.

A vast range in habitat types throughout the basin supports a large variety of wildlife. About 60 species of big game, upland game, and waterfowl make up the array of birds and mammals sought by hunters. Some 10 species are important for their fur value.

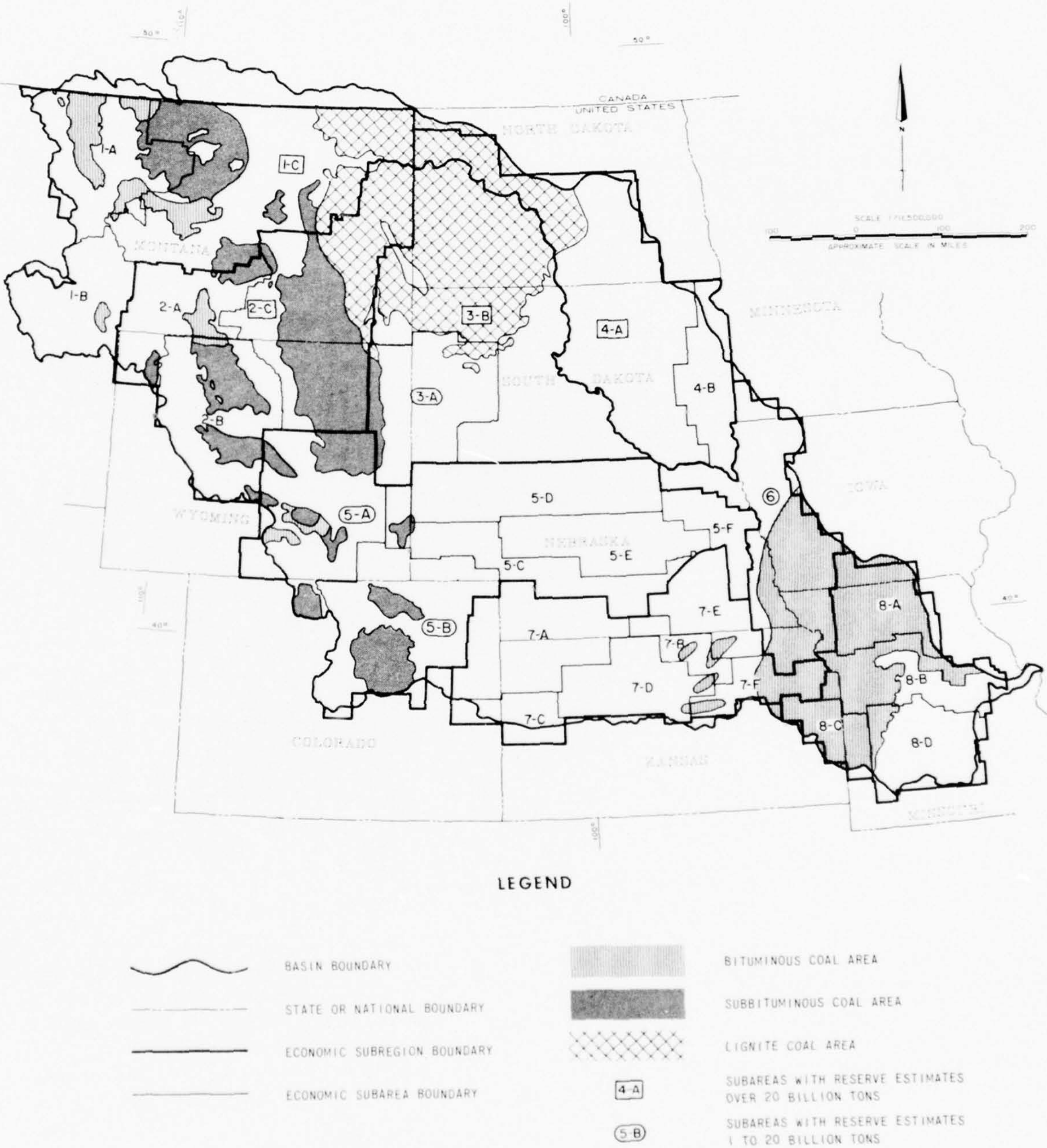
The big-game species range from the elk and grizzly bear of the western mountain country to antelope on the prairies. Deer found throughout the basin supply the bulk of the big-game harvest.

Upland game, the backbone of the basin hunting, accounts for about 74 percent of total hunter-days in the basin. The pheasant alone account for about 32 percent of the total hunting.

Waterfowl supply about 13 percent of the hunting, but even more important is the contribution of the migratory waterfowl produced in the basin to the total continental population. The major waterfowl production

FIGURE 10

COAL FIELDS AND RESERVES, JUNE 1965



of the contiguous 48 states occurs within the Missouri Basin.

Recreation

The basin with its large open spaces, rugged scenic regions, and intenstively developed recreation sites, offers a variety of recreation opportunities. These resources provide not only most of the outdoor pleasures of the basin's 7.4 million residents, but also attract millions of nonresident recreationists each year. With proper protection and development, the recreational assets should satisfy most of the leisure-time demands of an expanding population for many years to come.

The basin contains approximately 5,200 public recreation areas.[1] These include 47,632,000 acres of recreation land, 2,524,000 surface-acres of water, and 96,000 acres of marsh. Approximately 174,000 acres of land area, or four-tenths of 1 percent, are intensively developed for recreation use. Most of the basin's recreation lands and waters also serve other purposes, including wildlife, timber, and livestock production.

OUTLOOK

It appears that agriculture in its broadest aspects will continue to dominate the basin's economy well into the future. Manufacturing and any growth in heavy industry which the basin experiences will continue to be largely in the metropolitan areas. Only in a few localities will minerals and timber be important economic bases. There is not much likelihood that the basin will gain much in the refining of petroleum or metals, outside of the large urban areas. One exception to this would be in areas of large coal deposits, such as in the eastern part of the Yellowstone Subbasin, where these fields may be developed for the production of synthetic liquid fuels and other related products. With the expected continuation of migration from the rural areas, the small towns will continue to lose their service functions to larger neighbors except where they are able to diversify into such interprises as tourism and light industry. It appears that the major trends of the last 40 years will continue for some time into the future.

The trend to larger farms and the substitution of capital for labor undoubtedly will result in larger incomes per farmer and farm workers. Some of the "largeness" in farms may take a different direction from that of adding land to more intensified operations through such means as land conservation, more efficient machinery, irrigation equipment, and cattle feeding in the feed lot. Cattle in feed lots and individual irrigation where water is available have shown the greatest promise for expansion to the farmer in the basin and the trend in this direction is very likely to continue. In general, the shift to more intensive farming operations means a higher net income to the farm manager. It could also lead to more stable populations and annual incomes for the basin. The individual managers, by making these shifts, not only use their land more intensively, but put to work all of the resources, including water, that are available to them.

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[1] Excluding the private sector, for which "number of area" figures are not available.

Hatchery And Administration Facility For Trout Production

CHAPTER 2

AGRICULTURE

PRESENT DAY AGRICULTURAL CHARACTERISTICS

Agriculture in the Missouri Basin is an important part of the total agricultural sector of the national economy. The production of farm commodities and food products in the basin accounts for a large and indispensable portion of the Nation's food and fiber supply. Agriculture, the basin's largest single industry, has a dual specialization, the production of field crops (mostly food and feed grain) and livestock (mostly meat animals).

Agricultural employment in the basin has declined rapidly since 1940, in absolute numbers and as a percent of total employment. This decline has been offset somewhat by an increase in agriculture-related employment in the service sector. Rapid technological advances and an increase in the substitution of capital for labor has had the effect of shifting many farm employees into service employment. An off-farm increase in feed mixing and handling, fertilizer application, chemical service, and management and financing, as well as the contracting of actual farm operations, has diverted employment once classified as agricultural by the Bureau of Census into the service classification.

Basin agriculture has been significantly affected by public policies and programs. Originally, much of the land was homesteaded in 160-acre units. Current farm consolidation, also resulting from technological endeavors and the substitution of capital for labor, has been accelerated by the continuing struggle to adjust from the homestead concept and eastern culture carried over from settlement days to the Great Plains environment.

Basin agriculture has been marked by periodic spurts of optimism brought about by short periods of increased demands and higher prices, e.g., World War I and II and the Korean conflict. In between these brief periods of surging demand, agriculture has been plagued by lagging demand, low prices, over-production, excess capacity to produce, and lower incomes relative to other sectors of the economy.

During the 1950's there was a rapid build-up of stocks of wheat, feed grains, and other commodities produced in the basin. In this period, the Food for Peace Plan was initiated together with other programs of free domestic distribution and concession sales abroad. These types of programs furnished markets for nearly one-third of the grain produced for national export between 1954 and 1964. Agricultural prices in the Missouri Basin have been supported by national programs which include substantial cropland retirement to adjust supply to demand, and subsidized sales at home and abroad.

Increasing Size Of Farms Throughout The Basin Results In Many Abandoned Farmsteads

The climate of the basin poses a formidable challenge. Part of this natural instability is illustrated in plate 4, which shows the geographic and annual variation in precipitation in the basin. Local variations and monthly variability are much greater even than shown in plate 4. In addition, other unstable phenomena exist such as high-intensity downpours, tornadoes, hail, untimely frosts, dust storms, and short-term dry periods during the crucial growing season. Generally, the impact of the

Improved Mechanized Equipment Continues To Increase Farm Efficiency

variations in climate on agriculture has been recognized as more severe than any other large agricultural areas in the Nation. Under these conditions, planning decisions are subject to great deviation from "expected averages". Agriculture can adjust and produce economically in any climatic level if the weather is relatively stable and predictable. In vast areas of the basin, however, the "normal" climate varies widely and unpredictably. The driest summers in the vast midsection are like the arid western plains while the more favorable years may create typical corn belt conditions. The succession of wet years, drought years, and those in between does not follow any predictable pattern or cycle. Planning based upon average expectation frequently falls short of goals due to inadequate precipitation or fails to utilize favorable moisture to optimize production.

This climatic environment, plus the physical features of the basin, controls agriculture as it is today, and the potential agriculture as it relates to water and land resource development.

Agricultural Land Use

Many of the significant characteristics of agricultural organization are linked closely to the climatic and physical features of the basin. In general, rainfall belts range from a favorable subhumid environment in the lower basin and eastern plains to a semi-arid to arid environment in the western areas. With this transition from east to west, cropland gives way to grassland, farm size increases, and the density of farm population declines. The general transition is interrupted at points by irrigation which creates areas of diversified agriculture within the general limitations of local climatic conditions. These irrigation areas enhance and stabilize gross income by sustaining production of high-valued specialty crops and winter roughage and feed grains which support ranching operations in the arid areas.

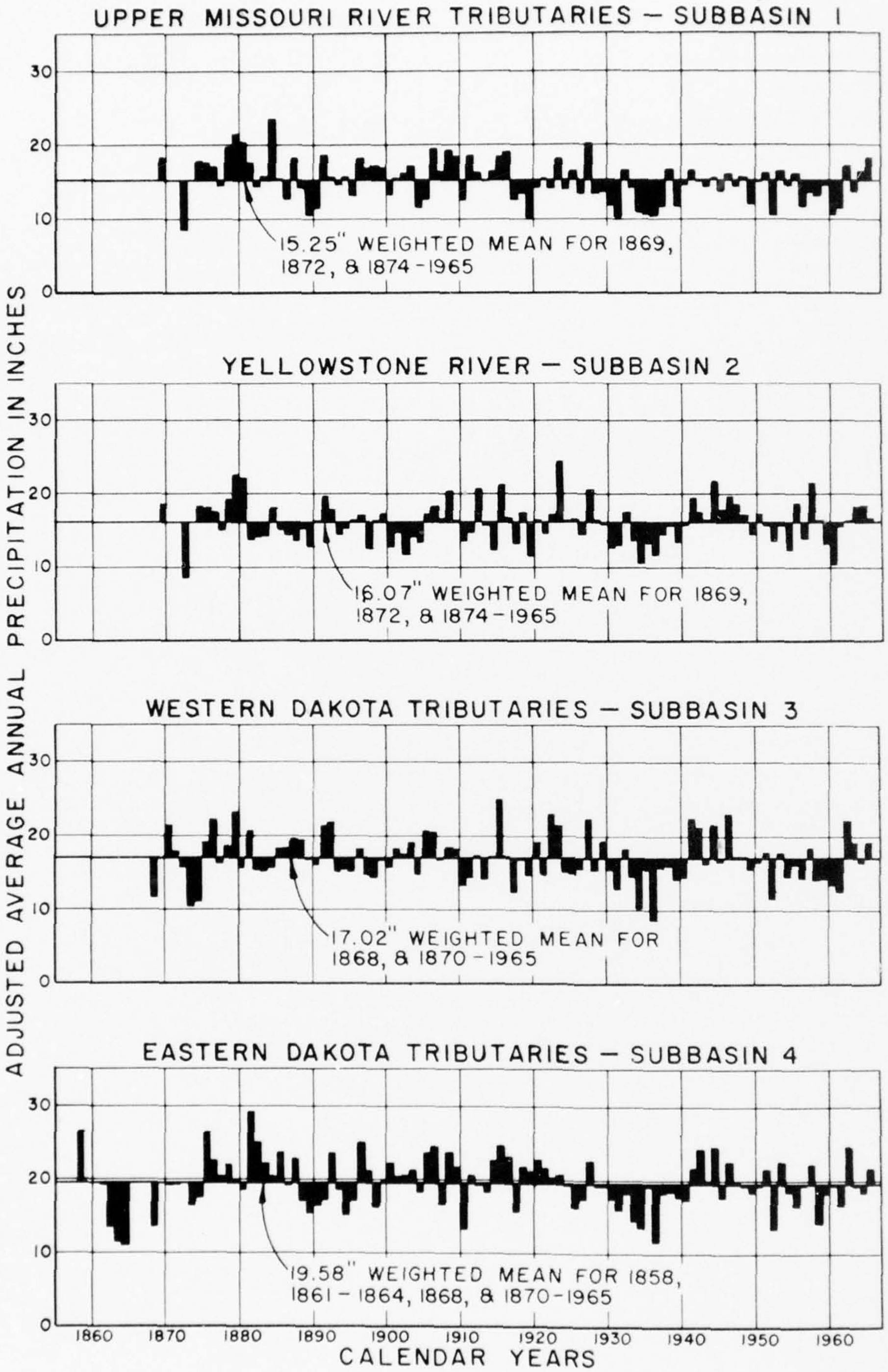
Approximately 312 million acres, or 95 percent of the land area in the Missouri River Basin, are used for some agricultural purpose, as shown in table 9. About 87 percent of the agricultural land and essentially all of the cropland are in private ownership. Federally owned land is an important source of livestock grazing and forest products.

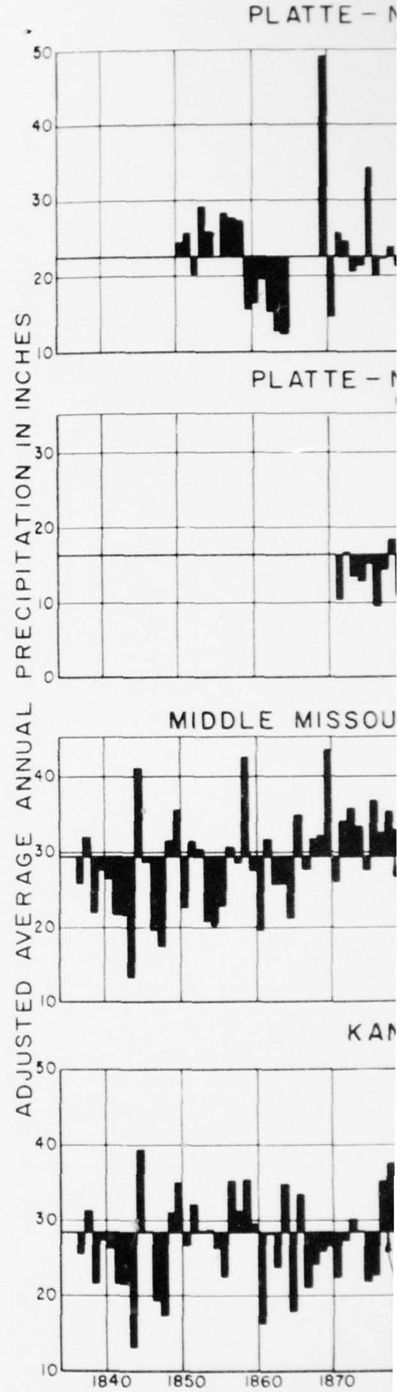
Grassland is the largest major land use category, as shown in table 10. About 61 percent or 189 million acres of the agricultural land is devoted to grazing. The highest proportion of grazing use occurs in the Upper Missouri, Yellowstone, Western Dakota, and Platte-Niobrara subbasins where more than two-thirds of the

Table 9 — INVENTORY OF LAND PRODUCING AGRICULTURAL PRODUCTS, BY SUBBASINS

Item	Upper Missouri	Yellow-stone	Western Dakota	Eastern Dakota	Platte-Niobrara	Middle Missouri	Kansas	Lower Missouri	Missouri Basin
	(Thousand Acres)								
Private Ag. Land:									
Cropland	10,710	3,374	9,295	21,008	15,634	11,219	22,341	10,208	103,789
(Irrig.) [1]	(953)	(1,031)	(198)	(119)	(2,784)	(103)	(1,703)	(5)	(6,896)
Pasture & Range	25,522	24,333	31,677	12,547	35,147	2,485	13,619	7,334	152,664
(Irrig.)	(149)	(157)	(11)	—	(202)	—	—	—	(519)
Forest & Woodland	1,964	1,550	977	211	1,936	631	597	5,788	13,654
(Grazed)	(1,356)	(1,357)	(908)	(110)	(1,410)	(560)	(382)	(3,103)	(9,186)
Other Ag. Land	254	91	209	594	621	447	552	793	3,561
Total Pvt. Ag. Land	38,450	29,348	42,158	34,360	53,338	14,782	37,109	24,123	273,668
Other Forest Land	—	—	—	—	—	118	4		122
Federal Land Producing:									
Ag. Products	11,932	13,804	5,131	39	7,449	1	69	177	38,602
(Grazed by Lvstk.)	(8,134)	(9,433)	(3,915)	(6)	(6,037)	---	(49)	(7)	(27,581)
(Forest)	(5,247)	(4,523)	(1,486)	(33)	(2,952)	(1)	(20)	(170)	(14,432)
Total Ag. Land	50,382	43,152	47,289	34,399	60,787	14,901	37,182	24,300	312,392

[1] Includes irrigated cropland in Bureau of Reclamation projects under construction or funded for construction.


UPPER MISSOURI RIVER TRIBUTARIES — SUBBASIN 1
15.25" WEIGHTED MEAN FOR 1869, 1872, & 1874-1965
YELLOWSTONE RIVER — SUBBASIN 2
16.07" WEIGHTED MEAN FOR 1869, 1872, & 1874-1965
WESTERN DAKOTA TRIBUTARIES — SUBBASIN 3
17.02" WEIGHTED MEAN FOR 1868, & 1870-1965
EASTERN DAKOTA TRIBUTARIES — SUBBASIN 4
19.58" WEIGHTED MEAN FOR 1858, 1861-1864, 1868, & 1870-1965
ADJUSTED AVERAGE ANNUAL PRECIPITATION IN INCHES
CALENDAR YEARS
0
10
20
30
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960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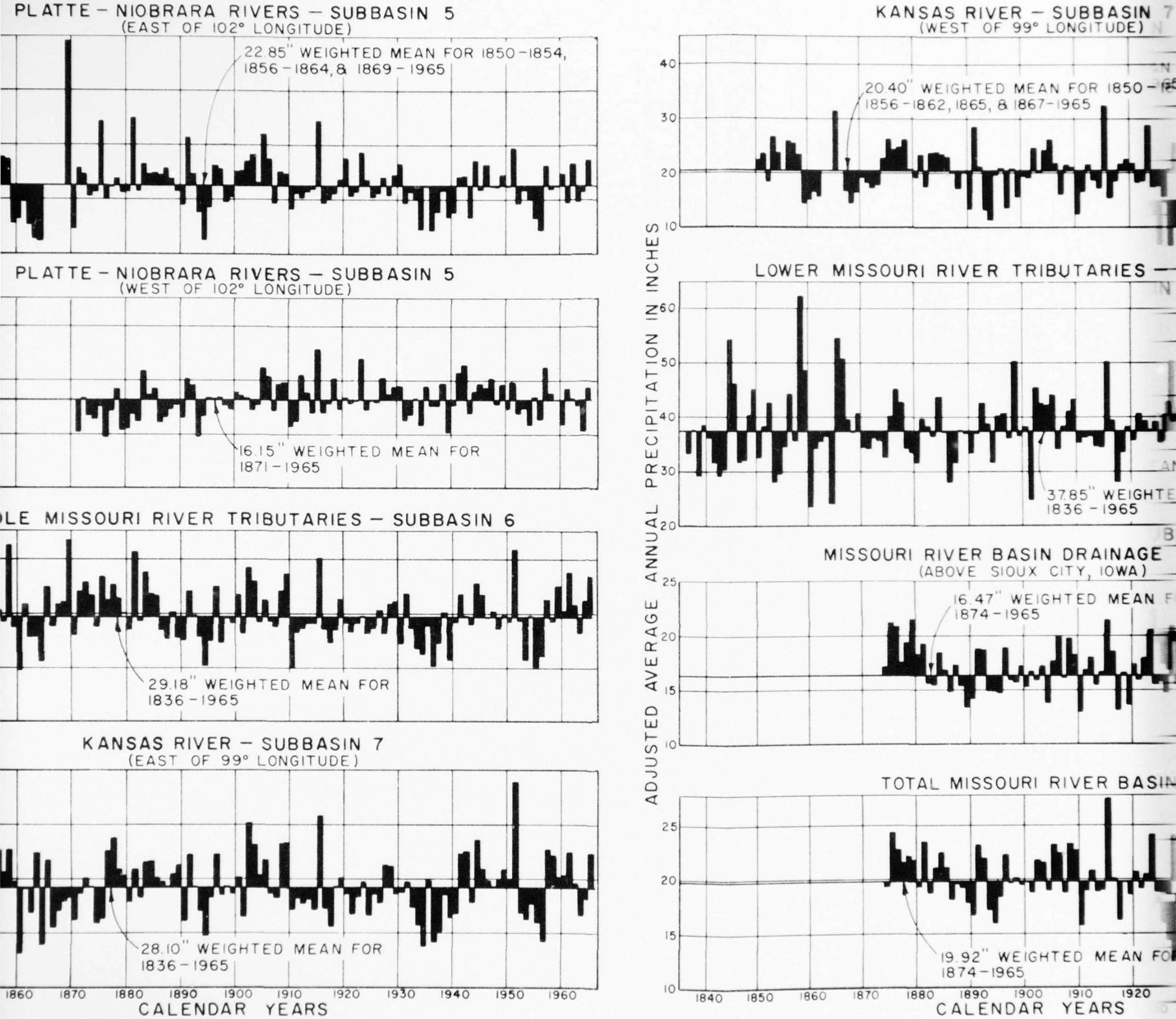

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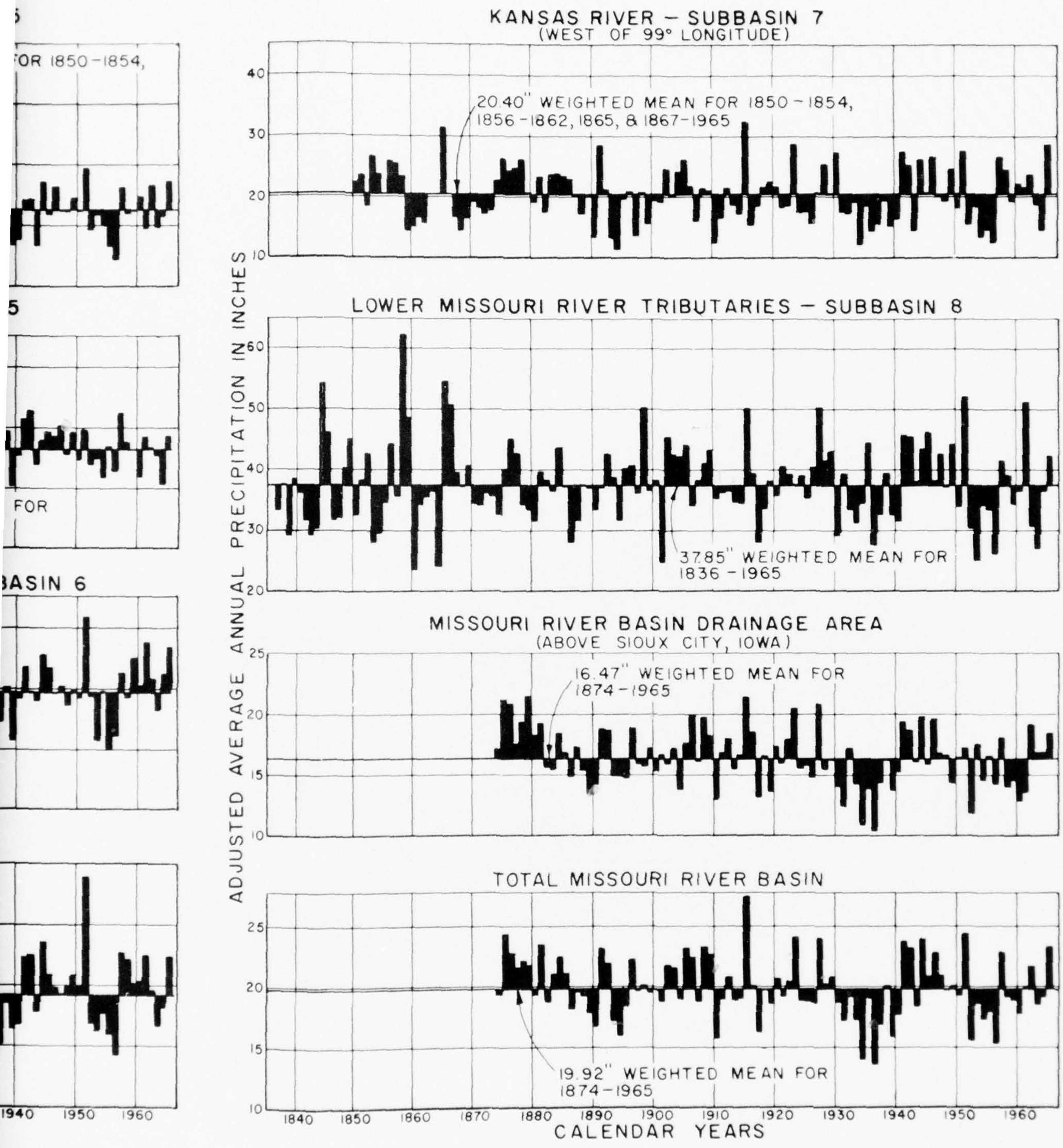


ADJUSTED AVERAGE ANNUAL PRECIPITATION IN INCHES

COMPREHENSIVE FRAMEWORK STUDY

MISSOURI RIVER BASIN

MISSOURI BASIN INTER-AGENCY COMMITTEE

PLATE 4

Table 10 – DISTRIBUTION OF MAJOR LAND USE IN AGRICULTURE BY SUBBASINS

Subbasin	Cropland	Pasture and Range	Forest and Woodland	Other Agric. Land	Total 1/
			(Percent)		
Upper Missouri	21	69	14	1	105
Yellowstone	8	81	14	*	103
Western Dakota	20	77	5	1	103
Eastern Dakota	61	37	1	2	101
Platte-Niobrara	26	70	8	1	105
Middle Missouri	75	20	5	3	103
Kansas	60	38	2	2	102
Lower Missouri	42	43	24	3	112
Missouri Basin	33	61	9	1	104

1/ Total indicated used is greater than 100 percent due to the grazing of forested land.

area is pasture and range. In the Eastern Dakota, Kansas, and Lower Missouri subbasins, approximately two-fifths of the land is in grass and in the Middle Missouri only one-fifth.

Total cropland in the basin is estimated at 104 million acres, or 33 percent of the land area. In general, the proportion of cropland declines from east to west. The Middle Missouri Subbasin is the most intensively cropped with 75 percent of the area cultivated. The Eastern Dakota and Kansas subbasins are 60 percent cropland, the Lower Missouri 42 percent, and the Yellowstone Subbasin is the lowest with only eight percent.

Seven percent, or about 6.9 million acres of the cropland in the Missouri Basin is irrigated. There are also 0.5 million acres of irrigated pastures for a total of 7.4 million acres of land irrigated annually. The Platte-Niobrara Subbasin has the largest area in irrigation or 3.0 million acres. Other important areas of irrigation are in the Kansas Subbasin with 1.7 million acres, and the Upper Missouri and Yellowstone subbasins, each with approximately 1 million acres. Smaller amounts of irrigation are found in the Western Dakota and Middle Missouri subbasins.

Forest and woodlands, much of which is grazed, are estimated at 28 million acres. Grazing of this acreage enhances the efficiency in resource utilization. Forests and woodlands are important in the Lower Missouri Subbasin, with 24 percent of the area in this use. Fourteen percent of the Yellowstone and Upper Missouri subbasins is classed as forests and woodlands, with lesser but locally significant amounts in the central subbasins.

Federally owned agricultural lands which contribute agricultural products are estimated at 38.6 million acres. These lands are largely in the mountains and western plains areas. Two-thirds of the Federal lands are located in the Yellowstone and Upper Missouri subbasins where such ownership comprises 32 and 24 percent of the agricultural land, respectively. The remaining third is largely in the Platte-Niobrara and Western Dakota subbasins where Federal ownership of agricultural land is 12 and 11 percent. In this report, Federal lands were inventoried only with respect to their contribution to agricultural output. No attempt was made to examine the condition and quality or to project the potential capacity of this land. The uses inventoried were grazing and forestry.[1]

Private agricultural land in the Missouri Basin is estimated at 273.7 million acres. This portion of the land base was inventoried by soil resource groups (SRG's) within land resource areas (LRA's) from information in the National Inventory of Soil and Water Conservation Needs developed by the United States Department of Agriculture.

Land resource areas are broad delineations used to divide the Missouri River Basin into 39 areas with similar physiographic features, types of agricultural development, and climatic environment. Within each land resource area, the soils, climate, geology, vegetation, topography, and agricultural development are similar and related.

Soil resource groups are aggregations of soil mapping units that have similar cropping patterns, yield characteristics, response to fertilizer, management, and land treatment measures. The inventory of the private agricultural land base contains approximately 15 to 20 soil resource groups per LRA.

These two levels of identification constitute the delineation of the private agricultural land base and form the inventory of land area and production capability used in the analysis in the following sections of this report.

In the Missouri Basin, crop production depends on many factors which vary from year to year. The selection of any particular base year could be influenced greatly by random variation, both in total basin production and among areas of the basin. To improve the reliability of the measurement of current production

[1] The small amount of Federal lands used for cultivated crop production is included in private agricultural land.

Livestock Grazing Utilizes A Large Portion Of The Land In The Basin

capability, a process was used to provide an estimate of present production with current technology, from which the impacts of abnormalities caused by weather and other hazards in a single year were weighted by their historical occurrence. Historical data for the years 1939 to 1963, adjusted by a process which progressively weighted each successive year in the historical series, were used to establish this measure which is called "current normal."

The final inventory is summarized by cropping patterns within subbasins in table 11. Further details of methodology and soil resource groups and land resource area descriptions are presented in the Land Resources Availability Appendix.

Table 11 – CURRENT NORMAL CROPPING PATTERNS OF PRIVATE AGRICULTURAL LAND, BY SUBBASINS

	SUBBASIN								
Crop	Upper Missouri	Yellow-stone	Western Dakota	Eastern Dakota	Platte-Niobrara	Middle Missouri	Kansas	Lower Missouri	Missouri Basin
	(Thousand Acres)								
NONIRRIG. CROPLAND									
All Wheat	3,376	683	2,224	3,074	2,301	450	6,799	985	19,892
Rye	31	6	77	294	156	3	153	1	721
Corn Grain	*	5	168	3,385	2,046	4,285	1,064	2,119	13,045
Corn Silage Equiv.	10	16	480	626	372	225	949	225	2,903
Sorghum Grain	0	0	60	101	497	310	2,413	293	3,674
Oats	127	59	740	2,889	789	1,216	289	522	6,631
Barley	1,364	192	544	1,117	438	12	505	101	4,273
Alfalfa Hay Equiv.	497	300	1,633	2,384	1,327	1,421	998	1,815	10,375
Flaxseed	23	7	86	1,255	0	8	0	0	1,379
Soybeans	0	0	*	357	140	1,058	182	1,429	3,166
Dry Beans	0	0	0	0	4	0	2	0	6
Potatoes	0	*	4	2	*	2	0	2	10
Sugar Beets	0	0	0	*	0	*	0	0	--
Cropland Pasture	1	24	184	349	701	275	393	719	2,646
Other Crops Harv.	115	15	30	5	42	49	73	88	417
Summer Fallow	3,734	816	2,078	1,932	2,273	*	3,750	0	14,583
Idle Cropland	479	117	454	1,045	640	555	1,030	510	4,830
Reserve Idle	0	103	335	2,101	1,124	1,247	2,038	1,394	8,342
TOTAL	9,757	2,343	9,097	20,889	12,850	11,116	20,638	10,203	96,893
IRRIGATED CROPLAND									
All Wheat	10	60	11	*	70	0	53	0	204
Corn Grain	1	9	15	15	945	69	863	1	1,918
Corn Silage Equiv.	11	44	16	8	261	7	158	0	505
Sorghum Grain	0	0	3	1	104	5	272	0	385
Barley	343	237	7	3	95	0	5	0	690
Alfalfa Hay Equiv.	514	436	96	67	689	2	133	0	1,937
Soybeans	0	0	0	*	12	2	6	0	20
Dry Beans	2	58	2	5	132	0	14	0	213
Potatoes	4	2	4	1	30	1	2	1	45
Sugar Beets	15	94	9	14	186	12	45	0	375
Cropland Pasture	17	42	27	3	61	*	6	0	156
Other Crops Harv.	0	3	1	1	16	4	11	3	39
Idle Cropland	29	30	7	1	85	1	51	0	204
Reserve Idle	7	16	0	0	98	0	84	0	205
TOTAL	953	1,031	198	119	2,784	103	1,703	5	6,896
CROPLAND TOTAL	10,710	3,374	9,295	21,008	15,634	11,219	22,341	10,208	103,789
Wild (Native) Hay	264	121	1,062	1,529	3,081	62	324	105	6,548
Pasture & Range	25,258	24,212	30,615	11,018	32,066	2,423	13,295	7,229	146,116
GRAZING TOTAL	25,522	24,333	31,677	12,547	35,147	2,485	13,619	7,334	152,664
Grazed Woodland	1,356	1,357	908	110	1,410	560	382	3,103	9,186
Non-grazed Woodland	608	193	69	101	526	71	215	2,685	4,468
FOREST TOTAL	1,964	1,550	977	211	1,936	631	597	5,788	13,654
Other Ag. Land	254	91	209	594	621	447	552	793	3,561
TOTAL AG. LAND	38,450	29,348	42,158	34,360	53,338	14,782	37,109	24,123	273,668

*Less than 500 acres.

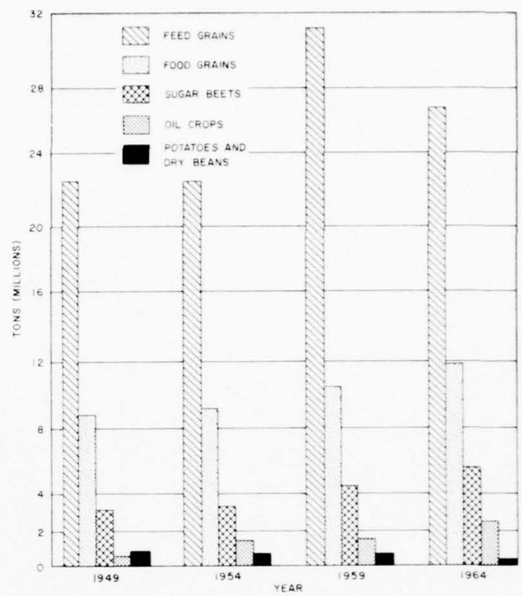
Agricultural Production

Data on total production seem to belie the production problems posed by the environment. Few other major regions in the Nation equal the Missouri Basin in the proportion of land which produces food and other commodities. Because of the high degree of specialization, the basin produces a greater proportion of the Nation's grain and meat. The area regularly produces a third or more of the Nation's wheat and is commonly known as the "bread basket" of the Nation; however, its share of the total production of feed grains is somewhat smaller. It produces 31 percent of the nation's sorghum, 29 percent of the barley, 22 percent of the corn, and 21 percent of the oats. In addition, the basin produces 40 percent of the Nation's rye, 30 percent of the sugar beets, 50 percent of the flaxseed, and one-fourth of the red meat animals — cattle, calves, hogs, and sheep.

With only 18 percent of the Nation's land, the basin contains almost 25 percent of its farmland and the same percentage of the Nation's cropland. Hence, the basin's share of grain and meat production bulks even larger in comparison to its percentage of the Nation's area. This share of the Nation's output is accomplished with only 11 percent of the Nation's agricultural employees. Historical production of crops by major commodities is illustrated by figure 11. Feed grains comprise a major portion of total crop output with wheat, oil crops, and sugar beets providing substantial portions of output.

What these data do not show is the annual variation in aggregate output. These variations cause a fluctuation in the aggregate output from the basin greater than for regions with more stable climate and natural moisture supplies. Within the basin, small areas and individual farmers face even wider fluctuations.

FIGURE 11
VOLUME OF CROP PRODUCTION BY MAJOR COMMODITIES
MISSOURI RIVER BASIN



Agricultural Sales

In 1964, the value of all farm products sold in the Missouri Basin was over five billion dollars, an increase of one-half billion dollars since 1959. The average value per farm of all farm products sold was $10,800 in 1959 and $13,000 in 1964, significantly higher than the national average. The sale of livestock and livestock products accounted for 70 percent of the total cash sales in the basin and was less than crop sales only in the Upper Missouri Subbasin, table 12. Livestock sales, however, include farm-to-farm movement prior to final marketing and domestically produced grain and roughage fed to livestock.

Gross Farm Income

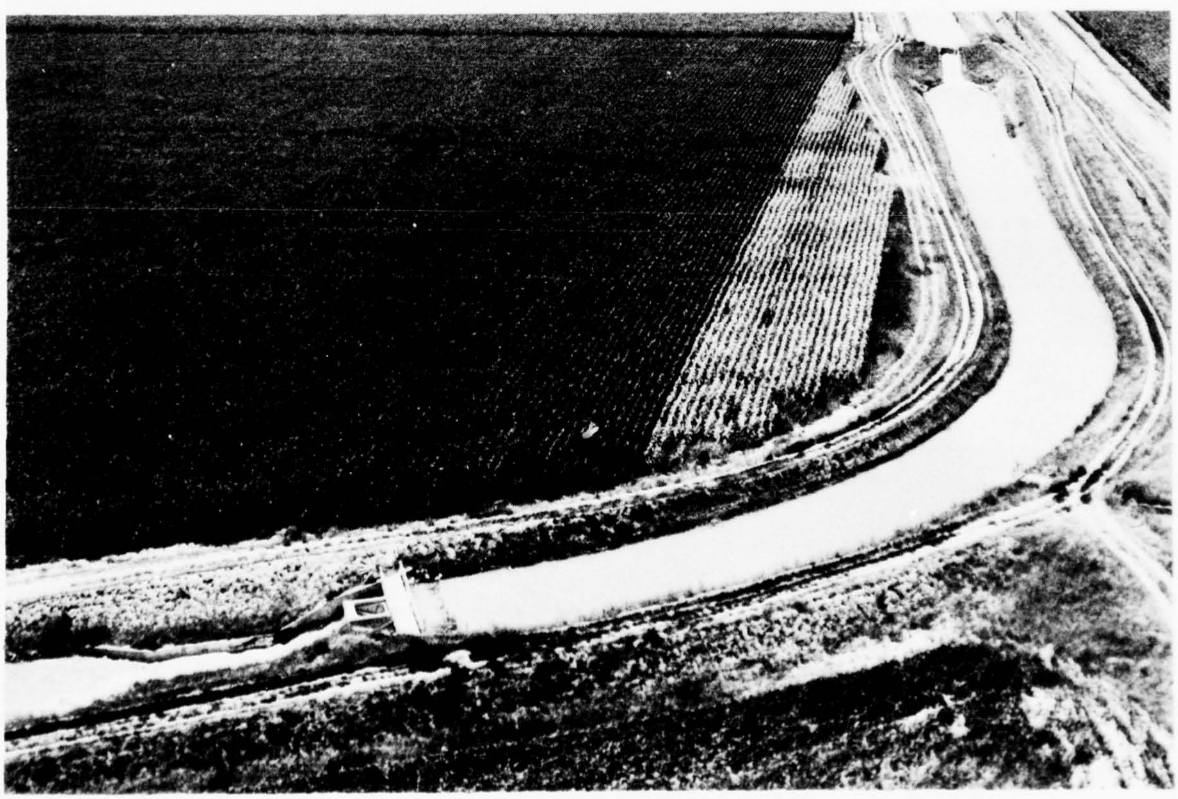
In the 1959-61 period, gross farm income in the basin was about 15 percent of the corresponding national

Table 12 — VALUE OF FARM PRODUCTS SOLD, 1959 AND 1964, BY SUBBASINS

Subbasin	Crop Sales 1959	Crop Sales 1964	Livestock Sales 1959	Livestock Sales 1964	Percent of 1964 Basin Total Sales
	(Million Dollars)				(Percent)
Upper Missouri	122	124	113	113	5
Yellowstone	43	51	121	118	3
Western Dakota	46	75	176	163	5
Eastern Dakota	114	202	389	449	13
Platte-Niobrara	263	249	588	689	18
Middle Missouri	276	331	986	1,096	28
Kansas	355	310	374	470	15
Lower Missouri	163	197	477	472	13
Missouri Basin	1,382	1,539	3,224	3,570	100

Source: U. S. Department of Commerce, Bureau of Census, Agriculture Census 1959 and preliminary 1964.

Irrigation Stabilizes and Enhances Agricultural Production



total. Gross farm income ranged from a high of over one billion dollars in the Platte-Niobrara and Middle Missouri subbasins to a low of 172 million in the Yellowstone Subbasin as shown in table 13.

Table 13 – GROSS ANNUAL FARM INCOME, BY SUBBASINS

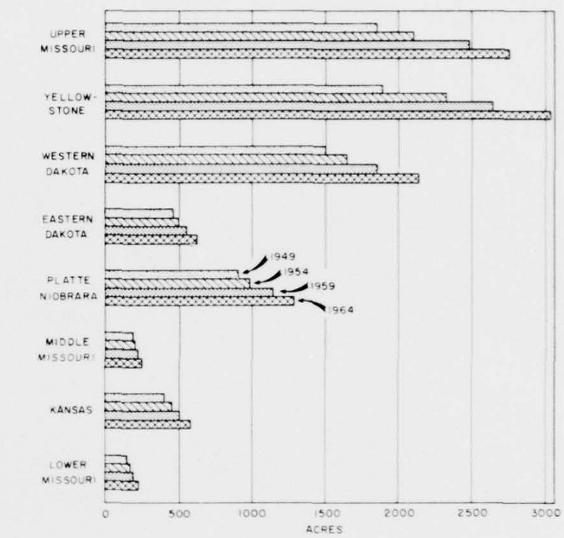
Subbasin	1959-61 Average
	(Million Dollars)
Upper Missouri	314
Yellowstone	172
Western Dakota	279
Eastern Dakota	655
Platte-Niobrara	1,057
Middle Missouri	1,196
Kansas	790
Lower Missouri	836
Missouri Basin	5,300

Farm Characteristics

One of the more significant changes in agriculture has been the steady decline in number of farms and ranches since the 1930's. This trend has occurred quite uniformly in all subbasins. The total Missouri Basin lost about 150,000 farms between 1949 and 1964, or nearly 30 percent, as shown in table 14. The national agricultural revolution by which manpower and work animals have been replaced by machine power is primarily responsible for this loss of farms. Basin conditions were favorable for farm consolidation and corporate-type concepts. Settlement laws and practices of the earlier period encouraged the development of farms too small for the basin's climate and resources. The 160-acre farm unit of the Homestead Act is in sharp contrast with the 690-acre average size of farm in 1964. Hence, reorganization of farms in the basin has been more pronounced than might have been necessary had the basin been settled under different policies which recognized the nature of the Great Plains environment and its unpredictability.

Most of the larger farms and ranches are in the western portion of the basin. The subbasin average size ranges from a high of 3,038 acres in the Yellowstone to a low of 232 in the Lower Missouri Subbasin as illustrated by figure 12.

FIGURE 12
AVERAGE FARM SIZE, BY SUBBASINS



Agricultural Employment and Population

Agricultural employment in the basin declined by nearly 280,000 workers between 1940 and 1960 as shown in table 15. In 1960, approximately 512,200 farmers and farm workers were enumerated by the population census.

Agricultural population declined approximately one million between 1940 and 1960, or nearly 40 percent.

Table 14 – NUMBER OF FARMS AND PERCENTAGE CHANGE, BY SUBBASINS

Subbasin	Number of Farms 1949	1954	1959[1]	1964	Percentage Change 1949-1964
	(Number)				(Percent)
Upper Missouri	18,287	17,140	15,355	14,484	21
Yellowstone	14,485	13,510	11,491	10,575	27
Western Dakota	27,072	24,966	22,002	20,099	26
Eastern Dakota	71,725	68,021	61,066	54,182	24
Platte-Niobrara	80,332	74,132	64,795	57,654	28
Middle Missouri	90,570	85,469	76,772	67,387	26
Kansas	80,836	75,187	66,354	58,624	27
Lower Missouri	145,194	129,288	109,577	97,061	33
Missouri Basin	528,501	487,713	427,412	380,066	28

[1] Unadjusted for farm definition change.
Source: Agricultural Census, 1949, 1954, 1959, and preliminary 1964.

Table 15 – AGRICULTURAL EMPLOYMENT AND POPULATION, BY SUBBASINS

Subbasin	Employment			Population		
	1940	1950	1960	1940	1950	1960
Upper Missouri	31,944	30,197	23,332	85,779	66,383	56,390
Yellowstone	28,159	24,598	17,900	81,631	64,088	48,160
Western Dakota	44,018	43,274	32,091	142,496	109,255	86,866
Eastern Dakota	108,106	108,488	80,434	326,318	272,155	222,086
Platte-Niobrara	129,703	123,951	93,427	394,247	314,652	241,361
Middle Missouri	143,630	132,570	92,929	424,837	349,469	280,050
Kansas	116,794	108,987	74,047	368,001	273,424	204,427
Lower Missouri	189,551	168,522	98,086	648,758	497,712	332,563
Missouri Basin	791,905	740,587	512,246	2,472,067	1,947,138	1,471,903

Source: U. S. Department of Commerce, Bureau of Census, Population Census, 1940, 1950, 1960.

Summary

All of the preceding discussion of agricultural characteristics has been concerned with average values of parameters, and with respect to relatively broad geographic areas. No data are presented to illustrate the erratic nature of the environment as manifested in production and income in small areas. The reader should be aware, nevertheless, that the instability and uncertainty faced by the individual farmer is much greater in certain portions of the Missouri Basin than in the more stable areas of the basin and throughout the Nation.

The data presented, as it pertains to farm units, indicates a consistent and progressive pattern toward consolidation into larger size and more economic farm operations. This consolidation has possibly been more dramatic and noticeable in portions of the basin because of a failure in earlier times to recognize the limitations of the environment. Recent trends in agriculture indicate an adjustment toward a more efficient combination of human and natural resources. This adjustment is characterized by larger farm units, lower densities of rural population, and a smaller share of the basin's populace being closely identified with agriculture. While agriculture is plagued with low incomes in the basin, the situation reflects an industry-wide problem rather than any particular basin disadvantage.

While this adjustment results in stronger farm units with per capita improvements in income and earnings, social costs caused by the sparse population density of rural areas have increased. Many in the rural sections have to travel longer distances to satisfy their needs for school, trades, services, medical attention, and other amenities. This conflict of efficient combinations of people and resources on one hand and vast distances in rural areas on the other is a social and environmental characteristic of great significance to a study of problems and needs.

OBJECTIVES AND NEEDS IN AGRICULTURE

An analysis of the regional and national problems and opportunities for economic development and their relationship to future needs in agriculture is complex. Problems, potentials and needs may be separate, identical, or interrelated. Each potential for resource development may be independent of, or may conflict with, or complement other potentials and objectives. The relationship is further complicated by the divergency of objectives at national, regional, and environmental levels. Any meaningful treatment of present problems and future needs must recognize their relationship to social objectives and financial opportunities involved in resource development. Accordingly, agricultural production is related to the following objectives:

1. National objectives
   a. Production demand
   b. Efficiency gains
2. Regional and local objectives
3. Environmental objectives

First, in relation to the national objective, future demand for agricultural production is defined as the amount of food and fiber required to support the level of economic activity consistent with the total economic base. Projected national requirements for food and fiber are allocated to regions compatible and consistent with the national framework of projections dated March 6, 1964, prescribed by the ad hoc Water Resources Council.

Future developmental needs, in relation to the national objectives, are determined by comparing the projected capability of the soil and water resources to produce agricultural products with the projected future demand. Resource development which could substitute food and fiber production at a cost lower than the production from resources currently utilized, constitutes a gain in efficiency and is consistent with national objectives. Thus, a related national objective is to supply the present and projected food and fiber requirements through the most efficient combination of resources at the lowest practicable cost.

The second-level objectives (regional and local) may be achieved through development of the national objectives already described. Regional and local objectives may include the desire to change the course of the economic growth and characteristics of one region in relation to the overall national economy. Such objectives may be accomplished by several means: More efficient use of a region's resources, fuller utilization of underemployed resources, winning industry from other areas, or as a national policy of income redistribution which diverts a portion of the Nation's capital into the development of a particular region.

Regional and local objectives are in harmony with national objectives in meeting agricultural production needs if such objectives involve expanded production. Regional and local objectives may go beyond the national objectives by seeking to produce food and fiber at levels in excess of the regional share allocated by the national framework projections. Such production might possibly divert agricultural activity in the region without changing the national supply and demand levels and invalidating price assumptions.

The third-level objectives (environmental) do not always lend themselves to an analysis in quantifiable terms. The preservation of unique natural resources, stabilization of income, maintenance of rural populations and viable rural economics, alleviation of low incomes, environmental quality, and economic-sized family farms are desirable environmental goals. These can become national benefits by the act of adopting such programs as national policy, or may be considered regional objectives.

National Food and Fiber Requirements

Projected national requirements for food and fiber, and the Missouri Basin's share thereof, were prepared in 1964 by the National Interregional Projections Committee of the United States Department of Agriculture. The projected agricultural production requirements of this basin, plus those of the 16 other major river basins, constitute the composite national demand.

The magnitude of the future demand for agricultural products was determined through consideration of the major forces which influence demand: Population, per capita income, consumers' tastes, industrial uses, livestock feeding efficiencies, imports, and exports. The appraisal of future conditions relies heavily on historical trends and relationships.

Domestic requirements for the major farm commodities are a function of projected population growth and per capita consumption. (The consumption of various agricultural products per person has been changing with rising incomes, shifting tastes, substitute products, and lower relative prices.) Per capita consumption by commodity was projected to 1980 and held constant at that level for the years 2000 and 2020. Industrial use of major farm commodities was maintained at a constant per capita level for all time periods. Thus, domestic consumption requirements for the later time periods became a direct function of population.

Net export (foreign exports minus imports) requirements were determined by projecting United States trade of agricultural commodities to 1980, and holding this projected level constant through 2000 and 2020.

Gross national requirements for livestock, livestock products, food grains, feed grains, fiber crops, and oil crops shown in table 16 were estimated as the sum of domestic consumption, other domestic uses, and net export requirements. Livestock and livestock product requirements were translated into feed grain demands and are included within the crop items in that table. For purposes of water and related land resources planning, the crop requirements in table 16 include the feed grain requirements of the livestock items and summarize total demands placed upon the Nation's agricultural resources, exclusive of roughage needs for livestock. Since the projection system includes an evaluation of net foreign trade, this level of agricultural production requirements becomes, in effect, a projection of production at the national level. Hence, this level of agricultural activity *determines* agricultural employment and population in the projected economic base.[2]

Missouri Basin Agricultural Product Requirements

The Missouri Basin's share of national production requirements for food grains, feed grains, and livestock was determined by a national-interregional analysis of historical shares and trends. Each product item was allocated to the 17 major regions independently. Hence commodity flows among regions are accounted for by the historical relationships of production among regions. No attempt was made to balance feed production and livestock needs beyond trends contained in the historical data.

The projected requirements allocated to the Missouri Basin are shown in table 17. These data show a generally favorable situation for the basin vis-a-vis the Nation. Production requirements for all major crops increase faster than the national requirements, indicating

[2]Further details of the national framework and methodology are presented in "Preliminary Projections of Economic Activity in the Agricultural and Forestry Sectors of the U.S. and its Water Resource Regions, 1980, 2000, and 2020," for use of the Water Resources Council, prepared by ERS and Forest Service, USDA, August 1967.

Table 16 – CURRENT NORMAL PRODUCTION AND PROJECTED AGRICULTURAL REQUIREMENTS, UNITED STATES

Commodity	Unit	Current Normal[1] Production	Projected Requirements 1980	2000	2020
			(Thousand Units)		
Corn	Bu.	3,853,138	5,237,143	6,921,893	9,222,214
Oats	Bu.	1,035,815	1,154,438	1,072,938	791,375
Barley	Bu.	439,720	526,000	536,083	501,458
Sorghum	Bu.	602,342	942,036	1,455,679	2,237,143
Wheat	Bu.	1,199,645	1,889,600	2,192,200	2,618,600
Rye	Bu.	34,140	40,732	53,893	72,518
Soybeans	Bu.	679,056	1,350,467	1,640,933	2,116,367
Potatoes	Cwt.	276,056	328,876	450,136	627,396
Sugar Beets	Ton	19,615	38,092	62,482	96,785
Fruits, Noncitrus	Ton	9,461	13,123	18,887	26,995
Vegetables	Cwt.	389,432	642,235	881,055	1,217,135
Flaxseed	Bu.	26,924	22,518	29,161	38,500
Beans, Dry Edible	Cwt.	19,194	23,450	30,980	41,580
			(Million Units)		
Beef and Veal[2]	Lb.	31,181	47,451	66,580	93,537
Lamb and Mutton[2]	Lb.	1,497	1,700	2,378	3,331
Pork[2]	Lb.	20,737	27,056	37,352	51,830
Chickens[2, 3]	Lb.	8,440	12,158	16,613	22,890
Turkeys[2]	Lb.	1,666	3,559	4,888	6,760
Milk	Lb.	124,840	145,089	198,719	274,269
Eggs	Each	62,974	75,528	104,065	144,289

[1]Current normal values reflect current production technology and prices from which the impacts of abnormalities caused by weather and other hazards in a single year were weighted by their historical occurrence. These values are based on historical data for the years 1939 to 1963 adjusted by a process which progressively weighted each successive year in the historical series.
[2]Live-weight basis.
[3]Includes broilers.

Table 17 – CURRENT NORMAL PRODUCTION AND PROJECTED AGRICULTURAL REQUIREMENTS, MISSOURI BASIN

Commodity	Unit	Current Normal[1] Production	Projected Requirements 1980	2000	2020
			(Thousand Units)		
Corn	Bu.	845,782	1,179,679	1,559,179	2,077,321
Oats	Bu.	218,646	263,250	244,750	180,438
Barley	Bu.	128,061	121,917	124,250	116,250
Sorghum	Bu.	184,992	324,250	501,036	770,036
Wheat	Bu.	430,855	635,300	737,000	880,300
Rye	Bu.	13,258	16,912	22,379	30,111
Soybeans	Bu.	86,270	115,077	144,648	186,558
Potatoes	Cwt.	8,947	6,775	9,273	12,924
Sugar Beets	Ton	5,750	10,936	17,938	27,787
Fruits, Noncitrus	Ton	39	54	77	111
Vegetables	Cwt.	4,030	5,780	7,930	10,954
Flaxseed	Bu.	13,457	9,917	12,902	17,036
Beans, Dry Edible	Cwt.	3,542	4,334	5,725	7,684
			(Million Units)		
Beef and Veal	Lb.	8,107	11,583	16,252	22,833
Lamb and Mutton	Lb.	478	506	708	992
Pork[2]	Lb.	4,678	5,858	8,089	11,222
Chickens[2, 3]	Lb.	208	182	250	346
Turkeys[2]	Lb.	155	215	296	409
Milk	Lb.	9,780	9,910	13,573	18,733
Eggs	Each	7,060	6,148	8,471	11,745

[1]Current normal values reflect current production technology and prices, from which the impacts of abnormalities caused by weather and other hazards in a single year were weighted by their historical occurrence. These values are based on historical data for the years 1939 to 1963 adjusted by a process which progressively weighted each successive year in the historical series. Current normal production is assumed to be approximately 10 percent above current requirements.
[2]Live-weight basis.
[3]Includes broilers.

Livestock Utilize Much Of The Feed Grain Within The Basin

relatively larger shares are expected to originate in the basin in the future. In absolute terms, projected requirements for all crops except oats and barley show substantial increases.

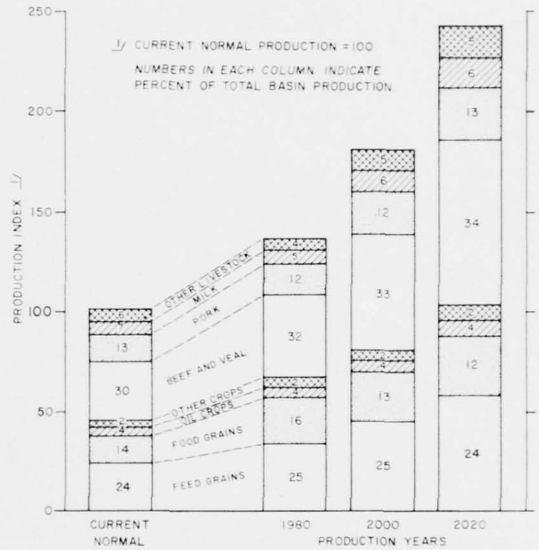
Increases in major livestock and livestock products requirements in the basin are projected at about the national rate; only poultry, poultry products, and dairy products are expected to increase in the basin at significantly lower-than-national rates. All livestock and livestock items are projected to increase in absolute terms.

The changing composition of major product groups is illustrated in figure 13. This shows that beef and veal production requirements will increase as a share of the total from 30 to 34 percent. Food grains decline slightly as a percent of total output requirements while all other groups remain relatively stable in relation to total requirements. Total requirements are projected to increase nearly two and one-half times by 2020.

Livestock Roughage Requirements

The production of roughage is closely linked geographically to livestock production due to the difficulty

FIGURE 13
CURRENT NORMAL AND PROJECTED CHANGE
IN AGRICULTURAL REQUIREMENTS
BY MAJOR COMMODITY GROUPS
MISSOURI RIVER BASIN



in harvesting pasture and range other than by grazing, and because of the high transportation cost of bulky hays and silages. Therefore, it was assumed that all roughage needed would be produced in the basin and that all forage produced would be utilized by livestock within the basin. Projected livestock production was converted into roughage requirements by use of projected livestock feeding efficiencies and ration composition as shown in tables 18 and 19. Projected feed grain requirements for livestock are already included in the regional projections of feed grains. Hence, in the remainder of this analysis, total demands for agricultural

Table 18 – PROJECTED FEED CONVERSION RATES FOR LIVESTOCK AND LIVESTOCK PRODUCTS[1], MISSOURI BASIN

Item	Year			
	CN	1980	2000	2020
	(Feed Units)			
Beef and Veal	10.7	9.7	8.0	6.8
Pork	4.3	4.0	3.5	3.0
Lamb and Mutton	13.5	11.4	9.3	8.1
Milk	1.3	1.1	1.0	0.9
Broilers	2.4	2.1	1.9	1.8
Turkeys	3.7	3.3	3.0	2.6
Eggs	3.4	3.0	2.7	2.4

[1] Feed units per pound of live weight produced (or product for milk and eggs). A feed unit is the feed value of one pound of corn or its equivalent.

Source: "Projections of Livestock Feeding Efficiencies: 1980-2000-2020; Missouri River Basin States," Great Plains Agricultural Council Publication No. 31; University of Nebraska, Lincoln, Nebraska, May 1968.

Table 19 – PROJECTED RATION COMPOSITION FOR LIVESTOCK AND LIVESTOCK PRODUCTS[1], MISSOURI BASIN

Item	CN	1980	2000	2020
	Year			
	(Percent)			
Beef and Veal:				
Roughage	70	67	65	65
Feed Grains	20	26	31	31
Supplemental Protein	10	7	4	4
Pork:				
Roughage	7	7	6	6
Feed Grains	83	84	86	87
Supplemental Protein	10	9	8	7
Lamb and Mutton:				
Roughage	78	74	70	69
Feed Grains	20	23	27	28
Supplemental Protein	2	3	3	3
Milk:				
Roughage	69	65	62	59
Feed Grains	27	32	35	39
Supplemental Protein	4	3	3	2
Broilers:				
Feed Grains	65	72	78	80
Supplemental Protein	30	25	20	18
Other	5	3	2	2
Turkeys:				
Feed Grains	70	71	73	74
Supplemental Protein	25	25	24	24
Other	5	4	3	2
Eggs:				
Feed Grains	80	85	90	90
Supplemental Protein	20	15	10	10
Other	0	0	0	0

[1]Composition of ration as corn equivalent feed units. A feed unit is the value of one pound of corn or its equivalent.

Source: "Projections of Livestock Feeding Efficiencies: 1980-2000-2020; Missouri River Basin States," Great Plains Agricultural Council Publication No. 31; University of Nebraska, Lincoln, Nebraska, May 1968.

food and fiber production are expressed in terms of field crops, roughage, and pasture.

Projected roughage production requirements were computed to be 123 billion feed units by 1980, 140 billion by 2000, and 164 billion by 2020. The acreage available for the production of permanent pasture, range, and grazed forest was held essentially constant in the private sector. An estimated 1.9 billion feed units of grazing output from Federal grazing land was assumed to be unchanged for all time periods.

Projected roughage requirements less the projected roughage production from native hay, permanent pasture, range, grazed forest, and Federal land equaled the residual requirement for roughage to be produced by cropland. This residual was allocated to corn silage, sorghum silage, sorghum forage, alfalfa hay, and other hay in the same proportions as in the current normal inventory. The feed unit requirement was then converted to the more commonly used production units shown in table 20.

PROJECTED LAND BASE

Lands required for habitation, transportation, defense, and industrial sites are assumed to be basic to the well-being and economic existence of people. Generally, the prices necessary to divert such lands from agricultural uses are not a deterrent to their acquisition and (when for public use), are acquired through negotiation or the right of eminent domain.

About 8 million acres of land are currently used for transportation; urban and built-up areas of more than 10 acres; industrial sites; railroad yards; airports; golf courses; institutional and public administration sites; highways; public roads; railroads; and idle or unused rural, open, nonagricultural areas. The requirements per capita vary throughout the basin. This variation is related to land values, population density, type of industry, and the amount of open nonagricultural land. Based on projected population, economic structure, and current densities within urban areas, estimates were made of lands required in the future for this purpose. This estimate indicated that an additional 4.8 million acres of land will be needed for this purpose to accommodate the projected 12 million population increase by the year 2020.

The projected losses to the agricultural land base also take into account gully erosion damage, needs of the mineral industry, and the land requirements for several major reservoirs funded for construction but not deducted from the current inventory of agricultural land. The total losses are expected to reduce the existing agricultural land base some 1,392,000 acres by 1980, 3,326,000 acres by 2000, and 6,169,000 acres by 2020. Requirements of the framework plan for expanded diversions of land for recreation, fish and wildlife, water developments, or other new uses are not accounted for in these estimates.

Table 20 – CROPLAND ROUGHAGE PRODUCTION REQUIREMENTS, MISSOURI BASIN

Crop	Unit	Current Normal	1980	2000	2020
		(Thousand Units)			
Alfalfa Hay Equivalents	Ton	21,628	24,100	27,200	37,000
Corn Silage Equivalents	Ton	25,448	29,100	34,000	46,000
Cropland Pasture	F.U.	4,414,608	5,831,407	6,687,041	7,042,709

PROJECTED PRODUCTION CAPABILITY

Agricultural production requirements may be met through various ways and means. Ways and means of increasing agricultural production are through the activities of research, technology, management, capital investment, conservation treatment, flood and erosion control, better drainage of agricultural lands through group drainage systems, irrigation of new lands, and irrigation system rehabilitation. The following sections set forth the production that might be expected with only certain specified activities continuing at present trends.

Specified Activities Continuing

A generalized model was developed and used to analyze and project land use and cropping patterns in the Missouri Basin. Production patterns for 1980, 2000, and 2020 presented initially in this chapter are based on the projected capability of the soil and water resources with only specified activities of research, technology, conservation treatment, and land management continuing, but subject to the assumptions and limitations listed in the following section. The mathematical process (linear programming) is a form of enterprise budgeting.

The linear programming model, as used, is a mathematical tool for determining land use and cropping patterns which might result if the identified soil units were used in such a way as to meet a specified level of output most efficiently. In the application of the model, the cost of production and yield per acre are specified for each of the soil units identified for each future time period. The model is used to mathematically compute a combination of crops by soil resource groups which would minimize the total cost of achieving a specified level of production within the constraints and assumptions adopted. Principal among the constraints placed upon the model were: (a) only those crops which appeared in the current normal cropping pattern on a particular soil within an LRA could be used in a projected cropping pattern, and (b) shifts from current cropping patterns toward more efficient combinations of land and individual crops were allowed within recognizable limits imposed by rotations, diversifications, institutional restrictions, and complementarity among roughage production, uses of pasture and range, and livestock enterprises. In addition, the amount of change between time periods was restricted to rates of change considered to be reasonable and supported by actual historical changes.

The results of this analysis are designed to provide a basic framework, for each of the time periods, which estimates the physical capability of the agricultural resources under the stated conditions for comparison of this production level to the regional share of national production requirements. A change in assumptions can produce a different solution, as can alternative development plans. The solution should be considered only as a planning guide. It supplies a unique solution of future agricultural production based upon the specifications or assumptions outlined earlier.

This solution is contingent also upon the projections of land depletion and technology given herein. Only activities of research, technology, conservation treatment, and land management are assumed to be parts of the projections of technological improvements affecting crop and pasture yields and livestock feeding efficiencies. Irrigated land was held constant at 7.4 million acres in all projected solutions. The effect of any future public or private development of irrigation, flood control, drainage, and gully control was not considered in the solution. Other factors not included as parts of this projection include grazing of crop aftermath, winter grazing of small grains, and double cropping.

Projections of crop yields for 1980, 2000, and 2020 were made by Agricultural Experiment Station Committees at the various land grant universities. Overall

Conservation Practices Insure Increased Yields, Fertility, And Minimum Loss Of Soil And Water

coordination was accomplished by an ad hoc committee of the Great Plains Council.

These committees studied research now underway, analyzed emerging technology, and considered the effects of alternative levels of fertilizer use. The final projections considered the enumerated factors as well as the rate of application of improved production technology and intensified production practices by farmers, and assumed the continued application and improvement of soil and water conservation practices.

Representative indices of increase shown in table 21 illustrate the overall magnitudes of production increase anticipated with these improvements. The yield projections by soil resource groups are contained in detail in "Projection of Crop Yields, Land Resource Regions, 1980, 2000, 2020, Missouri River Basin States," Great Plains Agricultural Council Publication Number 33, Nebraska Agricultural Experiment Station, 1969.

Table 21 – INDEX OF PROJECTED CROP YIELDS[1] MISSOURI BASIN

Commodity	1980	2000	2020
	(Current Normal = 100)		
NONIRRIGATED CROPLAND:			
Wheat	128	152	176
Rye	128	150	161
Corn, for Grain	138	166	190
Corn, for Silage	140	170	189
Sorghum, Grain	134	160	188
Sorghum, Silage	147	170	184
Sorghum, Forage	140	164	182
Oats	136	167	191
Barley	122	143	156
Alfalfa Hay	126	147	158
Other Hay	131	153	162
Flaxseed	130	150	170
Soybeans	122	137	148
Dry Beans	100	100	125
Sugar Beets	131	158	180
Potatoes	116	125	131
Cropland Pasture	134	153	166
IRRIGATED CROPLAND:			
Wheat	134	162	184
Barley	140	172	198
Corn, for Grain	145	186	218
Corn, for Silage	120	138	152
Sorghum, Grain	140	178	208
Sorghum, Forage	131	154	170
Alfalfa Hay	123	147	167
Other Hay	133	167	193
Soybeans	120	140	157
Dry Beans	106	112	118
Potatoes	129	150	168
Sugar Beets	115	129	142
Cropland Pasture	130	153	170
Native Hay	111	122	133
Range	127	147	162
Pasture	132	150	167

[1] The indices illustrate the general magnitude of increase in projected yields. In this form they are generalized for the entire basin, based on the current normal cropping pattern. They are inappropriate for analysis of yields on particular soils in specific areas.

Source: Adapted from "Projections of Crop Yields, Land Resource Regions, 1980, 2000, and 2020, Missouri River Basin States", Great Plains Agricultural Council Publication No. 33, Nebraska Agricultural Experiment Station, 1969.

The projected cropping patterns and production levels presented in this section were computed by soil resource groups within land resource areas in the basin. The results of the land resource area solutions were aggregated to subbasins by use of area factors. Projected production is summarized in table 22 and the irrigated and non-irrigated land use with its associated production is given in table 23. Greater detail of subbasin cropping patterns by major land use is included in tables 47 through 55 in the statistical supplement at the end of the chapter.

It should be noted that the production shown in table 22 for the years 1980 and 2000 is at the allocated requirement level, and is not based on the full utilization of all land. The difference between requirements (demand) and capabilities is expressed as "reserve idle" as shown in table 23. Total production in 1980 and 2000 would be the production levels shown plus the potential production from the 7.5 million acres of reserve idle land in 1980 and 6.7 million such acres in 2000. In 2020, the production levels shown represent the total production without any land in "reserve idle" and is below the requirements level given in table 17.

The Missouri Basin currently exports to other areas of the nation about 30 percent (374 million bushels) of its feed grain production. The projected production for the basin implies an increase in feed grains produced in excess of projected livestock feed requirements in the basin as shown in table 24. Exports are estimated to be 38 percent or 652 million bushels of the total by 1980, with an increase to 39 percent or 1,040 million bushels by 2020. The level of exports in 2020, however, is 253 million bushels below the level indicated in the national projections. Achievement of the required level of production in 2020 would increase exports to approximately 42 percent of feed grain production, or 1,293 million bushels.

Since such a large portion of feed grain production is exported, all of the regional livestock requirements (feed grain and roughage) can easily be met in all time periods. Hence, all potential sources of additional output can be analyzed on the basis of cash crop value without consideration of the effect on the livestock industry.

Livestock Production

Projected livestock production by subbasins is shown in table 25. Subbasin projections were made by projecting historical shares and trends to 1980 and holding this relationship constant through 2020. The projections of cattle and calves were adjusted to insure a complete harvest of pasture and range. Further adjustments were made to match the remaining cattle and calves requirements to grain-producing areas in approximately the same relationship among subbasins as shown by cattle feeding data in the 1964 Census of Agriculture.

Table 22 – PRIVATE CROPLAND AND GRAZING LAND PRODUCTION
MISSOURI BASIN

Commodity	Unit	Current Normal[1]	Projected Production[2]		
			1980	2000	2020
			(Thousand Units)		
Corn	Bu.	845,782	1,182,853	1,562,683	1,876,003
Oats	Bu.	218,646	263,247	245,380	175,778
Barley	Bu.	128,061	123,183	124,098	114,982
Sorghum	Bu.	184,992	324,599	501,508	720,234
Wheat	Bu.	430,855	637,093	736,897	811,824
Rye	Bu.	13,258	16,911	22,380	29,864
Soybeans	Bu.	86,270	119,573	146,696	175,866
Potatoes	Cwt.	8,947	6,770	9,269	12,748
Sugar Beets	Ton	5,750	10,925	17,920	25,622
Fruit, Noncitrus	Ton	39	54	77	111
Vegetables	Cwt.	4,030	5,780	7,930	10,954
Flaxseed	Bu.	13,457	9,963	12,901	17,186
Beans, Dry Edible	Cwt.	3,542	4,304	5,723	7,778
Alfalfa Hay Equivalents	Ton	21,628	24,080	27,220	37,007
Corn Silage Equivalents	Ton	25,448	29,148	34,324	46,059
Cropland Pasture	F.U.	4,414,608	5,831,407	6,687,041	7,042,709
Wild Hay	Ton	5,612	6,748	7,202	7,725
Pasture, Range, and Grazed Woodland	F.U.	56,988,932	71,788,456	81,578,405	87,152,102

[1]Current normal values reflect current production technology and prices, from which the impacts of abnormalities caused by weather and other hazards in a single year were weighted by their historical occurrence. These values are based on historical data for the years 1939 to 1963 adjusted by a process which progressively weighted each successive year in the historical series.

[2]Land use and development based on conditions as described in the previous section. Production in 1980 and 2000 is at the allocated requirement level and excludes production from reserve idle land. Production for 2020 is based on full utilization of the land.

Table 23 – PRIVATE AGRICULTURAL ACREAGE AND PRODUCTION, MISSOURI BASIN

Crop	Prod'n Unit	Current Normal		1980		2000		2020	
		Acres	Production	Acres	Production	Acres	Production	Acres	Production
		(1,000 Units)							
NONIRRIG. CROPLAND									
All Wheat	Bu.	19,892	424,155	22,630	628,624	22,246	726,864	22,179	802,339
Rye	Bu.	721	13,258	650	16,911	691	22,380	839	29,864
Corn Grain	Bu.	13,045	682,676	12,500	965,553	14,145	1,297,320	16,226	1,596,932
Corn Silage Equiv.	Ton	2,903	18,154	2,655	21,180	2,385	27,070	2,786	36,673
Sorghum Grain	Bu.	3,674	151,140	4,485	254,313	5,891	400,925	7,101	568,095
Oats	Bu.	6,631	218,646	5,753	263,247	4,337	245,380	2,939	175,778
Barley	Bu.	4,273	97,495	3,204	88,660	2,296	75,155	2,337	79,165
Alfalfa Hay Equiv.	Ton	10,375	16,525	9,438	18,261	9,007	20,600	11,365	29,065
Flaxseed	Bu.	1,379	13,457	1,104	9,963	1,034	12,901	1,105	17,186
Soybeans	Bu.	3,166	85,666	3,406	117,325	3,713	145,621	4,573	175,412
Dry Beans	Cwt.	6	24	5	17	5	15	12	64
Potatoes	Cwt.	10	684	10	686	7	657	21	1,367
Sugar Beets	Ton	0	2	0	7	2	35	223	4,641
Cropland Pasture	F.U.	2,646	3,960,411	2,629	5,245,369	2,618	6,002,878	2,465	6,273,820
Others Crops Harv.	---	417	---	418	---	414	---	350	---
Summer Fallow	---	14,583	---	15,346	---	14,905	---	14,489	---
Idle Cropland	---	4,830	---	4,805	---	4,742	---	4,619	---
Reserve Idle	---	8,342	---	7,158	---	6,653	---	0	---
TOTAL		96,893		96,196		95,091		93,629	
IRRIGATED CROPLAND									
All Wheat	Bu.	204	6,700	164	8,469	159	10,003	120	9,485
Corn Grain	Bu.	1,918	163,106	1,703	217,300	1,613	265,363	1,424	279,071
Corn Silage Equiv.	Ton	505	7,294	482	7,968	382	7,254	402	9,386
Sorghum Grain	Bu.	385	33,852	569	70,286	628	100,583	797	152,139
Barley	Bu.	690	30,566	528	34,518	599	48,943	378	35,817
Alfalfa Hay Equiv.	Ton	1,937	5,103	1,729	5,819	1,693	6,620	1,701	7,942
Soybeans	Bu.	20	604	65	2,248	23	1,075	10	454
Dry Beans	Cwt.	213	3,518	220	4,287	283	5,708	365	7,714
Potatoes	Cwt.	45	8,263	34	6,084	34	8,612	27	11,381
Sugar Beets	Ton	375	5,748	586	10,918	886	17,885	972	20,981
Cropland Pasture	F.U.	156	454,197	155	586,038	152	684,163	143	768,889
Other Crops Harv.	---	39	---	38	---	34	---	24	---
Idle Cropland	---	204	---	204	---	201	---	190	---
Reserve Idle	---	205	---	360	---	49	---	0	---
TOTAL		6,896		6,837		6,736		6,553	
CROPLAND TOTAL		103,789		103,033		101,827		100,182	
Wild (Native) Hay	Ton	6,548	5,612	6,532	6,748	6,507	7,202	6,489	7,725
Pasture & Range	F.U.	146,116	55,386,609	145,688	69,978,733	145,179	79,699,262	144,355	85,192,110
GRAZING TOTAL		152,664		152,220		151,686		150,844	
FOREST TOTAL	F.U.	13,654	1,602,323	13,493	1,809,723	13,350	1,879,143	13,102	1,959,992
Other Ag. Land		3,561		3,530		3,479		3,371	
TOTAL AG. LAND		273,668		272,276		270,342		267,499	

Table 24 – LIVESTOCK FEED REQUIREMENTS AND FEED GRAIN PRODUCTION MISSOURI BASIN

Commodity Group	Current Normal	1980	2000	2020
	(Million Feed Units)[1]			
Roughage Consumed[2]	101,919	123,410	139,835	158,268
Feed Grain Requirements				
Cattle & Calves	23,258	32,264	42,800	42,232
Pork	16,695	19,684	24,238	29,289
Sheep & Lambs	1,291	1,326	1,779	2,250
Milk	3,459	3,550	4,750	6,355
Chickens, Eggs & Turkeys	3,391	3,001	3,930	4,878
Total Feed Grain Consumption	48,094	59,825	77,607	95,004
Feed Grain Production[3]	69,016	96,374	126,542	153,270
Feed Grain Export to Other Areas	20,923	36,549	48,935	58,266

[1] A feed unit is the feed value of one pound of corn or its equivalent.

[2] Includes roughage component of ration for cattle and calves, sheep and lambs, pork, and milk production requirements expressed as gross requirements.

[3] Feed grain production consistent with projected production capability without specified activities and without reserve idle land.

Table 25 – CURRENT NORMAL AND PROJECTED LIVESTOCK AND LIVESTOCK PRODUCTS, BY SUBBASINS

Subbasin	Current Normal	1980	2000	2020
	(Million Pounds)			
CATTLE AND CALVES				
Upper Missouri	486	695	975	1,370
Yellowstone	405	579	813	1,142
Western Dakota	770	1,100	1,544	2,169
Eastern Dakota	1,054	1,506	2,113	2,968
Platte-Niobrara	1,946	2,780	3,900	5,480
Middle Missouri	1,378	1,969	2,763	3,882
Kansas	1,054	1,506	2,113	2,968
Lower Missouri	1,013	1,448	2,031	2,854
Missouri Basin	8,107	11,583	16,252	22,833
HOGS AND PIGS				
Upper Missouri	33	35	48	67
Yellowstone	23	29	40	56
Western Dakota	79	117	162	224
Eastern Dakota	635	879	1,213	1,683
Platte-Niobrara	622	785	1,084	1,504
Middle Missouri	1,753	2,255	3,115	4,321
Kansas	477	498	688	953
Lower Missouri	1,046	1,260	1,739	2,412
Missouri Basin	4,678	5,858	8,089	11,222
SHEEP AND LAMBS				
Upper Missouri	48	51	71	99
Yellowstone	74	76	106	149
Western Dakota	68	71	99	139
Eastern Dakota	80	81	113	159
Platte-Niobrara	103	114	161	225
Middle Missouri	45	47	66	92
Kansas	18	20	28	40
Lower Missouri	42	46	64	89
Missouri Basin	478	506	708	992
TURKEYS				
Upper Missouri	1	1	1	2
Yellowstone	1	1	1	2
Western Dakota	2	2	3	4
Eastern Dakota	20	28	38	53
Platte-Niobrara	26	36	50	69
Middle Missouri	28	39	54	74
Kansas	9	13	18	25
Lower Missouri	68	95	131	180
Missouri Basin	155	215	296	409
MILK				
Upper Missouri	255	258	353	487
Yellowstone	128	129	177	244
Western Dakota	167	169	231	319
Eastern Dakota	1,175	1,189	1,629	2,248
Platte-Niobrara	1,527	1,546	2,117	2,922
Middle Missouri	1,791	1,823	2,497	3,446
Kansas	1,077	1,090	1,493	2,061
Lower Missouri	3,660	3,706	5,076	7,006
Missouri Basin	9,780	9,910	13,573	18,733
CHICKENS				
Upper Missouri	2	2	2	3
Yellowstone	2	2	2	3
Western Dakota	2	2	2	3
Eastern Dakota	21	18	25	35
Platte-Niobrara	19	17	23	31
Middle Missouri	41	35	49	67
Kansas	20	18	25	35
Lower Missouri	101	88	122	169
Missouri Basin	208	182	250	346

Table 25 (Continued)

Subbasin	Current Normal	1980	2000	2020
	(Million Eggs)			
EGGS SOLD				
Upper Missouri	64	55	76	106
Yellowstone	56	49	68	94
Western Dakota	127	111	152	211
Eastern Dakota	1,553	1,414	1,948	2,701
Platte-Niobrara	565	984	1,355	1,879
Middle Missouri	2,683	1,844	2,542	3,524
Kansas	988	830	1,144	1,586
Lower Missouri	1,024	861	1,186	1,644
Missouri Basin	7,060	6,148	8,471	11,745

The projections of feed and livestock show that the demands for cattle and calves increase faster than projected production from a constant acreage of pasture and range. Historical trends in cattle feeding are consistent with this projected trend. Hence, a constant acreage of pasture and range will supply a declining portion of total feed for cattle and calves in the basin about as shown by projected ration compositions in table 19. Feed grains as a source of total cattle feed are projected to increase from a current 20 percent to 31 percent by 2020. A proportionate increase in cattle in feedlots is expected.

Comparison of Production Requirements to Production Capability With Specified Activities

The basin's agricultural production requirements and projected capability of the agricultural resources with specified activities of research, technology, management, land treatment conservation, and technical assistance continuing in 1980, 2000, and 2020 are compared in table 26 in terms of bushels of corn equivalent. Based on the assumptions used, an index of output was computed by using current normal prices as a common denominator. The production index of capability with specified activities included was computed from the solution previously described. It is based on projected production in table 22 plus the capability of reserve idle land shown in table 23. This projected level of agricultural capability was further reduced by a contingency of 5 percent in recognition of the serious effect of variations in food production below the level required.

Table 26 – PROJECTED AGRICULTURAL PRODUCTION, MISSOURI BASIN

Production Feature	Current	1980	2000	2020
	(Million Bu. Corn Equiv.)			
Regional Share of National Requirements	3,572	4,775	5,853	7,395
Research, Technology, Management, Land Treatment Conservation, and Technical Assistance	---	1,203	1,078	1,132

Table 27 shows that the projected capability, with only specified activities included and with the 5 percent contingency, will closely match requirements in 1980 and 2000. After 2000, crop production would need to be expanded by approximately 5 to 10 percent to meet 2020 requirements consistent with national objectives.

Table 27 – INDEX OF CROPLAND OUTPUT LEVELS UNDER ASSUMED CONDITIONS MISSOURI BASIN

Category	Year			
	CN	1980	2000	2020
	(Index)			
Projected Production Requirements	100	134	164	207
Projected Production Capability With Specified Activities	107	142	172	196
Ratio: Capability to Requirements	1.07	1.06	1.05	0.95

Agriculture in the Missouri Basin is a dominant economic activity, as well as an important source of related employment in the supply, service, and processing sectors. The economic structure as previously described contains certain consistent relationships between agricultural production, employment, and total basin activity.

The projected level of employment, population, and income in agriculture and the projected production requirements are component parts of the economic projections in the Economic Analysis and Projections Appendix. In other words, the impact of agricultural production at the projected requirement level on the supply, service, and trade sectors is included in the economic base projections of the total economy. If the agricultural economy should produce at levels other than the requirement level of production, this activity would likely produce levels of agricultural employment different than those in the economic projections. This would produce a corresponding adjustment in the related trade sectors.

The next section will translate projected production under these two conditions (projected requirements and projected capabilities) into a set of parameters which will form an economic framework consistent with these two levels of output. To facilitate presentation, economic indicators for the agricultural sector are presented in the following sections for the two conditions of output previously described. These levels will be referred to as "Conditions A and/or B" in the remaining analysis and are defined as follows.

Condition A – Projected requirements consistent with the national objective as given in detail in table 27.

Condition B – Projected production capability with only specified activities of research, technology, conservation treatment, and land management assumed to continue, as discussed previously. This level is consistent with the projected output summarized in table 23 plus the capability of the reserve idle land, reduced by a 5 percent contingency, and subject to other assumptions and limitations of the basic analytical solution previously described. Livestock production at the requirement level (Condition A) is assumed constant for all output levels and conditions.

Projected Employment Levels

The employment projections in the Economic Analysis and Projections Appendix are consistent with the projected agricultural requirements (Condition A). Total agricultural employment in the Missouri River Basin was allocated to subbasins on the basis of historical production shares applied to projected basin totals prior to the analysis of the projected resource capabilities and relative efficiencies among the subbasins.

This analysis has shown that projected agricultural capability with specified activities continuing will differ from projected requirements. Further, the analysis provides a means to improve the allocation of agricultural production and employment to subbasins. The projections of employment by subbasin shown in table 28 under Condition B are consistent with the projected production capabilities with only specified activities continuing.

Rural Farm Population

If a constant relationship is assumed between the projected level of agricultural employment and projected rural population, then the rural population would substantially equal that originally projected for 1980 and 2000. However, with only specified activities continuing the rural population estimate is reduced below the base projection by approximately 80,000 people in 2020 (see table 29).

Gross Farm Income

Gross farm income in the Missouri Basin is projected to increase nearly three times by 2020, or slightly greater than the Nation. However, gross farm income under Condition B would be reduced below the projected level by 653 million dollars in 2020 lacking resource development to expand production to the requirement level, as illustrated in table 30.

The results of this physical comparison of projected requirements and projected capability indicate the need for development of the basin's resources to meet the regional allocation of national demand. The results, however, are contingent upon the specific assumptions previously listed and a unique level of increased output in the agricultural sector in future time periods. The analysis provides an evaluation base for consideration of the effect of future development of agricultural resources, by both public and private means. Such things as private irrigation development, land drainage, and conversion of major land uses (cropland, pasture and range, and forest) will continue in the private sector even

Table 28 – CURRENT AND PROJECTED AGRICULTURAL EMPLOYMENT UNDER TWO ASSUMED PRODUCTION CONDITIONS, BY SUBBASINS

Subbasin	Year and Condition						
	1960	1980		2000		2020	
		A	B	A	B	A[1]	B
	(Thousand Employees)						
Upper Missouri	23.3	13.1	13.5	11.0	11.2	8.6	8.6
Yellowstone	17.9	11.4	11.9	9.0	9.1	7.6	7.1
Western Dakota	32.1	18.8	19.2	14.9	15.7	12.1	11.8
Eastern Dakota	80.4	53.8	56.1	43.0	45.8	39.6	39.0
Platte-Niobrara	93.4	56.1	57.9	47.0	47.7	45.3	42.1
Middle Missouri	92.9	62.2	64.9	52.0	52.6	46.6	44.7
Kansas	74.1	52.4	54.1	43.2	44.2	42.3	38.3
Lower Missouri	98.1	68.2	75.1	51.9	55.3	46.9	44.9
Missouri Basin	512.2	336.0	352.7	272.0	281.6	249.0	236.5

[1]Subbasin employment at the allocated production requirement level as projected in the Economic Analysis and Projections Appendix.

Table 29 – HISTORICAL AND PROJECTED RURAL FARM POPULATION UNDER TWO ASSUMED PRODUCTION CONDITIONS, BY SUBBASINS

Subbasin	Year and Condition						
	1960	1980		2000		2020	
		A	B	A	B	A[1]	B
	(Thousand People)						
Upper Missouri	56.4	30.6	30.9	25.7	26.0	19.9	18.3
Yellowstone	48.2	32.8	33.1	25.8	26.1	21.6	18.8
Western Dakota	86.7	46.1	46.6	36.6	37.0	29.4	26.4
Eastern Dakota	222.1	140.2	141.5	111.8	113.1	102.0	93.3
Platte-Niobrara	241.4	143.2	144.7	119.9	121.3	114.6	98.5
Middle Missouri	280.1	186.6	188.5	155.8	157.6	138.5	123.0
Kansas	204.4	138.5	139.9	114.0	115.3	110.6	92.8
Lower Missouri	332.6	234.9	237.3	178.5	180.6	160.0	141.9
Missouri Basin	1,471.9	952.9	962.5	768.1	770.0	696.6	613.9

[1]Subbasin population at the allocated production requirement level as projected in the Economic Analysis and Projections Appendix.

Table 30 – HISTORICAL AND PROJECTED GROSS FARM INCOME UNDER TWO ASSUMED PRODUCTION CONDITIONS, BY SUBBASINS

Subbasin	Year and Condition						
	1960	1980		2000		2020	
		A	B	A	B	A[1]	B
	(Million Dollars)						
Upper Missouri	314	411	423	541	553	669	648
Yellowstone	172	258	270	357	362	494	451
Western Dakota	279	427	435	573	605	799	747
Eastern Dakota	655	1,152	1,199	1,503	1,596	1,922	2,057
Platte-Niobrara	1,057	1,522	1,563	2,034	2,063	3,060	2,761
Middle Missouri	1,196	1,691	1,760	2,304	2,330	3,376	2,944
Kansas	790	1,377	1,420	1,828	1,867	2,183	2,240
Lower Missouri	836	1,216	1,328	1,676	1,776	2,238	2,226
Missouri Basin	5,300	8,054	8,398	10,816	11,152	14,741	14,088

[1]Subbasin gross farm income at the allocated production requirement level as projected in the Economic Analysis and Projections Appendix.

though they are not evaluated in this basic analysis. Such shortcomings do not invalidate the analysis as an analytical base, however, but merely affirm the need for continuing and careful reassessment as new information becomes available.

CURRENT AND FUTURE PROBLEMS

Problems pertaining to water and related land resource development may be defined as those physical and environmental hazards and constraints that prevent the economic utilization and preservation of the basin's natural resources at an optimum level. These problems have stemmed largely from pressure on the resources to provide short-run income without full recognition of the necessity for long-range maintenance of the capability of the resources and environment.

Early settlement of the basin was accomplished by fur traders and trappers who utilized the products of the land in its natural state and settlers who found the area a place to cross. The earliest agricultural endeavor was the settlement by cattlemen. Agricultural settlement faltered at the 98th Meridian until the Homestead Act and the railroads opened the vast midsection of the basin for settlement.

The settlers of this basin brought two centuries of experience in settlement techniques that were adapted to the humid regions of the east. They did not, at first, recognize the imperceptible change in the physical environment. Promotion to dispose of public domain, railroad land, and state educational lands; technologies such as the windmill, steel plow, and barbed wire; unusually wet years from the mid 1870's to 1886; plus the ever-present optimism of the times created humid-area institutions and farming practices in the basin.

During this period, the soil and water resources seemed unlimited. Land, particularly, was nearly a "free good" to be used to meet the economic pressure of short-term demands created by the necessity to establish a viable society in the plains. Wildlife, also, gave way to farmers and ranchers who could increase their income by the culture of domestic cattle and farming.

By the turn of the century, the end of the "unlimited" resource was in sight, and expanded output could be achieved only through intensified use. Intermittently favorable weather and near-disastrous drought continued to encourage development beyond the long-term capabilities of the resources and to create economic pressure on their use. Many times, short-term necessities were met, with full recognition that future generations could not receive their full resource heritage. Too little concern was shown for the long-range depreciation of natural beauty, wildlife, land and water quality, and other natural values. An awareness of these dangers started with Gifford Pinchot's efforts in the establishment of forest and park reserves and the Reclamation Act of 1902 which recognized the value of water. It remained for the drought and "dust bowl" of the 1930's, however, to bring widespread public attention to the plight of the land resources in the area.

By this time, the problems of the basin were clearly distinguishable, and many of them remain today. Landowners have become concerned about highly damaging practices in the use of land and water, thus adopting an efficiency concept to maintain and increase the production of the land. Floodwater damage alleviation and drainage of agricultural lands with excess water have been accomplished extensively. The value of water as a supplement to natural rainfall has been recognized and 7.4 million acres of land are currently irrigated. Rapid strides in "dry farming methods," adapted crops, and environmentally oriented management practices have contributed greatly toward a "regeneration" of the basin.

Progress has not been easy. Restoration of land damages has been slow. Investments in long-range preservation must compete for limited capital, thus making difficult individual choices between functional alternatives and between short-run versus long-run income. Other problems of non-use, or less than full use, are often a result of capital scarcity. Again the problem may be of a size beyond the solution of an individual. Such problems were necessarily deferred until mechanisms of collective investments were devised, and the necessary capital was available. Other potentials wait for the current pricing system to find a means to measure and weigh intrinsic values of social benefits and relate the cost of creating and preserving such values to the beneficiary.

In addition to the soil, water, and physical problems (but not separate from them) are the social and environmental difficulties created by the low-density populations, unstable production and incomes, and high-cost space problems in the majority of the Missouri Basin which depends upon agriculture for its principal support. The purpose of this section is to summarize some of the social and environmental questions of the basin and the physical problems and potentials which underlie them and represent a means of partial improvement.

Social and Environmental Problems

The Missouri Basin is, by Bureau of the Census criteria, urban in nature with 58 percent of the population currently residing in urban areas. It is important to note, however, that 65 percent of these urban people live in only 11 cities. As a consequence, the basin generally has a very low density of population.

Technology has increased the ratio of land-to-labor required to maintain adequate family incomes. This low density of agricultural and agriculturally related population in the basin is thus well adapted to maintain an efficient agricultural structure for the optimum utilization of the resources. In contrast, the low density of population means that social services are either inadequate or very costly per capita to institute or maintain. Hence, the spaciousness, sometimes valued so highly, and the agricultural adjustments necessary to efficiently adapt to the climate and physical resources, have a high social and economic price. Many other regions have muted the effects of agricultural adjustments by developing alternative industrial employment, and this has resulted in the maintenance of population density. The rate of industrialization in the Missouri Basin, however, has failed to keep pace, and outmigration from rural areas and the basin has resulted. Consequently, government, schools, trades, social services, and medical facilities and other amenities are forced to serve larger and larger areas in order to maintain efficiency. In many areas of the basin, agriculture as the only basic activity can no longer maintain viable local economies within desirable travel ranges.

The dominant feature of the climate in the basin is the fluctuation of rainfall in an unpredictable manner around an average which is less than desirable in most parts of the basin for full crop production. While variability is a marked characteristic of the climate, it may be that the area of the variation is just as critical. The variations in rainfall seem to be around a level critical to the needs of crops which farmers try to produce. Possibly, the excellent conditions experienced in the favorable years and the contrast of sharply reduced yields and periodic failures are greater in the Missouri Basin than anywhere in the Nation. Due to the increasing relative importance of cash costs as a percent of total operating costs, farmers are becoming more and more vulnerable to the uncertainties of weather and its consequences.

In periods of above-average effective precipitation, crops most susceptible to uncertainties of low rainfall frequently turn out to be most profitable. The prevailing optimism creates adjustments in cropping patterns each succeeding year of favorable conditions until a season of lower-than-normal rainfall takes an increased toll of an over-optimistic and unprepared agriculture. Conversely, after a series of drought years, many of the opportunities of a favorable year are foregone by anxious planning for another drought. To date, it is not possible to predict accurately what weather conditions will prevail in the year or months ahead.

While unable to control the natural climatic forces of flood and drought that affect agricultural operations, the farmer has alleviated the situation through the stabilizing effects of land and water resource development and management. On the one hand he has recognized the need and has sought flood and erosion control, and the benefits of better land drainage to rid himself of excess water. On the other, he has attempted to combat the effects of drought through the careful use and management of land and the available soil moisture. Significant improvements have been made through conservation practices, management strategies, cultural practices, and the use of drought-resistant plants to conserve soils and natural moisture. Another effective means of combatting the effects of uncertain and inadequate moisture on agricultural planning and production is the artificial application of supplemental water to the crops. Both surface and ground waters are utilized for this purpose. Irrigation development in the basin in the early 1960's totaled 7.4 million acres and is increasing at an average rate of 200,000 acres per year.

A wide difference in annual productivity and variability exists between irrigated and nonirrigated crops, in some areas of the basin, as illustrated by the available historical data. Data from three of the states with substantial amounts of existing irrigation (South Dakota, Montana, and Nebraska) are used to present the comparison on a statewide basis. In addition, Hamilton, York, Clay, and Fillmore counties in eastern Nebraska are selected to contrast a highly developed irrigated area located in a relatively favorable but quite variable rainfall belt. Corn was used as a representative crop in all areas but Montana, where barley was more typical. The results of this comparison are shown in figure 14. The graphic data in figure 14 show the range of annual variability that can be expected in crop yields in these areas under nonirrigated and irrigated agriculture as an arithmetic variance of the means.

Irrigated corn yields in the state of Nebraska varied from 59 bushels per acre in 1955 to 105 bushels per acre in 1966. The computed annual variability index ranged from 73 percent to 130 percent. During the same period, nonirrigated corn yields in Nebraska ranged from 11 bushels per acre in 1955 to 65 bushels per acre in 1966. The nonirrigated corn annual variability index ranged from 27 percent to 160 percent, representing a 76 percent greater variability than that of irrigated corn. Over the 12-year period analyzed, an average increase of about 35 bushels per acre was harvested for the irrigated corn over that not irrigated.

Irrigated corn yields in South Dakota varied from 58 bushels in 1958 to 84 bushels in 1966, with a computed annual variability index ranging from 85 to 122 percent. Thus such yields varied 26 bushels over the 10-year period and averaged 69 bushels. During the same period, nonirrigated corn yields averaged 36 bushels and ranged from 19 bushels in 1959 to 48 bushels in 1963. The corresponding annual variability index ranged from 34 to 137 percent.

In Montana, irrigated yields of barley averaged 43 bushels and ranged from 36 bushels in 1960 to 53 bushels in 1966, showing a variability index of 84 to 123 percent. Nonirrigated barley yields averaged 29 bushels, ranging from a low of 16 bushels in 1961 to a high of 38 bushels in 1965, with an annual variability index ranging from 55 percent in 1961 to 131 percent in 1965.

An average of the corn yields for Hamilton, York, Clay, and Fillmore counties, Nebraska, displayed similar results. Irrigated corn yields for this four-county area varied from 63 bushels per acre in 1955 to 111 bushels per acre in 1966, averaging over the 12-year period 81 bushels per irrigated acre. Over the same time period nonirrigated corn yields varied from 5 bushels per acre in 1956 to 56 bushels per acre in 1966, and averaged 33 bushels per acre. The derived variability index range was 78 percent to 137 percent on the irrigated and 15 to 170 percent on the nonirrigated corn. These figures indicate an increase in variability on nonirrigated corn for the four counties considered of 94 percent over that of irrigated corn in the area over the same 12-year period.

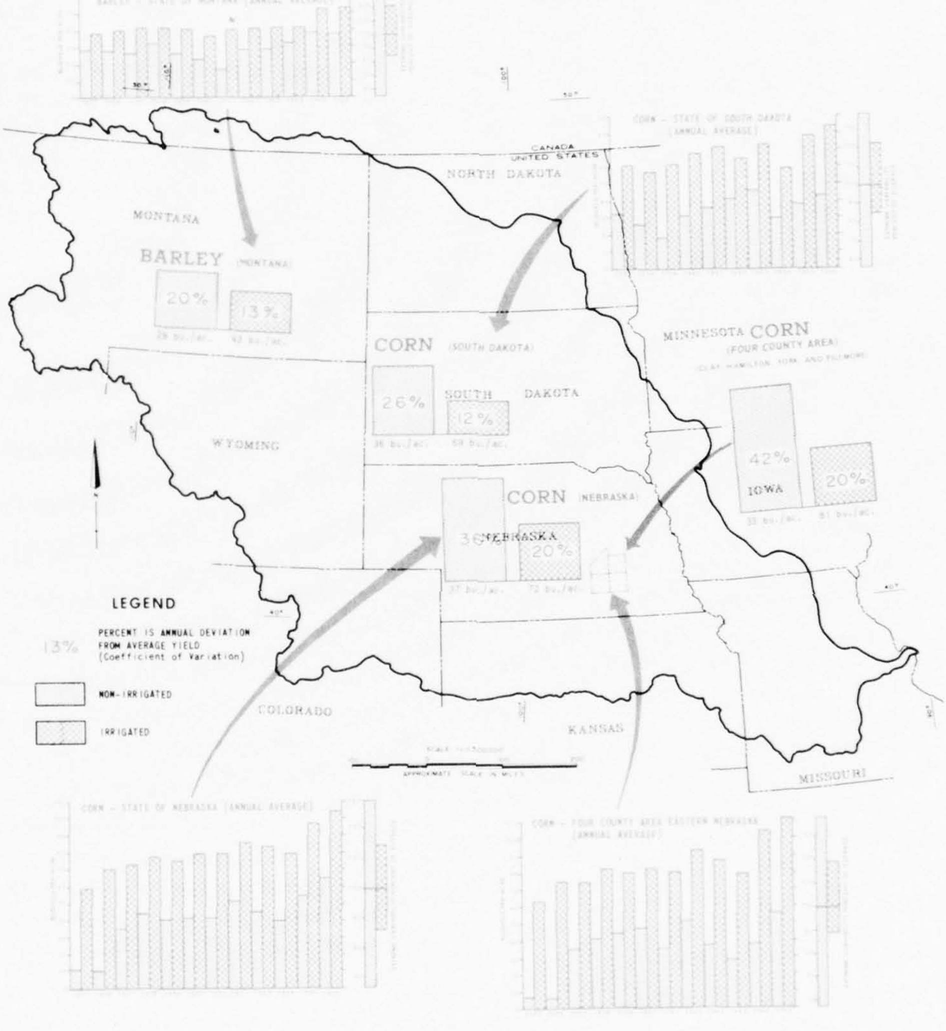
Examination of the current normal crop production in table 23 shows the potential for diversification of crops produced under irrigation. It may be noted that practically all of the dry edible beans, potatoes, and sugar beets are produced on irrigated cropland. Significant also is the irrigated production of roughage and feed grains in the arid subbasins that is a mainstay for a stabilized livestock industry in those areas.

Maintenance of the Land Resource Base

Maintenance and improvement of the 325 million acres of basin lands will require establishment and maintenance of land conservation measures on those lands not now adequately protected. Only with a stable land base can land owners and operators be expected to undertake the necessary investments of time, energy, and money to develop the high levels of productivity and efficient use that are necessary to satisfy future requirements. Measures that protect the land from the natural forces of water, wind, fire, and climate, affect land use and productivity, yield and quality of water,

FIGURE 14

YIELD VARIATIONS IN SELECTED AREAS FOR NON-IRRIGATED AND IRRIGATED CROPS



recreation uses, wildlife habitat, and environmental considerations generally. Measures specifically designed to control wind and water erosion also contribute to the reduction of flood hazards, improve water disposal in areas where needed, and generally enhance environmental, recreational, and fish and wildlife values. The extent of general maintenance or improvement measures needed is shown for individual major land uses by non-Federal and Federal ownerships in table 31 and by subbasins in the Land Resources Availability Appendix.

It is estimated that about 36 percent of the 97 million acres of non-irrigated cropland is adequately treated at the present time and about 30 percent needs only the installation of management measures to be considered adequately treated. Many of these practices, such as stubble mulching and strip cropping, can be installed with minimum expense. About 33 percent of the non-irrigated cropland requires vegetative and mechanical measures such as the construction of terraces and waterways to reduce erosion and soil loss. With existing programs it is expected that the proportion of land adequately treated will increase to about 48 percent by 1980, to 63 percent by 2000, and to 77 percent by 2020.

Table 31 – CURRENT AND PROJECTED LAND CONSERVATION TREATMENT AND NEEDS
MISSOURI BASIN

Time Period	Total	Total Adequately Treated[1]		Land Needing Treatment: Proper Management Practices Only		Land Needing Treatment: Proper Management & Vegetative and/or Mechanical Practices	
	Acres (000)	Acres (000)	Percent	Acres (000)	Percent	Acres (000)	Percent
NON-FEDERAL							
Cropland Nonirrigated							
Current	96,893	35,299	36	30,027	31	31,567	33
1980	96,196	46,086	48	23,983	25	26,127	27
2000	95,091	60,272	63	16,281	17	18,538	20
2020	93,629	71,730	77	9,576	10	12,323	13
Cropland Irrigated							
Current	6,896	2,603	38	1,633	24	2,660	38
1980	6,837	3,430	50	1,255	18	2,152	32
2000	6,736	4,472	67	819	12	1,445	21
2020	6,553	5,294	81	448	7	811	12
Pasture & Range							
Current	152,664	62,136	41	65,496	43	25,032	16
1980	152,220	78,237	51	53,595	35	20,388	14
2000	151,686	100,231	66	35,859	24	15,596	10
2020	150,844	117,601	78	21,706	14	11,537	8
Forest & Woodland							
Current	13,654	6,879	50	5,356	39	1,419	11
1980	13,493	7,535	56	4,724	35	1,234	9
2000	13,350	8,296	62	4,041	30	1,013	8
2020	13,102	8,941	68	3,343	26	818	6
Other (Agric. & Nonagric.)							
Current	11,600	9,653	83	885	8	1,062	9
1980	12,591	10,853	86	791	6	947	8
2000	14,474	12,891	89	675	5	908	6
2020	17,209	15,748	92	598	3	863	5
Total Non-Federal Land							
Current	281,707	116,570	41	103,397	37	61,740	22
1980	281,337	146,141	52	84,348	30	50,848	18
2000	281,337	186,162	66	57,675	21	37,500	13
2020	281,337	219,314	78	35,671	13	26,352	9
FEDERAL							
Pasture & Range							
Current	24,170	13,787	57	6,781	28	3,602	15
1980	24,170	15,488	64	5,870	24	2,852	12
2000	24,170	20,070	83	2,294	9	1,806	8
2020	24,170	23,178	96	513	2	479	2
Forest & Woodland							
Current	14,432	11,577	80	1,729	12	1,126	8
1980	14,432	11,932	83	1,382	10	1,118	7
2000	14,432	12,824	89	976	7	632	4
2020	14,432	13,360	93	749	5	323	2
Other (Agric. & Nonagric.)							
Current	4,380	3,939	90	174	4	267	6
1980	4,380	3,995	91	134	3	251	6
2000	4,380	4,141	95	77	2	162	3
2020	4,380	4,226	96	19	1	135	3
Total Federal							
Current	42,982	29,303	68	8,684	20	4,995	12
1980	42,982	31,375	73	7,386	17	4,221	10
2000	42,982	37,035	86	3,347	8	2,600	6
2020	42,982	40,764	95	1,281	3	937	2

[1] Land Adequately Managed Or Treated - includes all land on which the use, management and treatment meets the minimum standards of the conservation programs of the SCS, Soil Conservation Districts, the Indian Service, or of the Federal Land Management Agency concerned. It includes all types of management, vegetation, and mechanical practices.

About 38 percent of the 6.9 million acres of irrigated crop land is presently considered to be adequately treated. About 24 percent needs management measures such as the proper application of irrigation water, crop residue management, proper cropping systems, and maintenance of fertility; and about 38 percent needs mechanical measures, such as land leveling and smoothing, the installation of drainage ditches or tile, and the improvement of on-farm irrigation systems in addition to management measures. It is expected that with present programs the proportion of irrigated cropland adequately treated will increase to about 50 percent by 1980, to 67 percent by 2000, and to 81 percent by 2020.

Of the 177 million acres of pasture and range in the Missouri Basin, about 153 million acres are in non-Federal ownership, and 24 million acres are federally owned. About 41 and 57 percent respectively of these acreages are presently considered to be adequately treated. About 65 million acres, or approximately 43 percent, of the non-Federal and 28 percent of the Federal pasture and rangeland needs only the application of proper management practices, such as proper grazing, to maintain the grass in good condition. About 16 and 15 percent of the non-Federal and Federal pasture and rangeland needs improved management-type practices along with vegetative or mechanical practices. The pasture and rangeland adequately treated is expected to increase to about 51 and 64 percent by 1980, to 66 and 83 percent by 2000, and to 78 and 96 percent by 2020 for the non-Federal and Federal pasture and rangelands.

There are about 28.1 million acres of forest and woodland in the Missouri Basin with 13.6 million acres in non-Federal and 14.4 million acres in Federal ownership. It is estimated that 50 percent of the non-Federal owned and 80 percent of the federally owned forest and woodland are adequately managed or treated at the present time. These figures are expected to increase, for non-Federal and Federal lands respectively, to 56 and 83 percent in 1980, to 62 and 89 percent in 2000, and to 68 and 93 percent in 2020.

There are about 16 million acres classified as "Other Land" in the basin. Of this amount, about 11.6 million acres are in non-Federal ownership, including 3.6 million acres in agricultural uses such as farmsteads and farm roads, wildlife areas on farms and ranches, and idle land. The balance of the non-Federal lands in this grouping is in such uses as urban areas, city and state parks, highways and roads, and rural non-agricultural uses. The 4.4 million acres of Federal land are in parks, wilderness areas, wildlife refuges, and recreation areas around federally constructed impoundments. The conservation treatment status of these non-Federal and Federal lands is 83 and 90 percent adequately treated, eight and four percent require management-type measures, and nine and six percent require vegetative and mechanical measures, respectively. It is expected that the adequate treatment of the non-Federal and Federal lands in this classification will increase to 86 percent and 91 percent by 1980, to 89 and 95 percent by 2000, and to 92 and 96 percent by 2020, respectively.

Agricultural Drainage

There are approximately 15 million acres of agricultural land in the Missouri Basin which have been or are subject to an excess moisture problem (table 32). This is exclusive of the 717,000 acres of drainage shown as part of the irrigation system rehabilitation potential discussed in another section of this appendix.

Slow or impaired disposal of excess water from the surface or subsurface of land seriously reduces the full utilization of the land for agricultural purposes. Damages from excess water may vary from infrequent flooding in the spring and fall which disrupts timely preparation,

Table 32 — CURRENT STATUS OF AGRICULTURAL DRAINAGE, BY SUBBASINS

Item	Upper Missouri	Yellowstone	Western Dakota	Eastern Dakota	Platte-Niobrara	Middle Missouri	Kansas	Lower Missouri	Missouri Basin
	(Thousand Acres)								
CROPLAND									
Total	110.7	109.8	85.5	1,594.3	708.0	1,838.4	665.9	2,069.3	7,181.9
Not Feasible	8.3	0.3	32.9	326.4	80.4	61.4	101.0	33.6	644.3
Adequate	101.1	109.5	52.3	741.5	464.8	1,325.9	442.1	1,391.6	4,628.8
Potential	1.3	0	0.3	526.4	162.8	451.1	122.8	644.1	1,908.8
PASTURE & RANGE									
Total	742.0	279.5	751.5	1,769.8	1,493.6	511.7	406.6	661.6	6,616.3
Not Feasible	429.5	247.8	614.8	1,359.3	933.8	156.4	255.4	26.1	4,023.1
Potential	312.5	31.7	136.7	410.5	559.8	355.3	151.2	635.5	2,593.2
FOREST & WOODLAND									
Total	26.8	45.1	54.2	26.2	235.3	109.7	217.3	523.9	1,238.5
Not Feasible	20.2	39.9	42.4	14.9	212.3	58.2	185.0	60.3	633.2
Potential	6.6	5.2	11.8	11.3	23.0	51.5	32.3	463.6	605.3
OTHER	5.4	6.7	2.6	29.3	29.6	76.0	33.6	91.4	274.6
TOTAL AREA	884.9	441.1	893.8	3,419.6	2,466.5	2,535.8	1,323.4	3,346.2	15,311.3

Wind and Water Erosion Depreciates the Land Resources

Tile Drains Improve Poor Subsurface Drainage planting, and harvesting operations, to a nearly permanent "wetness" which restricts the use to native vegetation.

Drainage problems may be caused by surface water, subsurface water, or both. Surface drainage trouble can occur on flat uneven land with undeveloped or poor outlet channels for the disposal of excess rainfall, snowmelt, runoff from higher ground, or overflow from streams. Bad subsurface drainage conditions can occur on sloping lands due to soil permeability, on level lands with poor surface disposal, and in cases of high ground-water tables.

On-farm drainage structures are of two types – surface and subsurface. Drainage measures for the disposal of excess surface water include land forming to eliminate pockets, and lateral ditches at regularly spaced intervals with increased land elevations between. Tile drains are the most common form of subsurface drainage.

Of the 15.3 million acres of agricultural land with an inherent drainage problem, 4.6 million acres now are adequately drained. Of the remaining 10.7 million acres, 5.1 million acres are considered potentially suitable to drain for agricultural purposes, while the remaining 5.6 million acres are not considered to be potentially suitable for such improvement.

The 5.1 million acres of agricultural land suitable to drain represent a potential to reduce risk and instability, to increase production, and *to increase the* efficiency of use. Of this total, 1.9 million acres are currently being used for crop production. The land is all in land capability classes II through IV, meaning that the wetness hazard varies from slight to severe in terms of frequency. None of these lands has any significant amount of water on the surface of the soil except during short periods. The major problem is slowness of disposal which results in prolonged periods during which the soil is too wet for regular farming operations.

The 2.6 million acres of pasture and range considered suitable for drainage is all in land capability classes II and III. This land is suitable for crop production in its present state but has not been converted to crop production because of the water hazard, recent restraints on increases in cropland per unit, and the need for small amounts of pasture on most farm units regardless of the capability of the available land.

The remaining agricultural land considered suitable for drainage is 0.6 million acres of forest and woodland. This is all in land capability classes II and III. It is not significantly different from pasture except that it has a light cover of trees.

The remaining 5.6 million acres of land with a drainage problem suffers from higher frequency of damage, is wet over longer periods, and would require more extensive *measures of improvement*. Land capability classes V through VIII are included in this group plus Class IV pasture, range, and forest land. Nearly one-half of this land is class V which is frequently exposed to excess water and may have water on the surface or near the surface a significant portion of the time. Due to the frequency of the hazard, and the difficulty of solution, none of these lands represents an economic potential for crop production.

The inventory of drainage needs does not include land that is under water a majority of the time – this was classed as water area. The 5.1 million acres of land considered suitable for drainage involves little surface water, except for infrequent periods of short duration. Improved water disposal on cropland is conducive to more timely field operations and more efficient production of wet areas. Such action may reduce weedy cover beneficial to upland game species. The effect of this type of drainage has not been evaluated in quantitative terms on wildlife.

Agricultural Flood Damages

Flood damages are discussed in detail in chapter 7 of this appendix. A brief summary is included in this chapter only to complete the picture of agricultural problems. There are 14.3 million acres of flood plain land subject to flood damages. Of this total, there are 14.1 million acres of non-urban area subject to flood damage, as shown in table 33.

Table 33 – TOTAL NONURBAN AREA SUBJECT TO FLOOD DAMAGES, BY SUBBASINS

Subbasin	Nonurban Area Subject To Flood Damages
	(Thousand Acres)
Upper Missouri	844
Yellowstone	678
Western Dakota	1,270
Eastern Dakota	1,041
Platte-Niobrara	2,288
Middle Missouri	2,831
Kansas	2,414
Lower Missouri	2,706
Missouri Basin	14,072

Floods that occur in the tributary areas are not as spectacular as those which inundate the flood plains of the main stems of the rivers in the basin; however, they usually occur more frequently. Damages usually are not large for any one flood occurrence, but the aggregate can be quite significant over a period of time.

Flooding from snowmelt runoff usually occurs before many crops are seeded, but damages may result from the delay in planting. Summer rainstorms can cause damages which include the drowning of crops with no chance of replanting or substituting an alternate crop, the reduction of stands, leaching of fertilizer below the root zone, prevention of cultural practices to control weeds, and destruction of grain in various stages of ripening. Losses occur from reduced yields, lower quality products, and increased production and harvesting costs. Floods may also damage the land by scouring action and the deposition of silt, debris, and weed seeds.

Irrigation Expansion

Irrigated agriculture is the largest single use of water in the basin. Approximately 7.4 million acres of irrigated land (6.9 million acres of cropland and 0.5 million acres of pasture) currently require an annual farm delivery in excess of 14 million acre-feet, as shown in table 34. These data do not include evaporation and transpiration losses from reservoirs, canals, laterals, and waste areas caused by irrigation seepwater, nor do they consider return flows to the streams.

Table 34 – PRESENT ANNUAL FARM DELIVERY REQUIREMENTS OF IRRIGATION WATER, BY SUBBASINS

Subbasin	Irrigated Land	Annual Water Requirements
	(Thousand Acres)	(Thousand Acre-Feet)
Upper Missouri	1,102	1,984
Yellowstone	1,188	2,376
Western Dakota	209	376
Eastern Dakota	119	178
Platte-Niobrara	2,986	5,673
Middle Missouri	103	103
Kansas	1,703	3,406
Lower Missouri	5	5
Missouri Basin	7,415	14,101

Besides the 7.4 million acres of existing irrigation, about nine times this amount has been inventoried as physically suitable for potential irrigation development. This inventory is presented in detail in the Land Resources Availability Appendix. An indication of the foreseeable potential irrigation development is given in table 35.

Table 35 – POTENTIAL NEW IRRIGATION DEVELOPMENT, BY SUBBASINS

Subbasin	Source of Water		
	Ground Water	Surface	Total
	(Thousand Acres)		
Upper Missouri	55	495	550
Yellowstone	29	608	637
Western Dakota	119	643	762
Eastern Dakota	442	1,285	1,727
Platte-Niobrara	1,732	629	2,361
Middle Missouri	1,282	349	1,631
Kansas	1,898	319	2,217
Lower Missouri	412	558	970
Missouri Basin	5,969	4,886	10,855

Farm delivery water requirements for this potential level of irrigation development are shown on plate 5. Future analyses will be necessary to determine the availability of this amount of water and the priority of use. The expansion of irrigation is one of the major alternative methods which could influence the future pattern of increased agricultural production.

Irrigation Systems Rehabilitation

Some of the earliest irrigation in the Missouri River Basin was started about 1650 by the Taos Indians who lived along Ladder Creek in northern Scott County, Kansas. Vestiges of the canal they constructed to divert water from the creek are still visible.

Development of irrigation in the basin by settlers began in the early 1860's with short, inexpensive diversions developed by individual landowners. Later, longer and more expensive canal systems were developed and financed by groups of farmers, irrigation companies, and districts to direct water onto higher and more extensive terraces and upland areas.

State development of irrigation and power projects began after the passage of the Water Conservation Act of 1933, and various state laws allowing state participation in such activities. The Red Lodge-Rock Creek Project in Montana and the Tri-County Project in Nebraska are examples of State developments.

Some of the first irrigation construction on Indian lands began during the 1880's in the Wind and Crow Indian reservations. Formal construction came about ten years later with increasing acreages up to the present time. The approval of the Reclamation Act in 1902 signaled the beginning of non-Indian Federal construction of irrigation projects.

Surface water in the Missouri Basin states is subject to statutory control. The Congress, through legislation in 1866, 1870, and 1877, placed the administration of water rights under the states, and all the Missouri Basin States except Minnesota, Missouri, and Iowa have developed water laws based on the appropriation doctrine. Missouri essentially follows the doctrine of riparian rights. Iowa water law is a mixture of the riparian and appropriation doctrines. The Iowa water permit system is riparian for nonregulated waters, but modified appropriation for regulated waters. Most irrigation water in Iowa is regulated without a priority system but with a permit limited to 10 years. Irrigation efficiency can be a consideration when permit renewal is sought. Low-flow protection for Iowa surface waters severely limits consumptive users during periods of drought.

A principal element of the appropriation doctrine is "First in time – first in right." While all of the State constitutions declare the waters within the State to be the property of the public subject to appropriation, permits for use are essentially considered a property right by the permit holder. An irrigation water right not only greatly enhances the value of the land irrigated, but assures the user the continued right to use of the water when available and thereby protects his investment in storage, diversion, distribution, and drainage works. A water right once granted may not be taken from a user without just compensation, except through his abandonment.

While a water-right system controls the use of water and protects the user, it also establishes a pattern of use that is often difficult to change. Currently, investments in irrigation system improvements are made by the user or groups of users if such improvements are justified by reason of improving deliveries through savings of losses, elimination of drainage problems, or savings in operation and maintenance costs. A senior right holder with an assured water supply does not feel obligated to improve his irrigation system for the benefit of junior right holders. Also senior right holders are often reluctant to merge and combine systems with junior right holders due to difficulties in dividing the water saved, and also because of the barriers developed from historical conflicts. Merger agreements have and can be reached when common problems become intolerable and a basis for comity is developed.

Several factors contribute to less than optimum management and use of surface water for irrigation in the Missouri Basin. Because most of the precipitation in the western part of the basin occurs as snowfall, most of the water used for irrigation in that area comes from the snowmelt which supplies streams rising in the high mountains. Spring snowmelt results in peak flows during June and early July and generally (especially in the smaller streams) these flows drop off rapidly. This causes irrigation water shortages during July and August, at a time when most plant water demands are highest. Consequently, farmers in many areas have to plan their production on the basis of limited late season supplies, or allow part of the planted acreage to go without supplemental water during the critical period. Reduced yields or complete failure often result.

The imbalance in distribution of the precipitation and runoff in comparison to irrigation demands makes water storage necessary. Suitable storage sites often are not available near the area to be irrigated because of unfavorable topography or geology. This often results in the use of storage sites several miles upstream from the project lands, thus necessitating longer distribution systems.

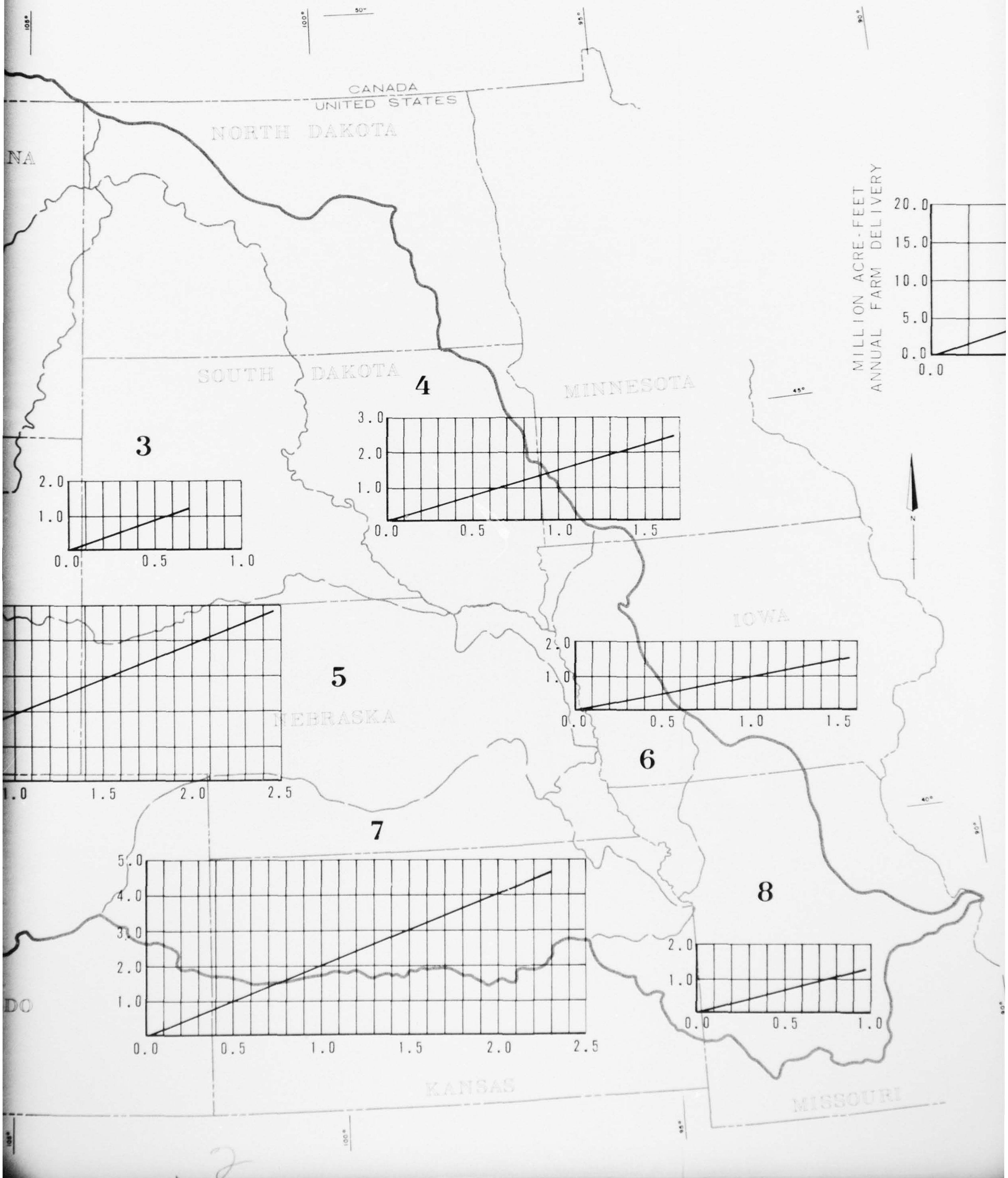
Although a great many privately sponsored projects met or exceeded engineering standards at the time of their installation, a substantial number of the early projects were built without the benefit of the overall planning, modern construction equipment, and adequate financing that have been available to projects of the last few decades. As a result, it has been a continuing effort on the part of the farmers, ranchers, and other water users to upgrade water supplies, deliveries, and operating efficiencies. Much has been accomplished but there remain ample opportunities for improvement.

Rehabilitation Of Older Irrigation Systems
Increases Efficiency Of Water Delivery

In many of the earlier irrigation systems, the canals were built to carry water to a given acreage; however, subsequent to the original construction, the canals were extended to irrigate additional lands. This has resulted in an inadequate capacity of the canals or laterals to deliver sufficient water to all the service area, even though an adequate supply may be available at the source. High losses of water by seepage are common in many parts of the basin. Although much of the water lost to permeable underground sand and gravel areas may later re-enter stream flows in the lower reaches of the stream, such losses may cause a water shortage to the system directly involved. Water deliveries to junior water right holders are frequently limited during peak demands.

Canal seepage or overapplication of water, or both, in conjunction with natural soil conditions result in the areas of excessively wet agricultural lands, ranging from


MONTANA
WYOMING
COLORADO
1
2
3
LOCATION MAP
MISSOURI RIVER BASIN
ALBERS EQUAL-AREA PROJECTION



CANADA
UNITED STATES
NORTH DAKOTA
SOUTH DAKOTA
MINNESOTA
NEBRASKA
IOWA
KANSAS
MISSOURI
MILLION ACRE-FEET
ANNUAL FARM DELIVERY
3
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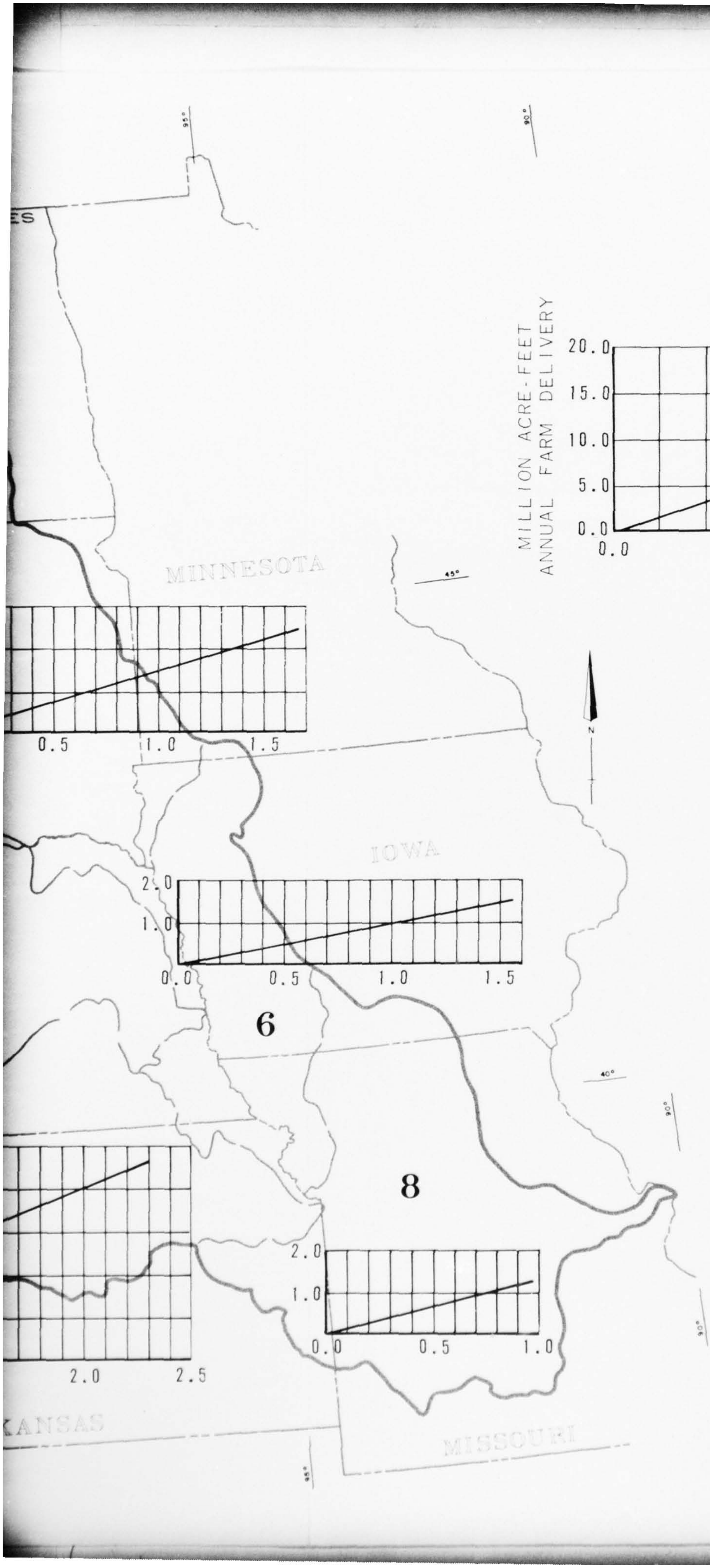
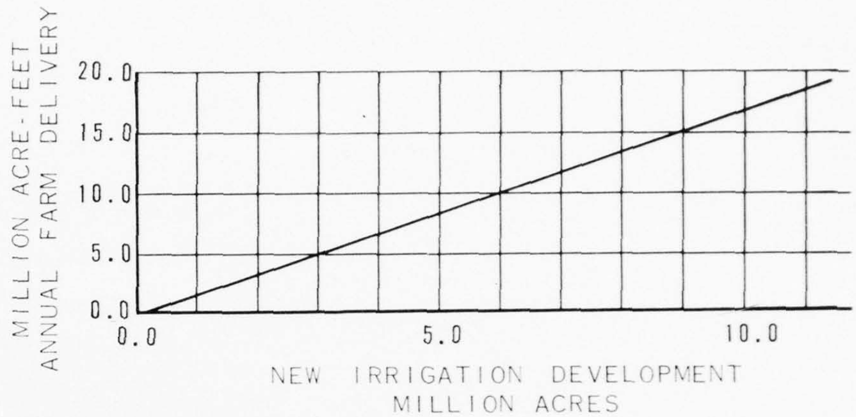




SUBBASINS

NO.	NAME
1	UPPER MISSOURI RIVER TRIBUTARIES
2	YELLOWSTONE RIVER
3	WESTERN DAKOTA TRIBUTARIES
4	EASTERN DAKOTA TRIBUTARIES
5	PLATTE-NIOBRARA RIVERS
6	MIDDLE MISSOURI RIVER TRIBUTARIES
7	KANSAS RIVER
8	LOWER MISSOURI RIVER TRIBUTARIES

SCALE 1/5,700,000

50 0 50 100 150 200

APPROXIMATE SCALE IN MILES

JUNE 1969

POTENTIAL IRRIGATION DEVELOPMENT AND FARM DELIVERY WATER REQUIREMENTS

COMPREHENSIVE FRAMEWORK STUDY

MISSOURI RIVER BASIN

MISSOURI BASIN INTER-AGENCY COMMITTEE

PLATE 5

slight to severe. Yields are reduced, production costs are increased, and in some cases an overapplication of water has changed the plant community in native meadows from one of desirable grasses to one of sedges and other water-tolerant plants which have a lower palatability and forage yield.

Floodwater often damages diversions, head gates, distribution systems, and the topography of irrigated fields. Many small canals and ditches do not have adequate provisions for cross-drainage of flood flows from small, normally dry washes which cross or intersect the system. Consequently, flash floods from the washes can cause considerable damage to the system, often interrupting the delivery of irrigation water during the critical growing season, with resulting crop failures a distinct possibility.

Some streams carry excessive sediment loads (especially after flash floods) and in some places where the sediment is fine clay, deposition on irrigated land seals in the surface and greatly reduces the soil permeability. After repeated applications of water carrying a clay load, the surface soil becomes finer textured and more difficult to till.

As a consequence of the conditions under which irrigation was developed, there are numerous instances where separate canals and ditches parallel and sometimes cross and recross each other. Operation and maintenance costs of duplicate facilities are high, as are the aggregate water losses. In some cases, operation costs are increased by a constant need to stabilize embankments and ditches, and to control unwanted vegetation. In these instances associated water losses are unusually high.

There are about 5,800,000 acres of irrigated land in the Missouri River Basin that are developed for service by group irrigation systems (table 36). Not all of the acreage is irrigated in any one year. The group facilities

Table 36 – CATEGORIES OF IMPROVEMENTS IN EXISTING GROUP IRRIGATION SYSTEM FACILITIES, BY SUBBASINS

Subbasin	Category*	Irrigation Service Area (Acres)	Storage (Ac. Ft.)	Delivery Ditches (Miles)
		(Thousand)		
Upper Missouri	A	1,154	649	18.1
	B	319	179	2.2
Subtotal		1,473	828	20.3
Yellowstone	A	895	342	5.4
	A & B	94	70	0.3
	B	121	[1]	0.3
	C	322	610	1.8
Subtotal		1,432	1,022	7.8
Western Dakota	A	51	33	0.2
	B	2	---	---
	B & C	74	414	0.6
	C	2	---	[2]
Subtotal		129	447	0.8
Eastern Dakota	B	7	---	0.1
	C	1	---	---
Subtotal		8	---	0.1
Platte-Niobrara	A	1,778	3,722	8.0
	A & B	93	---	0.7
	B	505	2	1.3
	C	215	2,108	1.6
Subtotal		2,591	5,832	11.6
Middle Missouri	(None)			
Kansas River	A	1	---	[2]
	B	165	769	1.0
	C	[3]	---	---
Subtotal		166	769	1.0
Lower Missouri	(None)			
Missouri Basin	A	3,879	4,746	31.7
	A & B	187	70	1.0
	B	1,119	950	4.9
	B & C	74	414	0.6
	C	540	2,718	3.4
Missouri Basin Total of All Classifications		5,799	8,898	41.6

[1]Less than 500 acre-feet. [2]Less than 50 miles. [3]Less than 500 acres. *See following text for definition.

to service these areas consist of irrigation reservoirs with an aggregate capacity of nearly nine million acre-feet and about 42,000 miles of group delivery canals or ditches. About 45 percent of the storage capacity is in reservoirs constructed by irrigation districts, water companies, or by the states, with Federal construction accounting for the remainder. Reservoirs constructed by Federal agencies not only supply water to the federally developed irrigation projects, but furnish supplemental water to lands developed and serviced by local districts and water companies. In addition to providing irrigation water, nearly all reservoirs also satisfy other multipurpose demands. With regard to delivery ditches, about 32,000 miles or 75 percent of the system were constructed by irrigation districts, water companies, or by the States. Approximately 10,000 miles or 25 percent were constructed by Federal agencies. The current facilities to provide irrigation water to 61,430 acres of Indian land consist of 52,610 acre-feet of storage and 675 miles of group delivery ditches.

The improvement needs for existing irrigation systems are broadly grouped into three categories:

Group A – System short of water during the irrigation season. Additional water supplies needed, which can be provided or improved by project-type measures to irrigate properly the present or anticipated crops.

Group B – Systems having drainage problems where project-type ditches and drains are required to alleviate the situation. Often the water causing the trouble stems from canal or ditch seepage.

Group C – Systems having high operation and maintenance costs, reorganization and consolidation needs, and erosion or sediment problems.

New or added storage is one of the most frequently needed measures in the Group "A" category. Also important is the improvement of delivery systems, either by lining of porous sections, improving diversion installations, consolidating delivery canals, or enlarging present facilities.

The installation of group drainage ditches and/or drains constitutes the most important measure needed in Group "B". Land preparation, smoothing, and field leveling are also needed.

With regard to Group "C", a reorganization and consolidation of present systems can sometimes materially lessen total canal mileage. Improvement of canal efficiency, through lining or other structural measures such as improved diversions, is also included in this category.

Measures which improve the efficiency of irrigation systems often alleviate interrelated problems. As an example, lining a porous section of a canal or delivery ditches reduces water losses so that more water can be delivered to fields at the end of the system. A reduction of losses can also reduce drainage problems in the wet areas of adjacent farmland. Similar interrelationships often exist between flood damage reduction and irrigation water storage facilities.

The inventory of needs indicates that the water supply of the irrigation systems can be improved by adding 185 reservoirs to store about 1,180,000 acre-feet of water (table 37).

Reorganization and consolidation of delivery systems, including canals and ditches, offer opportunities to improve water supplies and reduce operation and maintenance costs. It is estimated that about 3,400 miles of group delivery ditches could be eliminated through consolidation and reorganization. Some 5,400 miles need lining to reduce water losses, cut operational expenses, and increase the hydraulic capacity.

To improve the disposal of irrigation waste water and alleviate the drainage problems, approximately 4,600 miles of group drainage ditches are required. These, along with the installation of the associated on-farm drainage measures, would alleviate the excess water and drainage problems on some 717,000 acres. Drainage measures could have some adverse effect on fish and wildlife, but the exact amount will have to be determined from more exact data in the future.

Irrigation facilities serving Indian lands can be improved by adding three reservoirs with a combined storage capacity of 25,700 acre-feet, lining 83 miles of canals, and installing 61 miles of drainage ditches that are part of the totals shown in table 37.

All of these measures have the potential to improve irrigation supplies by making available a total of about 1.4 million acre-feet of water from storage, and a saving in canal and lateral losses (table 38). It is estimated that some 269,000 acre-feet of water could be salvaged from present losses to phreatophytes, evaporation, and deep percolation. The aggregate enhancement of water supply to the 3,900,000 acres with "A" type problems would be about ten percent. However, the improvement in water supply to individual systems could range as high as 40 percent. A substantial number of irrigation systems need no improvements in water supply, and therefore, irrigation water supplies would not be affected. If all system reorganization, ditch elimination, lining, storage, and drainage measures should be accomplished, the total effect on surface water would amount to a new depletion, or additional water use, of about 196,000 acre-feet annually.

Livestock Water

The eight subbasin designations used for the study are delineated as being hydrologically consistent but encompass marked differences in climate and soil. These two factors largely dictate the predominant type of

Table 37 – POTENTIAL REHABILITATION AND REORGANIZATION OF GROUP IRRIGATION SYSTEMS, BY SUBBASINS AND CATEGORY

Subbasin	Category	Elimination of Ditches (Mi.)	Group Ditch Lining (Mi.)	Additional Reservoir Storage		Drainage Ditches	
				Structures (No.)	(000) (Ac. Ft.)	(Mi.)	(Acres
Upper Missouri	A	2,183	976	74	240	---	---
	B	---	81	---	---	396	(79)
Subtotal		2,183	1,057	74	240	396	79
Yellowstone	A	691	902	49	294	114	(20)
	A & B	23	59	3	57	128	(23)
	B	2	10	---	---	501	(90)
	C	20	75	---	---	214	(39)
Subtotal		736	1,046	52	351	957	172
Western Dakota	A	21	14	20	27	---	---
	B	---	---	---	---	10	(2)
	B & C	---	20	---	---	---	---
	C	---	---	---	---	---	---
Subtotal		21	34	20	27	10	2
Eastern Dakota	B	---	---	---	---	2	(7)
	C	---	---	---	---	---	---
Subtotal		---	---	---	---	2	7
Platte-Niobrara	A	287	955	38[1]	262	---	---
	A & B	90	347	---	300	728	(101)
	B	23	881	1	---	2,500	(349)
	C	26	283	---	---	12	(2)
Subtotal		426	2,466	39	562	3,240	452
Middle Missouri	(None)						
Kansas River	A	---	5	---	---	---	---
	B	2	29	---	---	25	(5)
	C	---	755	---	---	---	---
Subtotal		2	789	---	---	25	5
Lower Missouri	(None)						
Missouri Basin	A	3,182	2,852	181	823	114	(20
	A & B	113	406	3	357	856	(124
	B	27	1,001	1	---	3,434	(532
	B & C	---	20	---	---	---	---
	C	46	1,113	---	---	226	(41
Missouri Basin Total of All Classifications		3,368	5,392	185	1,180	4,630	717

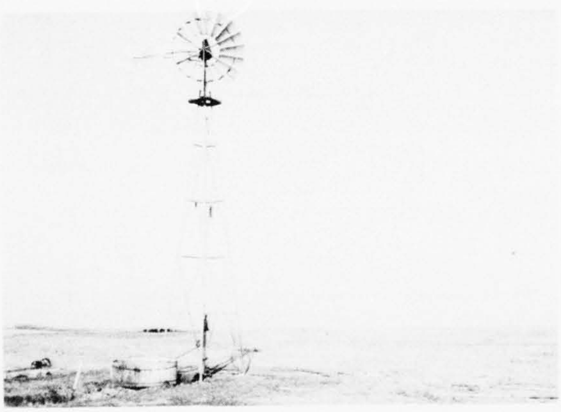
Table 38 – ESTIMATED POTENTIAL EFFECT OF GROUP IRRIGATION REHABILITATION AND IMPROVEMENT MEASURES ON WATER SUPPLY AND EQUIVALENT IRRIGATED ACREAGE, BY SUBBASINS

Subbasin	Potential Water Supply			Increased Net Future Depletions	Equivalent Irrigated Acreage
	Storage and Transportation Losses	Salvage	Total		
	(1,000 Acre-Feet – Average Annual)				(1,000 Acre
Upper Missouri	378	47	425	113	153
Yellowstone	336	65	401	72	68
Western Dakota	15	1	16	5	5
Eastern Dakota	---	---	---	---	---
Platte-Niobrara	610	147	757	15	246
Middle Missouri	---	---	---	---	---
Kansas	71	9	80	(-9)	27
Lower Missouri	---	---	---	---	---
Missouri Basin	1,410	269	1,679	196	499

agriculture enterprise practiced in any portion of the basin. A meaningful discussion of the problems related to supplying livestock water must recognize these broad climatic changes. Vast areas of grazing land are located in the arid and semiarid Great Plains portion of the basin. Grazing of this grassland without undue wind or water erosion requires good land management and adequate quantities of good quality water, strategically located. Meeting the water supply requirements is a serious problem in large portions of this area.

Ground water currently constitutes nearly three-fifths of the livestock water with surface supplies providing the balance. However, sources vary significantly between subbasins. Ground waters from both wells at headquarters and in pastures are the main source of water in five of the eight subbasins and range from a high of 84 percent in the Middle Missouri to a low of 30 percent in the Western Dakota Subbasin.

Surface water, mostly farm ponds and pits, predominates in three of the eight subbasins, providing as high as seven-tenths of the livestock water in the Western Dakota Subbasin. In substantial areas of these three subbasins, ground waters are limited at economic pumping depth or are highly mineralized, thereby generally lowering the desirability for livestock use.



Strategically Located Sources of Livestock Water Promote Efficient Use of Pasture and Range Land

In addition to areas which have a supply proble runoff from the badlands and steep raw banks that occ intermittently throughout this western portion of t basin is frequently heavily laden with colloidal clays th do not settle out. Often the ground water and even t smaller rivers are high in salts. When this low quali water is used by livestock it retards growth. Calv drinking good quality water have weaned out as much 125 pounds heavier than calves drinking silt laden extremely salty water according to recent USDA tria These water quality problems have created considerab interest in rural pipelines that supply both livestock a the domestic needs of the farmers and ranchers. A fe such pipelines have been installed, one of which is miles long.

Providing livestock water is less of a problem east the Great Plains in the more humid regions of the bas The eastern farm units are smaller than the weste ranches, and fewer watering facilities are required f each farm unit. Frequently headquarters water is all th is needed. Satellite facilities are installed when pastu are isolated from the headquarters supply.

Wells and stock ponds are used to meet the livesto needs in the east as well as in the west, but more th half of the total needs is supplied from ground water. this area, stock ponds, when used, are smaller because a more reliable runoff and high runoff rate. Ru pipelines are becoming popular where ground water not available in this eastern area; however, these pi lines usually are predicated on an unsatisfacto domestic supply rather than primarily to satisfy li stock requirements.

Beef cattle, calves, and sheep consume three-four of the livestock water in the Missouri Basin. Ot livestock, such as dairy cows, hogs and pigs, and poul consume the remaining portion. Consumption requi ments amount to about 343 million gallons per (table 39).

A great variety of wildlife also utilizes livestock wa developments for drinking, for living space, or for be Big game, particularly deer and antelope, frequen utilize them as a source of drinking water. Sage gro sharptails, and pheasants also find them attractive. M different species of waterfowl and shore birds use th for habitat. Livestock water developments having su cient depth and size, frequently provide a warm-wa sport fishery which produces bass, blue-gill, and chan catfish. In some areas where water temperatures are enough the developments are stocked with trout.

Waterfowl production on livestock water pond important in the north and central parts of the basin average annual production on artificial water area about four ducks per surface-acre in favorable ar maximum production has been realized where ponds fenced and shoreline vegetation protected. Livest ponds have a life span of about 20 to 30 years, and w

Table 39 – CURRENT AND PROJECTED LIVESTOCK WATER REQUIREMENTS, BY SUBBA

Subbasin	1960[1]			Projected Requirement	
	Beef Cattle and Sheep	Other Livestock & Poultry	Total	1980	2000
	(Million Gallons Per Day)				
Upper Missouri	19	1	20	31	42
Yellowstone	17	1	18	28	39
Western Dakota	23	3	26	43	60
Eastern Dakota	28	15	43	64	90
Platte-Niobrara	57	15	72	124	177
Middle Missouri	34	30	64	96	134
Kansas	36	12	48	70	98
Lower Missouri	44	15	59	89	124
Missouri Basin	258	92	350	545	764

[1] Estimates are for 1960 consumptive requirements except for the Kansas Subbasin, which is for the 1965 year.

they are no longer effective for livestock water, they must be replaced with new developments. Even though these obsolete ponds have little or no value for livestock, they continue to provide wildlife habitat and are especially important for waterfowl production. The increase in total numbers of livestock ponds and retention of any remaining storage capacities in the majority of the obsolete livestock ponds will provide about one-half the estimated total of 146,000 ponds needed for waterfowl habitat. Additionally, these developments furnish significant amounts of well distributed fisherman- and hunter-days.

Current annual water use for livestock purposes is about 1,140,000 acre-feet. Of this amount 392,000 acre-feet, or about one-third, are consumed by livestock, and 756,000 acre-feet, or two-thirds, are evaporated from farm ponds, as shown in table 40.

Table 40 – ESTIMATED AVERAGE ANNUAL WATER USE FOR LIVESTOCK PURPOSES (1960), BY SUBBASINS

Subbasin	Consumption Requirements[1]	Evaporation From Farm Ponds[2]	Total[3]
	(Thousand Acre-Feet)		
Upper Missouri	22	132	154
Yellowstone	20	69	89
Western Dakota	29	206	235
Eastern Dakota	48	42	90
Platte-Niobrara	81	70	151
Middle Missouri	72	18	90
Kansas	54	122	176
Lower Missouri	66	97	163
Missouri Basin	392	756	1,148

[1] Includes all types and classes of livestock, for 1960, except Kansas (1965).
[2] Average annual lake evaporation plus runoff minus precipitation.
[3] Water use is defined as water consumed from both surface and ground-water sources by livestock plus net evaporation losses from livestock ponds.

AGRICULTURAL DEVELOPMENT

Development needs in agriculture may relate to national, regional, and environmen of the next 50 years. The level of developm to meet the needs of one objective may be may oversupply the needs of other object cases, objectives might be in direct conflict the needs of one objective could preclude other objectives.

The resolution of any conflicts betwe and the determination of the specific agric opment necessary to optimize the needs of is a function of planning. This chapter pre tural development needs as they rela objectives. No attempt was made to assign or priorities to needs when they di objectives.

Agricultural Production Needs

It has been shown that agricultural pro be expanded. The projected capability o resources with only specified activities production requirements except for appro 10 percent between the years 2000 an expanded output is necessary to meet p and fiber requirements stemming fr objectives.

In addition to the national producti ciency gains may be realized by the problems and constraints which prevent t tion of the resources of the basin. It is qu many of the development potentials ma more economical than the present sour tion. If so, the more efficient producti development is in the interest of the nat inasmuch as it replaces other higher production and results in supplying na ments at a lower cost. This will have transferring activity from marginal acres (and areas) to the newly developed resources, assuming regional output is held at the requirement level.

There is understandably a regional and local objective to expand activity beyond the level of regional requirements which are disaggregated from national requirements. This regional development need can be met by the development of the same potentials which provide efficiency gains to meet the national objective. The regional objective is compatible in this respect, but diverges from the national objective with reference to the transfer of activity. For such development to meet regional objectives, the regional output would be allowed to increase aggregate output without letting economic pressure force the higher-cost areas out of production. This additional increment of production would add agricultural activity and related service activity to the level of economic activity in the base projections. The result would be a transfer of agricultural activity from other regions to the Missouri Basin. Hence, regional output tends to increase rather than be maintained at the requirement level.

The specific location of the higher-cost resources which will be replaced by efficient development and the relative efficiency of resources development potentials will not be known until similar information is available from the other major basins or regions. Only then can the regional implications of meeting national production demands be fully evaluated. In this interim, it is in the interest of all objective levels to determine the capability of existing resources and of the resource development potentials in this basin. All levels of objectives can be served by any development potential which can increase the efficiency of furnishing the Nation's food supply, regardless of ultimate interregional consequences.

Land Treatment

In a previous section, the capability of the agricultural resources (with only specified activities continuing) was projected. These projections included the effect of research, technology, improved managment, and the continuation of certain resource-oriented agricultural programs. This continuity of the management, conservation, and restoration of the land resources is an important assumption in the projected production capability.

To attain the projected agricultural production there must be increased intensities of technology, management, capital, and improved farming practices. Only with a stable land base can landowners and operators be expected to undertake such investments in time, energy, and funds.

The basic requirement for widespread attainment of soil conservation is the proper use of land for safe, continuous agricultural production. The purpose of the land treatment program is to sustain past acc ments and to increase the amount of adequatel cropland in the basin about 12 million acres by million acres by 2000, and 41 million acres b Such a rate of treatment will require the instal improved conservation management practices million acres of land and the installation of i management practices, plus mechanical practice additional 21 million acres. In addition to t needs, it is assumed that 4.6 million acres of will be retired to grass and replaced by 4.6 mill of grassland suitable for cultivation without pe harm.

The treatment needs on pasture and ra increase the amount of land adequately treated million acres by 1980, 40 million acres by 200 million acres by 2020. This will require i management practices on 22 million acres, proved management and mechanical con treatment on 36 million acres of pasture and ran

Privately owned forest and woodlands v treatment on 1 million additional acres b approximately 1.9 million acres by 2000, and lative total of improved treatment of 2.7 mill by 2020. This will require improved m practices on 2.1 million acres of land and i management plus mechanical practices on an a 0.6 million acres of forest and woodland.

Improved Water Facilities

Water needed for livestock consumption is to increase in direct proportion to projected production. This will amount to a threefold 350 million gallons per day currently to 1,05 gallons per day in 2020. Needs for development supplies at farm and ranch headquarters are co the rural domestic water needs in chapter 3. In to headquarter needs, there are further needs development away from farm and ranch headq meet expanded demands and to achieve bet bution of grazing. These mechanical mea included in the acreage of land treatment nee for pasture and range.

It is anticipated that ground water will conti the predominant source of water supplies; how subdivision of large pastures and other pasture management practices will increase the impo surface water, as illustrated by table 41. To need for better water distribution, it is project additional 116,000 farm ponds will be required (table 42). Currently, the grazing land a supplied with water is about 64 percent of acreage. By 2020, the percentage of gra adequately supplied is projected to be 8

Table 41 – CURRENT AND PROJECTED SOURCE OF LIVESTOCK WATER, BY SUBB

Subbasin	Current		1980		2000		
	Surf.	Ground	Surf.	Ground	Surf.	Ground	Su
	(Percent)						
Upper Missouri	63	37	69	31	70	30	7
Yellowstone	58	42	61	38	64	36	6
Western Dakota	70	30	71	29	71	29	7
Eastern Dakota	42	58	44	56	46	54	4
Platte-Niobrara	32	68	32	68	31	69	2
Middle Missouri	16	84	21	79	24	76	2
Kansas	36	64	38	62	39	61	3
Lower Missouri	49	51	49	51	52	48	5
Missouri Basin	43	57	46	54	47	53	4

Table 42 – CURRENT AND PROJECTED SURFACE AREA OF WATER USED FOR LIV
BY SUBBASINS

Subbasin	Period	Farm Ponds[1]		Other Water
		No.	Acres	Acres
		(Thousands)		
Upper Missouri	Current	22	65	22
	1980	33	89	22
	2000	39	89	22
	2020	45	90	21
Yellowstone	Current	14	34	16
	1980	19	42	16
	2000	24	48	15
	2020	25	42	15
Western Dakota	Current	56	96	11
	1980	67	96	11
	2000	73	96	11
	2020	75	96	11
Eastern Dakota	Current	40	30	44
	1980	49	36	36
	2000	52	39	32
	2020	53	40	30
Platte-Niobrara	Current	23	25	49
	1980	25	26	49
	2000	25	28	49
	2020	25	26	49
Middle Missouri	Current	16	13	13
	1980	24	22	12
	2000	30	27	11
	2020	34	34	10
Kansas	Current	38	46	13
	1980	42	50	13
	2000	45	68	13
	2020	45	76	13
Lower Missouri	Current	105	105	14
	1980	113	135	13
	2000	121	218	12
	2020	128	256	12
Missouri Basin	Current	314	414	182
	1980	372	496	172
	2000	409	613	165
	2020	430	660	150

[1] Farm ponds for livestock water include only the farm ponds used primarily for livestock water that
supplies throughout the grazing season or period of use.

ranging from a low of 82 percent in the Upper Missouri to a high of 95 percent in the Eastern Dakota Subbasin.

A probable increase in farm pond numbers, replacement, and relocation of existing ponds and wells will

improve the distribution of water suppl
grazing lands are projected to be 75 pe
supplied with water by 1980, 82 perce
86 percent by 2020 (table 43).

Table 43 – CURRENT AND PROJECTED GRAZING AREA ADEQUATELY SUPPLI
WITH WATER, BY SUBBASINS

Subbasin	Area Grazed				Grazing Area Adequa Supplied with Wate		
	Current	1980	2000	2020	Current	1980	200
	(Million Acres)				(Percent)		
Upper Missouri	35.0	34.9	34.8	34.6	54	67	77
Yellowstone	35.1	35.0	34.9	34.7	57	69	79
Western Dakota	36.5	36.4	36.3	36.1	67	77	84
Eastern Dakota	12.7	12.7	12.7	12.6	69	88	94
Platte-Niobrara	42.6	42.5	42.4	42.3	70	80	84
Middle Missouri	3.0	3.0	3.0	2.9	76	82	85
Kansas	14.1	14.1	14.0	13.9	69	74	80
Lower Missouri	10.4	10.3	10.2	10.1	75	80	81
Missouri Basin	189.4	188.9	188.3	187.2	64	75	82

The remaining 14 percent will not be adequately supplied by 2020, according to travel-distance criteria. This deficiency, however, is not considered to be serious since the aggregate "deficient area" will be comprised of fringe or odd areas in corners of pastures, areas of difficult accessibility, or areas of such low production that development of water supplies will probably never be feasible.

Total water use by livestock is projected to increase about 31 percent by 1980, 65 percent by 2000, and to double by 2020. The amount of water used by livestock will increase from 1.1 million acre-feet under current conditions to 2.3 million acre-feet by 2020. Currently, about 34 percent is actually consumed by livestock, while 66 percent is lost through evaporation from watering facilities. As a result of greater livestock use, the proportion of projected water requirements which is consumptively used will increase to slightly over one-half of total water requirements, as shown in table 44.

Social and Economic Environment

The strengthening of the agricultural, social, and economic environment in rural areas of the basin is a need toward which national policy is oriented. Considerable discussion has been devoted to the natural instability and uncertainty of this area and the problems inherent in the environment. This natural instability and variability in agricultural production and incomes is directly translated into local area economics which rely on agriculture for support. The nature of the area is such that trades and services must be prepared to handle large volumes of business in favorable years and suffer over-capacity and periodic unemployment in drought years.

There is a need for measures which
agricultural and dependent industrie
agricultural industry would in itself b
and would, in turn, produce efficiency g
volumes of business flows within rel
services.

All of the resource development
toried can contribute to production
moving production losses, eliminatin
effects of climate variability, and inc
ciency and productivity of the agricultu

In a primarily agricultural area, soil
limiting factors on the level of the agric
There are definite limits to crop proc
stock feed that can be produced
resources. The natural climate not
productivity, but creates damages that
full realization of potential production.
the Missouri Basin the nature of the
capability of the resources require exte
unit to provide adequate family farm
for an efficient combination of land an
to fully utilize current and projected
ever-decreasing density of rural popula
While improving per capita income,
creates a need for additional basic em
areas if travel distance to public and pri
be held to practicable limits.

Any of the development potentials w
capability of the resources to produce w
environmental and social need. Such
have the effect of increasing the tota
basin's agricultural industry to supply
income, and increase employment in r
total economy.

Table 44 – CURRENT AND PROJECTED ANNUAL WATER USE FOR LIVESTOCK PURPOSES, BY SUBBASINS

Subbasin	Period	Consumption Requirements[1]	Evaporation Sources[2]	Total[3]
		(Thousand Acre-Feet)		
Upper Missouri	Current	22	132	154
	1980	35	181	216
	2000	47	181	228
	2020	66	183	249
Yellowstone	Current	20	69	89
	1980	31	85	116
	2000	44	97	141
	2020	61	85	146
Western Dakota	Current	29	206	235
	1980	48	206	254
	2000	67	206	273
	2020	94	206	300
Eastern Dakota	Current	48	42	90
	1980	72	50	122
	2000	101	55	156
	2020	140	56	196
Platte-Niobrara	Current	81	70	151
	1980	139	72	211
	2000	198	78	276
	2020	268	72	340
Middle Missouri	Current	72	18	90
	1980	108	31	139
	2000	150	38	188
	2020	208	48	256
Kansas	Current	54	122	176
	1980	79	133	212
	2000	110	181	291
	2020	154	202	356
Lower Missouri	Current	66	97	163
	1980	100	127	227
	2000	139	203	342
	2020	195	238	433
Missouri Basin	Current	392	756	1.148
	1980	612	885	1.497
	2000	856	1,039	1.895
	2020	1,186	1,090	2.276

[1] Includes all types and classes of livestock for 1960, except Kansas (1965).
[2] Average annual lake evaporation plus runoff minus precipitation.
[3] Water use is defined as water consumed from both surface and ground-water sources by livestock plus net evaporation l[…] from livestock ponds.

Within the next half-century, the development of these potentials can significantly improve the quality of the agricultural economy. However, agriculture alone, will be unable to support the necessary trades and services and social facilities needed within desirable geographic distances.

FOREST RESOURCES

The forests of the Missouri Basin are concentrated largely in two major geographic areas: (1) in the Ozark Plateaus in the Lower Missouri Subbasin and adjacent areas in the southern portion of the basin; and (2) in the Rocky Mountains and Black Hills of the Upper Missouri, Yellowstone, Platte-Niobrara and Western Dakota subbasins (figure 15).

In the Lower Missouri Subbasin, forest and w[…] lands cover one-fourth of the land area. They are la[…] hardwood and almost all of them are privately owne[…] long period of heavy grazing and poor markets for f[…] products has resulted in an accumulation of sawti[…] stands that contain many cull trees and too few pol[…] sapling-seedling trees. The volumes average about […] board feet per acre.

The 22 million acres of forest in the western po[…] of the Missouri Basin comprise 73 percent of […] forest lands and represent 65 percent of the produ[…] from commercial forests (see table 45). A large […] portion of these forest lands is federally owned. […] western portion of the basin, trees seldom grow […] than 4,000 feet above sea level except along […] bottoms. A big proportion of the […]

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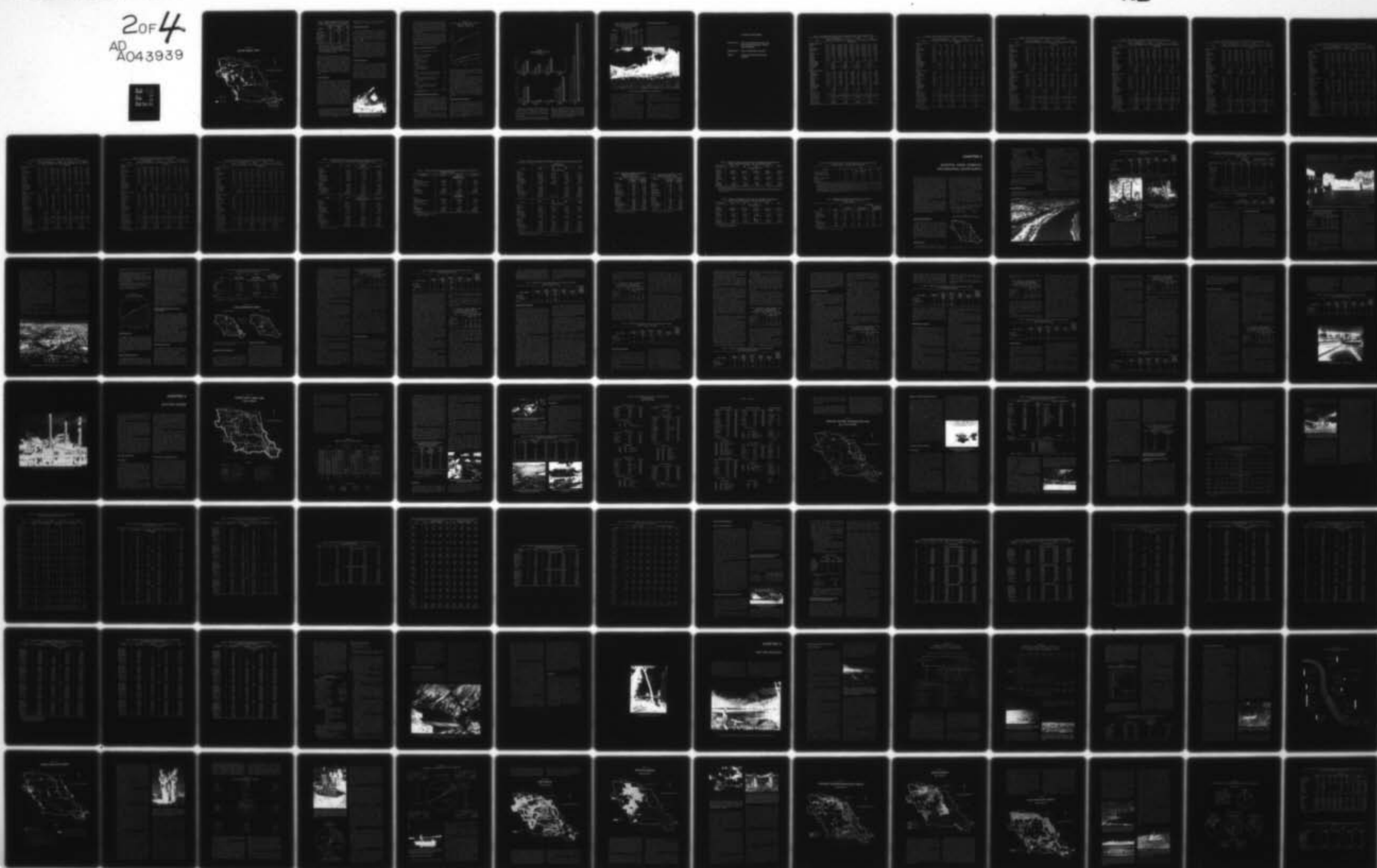

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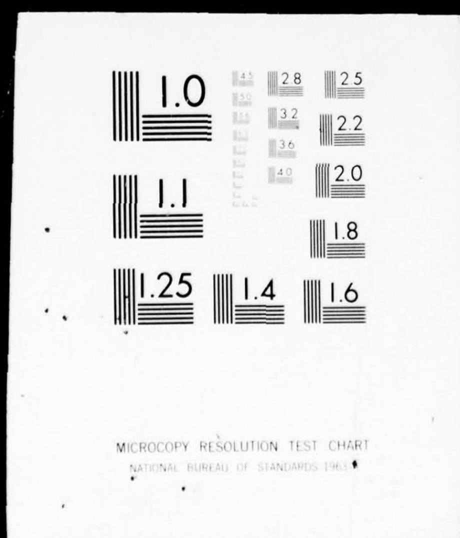


FIGURE 15

MAJOR FOREST TYPES

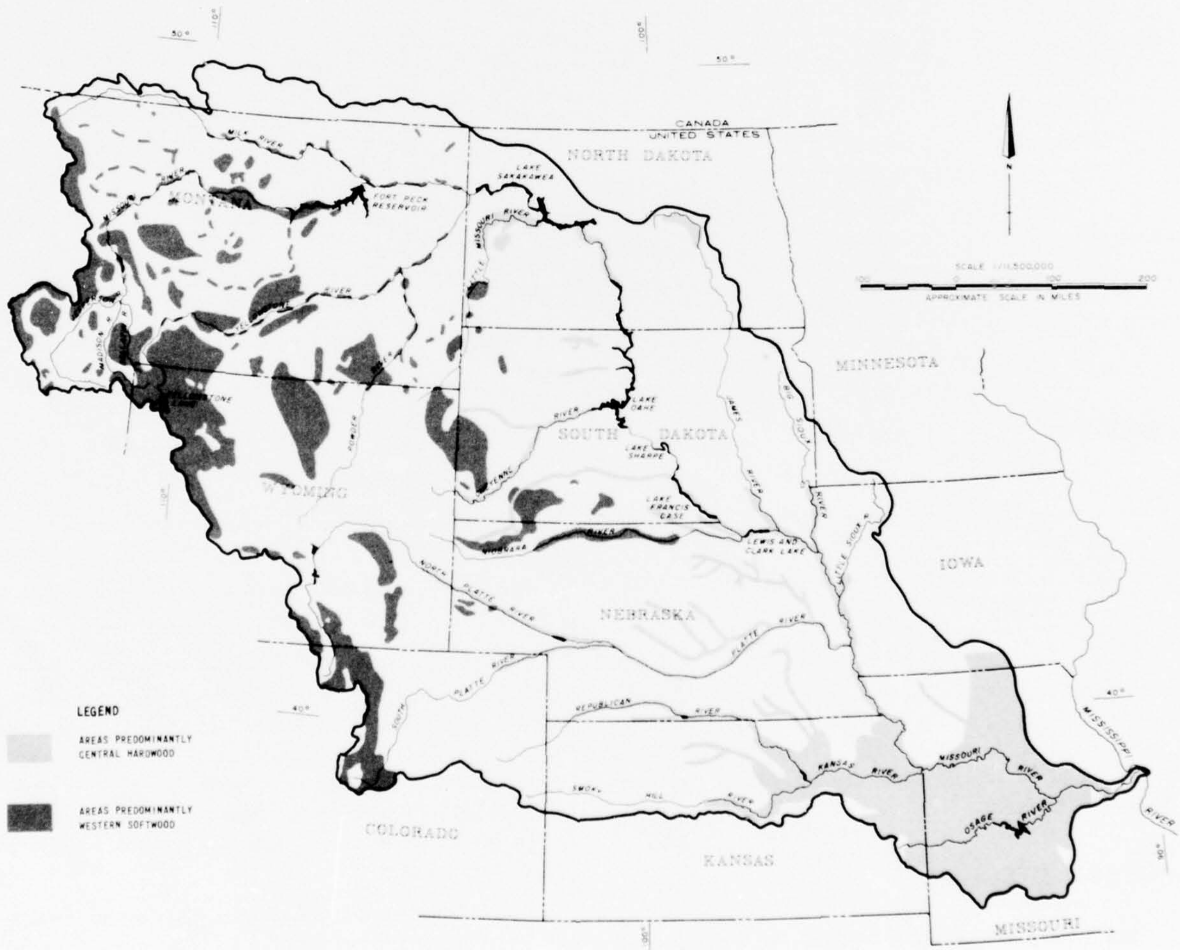


Table 45 – ACRES OF FOREST LAND BY CLASSES AND CURRENT INVENTORY, BY SUBBASINS

Subbasin	Commercial Forest Land[1]	Noncommercial Forest Land[2]	Total Forest Land
	(Thousand Acres)		
Upper Missouri	5,500	1,711	7,211
Yellowstone	3,166	3,871	7,037
Western Dakota	2,218	206	2,424
Eastern Dakota	129	31	160
Platte-Niobrara	4,150	978	5,128
Middle Missouri	1,019	17	1,036
Kansas	500	20	520
Lower Missouri	6,651	206	6,857
Missouri Basin	23,333	7,040	30,373

[1]Forest land which is producing, or is capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation.
[2]Unproductive forest land incapable of producing crops of commercial industrial wood. This also includes productive forest land withdrawn from commercial timber use through statute or administrative regulation.

elevations consists of low-quality stands of juniper and ponderosa pine which are classed as noncommercial forests. The commercial forests are located at somewhat higher elevations and consist mostly of lodgepole pine, Douglas fir, Englemann spruce, and ponderosa pine. They occur along the eastern slopes of the Continental Divide and on a number of mountain ranges to the east. At still higher elevations there are additional noncommercial areas of rugged sites with scrubby trees – largely subalpine fir, white bark pine, and Englemann spruce.

Timber Inventory

The volume of sound wood in the forest growing stock of the Missouri Basin is 19.1 billion cubic feet.[1] Sixty-five percent (62.5 billion board feet) of the growing stock is in sawtimber-size trees.[2] Softwoods make up 83 percent of the sawtimber volumes. Sixty-five percent of the timber inventory is on Federal land. Tree and log sizes are significant in determining grade, and indicate the quality of the sawtimber. Approximately 43 percent of the sawtimber volumes in the basin is in trees 15 inches and larger in diameter at breast height. About 30 percent is in trees 19 inches and larger. Thirty-nine percent of the softwoods and 59 percent of the hardwoods are trees over 15 inches in diameter. The remaining volume of growing stock, 35 percent, is in live pole-timber trees which meet many commercial needs but generally are too small to be made into lumber.

[1]Growing-stock trees are sound, live trees of commercial species. Growing-stock volume is the net volume in cubic feet of growing-stock trees 5.0 inches diameter-breast-height and over on commercial forest land.
[2]Sawtimber is measured in board-feet and includes only the portion of the growing stock inventory of softwoods over 9 inches in diameter and hardwoods over 11 inches in diameter in one or more 12-foot logs.

Timber Growth and Cut

Trees in the timber growing stock form the base for future timber growth. When ready for harvesting but not cut, they become a reserve of standing timber from which industries may draw to meet future requirements. Comparison of timber growth and cut provides a rough indication of the degree of undercutting or overcutting.

The *net annual* growth of all growing stock trees in the Missouri Basin is estimated to be 306 million cubic feet. Growth per acre amounts to about 13 cubic feet. The growth of sawtimber totals 961 million board feet annually. Sawtimber growth is approximately 45 board feet per acre per year. Most of the sawtimber stands, particularly in the western portion of the basin, are old-growth forests. In this section most of the sawtimber stands are overmature and subject to heavy mortality.

Forestry Production

The total harvest of timber in the Missouri Basin increased about 13 percent from 1952 to 1962, while the rise in wood consumption in the United States was some 17 percent. However, annual harvest of timber resources is only about one-half of the growth, thus increasing timber reserve inventory. A desirable cut will progressively improve the distribution of age classes and quality of the growing stock and maintain a desirable level of timber reserve in growing healthy conditions to

Timber Cut Within The Basin Is Used For Pulpwood, Lumber, And Veneer Logs

meet future needs for forest products. Timber product outputs in the basin totaled 138.9 million cubic feet in 1962. Ninety-two percent of this came from roundwood; the balance from plant by-products. The sawtimber portion of this harvest amounted to about 554 million board feet or only 57 percent of the net annual sawtimber growth.

About 461 million board feet were produced from logs comprising 55 percent of the annual cut. Seventy-five percent of the saw logs was cut in the western subbasins. Another 471,000 cords, or 26 percent of the annual cut, were used for fuelwood, chiefly in the Lower Missouri Subbasin. The cut of veneer logs and pulpwood together totaled six percent of the annual cut.

Summary of Significant Characteristics[5]

Inventory of sawtimber in billion board feet	62.5
Stand:	
Percent in sawtimber stands	73
Percent of other stands	27
Type of Wood:	
Percent in softwoods	83
Percent in hardwoods	17
Ownership:	
Percent Federal	65
Percent private industry	33
Percent other private	2
Size:	
Percent in trees over 15 inches in diameter	43
Percent in trees over 19 inches in diameter	30
Growth:	
Total annual growth in million cubic feet	306
Annual sawtimber growth in million board feet	961
Harvest:	
1962 total harvest in million cubic feet	104
1962 sawtimber harvest in million board feet	554

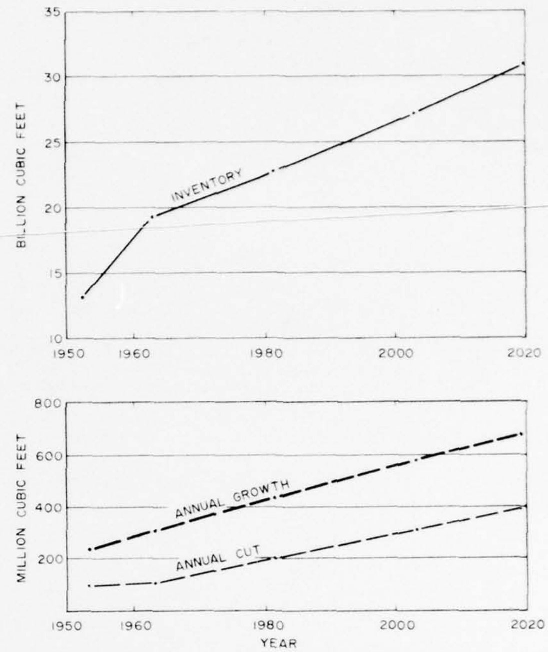
[5]Details of timber inventory, growth, and cut are included in tables 56 through 63.

Projected Demand, Growth, and Cut

By 1980, the national demand for forest products is expected to increase by one-third over the 1962 use. Projections from the same base indicate a 200 percent demand increase by 2000 and a 300 percent increase by 2020. In the Missouri Basin, the 1962 timber cut (demand) was 104,197 cubic feet. Projections for the basin show a demand of over 196,000 cubic feet by 1980, of 305,700 cubic feet by 2000, and 401,400 by 2020 as shown in figure 16.

Net annual growth is expected to increase at about the same rate as the timber cut, assuming that forest management programs will intensify the annual growth through 2020. As a consequence, growth will still exceed cut by 200 million cubic feet annually in 2020 and inventories will increase 140 percent to over 31 billion cubic feet of growing stock.

FIGURE 16
HISTORICAL AND PROJECTED ANNUAL TIMBER CUT, GROWTH, AND INVENTORY ON COMMERICAL FOREST LAND



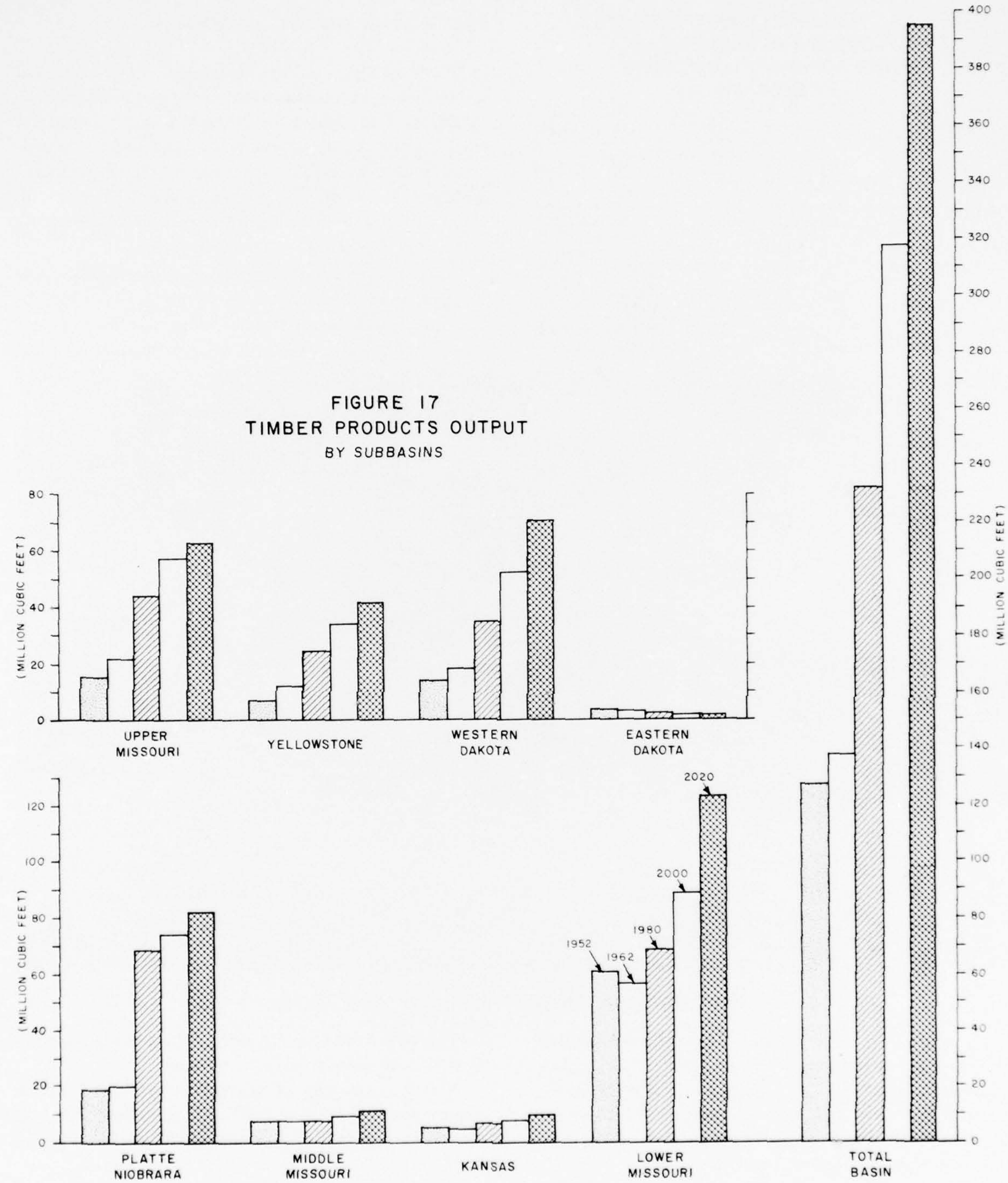
The cut of sawtimber is projected to rise from 554 million board feet in 1962 to 1,354 million in the year 2020. Although the cut (demand) will nearly equal sawtimber growth by 2020, the inventory of sawtimber reserves will increase by 11,000 million board feet.

The Lower Missouri Subbasin with 41 percent of the basin's timber output in 1962 will continue to be the major producer, but its share of the total is projected to decline to 31 percent. In contrast, the Upper Missouri Subbasin, presently with a 16 percent share, is projected to increase to 20 percent in 2020 as illustrated in figure 17.

Forest Products Employment

Most of the forest product industries are located near the forest areas in the western and southeastern portions of the Missouri Basin and in the Black Hills area of the Western Dakota Subbasin. Employment in primary wood-using manufacturing plants and forest-based industries will increase gradually during the next half-century. To meet requirements of the forest-based industries, forest managment and timber harvest will increase at about the same rate.

FIGURE 17
TIMBER PRODUCTS OUTPUT
BY SUBBASINS



Employment in timber-based manufacturing is projected to increase from 22,000 in 1962 to about 51,000 in 2020. Agricultural employment in timber harvesting is expected to increase from 5,152 to 9,000 during the same period.

By 2020, nearly half the total forest-products manufacturing employment will be in mills producing pulp, paper, and allied products. This contrasts with the 34 percent employed in this category in 1962. The remaining employees will be divided nearly equally between lumber and wood-product plants and timber harvesting. Over half of the timber-based employment will be in the Lower Missouri Subbasin.

Table 46 – HISTORICAL AND PROJECTED EMPLOYMENT IN TIMBER-BASED MANUFACTURING INDUSTRIES, BY SUBBASINS

Subbasin	1962	1980	2000	2020
	(Number Persons)			
Upper Missouri	890	1,635	1,720	1,585
Yellowstone	829	950	885	830
Western Dakota	1,388	1,550	1,530	1,425
Eastern Dakota	250	250	270	290
Platte-Niobrara	3,514	5,875	7,160	9,395
Middle Missouri	2,820	3,420	4,090	5,730
Kansas	940	1,040	1,270	1,450
Lower Missouri	11,520	14,230	20,990	30,790
Missouri Basin	22,151	28,950	37,915	51,495

Forest Needs and Opportunities

There are opportunities to increase water yield and streamflow in the timber areas of the basin. Forests can be managed to change the pattern of forest cover and thus induce snow accumulation and reduce evapotranspiration. Research over a wide variety of conditions indicates that an average increase of about 22 percent in water yield can be obtained from areas where systematic and timely harvesting of timber is practiced.

The best opportunities for managing the forest cover to produce an increased water supply are found in the National Forests in the western portion of the basin and in the commercial timber zone. Precipitation in these areas ranges from 20 to 50 inches annually, and half of this appears as streamflow. Application of cover-type conversion, watershed treatment, and water harvesting techniques would also increase water yield from the noncommercial timber lands which are generally in areas of 18 to 30 inches of annual precipitation.

Forest Lands Serve Multiple Purposes, Including Grazing

Timber supplies in the Missouri Basin can be increased above the projected levels by acceleration of tree planting, forest improvement thinning, intensive forest protection, and other forestry programs. Some of this will be accomplished through commercial harvesting by forest-based industries; however, many of the measures will require a substantial investment of funds and several decades of time for appreciable increases in allowable annual timber cuts. Most of such development will be in the National Forests in the west and on private lands in the southeastern portions of the basin.

With the harvesting of desirable annual cut, there are opportunities of treating 1,980,000 acres and increasing the average annual stream flow 436,000 acre-feet by 2020.

There is an increased need and opportunities are available for intensifying land management and development programs on forest and rangelands of Federal and State, as well as private ownerships. These opportunities include land treatment and watershed protection measures, development for recreation and public use, improvement of wildlife habitat, and provision of access to blocks of Federal and State lands for increased public use. The greatest possibilities are on Federal lands.

STATISTICAL SUPPLEMENT

Table 47 – PRIVATE AGRICULTURAL CROP ACREAGE AND PRODUCTION, MISSOURI BASIN

Crop	Prod'n Unit	Current Normal Acres	Current Normal Production	1980 Acres	1980 Production	2000 Acres	2000 Production	2020 Acres	2020 Production
		(Thousand Units)							
NONIRRIG. CROPLAND									
All Wheat	Bu.	19,892	424,155	22,630	628,624	22,246	726,864	22,179	802,339
Rye	Bu.	721	13,258	650	16,911	691	22,380	839	29,864
Corn Grain	Bu.	13,045	682,676	12,500	965,553	14,145	1,297,320	16,226	1,596,932
Corn Silage Equiv.	Ton	2,903	18,154	2,655	21,180	2,385	27,070	2,786	36,673
Sorghum Grain	Bu.	3,674	151,140	4,485	254,313	5,891	400,925	7,101	568,095
Oats	Bu.	6,631	218,646	5,753	263,247	4,337	245,380	2,939	175,778
Barley	Bu.	4,273	97,495	3,204	88,660	2,296	75,155	2,337	79,165
Alfalfa Hay Equiv.	Ton	10,375	16,525	9,438	18,261	9,007	20,600	11,365	29,065
Flaxseed	Bu.	1,379	13,457	1,104	9,963	1,034	12,901	1,105	17,186
Soybeans	Bu.	3,166	85,666	3,406	117,325	3,713	145,621	4,573	175,412
Dry Beans	Cwt.	6	24	5	17	5	15	12	64
Potatoes	Cwt.	10	684	10	686	7	657	21	1,367
Sugar Beets	Ton	0	2	0	7	2	35	223	4,641
Cropland Pasture	F.U.	2,646	3,960,411	2,629	5,245,369	2,618	6,002,878	2,465	6,273,820
Other Crops Harv.	---	417	---	418	---	414	---	350	---
Summer Fallow	---	14,583	---	15,346	---	14,905	---	14,489	---
Idle Cropland	---	4,830	---	4,805	---	4,742	---	4,619	---
Reserve Idle	---	8,342	---	7,158	---	6,653	---	0	---
TOTAL		96,893		96,196		95,091		93,629	
IRRIGATED CROPLAND									
All Wheat	Bu.	204	6,700	164	8,469	159	10,003	120	9,485
Corn Grain	Bu.	1,918	163,106	1,703	217,300	1,613	265,363	1,424	279,071
Corn Silage Equiv.	Ton	505	7,294	482	7,968	382	7,254	402	9,386
Sorghum Grain	Bu.	385	33,852	569	70,286	628	100,583	797	152,139
Barley	Bu.	690	30,566	528	34,518	599	48,943	378	35,817
Alfalfa Hay Equiv.	Ton	1,937	5,103	1,729	5,819	1,693	6,620	1,701	7,942
Soybeans	Bu.	20	604	65	2,248	23	1,075	10	454
Dry Beans	Cwt.	213	3,518	220	4,287	283	5,708	365	7,714
Potatoes	Cwt.	45	8,263	34	6,084	34	8,612	27	11,381
Sugar Beets	Ton	375	5,748	586	10,918	886	17,885	972	20,981
Cropland Pasture	F.U.	156	454,197	155	586,038	152	684,163	143	768,889
Other Crops Harv.	---	39	---	38	---	34	---	24	---
Idle Cropland	---	204	---	204	---	201	---	190	---
Reserve Idle	---	205	---	360	---	49	---	0	---
TOTAL		6,896		6,837		6,736		6,553	
CROPLAND TOTAL		103,789		103,033		101,827		100,182	
Wild (Native) Hay	Ton	6,548	5,612	6,532	6,748	6,507	7,202	6,489	7,725
Pasture & Range	F.U.	146,116	55,386,609	145,688	69,978,733	145,179	79,699,262	144,355	85,192,110
GRAZING TOTAL		152,664		152,220		151,686		150,844	
FOREST TOTAL	F.U.	13,654	1,602,323	13,493	1,809,723	13,350	1,879,143	13,102	1,959,992
Other Ag. Land		3,561		3,530		3,479		3,371	
TOTAL AG. LAND		273,668		272,276		270,342		267,499	

Table 48 – CROP ACREAGE AND PRODUCTION, UPPER MISSOURI SUBBASIN

Crop	Prod'n Unit	Current Normal		1980		2000		2020	
		Acres	Production	Acres	Production	Acres	Production	Acres	Production
					(1,000 Units)				
NONIRRIG. CROPLAND									
All Wheat	Bu.	3,376	67,519	3,692	88,231	3,815	106,205	3,805	106,500
Rye	Bu.	31	562	24	505	20	488	14	383
Corn Grain	Bu.	*	7	*	14	1	35	9	515
Corn Silage Equiv.	Ton	10	38	29	180	30	244	43	431
Sorghum Grain	Bu.	0	---	0	---	0	---	0	---
Oats	Bu.	127	3,796	142	5,701	116	5,811	329	25,347
Barley	Bu.	1,364	30,017	981	24,713	703	20,788	585	15,660
Alfalfa Hay Equiv.	Ton	497	435	504	527	470	591	509	955
Flaxseed	Bu.	23	138	29	129	16	61	31	122
Soybeans	Bu.	0	0	0	0	0	0	0	0
Dry Beans	Cwt.	0	0	0	0	0	0	0	0
Potatoes	Cwt.	0	0	0	0	0	0	0	0
Sugar Beets	Ton	0	0	0	0	0	0	0	0
Cropland Pasture	F.U.	1	599	1	787	1	890	1	1,196
Other Crops Harv.	---	115	---	115	---	115	---	105	---
Summer Fallow	---	3,734	---	3,375	---	3,489	---	3,777	---
Idle Cropland	---	479	---	487	---	482	---	476	---
Reserve Idle	---	0	---	367	---	472	---	0	---
TOTAL		9,757		9,746		9,730		9,684	
IRRIGATED CROPLAND									
All Wheat	Bu.	10	350	5	324	4	320	5	444
Corn Grain	Bu.	1	43	*	44	*	50	1	71
Corn Silage Equiv.	Ton	11	155	13	233	12	220	9	218
Sorghum Grain	Bu.	0	0	0	0	0	0	0	0
Barley	Bu.	343	15,413	242	15,698	282	23,109	235	21,789
Alfalfa Hay Equiv.	Ton	514	1,249	467	1,373	462	1,492	520	1,875
Soybeans	Bu.	0	0	0	0	0	0	0	0
Dry Beans	Cwt.	2	24	4	70	4	82	15	280
Potatoes	Cwt.	4	555	3	503	3	568	3	592
Sugar Beets	Ton	15	216	55	975	121	2,204	114	1,974
Cropland Pasture	F.U.	17	42,825	17	63,967	17	76,962	17	86,954
Other Crops Harv.	---	0	0	0	0	0	0	0	0
Idle Cropland	---	29	---	29	---	29	---	27	---
Reserve Idle	---	7	---	115	---	13	---	0	---
TOTAL		953		950		947		946	
CROPLAND TOTAL		10,710		10,696		10,677		10,630	
Wild (Native) Hay	Ton	264	264	264	264	254	290	264	311
Pasture & Range	F.U.	25,258	5,946,397	25,236	7,213,948	25,209	8,162,015	25,179	8,876,459
GRAZING TOTAL		25,522		25,500		25,463		25,443	
Grazed Woodland	F.U.	1,356	169,442	1,354	177,374	1,352	186,714	1,349	192,854
Non-grazed Woodland	---	608	---	606	---	605	---	591	---
FOREST TOTAL		1,964		1,960		1,957		1,940	
Other Ag. Land		254		253		252		251	
TOTAL AG. LAND		38,450		38,409		38,349		38,264	

*Less than 500 acres.

Table 49 – CROP ACREAGE AND PRODUCTION, YELLOWSTONE SUBBASIN

Crop	Prod'n Unit	Current Normal		1980		2000		2020	
		Acres	Production	Acres	Production	Acres	Production	Acres	Production
		(1,000 Units)							
NONIRRIG. CROPLAND									
All Wheat	Bu.	683	13,663	766	19,884	782	23,778	660	22,423
Rye	Bu.	6	112	7	173	14	376	13	340
Corn Grain	Bu.	5	111	6	206	6	265	9	537
Corn Silage Equiv.	Ton	16	62	8	42	9	62	7	49
Sorghum Grain	Bu.	0	0	0	0	0	0	0	0
Oats	Bu.	59	1,834	63	2,820	49	2,805	158	12,600
Barley	Bu.	192	4,041	157	4,004	149	4,986	152	4,569
Alfalfa Hay Equiv.	Ton	300	248	262	234	245	270	538	822
Flaxseed	Bu.	7	36	6	19	5	19	4	20
Soybeans	Bu.	0	0	0	0	0	0	0	0
Dry Beans	Cwt.	0	0	0	0	0	0	0	0
Potatoes	Cwt.	*	---	*	3	*	3	*	---
Sugar Beets	Ton	0	0	0	0	0	0	0	0
Cropland Pasture	F.U.	24	15,550	24	18,393	24	20,470	24	21,772
Other Crops Harv.	---	15	---	15	---	15	---	11	---
Summer Fallow	---	816	---	752	---	765	---	621	---
Idle Cropland	---	117	---	117	---	117	---	93	---
Reserve Idle	---	103	---	152	---	125	---	0	---
TOTAL		2,343		2,335		2,305		2,290	
IRRIGATED CROPLAND									
All Wheat	Bu.	60	2,100	40	2,149	36	2,390	27	2,285
Corn Grain	Bu.	9	659	7	633	5	454	5	530
Corn Silage Equiv.	Ton	44	524	42	630	35	496	33	726
Sorghum Grain	Bu.	0	---	0	0	0	0	0	0
Barley	Bu.	237	10,893	202	13,716	213	17,958	91	9,245
Alfalfa Hay Equiv.	Ton	436	988	337	984	344	1,190	299	1,213
Soybeans	Bu.	0	0	0	0	0	0	0	0
Dry Beans	Cwt.	58	874	56	1,033	70	1,341	196	4,239
Potatoes	Cwt.	2	299	2	343	2	403	1	300
Sugar Beets	Ton	94	1,384	131	2,347	208	4,028	235	4,602
Cropland Pasture	F.U.	42	104,717	41	133,128	41	156,806	41	172,733
Other Crops Harv.	---	3	---	3	---	3	---	3	---
Idle Cropland	---	30	---	30	---	30	---	28	---
Reserve Idle	---	16	---	130	---	18	---	0	---
TOTAL		1,031		1,021		1,005		959	
CROPLAND TOTAL		3,374		3,356		3,310		3,249	
Wild (Native) Hay	Ton	121	110	121	125	121	140	120	150
Pasture & Range	F.U.	24,212	4,052,416	24,164	5,274,284	24,101	6,079,426	24,001	6,592,143
GRAZING TOTAL		24,333		24,285		24,222		24,121	
Grazed Woodland	F.U.	1,357	143,864	1,355	153,160	1,351	161,150	1,338	167,876
Non-grazed Woodland	---	193	---	193	---	192	---	192	---
FOREST TOTAL		1,550		1,548		1,543		1,530	
Other Ag. Land		91		91		91		90	
TOTAL AG. LAND		29,348		29,280		29,166		28,990	

*Less than 500 acres.

Table 50 – CROP ACREAGE AND PRODUCTION, WESTERN DAKOTA SUBBASIN

Crop	Prod'n Unit	Current Normal		1980		2000		2020	
		Acres	Production	Acres	Production	Acres	Production	Acres	Production
		(1,000 Units)							
NONIRRIG. CROPLAND									
All Wheat	Bu.	2,224	40,028	2,524	57,757	2,358	64,625	2,620	66,174
Rye	Bu.	77	1,234	53	1,003	98	2,869	129	3,344
Corn Grain	Bu.	168	3,025	119	3,227	134	4,795	305	10,888
Corn Silage Equiv.	Ton	480	1,603	435	1,974	360	2,208	375	2,786
Sorghum Grain	Bu.	60	1,016	47	1,367	59	2,176	161	5,456
Oats	Bu.	740	19,233	526	18,636	353	15,580	502	23,075
Barley	Bu.	544	11,978	391	10,398	277	8,868	177	7,118
Alfalfa Hay Equiv.	Ton	1,633	1,651	1,430	1,600	1,281	1,760	1,437	2,619
Flaxseed	Bu.	86	604	75	446	70	478	147	1,178
Soybeans	Bu.	*	1	*	6	*	12	8	197
Dry Beans	Cwt.	0	0	0	0	0	0	0	0
Potatoes	Cwt.	4	251	4	240	3	229	4	301
Sugar Beets	Ton	0	0	0	0	0	0	0	0
Cropland Pasture	F.U.	184	208,294	183	263,530	181	297,315	181	310,825
Other Crops Harv.	---	30	---	30	---	30	---	30	---
Summer Fallow	---	2,078	---	2,422	---	2,264	---	2,530	---
Idle Cropland	---	454	---	454	---	450	---	443	---
Reserve Idle	---	335	---	392	---	1,154	---	0	---
TOTAL		9,097		9,085		9,072		9,049	
IRRIGATED CROPLAND									
All Wheat	Bu.	11	420	11	563	11	676	9	664
Corn Grain	Bu.	15	983	8	724	8	906	14	1,904
Corn Silage Equiv.	Ton	16	161	16	200	12	178	22	702
Sorghum Grain	Bu.	3	147	4	256	4	328	1	109
Barley	Bu.	7	308	9	547	9	707	9	804
Alfalfa Hay Equiv.	Ton	96	234	82	267	76	292	78	344
Soybeans	Bu.	0	0	0	0	0	0	0	0
Dry Beans	Cwt.	2	40	5	93	5	108	5	103
Potatoes	Cwt.	4	504	4	570	3	569	2	384
Sugar Beets	Ton	9	116	5	97	27	510	21	472
Cropland Pasture	F.U.	27	73,295	27	93,693	26	108,045	26	119,739
Other Crops Harv.	---	1	---	1	---	1	---	1	---
Idle Cropland	---	7	---	6	---	6	---	6	---
Reserve Idle	---	0	---	20	---	8	---	0	---
TOTAL		198		198		196		194	
CROPLAND TOTAL		9,295		9,283		9,268		9,243	
Wild (Native) Hay	Ton	1,062	746	1,061	853	1,060	959	1,059	992
Pasture & Range	F.U.	30,615	9,883,731	30,585	12,776,672	30,534	14,845,185	30,462	16,361,154
GRAZING TOTAL		31,677		31,646		31,594		31,521	
Grazed Woodland	F.U.	908	139,883	905	147,515	900	156,461	895	163,416
Non-grazed Woodland	---	69	---	68	---	66	---	65	---
FOREST TOTAL		977		973		966		960	
Other Ag. Land		209		208		205		200	
TOTAL AG. LAND		42,158		42,110		42,033		41,924	

*Less than 500 acres.

Table 51 – CROP ACREAGE AND PRODUCTION, EASTERN DAKOTA SUBBASIN

Crop	Prod'n Unit	Current Normal		1980		2000		2020	
		Acres	Production	Acres	Production	Acres	Production	Acres	Production
		(1,000 Units)							
NONIRRIG. CROPLAND									
All Wheat	Bu.	3,074	61,472	3,949	92,798	3,727	104,359	3,645	129,907
Rye	Bu.	294	6,468	289	8,830	265	9,974	225	9,008
Corn Grain	Bu.	3,358	141,051	3,059	183,558	3,347	237,623	5,643	368,648
Corn Silage Equiv.	Ton	626	3,523	616	6,935	579	8,074	628	11,087
Sorghum Grain	Bu.	101	2,914	241	14,290	300	21,565	1,213	107,834
Oats	Bu.	2,889	106,904	2,813	143,108	2,467	152,973	1,183	70,598
Barley	Bu.	1,117	30,145	863	28,023	583	21,553	844	28,876
Alfalfa Hay Equiv.	Ton	2,384	4,077	2,140	4,455	2,276	5,581	2,671	7,951
Flaxseed	Bu.	1,255	12,548	965	8,919	936	12,152	919	15,724
Soybeans	Bu.	357	7,487	402	12,456	508	16,246	590	13,471
Dry Beans	Cwt.	0	0	0	0	0	0	0	0
Potatoes	Cwt.	2	103	2	88	1	80	1	54
Sugar Beets	Ton	*	*	*	1	*	4	13	283
Cropland Pasture	F.U.	349	511,134	346	671,889	346	772,517	335	837,800
Other Crops Harv.	---	5	---	5	---	5	---	5	---
Summer Fallow	---	1,932	---	2,768	---	2,405	---	1,642	---
Idle Cropland	---	1,045	---	1,044	---	1,043	---	1,040	---
Reserve Idle	---	2,101	---	1,336	---	1,952	---	0	---
TOTAL		20,889		20,838		20,740		20,597	
IRRIGATED CROPLAND									
All Wheat	Bu.	*	4	*	8	*	10	0	0
Corn Grain	Bu.	15	914	8	663	8	835	9	1,144
Corn Silage Equiv.	Ton	8	101	6	90	5	88	6	124
Sorghum Grain	Bu.	1	55	1	104	1	134	*	41
Barley	Bu.	3	146	3	230	3	286	3	325
Alfalfa Hay Equiv.	Ton	67	226	76	312	68	340	64	373
Soybeans	Bu.	*	13	*	15	*	18	*	20
Dry Beans	Cwt.	5	81	2	43	6	128	15	315
Potatoes	Cwt.	1	157	*	74	*	79	*	---
Sugar Beets	Ton	14	197	11	204	12	234	10	224
Cropland Pasture	F.U.	3	8,445	3	12,474	3	14,315	3	14,024
Other Crops Harv.	---	1	---	1	---	1	---	1	---
Idle Cropland	---	1	---	4	---	4	---	4	---
Reserve Idle	---	0	---	3	---	6	---	0	---
TOTAL		119		118		117		115	
CROPLAND TOTAL		21,008		20,956		20,857		20,712	
Wild (Native) Hay	Ton	1,529	1,376	1,528	1,680	1,527	1,832	1,524	1,951
Pasture & Range	F.U.	11,018	6,911,409	10,997	8,500,418	10,965	9,615,460	10,936	10,400,666
GRAZING TOTAL		12,547		12,525		12,492		12,460	
Grazed Woodland	F.U.	110	42,893	110	46,470	109	47,961	107	48,667
Non-grazed Woodland	---	101	---	100	---	100	---	100	---
FOREST TOTAL		211		210		209		207	
Other Ag. Land		594		593		590		585	
TOTAL AG. LAND		34,360		34,284		34,148		33,964	

*Less than 500 acres.

Table 52 – CROP ACREAGE AND PRODUCTION, PLATTE-NIOBRARA SUBBASIN

Crop	Prod'n Unit	Current Normal		1980		2000		2020	
		Acres	Production	Acres	Production	Acres	Production	Acres	Production
		(1,000 Units)							
NONIRRIG. CROPLAND									
All Wheat	Bu.	2,301	48,326	2,597	75,307	2,737	93,048	3,220	135,824
Rye	Bu.	156	2,659	124	3,125	148	4,395	208	7,700
Corn Grain	Bu.	2,046	83,889	1,886	107,513	1,766	114,810	1,685	143,600
Corn Silage Equiv.	Ton	372	2,166	370	1,952	325	2,552	350	4,000
Sorghum Grain	Bu.	497	21,376	588	32,639	763	52,824	870	75,420
Oats	Bu.	789	23,663	669	28,181	429	21,805	205	12,503
Barley	Bu.	438	8,750	329	8,503	257	8,489	300	12,424
Alfalfa Hay Equiv.	Ton	1,327	2,237	1,275	2,603	1,401	3,327	1,800	4,690
Flaxseed	Bu.	0	0	0	0	0	0	0	0
Soybeans	Bu.	140	3,495	277	9,144	337	12,139	535	21,818
Dry Beans	Cwt.	4	15	4	13	4	12	11	57
Potatoes	Cwt.	*	36	*	30	*	29	10	500
Sugar Beets	Ton	0	0	0	0	0	0	0	0
Cropland Pasture	F.U.	701	911,849	691	1,150,016	688	1,306,938	653	1,401,609
Other Crops Harv.	---	42	---	42	---	41	---	30	---
Summer Fallow	---	2,273	---	2,088	---	2,125	---	1,868	---
Idle Cropland	---	640	---	636	---	625	---	580	---
Reserve Idle	---	1,124	---	1,184	---	945	---	0	---
TOTAL		12,850		12,760		12,591		12,325	
IRRIGATED CROPLAND									
All Wheat	Bu.	70	1,971	54	2,460	57	3,260	29	2,276
Corn Grain	Bu.	945	77,488	785	97,852	799	127,542	609	118,345
Corn Silage Equiv.	Ton	261	3,734	284	4,370	226	4,185	240	5,026
Sorghum Grain	Bu.	104	8,979	169	19,885	180	27,911	286	59,300
Barley	Bu.	95	3,610	67	3,963	87	6,411	35	3,116
Alfalfa Hay Equiv.	Ton	689	1,898	637	2,250	616	2,561	630	3,400
Soybeans	Bu.	12	345	49	1,633	9	355	6	243
Dry Beans	Cwt.	132	2,240	102	1,971	153	3,108	115	2,340
Potatos	Cwt.	30	6,190	21	3,771	21	5,481	15	7,751
Sugar Beets	Ton	186	2,934	329	6,208	367	7,694	453	10,354
Cropland Pasture	F.U.	61	196,024	61	247,493	59	287,395	50	318,310
Other Crops Harv.	---	16	---	14	---	12	---	3	---
Idle Cropland	---	85	---	83	---	81	---	75	---
Reserve Idle	---	98	---	92	---	4	---	0	---
TOTAL		2,784		2,747		2,671		2,546	
CROPLAND TOTAL		15,634		15,507		15,262		14,871	
Wild (Native) Hay	Ton	3,081	2,501	3,073	3,145	3,070	3,214	3,062	3,508
Pasture & Range	F.U.	32,066	10,611,333	31,959	13,978,018	31,770	16,271,523	31,498	17,366,187
GRAZING TOTAL		35,147		35,032		34,840		34,560	
Grazed Woodland	F.U.	1,410	136,751	1,406	144,870	1,387	151,470	1,340	155,821
Non-grazed Woodland	---	526	---	524	---	523	---	520	---
FOREST TOTAL		1,936		1,930		1,910		1,860	
Other Ag. Land		621		618		612		597	
TOTAL AG. LAND		53,338		53,087		52,624		51,888	

*Less than 500 acres.

Table 53 – CROP ACREAGE AND PRODUCTION, MIDDLE MISSOURI SUBBASIN

Crop	Prod'n Unit	Current Normal		1980		2000		2020	
		Acres	Production	Acres	Production	Acres	Production	Acres	Production
		(1,000 Units)							
NONIRRIG. CROPLAND									
All Wheat	Bu.	450	13,052	598	24,076	614	28,937	459	23,412
Rye	Bu.	3	59	2	40	1	22	1	20
Corn Grain	Bu.	4,285	282,801	4,589	445,114	5,463	611,856	5,110	678,928
Corn Silage Equiv.	Ton	225	2,454	206	2,450	240	5,097	315	5,381
Sorghum Grain	Bu.	310	17,643	384	30,486	516	49,194	624	68,528
Oats	Bu.	1,216	41,353	895	41,585	489	27,390	275	20,574
Barley	Bu.	12	336	11	476	8	375	4	195
Alfalfa Hay Equiv.	Ton	1,421	3,135	1,299	3,652	1,172	3,810	1,580	4,969
Flaxseed	Bu.	8	131	29	450	7	191	4	142
Soybeans	Bu.	1,058	30,679	1,050	37,786	1,101	41,853	920	38,726
Dry Beans	Cwt.	0	0	0	0	0	0	0	0
Potatoes	Cwt.	2	150	2	162	1	123	1	99
Sugar Beets	Ton	*	2	*	6	2	31	210	4,358
Cropland Pasture	F.U.	275	569,184	273	775,820	271	885,301	256	950,002
Other Crops Harv.	---	49	---	50	---	49	---	49	---
Summer Fallow	---	*	---	*	---	*	---	*	---
Idle Cropland	---	555	---	550	---	540	---	540	---
Reserve Idle	---	1,247	---	1,051	---	229	---	0	---
TOTAL		11,116		10,989		10,703		10,348	
IRRIGATED CROPLAND									
All Wheat	Bu.	0	0	0	0	0	0	0	0
Corn Grain	Bu.	69	6,093	60	7,918	63	10,694	44	8,859
Corn Silage Equiv.	Ton	7	124	14	389	6	154	17	668
Sorghum Grain	Bu.	5	468	7	941	8	1,404	25	5,051
Barley	Bu.	0	0	0	0	0	0	0	0
Alfalfa Hay Equiv.	Ton	2	7	1	7	1	8	1	5
Soybeans	Bu.	2	65	7	305	10	534	1	39
Dry Beans	Cwt.	0	0	0	0	0	0	0	0
Potatoes	Cwt.	1	90	1	104	1	120	1	89
Sugar Beets	Ton	12	150	2	46	3	69	3	70
Cropland Pasture	F.U.	*	417	*	622	*	699	*	781
Other Crops Harv.	---	4	0	5	0	5	0	4	0
Idle Cropland	---	1	---	4	---	3	---	2	---
Reserve Idle	---	0	0	0	0	0	0	0	0
TOTAL		103		101		100		98	
CROPLAND TOTAL		11,219		11,090		10,803		10,446	
Wild (Native) Hay	Ton	62	100	62	116	62	128	60	133
Pasture & Range	F.U.	2,423	2,739,906	2,400	3,715,002	2,378	4,196,586	2,360	4,385,232
GRAZING TOTAL		2,485		2,462		2,440		2,420	
Grazed Woodland	F.U.	560	202,802	555	239,438	546	248,157	535	252,760
Non-grazed Woodland	---	71	---	69	---	69	---	67	---
FOREST TOTAL		631		624		615		602	
Other Ag. Land		447		442		435		414	
TOTAL AG. LAND		14,782		14,618		14,293		13,882	

*Less than 500 acres.

Table 54 – CROP ACREAGE AND PRODUCTION, KANSAS SUBBASIN

Crop	Prod'n Unit	Current Normal		1980		2000		2020	
		Acres	Production	Acres	Production	Acres	Production	Acres	Production
		(1,000 Units)							
NONIRRIG. CROPLAND									
All Wheat	Bu.	6,799	149,751	7,316	219,477	7,077	249,097	6,230	218,513
Rye	Bu.	153	2,144	150	3,200	144	4,220	248	9,049
Corn Grain	Bu.	1,064	44,673	878	53,212	939	71,620	1,335	128,601
Corn Silage Equiv.	Ton	949	6,130	799	5,864	682	6,574	838	9,931
Sorghum Grain	Bu.	2,413	94,111	2,842	149,125	3,738	233,998	3,842	270,746
Oats	Bu.	289	7,236	241	7,894	161	6,458	177	7,047
Barley	Bu.	505	9,591	398	9,835	269	7,900	255	9,188
Alfalfa Hay Equiv.	Ton	998	2,052	908	2,071	780	2,060	990	2,909
Flaxseed	Bu.	0	0	0	0	0	0	0	0
Soybeans	Bu.	182	1,004	216	6,608	221	7,334	855	27,442
Dry Beans	Cwt.	2	9	1	4	1	3	1	7
Potatoes	Cwt.	0	0	0	0	0	0	*	3
Sugar Beets	Ton	0	0	0	0	0	0	0	0
Cropland Pasture	F.U.	393	607,873	393	866,076	390	905,535	375	950,147
Other Crops Harv.	---	73	---	73	---	72	---	50	---
Summer Fallow	---	3,750	---	3,941	---	3,857	---	4,051	---
Idle Cropland	---	1,030	---	1,022	---	1,010	---	992	---
Reserve Idle	---	2,038	---	1,359	---	1,072	---	0	---
TOTAL		20,638		20,537		20,413		20,239	
IRRIGATED CROPLAND									
All Wheat	Bu.	53	1,855	54	2,965	51	3,377	50	3,816
Corn Grain	Bu.	863	76,841	834	109,316	729	124,727	741	148,060
Corn Silage Equiv.	Ton	158	2,495	107	2,056	86	1,933	75	1,922
Sorghum Grain	Bu.	272	24,203	388	49,100	435	70,806	485	87,638
Barley	Bu.	5	196	5	369	5	472	5	538
Alfalfa Hay Equiv.	Ton	133	501	129	626	126	737	109	732
Soybeans	Bu.	6	181	9	295	4	168	3	152
Dry Beans	Cwt.	14	259	51	1,077	45	941	19	437
Potatoes	Cwt.	2	418	2	692	3	1,360	4	2,177
Sugar Beets	Ton	45	751	53	1,041	148	3,146	136	3,285
Cropland Pasture	F.U.	6	28,474	6	34,661	6	39,941	6	56,348
Other Crops Harv.	---	11	---	11	---	9	---	9	---
Idle Cropland	---	51	---	48	---	48	---	48	---
Reserve Idle	---	84	---	0	---	0	---	0	---
TOTAL		1,703		1,697		1,695		1,690	
CROPLAND TOTAL		22,341		22,234		22,108		21,929	
Wild (Native) Hay	Ton	324	388	323	419	320	483	315	515
Pasture & Range	F.U.	13,295	6,812,809	13,237	7,105,170	13,201	7,958,406	13,165	8,593,285
GRAZING TOTAL		13,619		13,560		13,521		13,480	
Grazed Woodland	F.U.	382	105,842	370	120,188	371	126,242	369	129,345
Non-grazed Woodland	---	215	---	210	---	208	---	201	---
FOREST TOTAL		597		580		579		570	
Other Ag. Land		552		545		540		536	
TOTAL AG. LAND		37,109		36,919		36,748		36,515	

*Less than 500 acres.

Table 55 – CROP ACREAGE AND PRODUCTION, LOWER MISSOURI SUBBASIN

Crop	Prod'n Unit	Current Normal		1980		2000		2020	
		Acres	Production	Acres	Production	Acres	Production	Acres	Production
		(1,000 Units)							
NONIRRIG. CROPLAND									
All Wheat	Bu.	985	30,524	1,188	51,084	1,136	56,815	1,540	99,586
Rye	Bu.	1	20	1	35	1	36	1	20
Corn Grain	Bu.	2,119	127,119	1,963	172,709	2,489	256,316	2,130	265,215
Corn Silage Equiv.	Ton	225	2,178	192	1,783	160	2,259	230	3,008
Sorghum Grain	Bu.	293	14,080	383	26,406	515	41,168	391	40,111
Oats	Bu.	522	14,627	404	15,322	273	12,558	110	6,034
Barley	Bu.	101	2,637	74	2,708	50	2,196	20	1,135
Alfalfa Hay Equiv.	Ton	1,815	2,690	1,620	3,119	1,382	3,201	1,840	4,150
Flaxseed	Bu.	0	0	0	0	0	0	0	0
Soybeans	Bu.	1,429	40,000	1,461	51,125	1,546	68,037	1,665	73,758
Dry Beans	Cwt.	0	0	0	0	0	0	0	0
Potatoes	Cwt.	2	144	2	163	2	193	5	410
Sugar Beets	Ton	0	0	0	0	0	0	0	0
Cropland Pasture	F.U.	719	1,135,928	718	1,498,858	717	1,723,912	640	1,800,469
Other Crops Harv.	---	88	---	88	---	87	---	70	---
Summer Fallow	---	0	0	0	0	0	0	0	0
Idle Cropland	---	510	---	495	---	475	---	455	---
Reserve Idle	---	1,394	---	1,317	---	704	---	0	---
TOTAL		10,203		9,906		9,537		9,097	
IRRIGATED CROPLAND									
All Wheat	Bu.	0	0	0	0	0	0	0	0
Corn Grain	Bu.	1	85	1	140	1	155	1	158
Corn Silage Equiv.	Ton	0	0	0	0	0	0	0	0
Sorghum Grain	Bu.	0	0	0	0	0	0	0	0
Barley	Bu.	0	0	0	0	0	0	0	0
Alfalfa Hay Equiv.	Ton	0	0	0	0	0	0	0	0
Soybeans	Bu.	0	0	0	0	0	0	0	0
Dry Beans	Cwt.	0	0	0	0	0	0	0	0
Potatoes	Cwt.	1	50	1	27	1	32	1	88
Sugar Beets	Ton	0	0	0	0	0	0	0	0
Cropland Pasture	F.U.	0	0	0	0	0	0	0	0
Other Crops. Harv.	---	3	---	3	---	3	---	3	---
Idle Cropland	---	0	---	0	---	0	---	0	---
TOTAL		5		5		5		5	
CROPLAND TOTAL		10,208		9,911		9,542		9,102	
Wild (Native) Hay	Ton	105	127	100	146	93	156	85	165
Pasture & Range	F.U.	7,229	8,428,608	7,110	11,415,221	7,021	12,570,661	6,754	12,616,984
GRAZING TOTAL		7,334		7,210		7,114		6,839	
Grazed Woodland	F.U.	3,103	660,846	3,049	780,708	2,987	800,988	2,914	849,253
Non-grazed Woodland	---	2,685	---	2,619	---	2,584	---	2,519	---
FOREST TOTAL		5,788		5,668		5,571		5,433	
Other Ag. Land		793		780		754		698	
TOTAL AG. LAND		24,123		23,659		22,981		22,07[illegible]	

*Less than 500 acres.

Table 56 – VOLUME OF GROWING STOCK AND SAWTIMBER ON COMMERCIAL FOREST LAND, MISSOURI BASIN – BY SPECIES AND STAND-SIZE CLASSES, 1962

Species	Growing Stock		
	Total	Poletimber	Sawtimber
	(Thousand Cubic Feet)		
Softwoods:			
Douglas-fir	2,886,453	663,960	2,222,493
Ponderosa pine	2,900,379	711,362	2,189,017
True firs	768,728	302,480	466,248
Spruce	2,300,794	353,305	1,947,489
Lodgepole pine	6,132,230	2,934,218	3,198,012
Southern pines	19,600	9,500	10,100
Eastern red cedar	10,300	9,100	1,200
Other softwoods	650,647	198,942	451,705
Total Softwoods	15,669,131	5,182,867	10,486,264
Hardwoods:			
Select oaks	628,200	268,000	360,200
Other oaks	710,300	405,600	304,700
Hickory	165,700	101,600	64,100
Ash and Walnut	235,300	98,000	137,300
Cottonwood and Aspen	957,598	368,642	588,956
Other hardwoods	764,873	258,304	506,569
Total Hardwoods	3,461,971	1,500,146	1,961,825
TOTAL	19,131,102	6,683,013	12,448,089

Species	Sawtimber		
	Total	In Sawtimber Stands	In Other Stands
	(Thousand Board Feet[1])		
Softwoods:			
Douglas-fir	10,876,713	7,160,540	3,716,173
Ponderosa pine	10,061,321	7,446,668	2,614,653
True firs	2,218,741	1,881,206	337,535
Spruce	10,737,652	9,920,123	817,529
Lodgepole pine	15,953,405	9,591,177	6,362,228
Southern pines	64,500	20,700	43,800
Eastern red cedar	7,500	1,100	6,400
Other softwoods	2,255,018	1,650,833	604,185
Total Softwoods	52,174,850	37,672,347	14,502,503
Hardwoods:			
Select oaks	2,138,900	1,635,900	503,000
Other oaks	1,805,200	1,120,200	685,000
Hickory	395,000	284,900	110,100
Ash and Walnut	710,500	558,100	152,400
Cottonwood and Aspen	2,560,574	2,243,871	316,703
Other hardwoods	2,751,901	2,211,212	540,689
Total Hardwoods	10,362,075	8,054,183	2,307,892
TOTAL	62,536,925	45,726,530	16,810,395

[1] International one-fourth log rule.

Table 57 – VOLUME OF GROWING STOCK AND SAWTIMBER ON COMMERCIAL FOREST LAND, MISSOURI BASIN, 1962

Ownership Class	All Species	Softwoods	Hardwoods
		GROWING STOCK (Thousand Cubic Feet)	
Federal			
National Forests	11,918,947	11,648,903	270,044
Bureau of Land Management	539,589	508,269	31,320
Other Federal	50,613	10,569	40,044
State, County, and Municipal	422,698	363,740	58,958
Private:			
Indian	263,413	216,721	46,692
Forest Industry	4,500	500	4,000
Other Private[2]	5,931,342	2,920,429	3,010,913
Total All Ownerships	19,131,102	15,669,131	3,461,971
		SAWTIMBER (Thousand Board Feet[1])	
Federal:			
National Forests	39,073,409	38,793,913	279,496
Bureau of Land Management	1,708,189	1,654,950	53,239
Other Federal	183,757	30,284	153,473
State, County and Municipal	1,347,340	1,214,122	133,218
Private:			
Indian	804,941	670,032	134,909
Forest Industry	11,500	1,500	10,000
Other Private[2]	19,407,789	9,810,049	9,597,740
Total All Ownerships	62,536,925	52,174,850	10,362,075

[1]International one-fourth inch log rule.
[2]Includes farmer-owned.

Table 58 – VOLUME OF SAWTIMBER ON COMMERCIAL FOREST LAND, MISSOURI BASIN, 1962

Species	All Classes	9.0 – 10.9	11.0 – 12.9	13.0 – 14.9
	Diameter Class (Inches at Breast Height) (Thousand Board Feet[1])			
Softwoods:				
Douglas fir	10,876,713	2,146,464	1,462,294	1,494,773
Ponderosa pine	10,061,321	2,084,871	1,832,837	1,765,238
True firs	2,218,741	867,327	501,707	352,683
Spruce	10,737,652	1,174,387	1,473,271	1,603,693
Lodgepole pine	15,953,405	6,695,752	3,932,715	2,631,094
Southern pines	64,500	31,100	16,000	12,700
Eastern red cedar	7,500	2,900	1,900	1,700
Other softwoods	2,255,018	699,234	436,426	369,753
Total Softwoods	52,174,850	13,702,035	9,657,150	8,231,634
Hardwoods:				
Select oaks	2,138,900	- - -[2]	649,800	491,400
Other oaks	1,805,200	- - -	505,400	338,000
Hickory	395,000	- - -	97,200	89,600
Ash and Walnut	710,500	- - -	154,600	195,700
Cottonwood and Aspen	2,560,574	- - -	524,004	290,905
Other hardwoods	2,751,901	- - -	459,824	385,745
Total Hardwoods	10,362,075	- - -	2,390,828	1,841,350
All Species	62,536,925	13,702,035	12,047,978	10,072,984

Species	15.0 – 16.9	17.0 – 18.9	19.0 – 20.9	21.0 & Larger
	(Thousand Board Feet[1])			
Softwoods:				
Douglas fir	1,466,381	1,096,373	847,256	2,363,172
Ponderosa pine	1,549,532	1,163,280	768,582	896,981
True firs	261,769	130,678	50,553	54,024
Spruce	1,580,151	1,328,383	1,061,034	2,516,733
Lodgepole pine	1,480,194	733,264	282,817	197,569
Southern pines	4,300	- - -	400	- - -
Eastern red cedar	1,000	- - -	- - -	- - -
Other softwoods	284,121	190,671	93,866	180,947
Total Softwoods	6,627,448	4,642,649	3,104,508	6,209,426
Hardwoods:				
Select oaks	363,400	207,300	171,700	255,300
Other oaks	269,500	187,500	157,500	297,300
Hickory	80,100	57,300	35,200	35,600
Ash and Walnut	145,900	89,400	68,200	56,700
Cottonwood and Aspen	285,207	254,747	253,573	952,138
Other hardwoods	444,638	318,492	346,602	796,600
Total Hardwoods	1,588,745	1,114,739	1,032,775	2,393,633
All Species	8,216,193	5,757,388	4,137,283	8,603,064

[1]International one-fourth inch log rule.
[2]*Minimum diameter breast high:* softwoods 9.0 inches; hardwoods 11.0 inches.

Table 59 – NET ANNUAL GROWTH OF TIMBER ON COMMERCIAL FOREST LAND, MISSOURI BASIN, 1962

Species	Growing Stock	Sawtimber
	(Thousand Cubic Feet)	(Thousand Board Feet[1])
Softwoods:		
Douglas fir	26,646	91,027
Ponderosa pine	50,570	178,562
True firs	2,822	7,331
Spruce	22,340	107,899
Lodgepole pine	66,093	144,067
Southern pines	490	2,390
Eastern red cedar	930	730
Other softwoods	6,566	23,874
Total Softwoods	176,457	541,218
Hardwoods:		
Select Oaks	24,300	106,840
Other oaks	22,470	50,680
Hickory	9,070	18,050
Ash and Walnut	14,890	53,818
Cottonwood and Aspen	18,134	57,234
Other hardwoods	41,080	133,252
Total Hardwoods	129,944	419,874
TOTAL	306,401	961,092

[1] International one-fourth inch log rule.

Table 60 – TIMBER CUT ON COMMERCIAL FOREST LAND, MISSOURI BASIN, 1962

Species	Growing Stock	Sawtimber
	(Thousand Cubic Feet)	(Thousand Board Feet[1])
Softwoods:		
Douglas fir	11,029	75,679
Ponderosa pine	18,501	88,907
True firs	594	3,258
Spruce	6,139	33,939
Lodgepole pine	29,242	170,497
Southern pines	389	1,724
Eastern red cedar	243	713
Other softwoods	---	---
Total Softwoods	66,137	374,717
Hardwoods:		
Select oaks	16,207	76,123
Other oaks	6,858	31,982
Hickory	1,221	4,472
Ash and Walnut	3,222	15,892
Cottonwood and Aspen	4,467	25,455
Other hardwoods	6,085	25,652
Total Hardwoods	38,060	179,576
TOTAL	104,197	554,293

[1] International one-fourth inch log rule.

Table 61 – TIMBER CUT, GROWTH, AND INVENTORY OF GROWING STOCK ON COMMERCIAL FOREST LAND, MISSOURI BASIN – 1952, 1962, AND PROJECTIONS

Species Group	1952	1962	1980	2000	2020
			(Thousand Cubic Feet)		
Inventory[1]					
All Species	13,400,455	19,131,102	22,595,500	26,740,400	30,984,600
Softwoods	10,758,403	15,669,131	17,418,900	19,394,800	21,516,000
Hardwoods	2,642,052	3,461,971	5,176,600	7,345,600	9,468,600
Growth[2]					
All Species	233,114	306,401	409,700	522,200	626,300
Softwoods	139,689	176,457	232,900	290,800	338,400
Hardwoods	93,425	129,944	176,800	231,400	287,900
Cut[3]					
All Species	91,856	104,197	196,400	305,700	401,400
Softwoods	44,202	66,137	131,800	187,800	223,700
Hardwoods	47,654	38,060	64,600	117,900	177,700

[1] As of January 1, 1953 and 1963.
[2] The growth in 1962 is gross growth reduced by current mortality. For other years, growth is reduced by average mortality.
[3] The cut in 1962 is timber harvested. For other years, it also includes volume "lost" due to flooding, land clearing, and land reclassification.

Table 62 – TIMBER CUT, GROWTH, AND INVENTORY OF SAWTIMBER ON COMMERCIAL FOREST LAND, MISSOURI BASIN – 1952, 1962, AND PROJECTIONS

Species Group	1952	1962	1980	2000	2020
			(Thousand Board Feet[2])		
Inventory[1]					
All Species	48,699,274	62,536,925	67,834,400	71,700,900	73,604,100
Softwoods	40,047,537	52,174,860	54,379,800	55,969,900	56,977,200
Hardwoods	8,651,737	10,362,075	13,454,600	15,731,000	16,626,900
Growth					
All Species	743,042	961,092	1,138,500	1,315,100	1,430,700
Softwoods	424,541	541,218	636,400	800,300	855,800
Hardwoods	318,501	419,874	452,100	514,800	574,900
Cut					
All Species	318,340	554,293	877,400	1,145,200	1,365,400
Softwoods	154,565	374,717	581,700	735,500	810,400
Hardwoods	163,775	179,576	295,700	409,700	555,000

[1] As of January 1, 1953 and 1963.
[2] International one-fourth inch log rule.

Table 63 – ESTIMATED EMPLOYMENT IN TIMBER-BASED MANUFACTURING INDUSTRIES, MISSOURI BASIN – 1952, 1962, AND PROJECTIONS

Industry	1952	1962	1980	2000	2020
	(Thousand Employees)				
Lumber and Wood Products[1]	7.8	8.9	10.3	10.9	11.9
Sawmills and Planing Mills	(4.2)	(4.4)	(4.8)	(4.6)	(4.5)
Veneer and Plywood Plants	(0.1)	(0.1)	(0.3)	(0.5)	(0.6)
Other	(3.5)	(4.4)	(5.2)	(5.8)	(6.8)
Pulp, Paper, and Allied Products[2]	6.3	8.2	13.2	17.5	19.1
Timber Harvesting[3]	6.0	5.1	6.7	8.0	9.6
Missouri Basin	20.1	22.2	29.0	37.9	51.5

[1]Includes employment at veneer and plywood plants, sawmills, shingle mills, cooperage stock mills, and planing mills engaged in producing lumber and wood basic materials; and establishments engaged in manufacturing finished articles made entirely or mainly of wood. (Major group 24 excluding code No. 241 as defined by the Bureau of the Census.)

[2]Includes employment at establishments manufacturing pulp primarily from wood and from rags and other fibers, converting these pulps into paper or board; and the manufacture of paper and paperboard into converted products such as coated paper, paper bags, paperboard boxes, and envelopes. (Major group 26 defined by the Bureau of Census.)

[3]Includes employment in timber harvesting derived by dividing output of each product by annual output per employee. This includes the employment reported by S.I.C. Code No. 241.

Table 64 – CURRENT LAND CONSERVATION TREATMENT AND NEEDS PRIVATE AND FEDERAL AGRICULTURAL LAND MISSOURI BASIN

Item	Total	Total Adequately Treated		Land Needing: Proper Management Practices Only		Land Needing: Proper Management & Vegetative &/or Mech. Practices	
	(Acres)[1]	(Acres)[1]	(%)	(Acres)[1]	(%)	(Acres)[1]	(%)
Private Land[2]							
Cropland	103,789	37,902	36	31,600	31	34,227	33
Pasture & Range	152,664	62,136	41	65,496	43	25,032	16
Forest & Woodland	13,654	6,879	50	5,356	39	1,419	11
Other Ag.	3,561	2,932	82	262	8	367	10
Total	273,668	109,849	40	102,774	38	61,045	22
Federal Land							
Pasture & Range	24,170	13,787	57	6,781	28	3,602	15
Forest & Woodland	14,432	11,577	80	1,729	12	1,126	8
Missouri Basin	38,602	25,364	66	8,510	22	4,728	12

[1]Thousands

[2]Includes State, county, and local government lands.

CHAPTER 3

MUNICIPAL, RURAL DOMESTIC, AND INDUSTRIAL WATER SUPPLY

The objectives of this chapter are (1) to examine present municipal and industrial water utilization, (2) to project future municipal, rural-domestic and industrial water demands, and (3) to compare existing system water service capability and quality of water supply with a rated normal to indicate areas of system inadequacy.

To establish information for this study all existing water utilization data available were tabulated, then sent to the appropriate States for their review, revision, updating, and return. The States were asked particularly to include any available information on industrial water supplies. Additional industrial data were obtained from the Bureau of Census, the Bureau of Mines, and the Federal Power Commission.

Water quality criteria were developed for municipal and domestic and industrial water uses. The quality of existing sources of supply was then compared with these criteria. These planning criteria were established prior to the adoption of Federal-State water quality standards, but are quite similar to the official standards which have since been adopted and approved.

WATER REQUIREMENTS

Rates of municipal water use vary greatly throughout the basin. The climate, as affected by altitude and humidity, influences the per capita water use significantly. The rate is affected also by such items as lawn sprinkling, kitchen and sanitary uses, and the amount of commercial use by industries. Within the basin per capita use varies from 11 to 720 gallons per day. For uniformity in planning rates were selected for the size of the community and its general geographical area.

Planning Criteria

Climatic differences were allowed for in the planning criteria by establishing demand variance according to the Precipitation Effectiveness Index (P.E.I.)[1]. The P.E.I. was devised to express that part of precipitation which is effective in meeting moisture requirements of plants. A 44 P.E.I. was established to approximate the geographic limit below which lawn sprinkling and shrub and garden irrigation are important parts of municipal water requirements. The location of this value roughly coincides with that of a line representing 22-inch average annual precipitation, and is shown on figure 18.

Cities over 10,000 population were inventoried to determine present average water use. Where present use was in excess of 125 to 150 gallons per capita per day a check was made of industrial water use and unit values adjusted accordingly. These adjusted values then became the future per capita demand criteria for the community.

For communities under 10,000 population, the following future water demand criteria were adopted.

Places of 2,500 to 10,000 population:

East of 44 P.E.I. line	125 g/c/d
West of 44 P.E.I. line	150 g/c/d

FIGURE 18

PRECIPITATION EFFECTIVENESS INDEX LINE

[1] For further information refer to page 102 of USDA Yearbook for 1941.

Places with less than 2,500 population:

East of 44 P.E.I. line	80 g/c/d
West of 44 P.E.I. line	120 g/c/d

Rural homes:

With pressurized system	50 g/c/d
Without pressurized system	10 g/c/d

Where average water use figures were currently greater than those shown, a check was made of industrial water uses, and the values adjusted accordingly.

Following adequate treatment of all wastes, the return flow will be:

Places greater than 10,000 population based on existing data.

Places of 2,500 to 10,000 population: Return flow of 100 g/c/d

Places with less than 2,500 population: Return flow of 75 g/c/d

Some communities with less than 10,000 people currently use more water than the limits established by criteria. When this occurred it was assumed that all excess diversion was consumptively used.

Present Water Service

The 1965 basin population was estimated to be 8,560,000 persons, with 5,180,000 or 60 percent residing in 231 urban places[1] and 3,380,000 persons classed as rural. Farm residents were 1,340,000 and rural nonfarm residents, 2,040,000.

The water supplies for the majority of the cities and towns noted in table 65 generally are quite good. The principal problem confronting these communities is that of providing water to the new homes being built, generally in subdivisions on the periphery of the populated areas. Six such places have limited supplies and are forced, in times of drought, to ration water during peak use periods. Efforts are underway continuously to improve either the source of supply or the distribution system.

Denver, one of the largest cities in the basin, imports water from outside the Missouri River Basin. Supplies are adequate for the present population; however, it is anticipated the growth of this area will necessitate development of new supplies.

Development of water supplies in the rural sector of the basin has lagged behind the urban sector, although rather dramatic improvements in the rural supplies have been made recently. The nearly 2,400 incorporated villages and towns in the Missouri Basin range in population from 2,500 down to about 75 persons, with an aggregate population slightly over 1.1 million. Over 1,500 of these places have central water systems serving

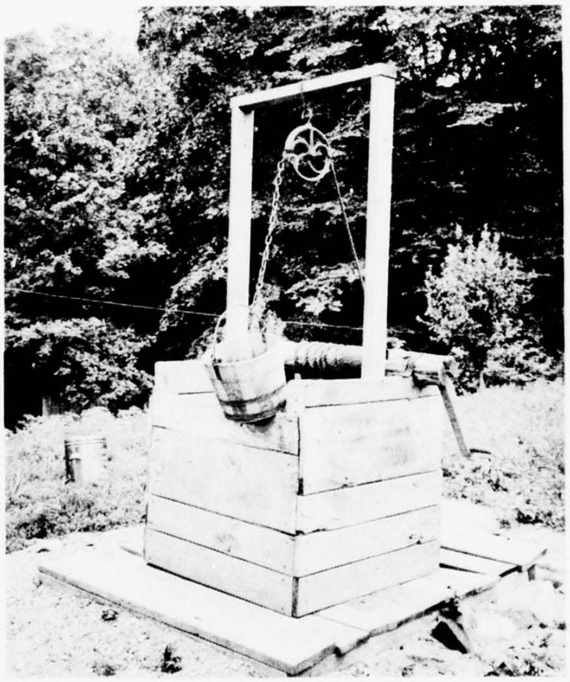
[1] An urban place is defined as having a population of over 2,500.

The Missouri River And Many Tributaries Are An Important Source of Municipal Water

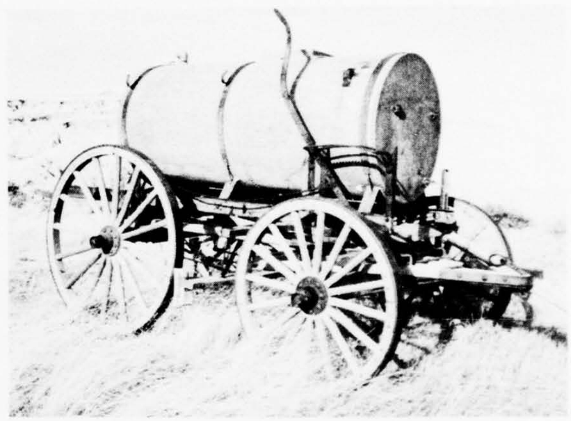
Table 65 – SUMMARY OF EXISTING MUNICIPAL WATER SUPPLIES BY SOURCE
MISSOURI BASIN

Source of Supply	Number of Supplies	Total Population Served	Ranges of Per Capita Use	Improved Quality Desired	Inadequate Quantity	Number of Supplies Requiring Additional Treatment
		(1000)	(gpcd)			
Surface Water	209 (193)*	3378 (2989)	29-558	11	---	6
Ground Water	1514 (1200)	2184 (1525)	11-720	414	6	125
Combined Ground and Surface Water	50	718	51-344	10	---	3
Total	1773 (1393)	6280 (4514)	11-720	435	6	134

*Values in parentheses, 1953 data, are presented for comparison to show municipal water supply development.



Shallow Improperly Developed Wells Are Unsafe For Domestic Use



Where Satisfactory Ground Water Is Unavailable, the Tank Wagon Is Being Replaced By Modern Water Systems

1,030,000 people. About 800 places with a total population of 97,000 do not have a central water supply. In the rural sector, there are about 2,253,000 people that live in individual households, in unincorporated places, or on farms. Of this amount, approximately 70,000 people are served by central water supplies. Nearly two-thirds of the total population in the rural category, or 1.5 million people, are served by individual pressure systems. About one-third of the population living in individual households (both farm and nonfarm, or 727,000 people) does not have running water provided by either individual pressure or public water systems. This situation is significant in the consideration of any projection of demand (table 66).

Some industries obtain their water supply from municipal systems and are considered as a part of the present and future municipal water demand.

Industrial water use data are limited. Only actual available records were used in the study. There were 549 industries reported to have separate water supply systems, 127 being for cooling water only. Consumptive use is small for some types of industry and the return flow is available for reuse downstream. Some industries operate on a seasonal basis. The municipal and industrial water evaluation includes all water requirements of these (549) industrial plants. The number of industries reported is probably about 10 percent of the actual number of industries operating in the basin.

Reuse of Water

The increasing use of water and the problem of providing additional supply have given rise to much speculation, discussion, research and, in some cases, action regarding reuse of water. A number of industries

Table 66 – NUMBER OF PLACES & POPULATION SERVED BY CENTRAL WATER SYSTEMS, OR INDIVIDUAL HOUSEHOLD SYSTEMS, AND POPULATION WITHOUT RUNNING WATER, 1965 (ADJUSTED) MISSOURI BASIN

Population Component	Total		With Public Water Service		W/O Public Water Service but With Running Water		W/O Running Water
	Places	Population	Places	Population Served	Places	Population	Population
	(No.)	(000)	(No.)	(000)	(No.)	(000)	(000)
Urban							
100,001 & over	7	2,500	7	2,515	0	0	
50,001-100,000	8	680	8	690	0	0	
25,001-50,000	14	560	14	572	0	0	
10,001-25,000	39	630	39	640	0	0	
5,501-10,000	52	400	52	411	0	0	
2,501-5,500	111	410	111	422	0	0	
Subtotal	231	5,180	231	5,250	0	0	
Rural Non-Farm							
1,001-2,500	319	531	319	531	0	0	
Under 1,000	2,055	596	1,223	499	832	97	
Households	[1]	913		(55)[2]	[1]	572	286
Subtotal	(2,374)	2,040	---	1,085	832	669	286
Rural Farm	---	1,340		(15)[2]	---	884	441
Total	2,605	8,560	1,773	6,280	832	1,553	727

[1] Number of places not determined. Households range from single dwelling to those in an unincorporated village.
[2] Included in population served by urban central systems.

Table 67 – SUMMARY OF EXISTING INDUSTRIAL WATER SUPPLIES BY SOURCE MISSOURI BASIN

Source of Supply	Reported Number of Supplies		Improved Quality Desired	Inadequate Quantity	Number of Supplies Requiring Additional Treatment
	Process Water	Cooling Only			
Surface Water	105	49	0	0	0
Ground Water	254	55	12	2	2
Combined Surface and Ground Water	63	23	0	0	0

presently treat and recycle waste waters or use municipal sewage to conserve water or reduce stream pollution, or both. A number of cities do draw water from rivers containing quantities of variously treated sewage discharged by upstream cities. The importance of adequate waste treatment facilities and intake purification processes cannot be overemphasized.

Water use is either consumptive or nonconsumptive. A considerable portion of the water diverted for municipal or industrial purposes is returned to the stream and becomes available for further use downstream, provided reasonable quality is maintained in the return water. Because water can be reused, an excess of gross use over supply is not an automatic indicator of water shortage. The gross demands illustrate the overall magnitude of water requirements, but they do not reflect sources of supply, location, consumptive use or water returned to the stream for further use. The apparent gross demand of 2,778,000 acre-feet in 1965 for municipal, rural domestic, and industrial water is met by the use of 18 percent ground water and 82 percent surface water.

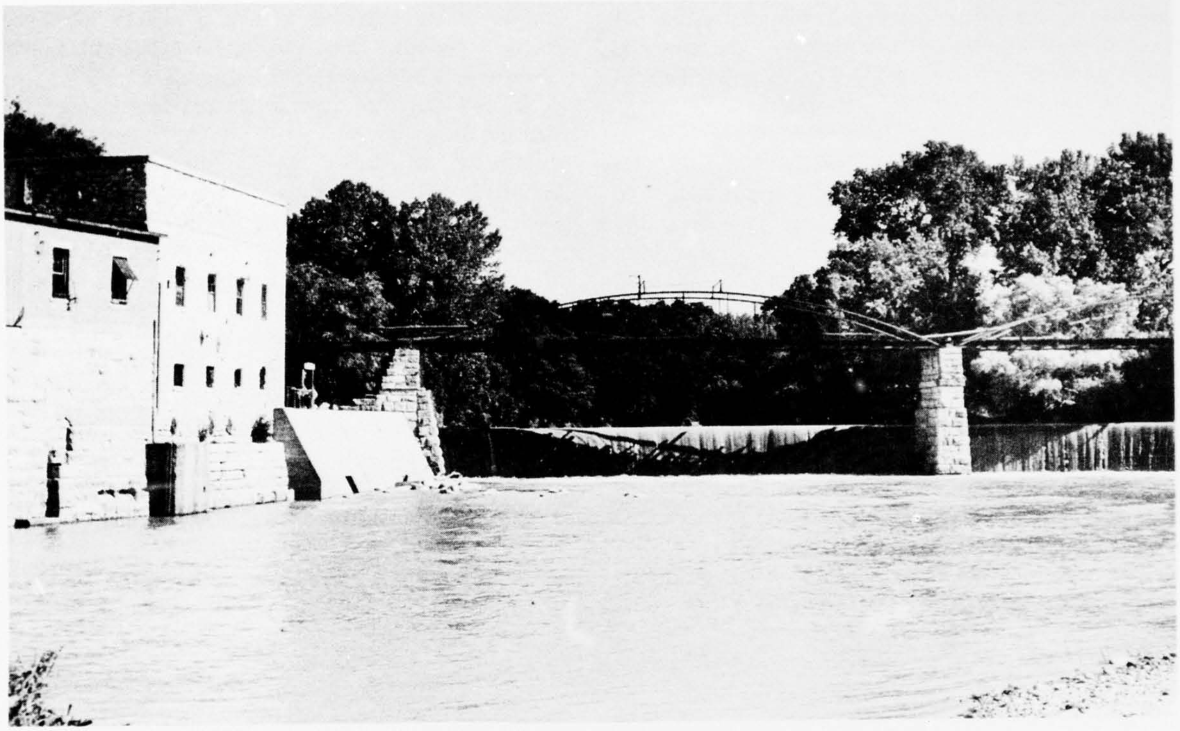
Future Water Demands

An assessment of future municipal, rural domestic, and industrial water requirements and supply is a vital part of a framework study. Availability of adequate supplies of suitable quality is essential to the well-being and development of any area. To establish requirements of these functional uses is therefore of highest priority.

This study, based on the existing conditions, makes projections as to the future demands of a single purpose functional use of municipal, rural domestic, or industrial water requirements developed for each key year of the study period in each subbasin.

In determining future water demands, the present demands of all communities having a water supply system and all reported industries known to have independent sources of supply were studied. Populations were determined from the Bureau of Census records and surveys by State authorities; industrial data were obtained from the Bureau of Census, the Bureau of Mines, the Federal Power Commission, and State, county and city records.

By 2020, it is estimated there will be 485 places in the Missouri Basin with a population of 2,500 or more (table 68). The aggregate urban population is projected to be 15.4 million with nearly 11 million of these living in 23 urban centers in the basin. The total increase of the urban population will be about 10.5 million people who will need new supplies, improved distribution systems, or both.



This Dam at Blue Rapids Provided The Water For The First Municipal Supply System in the State of Kansas

Table 68 – MUNICIPAL, RURAL DOMESTIC, AND INDUSTRIAL WATER DEMANDS, MISSOURI BASIN, 1965-2020

Use	1965	1980	2000	2020
	(1,000 Acre-Feet)			
Municipal & Rural Domestic	1,063	1,469	2,117	3,199
Industrial (General)	405	790	916	1,112
Mineral	82	178	188	192
Thermal-Electric Power	1,724	3,122	4,300	4,878
Coal Hydrogenation	0	200	375	750
Total	3,274	5,759	7,896	10,131

The changes in the rural nonfarm sector will also be significant. It is estimated there will be 2,605 incorporated villages and places with an aggregate population of about 3.2 million by 2020. In view of the present trends, it is anticipated that all of these places will have public water service or its equivalent. The total basin population living in rural farm households will decrease to about 700,000.

About 20 percent of the rural people will be served by public systems. Of the remaining rural population, it is estimated that only 60,000 people, or less than one-third of one percent of the total basin population, will be without a pressure water system by 2020.

Water demands have been projected for municipal, rural domestic, and industrial uses. Industrial demands have been subdivided for further clarity into general industrial, mineral, thermal power, and where applicable coal-hydrogenation categories. The general industrial category will be referred to in the remainder of this chapter simply as "Industrial (General)."

In the framework planning there is need to take into account not only the magnitude of projected average annual demands for municipal, rural domestic, industrial, mineral processing, and thermal-electric power water uses, but also the pattern of their seasonal variation. This over-all pattern now and in the future varies by river reaches and thus by subbasin depending largely on the makeup of the nonrural domestic uses indicated. Rural domestic demands are reasonably constant throughout the year. With the separate projections of water demands for each of the other four categories, as presented later, and the degree to which these do or don't apply to ground waters, it is possible to give each its due weight and determine representative patterns of seasonal demand on surface waters in any given reach of stream. Considering their importance, it should be the objective to fully satisfy projected municipal and rural domestic water requirements from available ground and/or surface water supplies. The demands for industrial, mineral, and thermal-electric power uses should be supplied to the extent practicable within physical and legal limitations, the options available, and tolerable shortages that will not significantly diminish the productive capability of the enterprises projected.

Municipal and rural domestic water demands are expected to increase from a 1965 level of 1,063,000 acre-feet to 3,199,000 acre-feet by the year 2020. The evidence of population densities increasing in the future in the areas that are most populated today is reflected in the water demand figures. The municipal and rural domestic demands of the Platte-Niobrara Subbasin make up nearly 40 percent of the 2020 basin demand compared with 34 percent currently. The Platte-Niobrara and the Lower Missouri subbasins combine to make up nearly two-thirds of the basin's 2020 municipal and domestic demand.

Water demands for industrial development are expected to increase from 405,000 acre-feet to 1,112,000 acre-feet in 2020.

The three largest industrial areas in the future as measured by water demand will be the Yellowstone, Platte-Niobrara, and Lower Missouri subbasins. Together they make up about 80 percent of the 2020 demand.

Metallic mineral resources are found in the mountains and outwash plains in the western part of the basin and in the Black Hills. The uranium and thorium deposits in the basin are expected to face a rapidly increasing demand. Increases in taconite and molybdenum mining along with development of high alumina-bearing igneous rocks and clays are expected in response to the large demand for metals.

Almost all of the Missouri Basin is generously endowed with a variety of nonmetallic mineral resources. The bulk of the output will be consumed locally to meet construction industry needs at a minimum cost. The use of water in sand and gravel pit operations is incidental to pit operations except for washing. Because of this no water demands have been included for sand and gravel operations.

Mineral fuels represent the greatest mineral value in the basin. The coal resources of the basin show enormous potential. In contrast, the oil and gas resource development is expected to peak near 1980 and decline from that time on. This will occur, not from a lack of demand, but because known petroleum reserves in the basin are not increasing, because recent offshore exploration has shown impressive discoveries, and because there

Water Is Required For The Production, Refining, And Utilization of Fossil Fuels

is increasing competition from low-cost foreign crude oil.

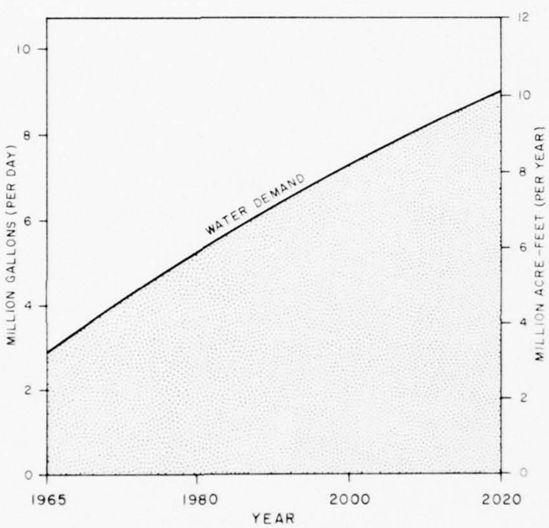
Mineral demands will increase from 82,000 acre-feet to 192,000 acre-feet between 1965 and 2020.

The projected water demand for thermal-electric power production will be 4,878,000 acre-feet in 2020, up from 1,724,000 in 1965. These demands are described fully in chapter 4.

Table 68 shows the total municipal, rural domestic, and industrial water demands for selected years.

Figure 19 graphically portrays the growth in water demand in the Missouri River Basin.

FIGURE 19
MUNICIPAL, RURAL-DOMESTIC,
AND INDUSTRIAL WATER DEMAND



WATER QUALITY

Chemically pure water in nature is practically unknown. Even the falling rain contains gasses and solids absorbed from the atmosphere. Upon reaching the land and passing through the various phases of the hydrologic cycle, water continues its solvent action in collecting both dissolved and suspended matter. The kind and amount of these impurities govern the quality of a given water, and any degradation of the quality will limit the beneficial uses.

Factors Influencing Quality

Topography and geology will influence the quality of water. Relief of the land, amount of moisture already present, and condition of the land surface, collectively, will determine the runoff rate or length of time that water contacts surface materials. Carbon dioxide and acids from decaying vegetation dissolved in water greatly enhance the solution of calcium, magnesium, and the heavy metals frequently found in waters. Upland streams generally exhibit an increase in sediment load and a decrease in dissolved solids during periods of high flow. These conditions are reversed during periods of minimum flow. Often this quality characteristic of surface waters is most significant in determining the usefulness of a given source. Conversely, the mineral content of ground water is relatively constant, but it is usually higher than surface waters. Condition, type, and physical structure of geological formations also greatly affect the amount of solids dissolved. Primary characteristics of ground water are an absence of color and suspended sediment and a nearly uniform temperature.

Man makes drastic changes in water quality for and during municipal and industrial uses, then later returns the water, together with water-borne wastes, to the land and surface streams. Many factors, such as agricultural activities, accelerated natural erosion, and reservoir storage may also affect water quality.

Water Quality Objectives (Criteria) and Source of Data

Water quality objectives were established for domestic-municipal and industrial water supplies. These are compatible to State water quality criteria developed in accordance with the Federal Clean Water Act. Since the quality of water resources varies greatly throughout the Missouri Basin, quality objectives were developed by "degree of acceptability" for each functional use. Plan formulation, based on existing regional practice, may deviate with the "degree of acceptability" values which are inherently unique to a particular region.

Where data were available, the quality characteristics of existing water supplies for municipal and industrial uses were compared with the water quality objectives shown in table 69 to determine the degree of acceptability. For purposes of this study, existing supplies with high levels of mineral content and generally considered of undesirable quality were classified as "inadequate."

Water Quality Problems

The ground-water supplies in the high plains area, figure 20, have high concentrations of total dissolved solids (TDS) which exceed the suggested limits for municipal, rural domestic, and industrial uses.

The surface waters in the basin have a varied total dissolved solids concentration as shown in figure 20. Surface waters available often have a lower average total dissolved solids concentration than the ground waters in the area; thus, better quality may be obtained by converting to a surface water source. Some 435 places

Table 69 – QUALITY OBJECTIVES FOR MUNICIPAL, RURAL DOMESTIC, AND INDUSTRIAL WATER SUPPLIES

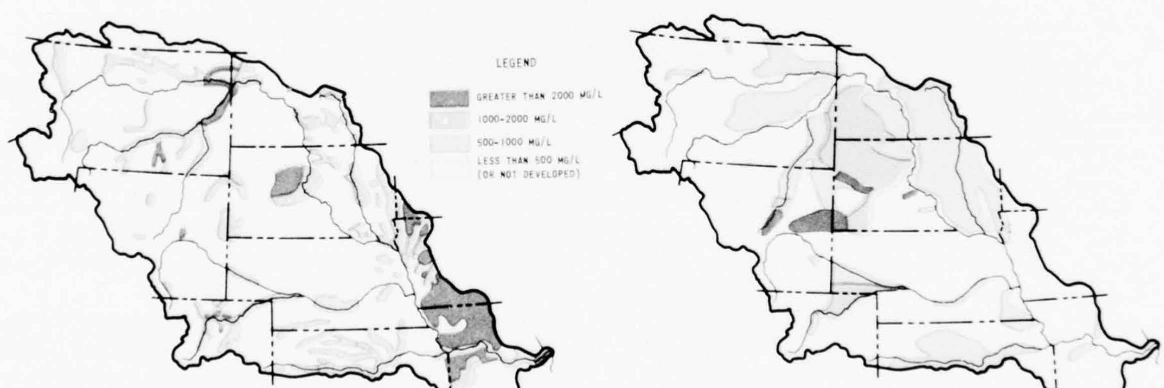
Content	Good	Usable	Undesirable
	Supply Requiring Minimal Treatment	Supply Requiring Usual Treatment	Supply Requiring Extensive Treatment. Use Alternate Source If Available
		Municipal and Domestic Supplies	
Total Dissolved Solids (average)	< 500 mg/l*	< 1500 mg/l	> 2000 mg/l
Chlorides	< 250 mg/l	< 400 mg/l	> 400 mg/l
Sulfates	< 250 mg/l	< 500 mg/l	> 500 mg/l
Nitrates	< 10 mg/l	< 45 mg/l	> 45 mg/l
Sodium	< 10 mg/l	< 100 mg/l	> 200 mg/l
Fluorides	< 1 mg/l	< 2.5 mg/l	> 2.5 mg/l
Iron and Manganese (as Fe)	< 0.3 mg/l		> 0.3 mg/l
		Industrial Supplies	
Total Dissolved Solids	< 500 mg/l	< 1000 mg/l	> 1000 mg/l
Chlorides	< 200	< 250	> 250
Sulfates		< 250	

*Milligrams per liter – generally equivalent to parts per million (ppm).
< = Less than. > = Greater than.

FIGURE 20

TOTAL DISSOLVED SOLIDS

GROUND WATER SURFACE WATER



are using water sources with a natural mineral quality which contravenes the planning criteria.

SUBBASIN REQUIREMENTS

The following section discusses the individual subbasins as to the existing water supplies and the municipal, rural, and industrial uses. Each subbasin was studied to develop the information presented in the preceding basin summary; therefore, the water quality criteria are identical to those previously discussed.

Upper Missouri Subbasin

The Upper Missouri Subbasin includes parts of the Rocky Mountain Province and the northwest ranching region. The western mountainous portion contains large mineral and timber reserves, excellent fish and wildlife resources, and exceptional scenic and recreational values. The eastern portion of the subbasin contains valuable oil and coal resources. It is less watered than the western portion and presents an economy dominated by dryland farming and ranching. In sections where land and water resources permit, an irrigation-based agriculture has developed. The entire subbasin has benefited greatly from the readily available hydroelectric power potential.

Subbasin trends indicate that the relative economic importance of agriculture will decline in the future and the noncommodity-producing sector will rapidly increase. The large deposits of mineable coal located in the eastern portions could support a significant industrial development in the future.

With these economic developments the population of the Upper Missouri Subbasin is expected to increase to 605,000 by the year 2020. The 1960 population of 298,200 was classified as follows: 161,100 rural, farm residents 56,400, 104,700 rural nonfarm, and 137,100 as urban. There are 329 municipalities and villages (places) in the subbasin. It was estimated that 95 of the places, with 215,000 persons or 68 percent of the subbasin population, were served by public water supply systems in 1964. Central water systems served 62,000 rural people and 101,000 persons in the basin were served by private wells.

The most current available data (1965) on municipal and rural-domestic water use were used in making water demand projections.

Future municipal and rural-domestic water requirements were estimated on the basis of the existing or projected size of the communities and their location with respect to the "44" precipitation effectiveness index line. These estimated municipal and rural-domestic demands are expected to increase from 46,000 acre-feet in 1965 to 94,000 acre-feet in 2020.

Some industries obtain their water supply from municipal systems and are considered in the municipal demand totals. Sixty-two industries in the subbasin were reported in 1965 to have separate water supplies.

Only limited industrial use data are available. Those industries reporting used 31,000 acre-feet of water annually and their demands are expected to increase to 59,000 acre-feet by 2020. The projected demand for water for thermal-electric power production is 455,000 acre-feet by year 2020, although there are no thermal-electric power generation stations in this subbasin at present.

Mineral industry water demands in the subbasin are small and are expected to peak at about 7,000 acre-feet by year 2000.

Total municipal and industrial water demands are expected to grow from 79,000 acre-feet in 1965 to a 2020 demand of 611,000 acre-feet. Table 70 is a summary of these current and projected municipal and industrial demands.

The annual gross demand of 79,000 acre-feet in 1965 was met 63 percent by surface water diversions and 37 percent by ground-water withdrawals. Great Falls, Montana, with the largest water supply system in the subbasin, serves 72,000 persons and a number of industries. Next in order of size are the public water facilities of Helena and Bozeman, Montana, which serve 25,000 and 13,250 people, respectively.

Table 70 – MUNICIPAL, RURAL DOMESTIC, AND INDUSTRIAL WATER DEMANDS, UPPER MISSOURI SUBBASIN, 1965-2020

Use	1965	1980	2000	2020
	(1,000 Acre-Feet)			
Municipal and Rural Domestic	46	52	66	94
Industrial (General)	31	37	57	59
Mineral	2	6	7	3
Thermal-Electric Power	0	159	445	455
Total	79	254	575	611

The population in the Upper Missouri is expected to increase from 316,000 in 1965 to about 605,000 in 2020. Central water services are expected to increase from 215,000 to 526,000, an increase of 311,000 that will need new supplies, treatment, and distribution systems. Included in the increased services by central systems are 230,000 urban people, 81,000 people living in villages and communities under 2,500 and rural nonfarm households, and about 2,000 people in farm households. Individual pressure systems are expected to service 77,000 or 95 percent of the population in farm and nonfarm households and only 2,000, or about 1/3 of one percent of the population of the basin will be without running water by 2020.

Fifteen of the subbasin's 215 water supply systems in 1965 were classed as inadequate – 12 because of quality and three because of capacity. Improvement of 46 additional systems would be desirable. Table 71 summarizes the degree of adequacy of existing municipal water supplies. Eighteen million dollars will be required by year 1980 to provide the facilities to adequately treat the present water supply and provide for future water treatment plant enlargements, additions, the rehabilitation of obsolete plants, and for new construction. An additional $22 million will be required in the 1980-2000 period and $24 million between year 2000 and 2020.

Yellowstone Subbasin

The Yellowstone Subbasin includes parts of the Rocky Mountain Province and the northwest ranching region. The scenic resources of the region attract tourists from all over the nation, with Yellowstone Park accounting for over 2 million visitors annually. The heavy recreational uses of the park place a significant demand upon the water resources.

In the plains area, surface conditions and climate combine to permit an agricultural economy of mixed dryland farming and cattle ranching. Other basic economic activities include the production and related processing of metals, nonmetals, and fuels.

Subbasin trends indicate that the relative economic importance of agriculture will decline and the importance of the noncommodity producing sector will

Table 71 – SUMMARY OF EXISTING MUNICIPAL WATER SUPPLIES BY SOURCE
UPPER MISSOURI SUBBASIN

Source of Supply	Number of Supplies	Total Population Served	Ranges of Per Capita Use	Improved Quality Desired	Inadequate Quantity	Number of Supplies Requiring Additional Treatment
		(1000)	(gpcd)	(No.)	(No.)	
Surface Water	16	107	80-335	1	---	---
Ground Water	70	58	48-720	39	3	9
Combined Surface and Ground Water	9	50	120-344	6	---	3
Total	95	215	48-720	46	3	12

rapidly increase. The vast deposits of mineable coal located in the eastern part of the subbasin could support a large industrial development, and it appears that such development will be directed to the production of thermal-electric power and the hydrogenation of coal.

Because of the area's potential, the population of the Yellowstone Subbasin is expected to increase to a 2020 population of 690,000 compared with the 1960 population of 270,400. The 1960 population was classified as follows: 146,100 urban, 76,100 rural nonfarm, and 48,200 rural farm. There were 77 places in the categories of municipalities and villages in the subbasin in 1965. It was estimated in 1965 that 65 of these places, with 194,000 persons or 80 percent of the subbasin population, were served by public water supply systems. Approximately 97,000 persons were served by individual water systems, and 30,000 rural people were served by the central water systems of nearby municipalities. The most current available data (1965) on municipal and industrial water uses have been used in this analysis.

Future municipal and rural-domestic water requirements were estimated on the basis of the existing or projected size of the communities and their location with respect to the "44" precipitation effectiveness index line. These estimated municipal and rural-domestic demands are expected to increase from 41,000 acre-feet in 1965 to 124,000 acre-feet in 2020.

Only limited industrial use data are presently available. Those industries reporting used 89,000 acre-feet of water annually and industrial water demands are expected to increase to 294,000 acre-feet by year 2020. Sugar-mill and oil refining are expected to produce much of this increased demand.

The gross demands for water for thermal-electric power production of 97,000 acre-feet in 1965 are projected to be 875,000 acre-feet in 2020.

Mineral industry demands reported as 16,000 acre-feet in 1965 will grow to 63,000 acre-feet in 2020. The present mineral industry produces petroleum, uranium, coal, gypsum, and other construction materials. Petroleum production demands are expected to peak in 1980 and decline as reserves are depleted and development shifts to coal hydrogenation, with an anticipated water demand of about 750,000 acre-feet by 2020. There are no coal hydrogenation plants in the subbasin today.

Total municipal and industrial water demands are expected to grow from 243,000 acre-feet in 1965 to a 2020 demand of 2,106,000 acre-feet. Table 72 is a summary of these current and projected municipal and industrial demands.

Table 72 – MUNICIPAL, RURAL DOMESTIC, AND INDUSTRIAL WATER DEMANDS, YELLOWSTONE SUBBASIN, 1965-2020

Use	1965	1980	2000	2020
	(1,000 Acre-Feet)			
Municipal & Rural Domestic	41	58	86	124
Industrial (General)	89	292	263	294
Mineral	16	50	57	63
Thermal-Electric Power	97	390	803	875
Coal Hydrogenation	0	200	375	750
Total	243	990	1,584	2,106

In 1965 the gross demand of 243,000 acre-feet was met 94 percent by surface water diversions and 6 percent from ground-water withdrawals. Billings, Montana, with the largest water supply system in the subbasin, serves 65,540 persons and a complex of industries. The second largest public water supply system in the subbasin is Sheridan, Wyoming, serving a population of 12,000.

The population in the Yellowstone is expected to increase from 291,000 in 1965 to about 690,000 in 2020. Central water services are expected to increase from 194,000 to 617,000, an increase of 423,000 who will need new supplies, treatment, and distribution systems. Included in the increased services by central systems are 377,000 urban people, 46,000 people living in villages and communities under 2,500 and rural nonfarm households, and about 2,000 people in farm households. Individual pressure systems are expected to service 78,000, or 95 percent of the population in farm and nonfarm households and only 2,000, or less than 1/3 of one percent of the population of the basin will be without running water by 2020.

Table 73 summarizes the degree of adequacy of existing municipal and industrial water supply systems. One water system was classed as inadequate because of the limited supply. Sources of supply with better quality would be desirable for four other places. By year 1980, $14 million will be required to provide the facilities to adequately treat the present water supply and provide for future water treatment plant enlargements, additions, the rehabilitation of obsolete plants, and for new construction. An additional $24 million will be required in the 1980-2000 period and $19 million between year 2000 and 2020.

Table 73 – SUMMARY OF EXISTING MUNICIPAL WATER SUPPLIES BY SOURCE
YELLOWSTONE SUBBASIN

Source of Supply	Number of Supplies	Total Population Served	Ranges of Per Capita Use	Improved Quality Desired	Inadequate Quantity	Number of Supplies Requiring Additional Treatment
		(1000)	(gpcd)	(No.)	(No.)	
Surface Water	18	108	67-227	2	---	---
Ground Water	38	44	25-253	2	1	---
Combined Surface and Ground Water	9	42	108-333	---	---	---
Total	65	194	25-333	4	1	---

Western Dakota Subbasin

Most of this subbasin is sparsely settled and economically dependent upon agriculture and related industries. Farmers are heavily dependent upon livestock, with over two-thirds of the farms classified as livestock farms and nearly 80 percent of cash receipts obtained from the marketing of livestock. Where water supply and water quality are adequate, irrigated agriculture is practiced.

The Black Hills district of the subbasin has developed a thriving tourist and recreation industry which has become the "number one" income industry of this area. The mountain scenery, a moderate summer climate, and points of historical significance assure a bright future for the tourist industry in this part of the subbasin. The Black Hills area is noted also for its mineral and timber resources which have contributed heavily to the economy for over 100 years.

Present trends indicate that the relative economic importance of agriculture will decline, while manufacturing, other commodity-producing industries and noncommodity-producing industries will show increases.

Because of the expected economic development, the population of the subbasin is expected to grow from a 1960 total of 299,500 persons to 612,000 in the year 2020. The 1960 population was classified 199,300 rural and 100,200 urban. Farm residents numbered 86,800 and 112,500 were classified rural nonfarm. There were 450 places in the categories of municipalities and villages in 1960. In 1965, it was estimated that 110 of these places with 186,000 persons (59 percent of the subbasin population) were served by public water supply systems. Central water systems served an additional 71,000 people in the rural areas. Approximately 128,000 persons in the subbasin were served by individual water systems.

Future municipal and rural-domestic water requirements were estimated on the basis of the existing or projected size of the communities and their location with respect to the "44" precipitation effectiveness index line. These estimated municipal and rural domestic demands are expected to increase from 25,000 acre-feet in 1965 to 60,000 acre-feet in year 2020.

Only limited industrial use data are presently available. Some industries obtain their water supply from municipal systems and their water use is considered in the municipal demand totals. Twenty-seven industries in the subbasin in 1965 were reported to have individual supplies. The annual water use for the limited number of industries reported in 1965 was 10,000 acre-feet. Water demands for future industrial development are expected to increase to 19,000 acre-feet by 2020.

The water needed for thermal-electric power production in the future is projected to be 398,000 acre-feet in 2020, up from 49,000 acre-feet in 1965.

Projected mineral developments in metals, nonmetals and fuels will demand additional water in the future. Gold is expected to remain the most important metal with increasing output through 1980, but decreasing beyond that time. Uranium production will become more important. The production of nonmetals, primarily in the construction group of minerals, will grow due to population increases and increasing demand. Water diverted for sand and gravel production is not included in the total requirement figures. In the fuels section, petroleum output is expected to peak shortly after 1980. The subbasin has large lignite reserves, but is expected to lose part of its share of the market because of higher quality coal in the surrounding areas. Total mineral industry water demands will grow from 19,000 acre-feet in 1965 to 49,000 acre-feet by 2020.

Total municipal and industrial water demands are expected to grow from 103,000 acre-feet in 1965 to a 2020 demand of 526,000 acre-feet. Table 74 is a summary of these current and projected municipal and industrial demands.

Table 74 – MUNICIPAL, RURAL DOMESTIC, AND INDUSTRIAL WATER DEMANDS, WESTERN DAKOTA SUBBASIN, 1965-2020

Use	1965	1980	2000	2020
	(1,000 Acre-Feet)			
Municipal & Rural Domestic	25	34	47	60
Industrial (General)	10	15	17	19
Mineral	19	28	34	49
Thermal-Electric Power	49	298	362	398
Total	103	375	460	526

In 1965 the gross demand of 103,000 acre-feet was met 78 percent by surface water diversions and 22 percent from ground-water withdrawals. Rapid City, South Dakota, with the largest water supply system in the subbasin, serves approximately 50,000 persons and several industries. Next in order of size are the public water facilities of Mandan and Dickinson, North Dakota, which serve 11,000 and 10,000 people, respectively.

The population in the Western Dakota Subbasin is expected to increase from 314,000 in 1965 to about 612,000 in 2020. Central water services are expected to increase from 186,000 to 543,000, an increase of 357,000 who will need new supplies, treatment and distribution systems. Included in the increased services by central systems are 228,000 urban people, 129,000 people living in villages and communities under 2,500 and rural nonfarm households, and about 6,000 people in farm households. Individual pressure systems are expected to service 65,000 or over 95 percent of the remaining population in farm and nonfarm households and only 4,000, or less than one percent of the population of the basin will be without running water by 2020.

Table 75 summarizes the degree of adequacy of existing municipal and industrial water supply systems in the subbasin. Seven of the 110 water supply systems in service in the subbasin in 1965 were inadequate in regard to water treatment. None of the systems was classed inadequate in regard to quantity; however, the town of Dickinson may have inadequate supplies in the near future. Improvements would be desirable for 51 other systems. By the year 1980, $21 million will be required to provide the facilities to adequately treat the present water supply and provide for future water treatment plant enlargements, additions, the rehabilitation of obsolete plants, and for new construction. An additional $27 million will be required in the 1980-2000 period and $24 million between year 2000 and 2020.

Table 75 – SUMMARY OF EXISTING MUNICIPAL WATER SUPPLIES BY SOURCE WESTERN DAKOTA SUBBASIN

Source of Supply	Number of Supplies	Total Population Served	Ranges of Per Capita Use	Improved Quality Desired	Inadequate Quantity	Number of Supplies Requiring Additional Treatment
		(1000)	(gpcd)	(No.)	(No.)	
Surface Water	8	21	64-397	1	---	---
Ground Water	97	90	44-204	49	---	7
Combined Surface and Ground Water	5	75	75-120	1	---	---
Total	110	186	44-397	51	---	7

Eastern Dakota Subbasin

This subbasin has a well developed agricultural economy and over 60 percent of the land is under cultivation. Industrial development is confined mainly to the processing of agricultural products. Because of the land capabilities and the present lack of industrial development there are many small communities and a low population density. The population is comparatively well distributed.

The subbasin contains large reserves of petroleum and lignite and future industrial expansion is expected as these resources are developed to support the construction of large thermal-electric power stations.

Present trends indicate the relative economic importance of agriculture and other commodity producing industries will decline. Employment in the noncommodity producing industries is expected to expand rapidly due to continuing urbanization, rising personal income, and the expansion of service industries.

Because of the expected economic development, the population of the Eastern Dakota Subbasin is expected to grow from a 1960 level of 669,600 persons to 1,305,000 in the year 2020. The 1960 population was classified 423,100 as rural and 246,500 as urban. Farm residents numbered 222,100 and 201,000 were classified as rural nonfarm. There were 572 places in the categories of municipalities and villages in 1960.

It was estimated that 269 of these places (1965) with 418,000 persons or 60 percent of the subbasin population, were served by public water supply systems. Central water systems also served 144,000 rural people. Approximately 279,000 were served by individual water systems.

Future municipal and rural-domestic water requirements were estimated on the basis of the existing or projected size of the communities and their location with respect to the "44" precipitation effectiveness index line. These estimated municipal and rural-domestic demands are expected to increase from 54,000 acre-feet in 1965 to 188,000 acre-feet in year 2020.

The industrial water use data are incomplete since no up-to-date inventory was available. Some industries obtain their water supply from municipal systems and are considered in the municipal demand totals. There were 31 industries in the subbasin in 1965 reported to have individual water supplies. Water demands for industrial development are expected to increase from 2,000 acre-feet reported in 1965 to 4,000 acre-feet by 2020.

The future demands for water for thermal-electric power production are projected to be 701,000 acre-feet by 2020, up from 17,000 acre-feet in 1965.

Water will be required for projected mineral developments in the nonmetal and fuels areas. Production of the construction group of minerals will grow due to population increases and increased demand. Water diverted for sand and gravel production, however, is not included in the total water requirement figures. In the fuels sector, water needs should parallel the predicted increase in oil and gas output to 1980 and remain unchanged to 2020. Water needs for lignite production are expected to increase through year 2000 and then level out. Total growth of mineral industry water demand is lost in the rounding of figures and is expected to remain unchanged at 4,000 acre-feet per year between 1965 and 2020.

Total municipal and industrial water demands are expected to grow from 77,000 acre-feet in 1965 to a 2020 demand of 897,000 acre-feet. Table 76 is a summary of these current and projected municipal and industrial demands.

In 1965 the gross demand of 77,000 acre-feet was met 42 percent by surface-water diversions and 58 percent from ground-water withdrawals. Sioux Falls, S. Dak., with the largest water supply system in the subbasin, serves 65,000 persons and several industries. Next in order of size after Sioux Falls are the public water facilities of Bismarck, N. Dak., and Aberdeen, S. Dak., which serve 30,000 and 26,000 people, respectively.

The population in the Eastern Dakota Subbasin is expected to increase from 697,000 in 1965 to about 1,305,000 in 2020. Central water services are expected to increase from 418,000 to 1,164,000, an increase of 746,000 who will need new supplies, treatment, and distribution systems. Included in the increased services by central systems are 506,000 urban people, 240,000 people living in villages and communities under 2,500

Table 76 – MUNICIPAL, RURAL DOMESTIC, AND INDUSTRIAL WATER DEMANDS, EASTERN DAKOTA SUBBASIN, 1965-2020

Use	1965	1980	2000	2020
	(1,000 Acre-Feet)			
Municipal & Rural Domestic	54	103	143	188
Industrial (General)	2	2	3	4
Mineral	4	4	4	4
Thermal-Electric Power	17	199	432	701
Total	77	308	582	897

and rural households, and about 16,000 people in farm households. Individual pressure systems are expected to service 135,000 or 95 percent of the remaining population in farm and nonfarm households and only 6,000, or about 1/2 of one percent of the population of the basin will be without running water by 2020.

Table 77 summarizes the degree of adequacy of existing municipal and industrial water supply systems in the subbasin. Thirty-one of the 269 water supply systems in the subbasin in 1965 were classified as inadequate – 30 required additonal treatment and one

Table 77 – SUMMARY OF EXISTING MUNICIPAL WATER SUPPLIES BY SOURCE EASTERN DAKOTA SUBBASIN

Source of Supply	Number of Supplies	Total Population Served	Ranges of Per Capita Use	Improved Quality Desired	Inadequate Quantity	Number of Supplies Requiring Additional Treatment
		(1000)	(gpcd)	(No.)	(No.)	
Surface Water	10	102	76-144	2	---	---
Ground Water	257	286	11-303	175	1	30
Combined Surface and Ground Water	2	30	86	2	---	---
Total	269	418	11-303	179	1	30

had a limited supply of water. Improvements would be desirable for 179 of the remaining systems. By the year 1980, $47 million will be required to provide the facilities to adequately treat the present water supply and provide for future water treatment plant enlargements, additions, the rehabilitation of obsolete plants, and for new plant construction. An additional $62 million will be required in the 1980-2000 period and $49 million between year 2000 and 2020.

Platte-Niobrara Subbasin

The Platte River is formed by the junction of the North Platte and South Platte rivers near North Platte, Nebraska. Both rivers have their headwaters in the Rocky Mountains of Colorado. The Niobrara River rises in the low hills of east central Wyoming and flows easterly through Wyoming and Nebraska to its junction with the Missouri River.

The subbasin population is poorly distributed, with the largest proportion concentrated in the Denver, Colorado, metropolitan area. This area contains a highly diversified industrial complex. The irrigated agricultural development in the South Platte area near Denver adds greatly to its economy. Due to the high growth rate and increasing dominance of the Denver metropolitan area, manufacturing employment has experienced more rapid growth in the subbasin than nationally.

The western and mountainous area of the subbasin contains most of the mining activity. Petroleum, natural gas, coal, nonmetallic and metallic minerals constitute the basic mineral production. This subbasin has a diverse agricultural economy dependent primarily upon livestock, cash grains, and specialty crops. Wheat, corn, sugar beets, milk, beef, veal, and pork are the major agricultural products and are expected to comprise the major portion of the farmers' receipts in the future.

Present trends indicate the economic importance of agriculture will decline while all the manufacturing, noncommodity-producing and commodity-producing industries will rapidly increase.

In view of the large economic potential of the subbasin, the population of the Platte-Niobrara Subbasin is expected to grow from a 1960 level of 1,963,000 persons to 6,940,000 in the year 2020. The 1960 population was classified 571,500 rural and 1,392,400 urban. Farm residents numbered 241,400 and 330,100 were classified rural nonfarm. There were 1,286 places in the categories of municipalities and villages in 1960.

Future municipal and rural-domestic water requirements were estimated on the basis of the existing or projected size of the communities and their location with respect to the "44" precipitation effectiveness index line. These estimated municipal and rural domestic demands are expected to increase from 365,000 acre-feet in 1965 to 1,217,000 acre-feet in 2020.

Based on the limited industrial data available, water demands for industrial development are expected to increase from the reported use of 142,000 acre-feet in 1965 to a projected demand of 230,000 acre-feet by year 2020.

The demand for water for power production is projected to grow from 454,000 acre-feet in 1965 to 528,000 acre-feet in 1980, but to decline from 1980 on to only 202,000 acre-feet per year by 2020 due to increased use of supplemental cooling systems.

Water will be required for projected mineral developments in the nonmetals, metals, and fuel sectors. Production of non-metallic minerals (entirely in the construction group) will grow due to population increases and increased demand. Water diverted for sand and gravel production is not included in the total water requirement figures. In the metals sector, iron and uranium ores have been and will be the most important sources of metal in terms of both value and water use. In the fuels sector, high volume water needs for oil and gas production may peak by 1980, but water needs for coal production will continue to expand through 2020. Total mineral industry water demands are expected to grow from 28,000 acre-feet in 1965 to 42,000 acre-feet by the year 2020.

Total municipal and industrial water demands are expected to grow from 989,000 acre-feet in 1965 to a 2020 demand of 1,691,000 acre-feet. Table 78 is a summary of these current and projected municipal and industrial demands.

Table 78 – MUNICIPAL, RURAL DOMESTIC, AND INDUSTRIAL WATER DEMANDS, PLATTE-NIOBRARA SUBBASIN, 1965-2020

Use	1965	1980	2000	2020
	(1,000 Acre-Feet)			
Municipal & Rural Domestic	365	514	798	1,217
Industrial (General)	142	195	218	230
Mineral	28	60	56	42
Thermal-Electric Power	454	528	300	202
Total	989	1,297	1,372	1,691

In 1965 the gross demand of 989,000 acre-feet was met 82 percent by surface water diversions and 18 percent from ground-water withdrawals. Denver, with the largest water supply system in the subbasin, serves 1 million persons and a complex of industries. Next in order of size are the public water facilities of Lincoln, Nebraska and Cheyenne, Wyoming, which serve 138,000 and 46,200 people, respectively.

The population in the Platte-Niobrara Subbasin is expected to increase from 2,238,000 in 1965 to about 6,940,000 in 2020. Central water services are expected to increase from 1,876,000 to 6,660,000, an increase of 4,784,000 people who will need new supplies, treatment, and distribution systems. Included in the increased services by central systems are 4,532,000 urban people, 252,000 people living in villages and communities under 2,500 and in rural nonfarm households, and about 24,000 people in farm households. Individual pressure systems are expected to service 270,000, or about 95 percent of the population in farm and nonfarm households and only 10,000, or less than 1/6 of one percent of the population of the basin will be without running water by 2020.

Table 79 summarizes the degree of adequacy of existing municipal and industrial water supply systems in the subbasin.

Table 79 – SUMMARY OF EXISTING MUNICIPAL WATER SUPPLIES BY SOURCE
PLATTE-NIOBRARA SUBBASIN

Source of Supply	Number of Supplies	Total Population Served	Ranges of Per Capita Use	Improved Quality Desired	Inadequate Quantity	Number of Supplies Requiring Additional Treatment
		(1000)	(gpcd)	(No.)	(No.)	
Surface Water	37	1100	40-558	---	---	---
Ground Water	288	578	30-475	---	---	---
Combined Surface and Ground Water	15	198	73-291	---	---	---
Total	340	1876	30-558	---	---	---

By the year 1980, $115 million will be required to provide the facilities to adequately treat the present water supply and provide for future water treatment plant enlargements, additions, the rehabilitation of obsolete plants and for new plant construction. An additional $166 million will be required in the 1980-2000 period and $179 million between year 2000 and 2020.

Middle Missouri Subbasin

This subbasin includes the lands drained by the main stem of the Missouri River and its tributaries below the mouth of the Big Sioux River near Sioux City, Ia., to a point just above Kansas City, exclusive of the Platte River (Colorado, Nebraska, Wyoming) drainage.

The deep, fertile soils and generally adequate precipitation of the subbasin have aided the development of a highly productive agricultural economy. Many industries in the subbasin are processors of agricultural products or manufacture items for farmstead use. Manufacturing employment in the subbasin has grown relatively faster than nationally.

Mineral production has been limited generally to nonmetallics which are fairly well distributed throughout the subbasin. In the southern part of the subbasin, there are small amounts of petroleum production and limited coal deposits.

Present trends indicate that the economic importance of agriculture will decline while the remainder of the economy will rapidly increase. Because of the economic potential of the subbasin, the population is expected to grow from a 1960 level of 1,293,500 persons to 2,430,000 in the year 2020. The 1960 population was classified 740,400 urban, 280,000 farm residents, and 273,100 rural nonfarm. There were 576 places in the categories of municipalities and villages in 1960. More than 75 percent of the population is concentrated in three metropolitan areas.

In 1965 it was estimated that 255 of these places, with 941,000 persons or 70 percent of the subbasin population, were served by public water supply systems. Central water systems served 140,000 rural people. Approximately 395,000 persons were served by individual water systems.

Future municipal and rural-domestic water requirements were estimated on the basis of the existing or projected size of the communities and their location with respect to the "44" precipitation effectiveness index line. These estimated municipal and rural domestic demands are expected to increase from 154,000 acre-feet in 1965 to 470,000 acre-feet in 2020.

Some industries obtain their water supply from municipal systems and are considered in the municipal demand totals. In 1965, there were 42 industries in the subbasin reported to have individual water supplies. Based on this limited available industrial data, water demands for industrial development are expected to increase from the reported use of 11,000 acre-feet in 1965 to a projected demand of 68,000 acre-feet by year 2020.

The demand for water for power production is projected to grow from 480,000 acre-feet in 1965 to 1,237,000 acre-feet in 2020.

Essentially all of the mineral production of the subbasin will be sand and gravel and, since water diverted for such purposes is not included in the total water requirement figures, no demand by the mineral industry is forecast for this subbasin.

Total municipal and industrial water demands are expected to grow from 645,000 acre-feet in 1965 to a 2020 demand of 1,775,000 acre-feet. Table 80 is a summary of these current and projected municipal and industrial demands.

Table 80 – MUNICIPAL, RURAL DOMESTIC, AND INDUSTRIAL WATER DEMANDS, MIDDLE MISSOURI SUBBASIN, 1965-2020

Use	1965	1980	2000	2020
	(1,000 Acre-Feet)			
Municipal & Rural Domestic	154	256	343	470
Industrial (General)	11	34	49	68
Mineral	---	---	---	---
Thermal-Electric Power	480	753	1,040	1,237
Total	645	1,043	1,432	1,775

In 1965 the gross demand of 645,000 acre-feet was met 89 percent by surface water diversions and 11 percent from ground-water withdrawals. Omaha, Nebraska, which has the largest water supply system in the subbasin, serves 370,000 persons and a complex of industries. St. Joseph, Mo., serving a population of 92,000 and Sioux City, Ia., with 85,000 are next in order of size.

The population in the Middle Missouri is expected to increase from 1,336,000 in 1965 to about 2,430,000 in 2020. Central water services are expected to increase from 941,000 to 2,276,000, an increase of 1,335,000 who will need new supplies, treatment, and distribution systems. Included in the increased services by central systems are 1,129,000 urban people, 206,000 people living in villages and communities under 2,500 and in rural nonfarm households, and about 26,000 people in farm households. Individual pressure systems are expected to service 143,000 or 95 percent of the population in farm and nonfarm households and only 12,000, or about 1/2 of one percent of the projected population of the basin will be without running water by 2020.

Table 81 summarizes the degree of adequacy of existing municipal and industrial water supply systems in the subbasin. Four of the 255 water supply systems in 1965 were classified as inadequate – three required additional treatment and the other had inadequate capacity. Improvements would be desirable for three other systems. By the year 1980, $75 million will be required to provide the facilities to adequately treat the present water supply and to provide for future water treatment plant enlargements, additions, rehabilitation of obsolete plants, and for new plant construction. An additional $75 million will be required in the 1980-2000 period and $70 million between year 2000 and 2020.

Table 81 – SUMMARY OF EXISTING MUNICIPAL WATER SUPPLIES BY SOURCE MIDDLE MISSOURI SUBBASIN

Source of Supply	Number of Supplies	Total Population Served	Ranges of Per Capita Use	Improved Quality Desired	Inadequate Quantity	Number of Supplies Requiring Additional Treatment
		(1000)	(gpcd)	(No.)	(No.)	
Surface Water	13	570	54-188	---	---	---
Ground Water	242	371	50-286	3	1	3
Combined Surface and Ground Water	---	---	---	---	---	--
Total	255	941	50-286	3	1	3

Kansas Subbasin

The Kansas River joins the Missouri River at Kansas City. The subbasin is a relatively long and narrow area draining parts of eastern Colorado, southern Nebraska, and northern Kansas. The western two-thirds of the subbasin is arid to semiarid while the eastern third is subhumid.

The economy of the subbasin is largely supported by agriculture. Approximately 85 percent of the area is under cultivation, with wheat and livestock the two largest sources of farm income. Industrial activity centered in the larger municipalities consists principally of meat packing, flour milling, and the processing of other agricultural products. The development of the oil and gas industry in western Kansas adds greatly to the income of the basin. This industry enabled Kansas to rank first in the Missouri Basin States in the value of mineral products in 1966. Large oil refineries are located at Kansas City and Phillipsburg, Kans. The rubber, chemical, and allied industries also are represented in the lower Kansas River valley. Present trends here, as elsewhere, indicate the economic importance of agriculture will decline while the remainder of the economy is expected to show steady increases.

The subbasin population is not well distributed, most of the people being concentrated along the Kansas River and the lower Smoky Hill River in the eastern half of Kansas.

In view of the economic potential of the subbasin, the population is expected to grow from a 1960 population level of 902,500 persons to 1,746,000 in the year 2020. The 1960 population was classified as: 50,600 rural and 401,900 urban, 204,400 as farm residents, and 296,200 as rural nonfarm. There were 355 places in the categories of municipalities and villages in 1960.

It was estimated in 1965 that 348 of these places with 629,000 persons, or 67 percent of the subbasin population, were served by public water supply systems. Central systems served 190,000 rural people. Approximately 313,000 persons in the basin were served by individual water systems.

Future municipal and rural-domestic water requirements were estimated on the basis of the existing or projected size of the communities and their location with respect to the "44" precipitation effectiveness index line. These estimated municipal and rural domestic demands are expected to increase from 123,000 acre-feet in 1965 to 245,000 acre-feet in 2020.

Some industries obtain their water supply from municipal systems and are considered in the municipal demand totals. There were 83 industries in the subbasin reported in 1965 to have individual water supplies. Based on this limited available industrial data, water demands for industrial development are expected to increase from the reported use of 24,000 acre-feet in 1965 to a projected demand of 76,000 acre-feet by year 2020.

The demands for water for thermal-electric power production are projected to be 52,000 acre-feet in 2020, up from 19,000 acre-feet in 1965.

Water demands for the mineral industry will fall in the nonmetals and fuels sectors. Essentially, all of the nonmetallic developments are in the construction minerals category. Water diverted for sand and gravel production is not included in the water requirement figures. Oil and gas production is projected to increase through the year 2000 and then level out and corresponding water requirements are expected to parallel the production. Water needed for coal production has been considered negligible. Total mineral industry water demands are expected to grow from 9,000 acre-feet in 1965 to 20,000 acre-feet by the year 2020.

Total municipal and industrial water demands are expected to grow from 175,000 acre-feet in 1965 to a 2020 demand of 393,000 acre-feet. Table 82 is a summary of these current and projected municipal and industrial demands.

Table 82 – MUNICIPAL, RURAL DOMESTIC, AND INDUSTRIAL WATER DEMANDS, KANSAS SUBBASIN, 1965-2020

Use	1965	1980	2000	2020
	(1,000 Acre-Feet)			
Municipal & Rural Domestic	123	129	174	245
Industrial (General)	24	44	57	76
Mineral	9	20	20	20
Thermal-Electric Power	19	15	35	52
Total	175	208	286	393

In 1965 the gross demand of 175,000 acre-feet was met 41 percent by surface water diversions and 59 percent from ground-water withdrawals. Topeka, Kansas, which has the largest water supply system in the subbasin, serves about 135,000 persons and a complex of industries. Next in order of size are the public water facilities of Lawrence and Salina, Kansas, which serve 42,000 and 40,600 persons, respectively.

The population in the Kansas Subbasin is expected to increase from 942,000 in 1965 to about 1,746,000 in 2020. Central water services are expected to increase from 629,000 to 1,580,000, an increase of 951,000 who will need new supplies, treatment, and distribution systems. Included in the increased services by central systems are 593,000 urban people, 358,000 people living in villages and communities under 2,500 and rural households, and about 20,000 people in farm households. Individual pressure systems are expected to service 157,000 or 95 percent of the population in farm and nonfarm households and only 10,000, or less than one percent of the population of the basin will be without running water by 2020.

Fifty-three of the 348 water supply systems required additional treatment in 1965 and were classified as inadequate. Improvements would be desirable for 93 other systems. Table 83 summarizes the degree of adequacy of existing municipal supplies. By the year 1980, $106 million will be required to provide the facilities to adequately treat the present water supply

Table 83 – SUMMARY OF EXISTING MUNICIPAL WATER SUPPLIES BY SOURCE KANSAS SUBBASIN

Source of Supply	Number of Supplies	Total Population Served	Ranges of Per Capita Use	Improved Quality Desired	Inadequate Quantity	Number of Supplies Requiring Additional Treatment
		(1000)	(gpcd)	(No.)	(No.)	
Surface Water	11	170	82-159	---	---	---
Ground Water	332	372	37-333	92	---	53
Combined Surface and Ground Water	5	87	84-135	1	---	---
Total	348	629	37-333	93	---	53

and provide for future water treatment plant enlargements, additions, the rehabilitation of obsolete plants and for new plant construction. An additional $149 million will be required in the 1980-2000 period and $145 million between 2000 and 2020.

Lower Missouri Subbasin

The population of this subbasin is not well distributed; over half of the people reside in the Kansas City or Springfield, Missouri, metropolitan areas. The remainder of the population is generally distributed throughout the counties of the subbasin.

The subbasin has a well-developed agricultural economy and has been a leading producer in the Missouri Basin of soybeans, non-citrus fruits, chickens, turkeys, and milk. The rich bottomlands are high producers of feed and food grains. The uplands are noted for their livestock and livestock products. Industrial activities are concentrated generally in the larger cities, where manufacturing activity has grown faster than the national trends during the past two decades. Nearly 20 percent of the subbasin employment is now in manufacturing. Mineral industry growth will depend upon expansion in the nonmetallic and fuels sectors. The nonmetallic minerals are primarily in construction materials — sand, gravel, stone, cement, and clays. Coal production is expected to expand to meet the demands for thermal-electric power production. Future petroleum output is uncertain, depending upon technological developments in the production of viscous crude oil. Present trends indicate that the economic importance of agriculture will decline while the noncommodity-producing industries, manufacturing, and other commodity-producing industries will rapidly increase.

In view of the large economic potential of the subbasin, the population of the Lower Missouri Subbasin is expected to grow from a 1960 population of 2,233,500 to 5,732,000 in the year 2020. The 1960 population was classified as: 842,200 rural and 1,391,300 urban. Farm residents numbered 332,600 persons and 509,600 were classified rural nonfarm. There were 1,237 places in the categories of municipalities and villages in 1960.

It was estimated in 1965 that 291 of these places, with 1,821,000 persons or 75 percent of the subbasin population, were served by public water supply systems. Central systems served 211,000 rural people. Approximately 602,000 persons in the subbasin were served by individual water systems.

Future municipal and rural domestic water requirements were estimated on the basis of the existing or projected size of the communities and their location with respect to the precipitation effectiveness index line. These estimated municipal and rural domestic demands are expected to increase from 255,000 acre-feet in 1965 to 801,000 acre-feet in 2020.

Some industries obtain their water supply from municipal systems and are considered in the municipal water demand totals. There were 92 industries in the subbasin reported in 1965 to have individual water supplies. Based on this limited available industrial data, water demands for industrial development are expected to increase from the reported use of 96,000 acre-feet in 1965 to a projected demand of 362,000 acre-feet in 2020.

The demands for water for thermal-electric power production are projected to be 958,000 acre-feet in 2020, up from 608,00 acre-feet in 1965.

Water demands for the mineral industry will be in the nonmetals and fuels sector. Essentially all of the nonmetal developments are in the construction minerals. Water diverted for sand and gravel production is not included in the total water requirements figures. Only a small amount of water will be required for the production of coal. Total mineral industry water demands are expected to grow from 4,000 acre-feet in 1965 to 11,000 acre-feet by the year 2020.

Total municipal and industrial water demands are expected to grow from 963,000 acre-feet in 1965 to a 2020 demand of 2,132,000 acre-feet. Table 84 is a summary of these current and projected municipal and industrial demands.

Table 84 – MUNICIPAL, RURAL DOMESTIC, AND INDUSTRIAL WATER DEMANDS, LOWER MISSOURI SUBBASIN, 1965-2020

Use	1965	1980	2000	2020
	(1,000 Acre-Feet)			
Municipal & Rural Domestic	255	323	460	801
Industrial (General)	96	171	252	362
Mineral	4	10	10	11
Thermal-Electric Power	608	780	885	958
Total	963	1,284	1,607	2,132

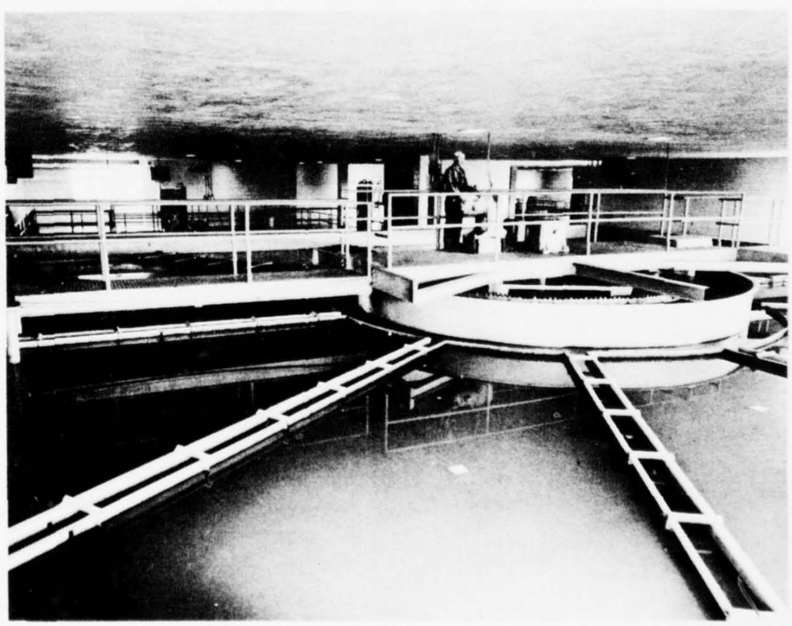
In 1965 the gross demand of 963,000 acre-feet was met 88 percent by surface water diversions and 12 percent from ground-water withdrawals. Kansas City, Missouri, with the largest water supply system in the subbasin, serves about 700,000 people and a complex of industries. The second largest public water supply system in the basin is Independence, Missouri, serving a population of 112,900.

The population in the Lower Missouri Subbasin is expected to increase from 2,423,000 in 1965 to about 5,732,000 in 2020. Central water services are expected to increase from 1,821,000 to 5,470,000, an increase of 3,649,000 who will need new supplies, treatment, and distribution systems. Included in the increased services by central systems are 2,805,000 urban people, 844,000 people living in villages and communities under 2,500 and rural households, and about 26,000 people in farm households. Individual pressure systems are expected to service 248,000 or 95 percent of the remaining population in farm and nonfarm households and only 14,000, or less than 1/4 of one percent of the population of the basin will be without running water by 2020.

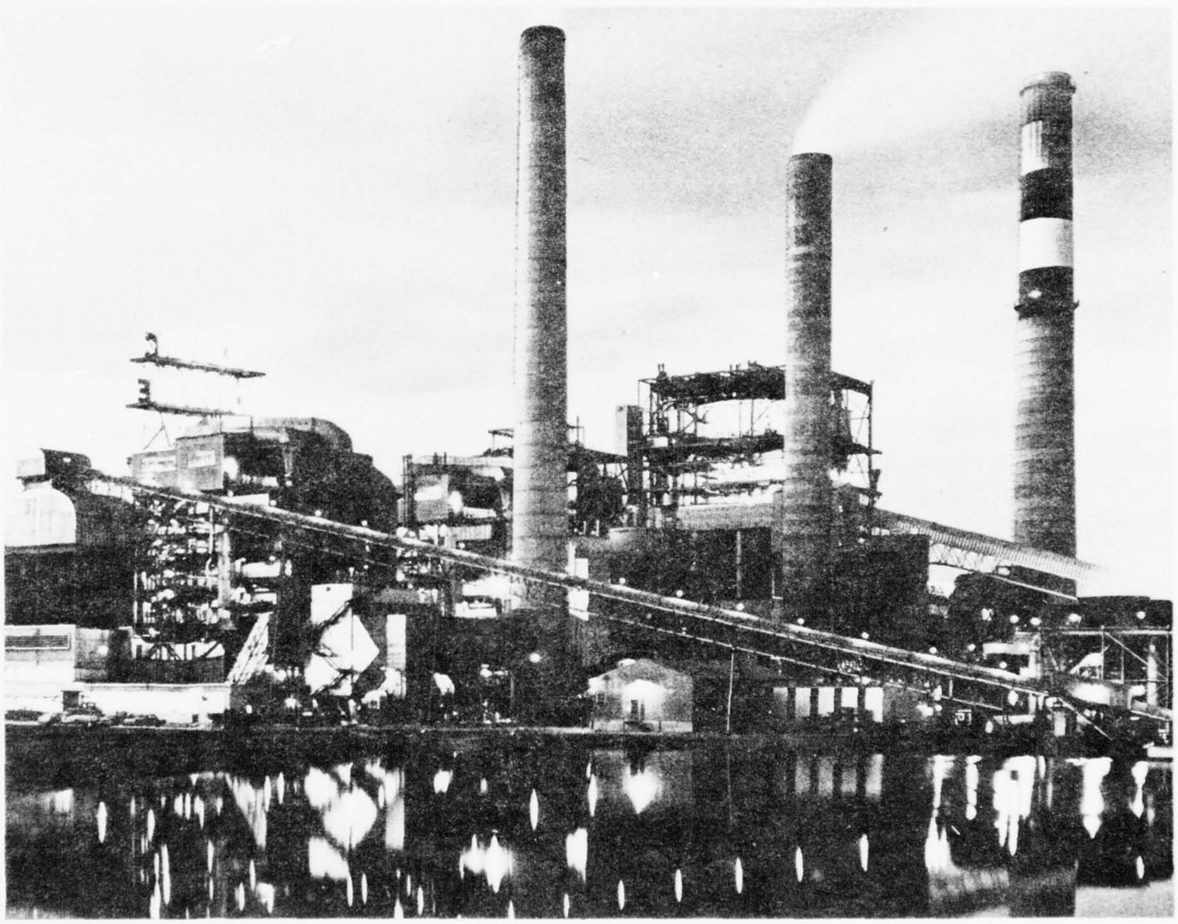
Twenty-nine of the 291 water supply systems in 1965 were classified as inadequate. Improvements in treatment would be desirable for 59 other systems as shown in the data summarized in table 85. By the year 1980, $115 million will be required to provide the facilities to adequately treat the present water supply and provide for future water treatment plant enlargements, additions, the rehabilitation of obsolete plants, and for new plant construction. An additional $148 million will be required in the 1980-2000 period and $136 million between year 2000 and 2020.

Table 85 – SUMMARY OF EXISTING MUNICIPAL WATER SUPPLIES BY SOURCE
LOWER MISSOURI SUBBASIN

Source of Supply	Number of Supplies	Total Population Served	Ranges of Per Capita Use	Improved Quality Desired	Inadequate Quantity	Number of Supplies Requiring Additional Treatment
		(1000)	(gpcd)	(No.)	(No.)	
Surface Water	96	1200	29-274	5	---	6
Ground Water	190	385	18-284	54	---	23
Combined Surface and Ground Water	5	236	51-120	---	---	---
Total	291	1821	18-284	59	---	29



Potable Water Supply – A Public Necessity



Steam-Electric Power Generation Reflects In Adequate Water For Cooling

CHAPTER 4

ELECTRIC POWER

The projections of future electric power needs are made, not only to determine the probable effect on the basin economy and use of its natural resources, such as fuel, but also to develop estimates of future needs for cooling water.

Historic and future electric power requirements presented herein are for the Missouri River Basin Power Region. The power region varies only slightly from the basin in area, having been designated to follow generally the boundaries of Federal Power Commission Power Supply Areas, hereinafter referred to as PSA's. Data given are by subareas which correspond to PSA's or portions thereof within the power region and are further disaggregated to subbasins.

Predictions that have been made as to the types of thermal-electric generating stations which will supply the future power requirements, taking into account the existing and potential hydroelectric projects, are utilized in estimating future needs for cooling water. The power requirements projections utilized are based on the latest views of the related Regional Advisory Committees currently engaged in assisting the FPC in updating the Federal Power Commission's National Power Survey.

EXISTING SITUATION

Power Region

The MRB Power Region consists of all or parts of the 10 states comprising the Missouri River Basin — Montana, Wyoming, Colorado, Kansas, North Dakota, South Dakota, Nebraska, Minnesota, Iowa, and Missouri. The boundary coincides with that of the Appendix on Economic Analysis and Projections, except that St. Charles and Franklin counties, Missouri, and Sweetwater County, Wyoming, are included in the power region; and only the areas in Glacier and Silver Bow counties, Montana, served respectively by the Glacier County and Vigilante Cooperatives, are included.

The subregional breakdown of the area contained within the designated study boundary does not lend itself readily to power analysis; therefore, the FPC Power Supply Area (PSA) was selected as the unit for estimation of projected power requirements. PSA's represent geographic areas which are essentially the service areas of groups of major electric utilities. Unless otherwise stated, data given by PSA's include only that portion of the PSA within the MRB Power Region. This region includes parts of PSA's 15, 16, 17, 26, 29, 30, 31, 32, 34, and the whole of 27 and 28. PSA 15 excludes the city of St. Louis and St. Louis and Jefferson counties, but includes St. Charles and Franklin counties (see figure 21).

For purposes of conformity, the projected PSA power requirements, power supply, and water requirements and consumptive use are disaggregated to the study subbasins: Upper Missouri, Yellowstone, Western Dakota, Eastern Dakota, Platte-Niobrara, Middle Missouri, Kansas, and Lower Missouri, as well as to that portion of the Red River of the North Basin included in the MRB Power Region. The difference between the Missouri River Basin and the Power Region is the included portion of the Red River Basin. In the tables presenting subbasin data, the Missouri River Basin has been subtotaled for correlation with other chapters of this appendix.

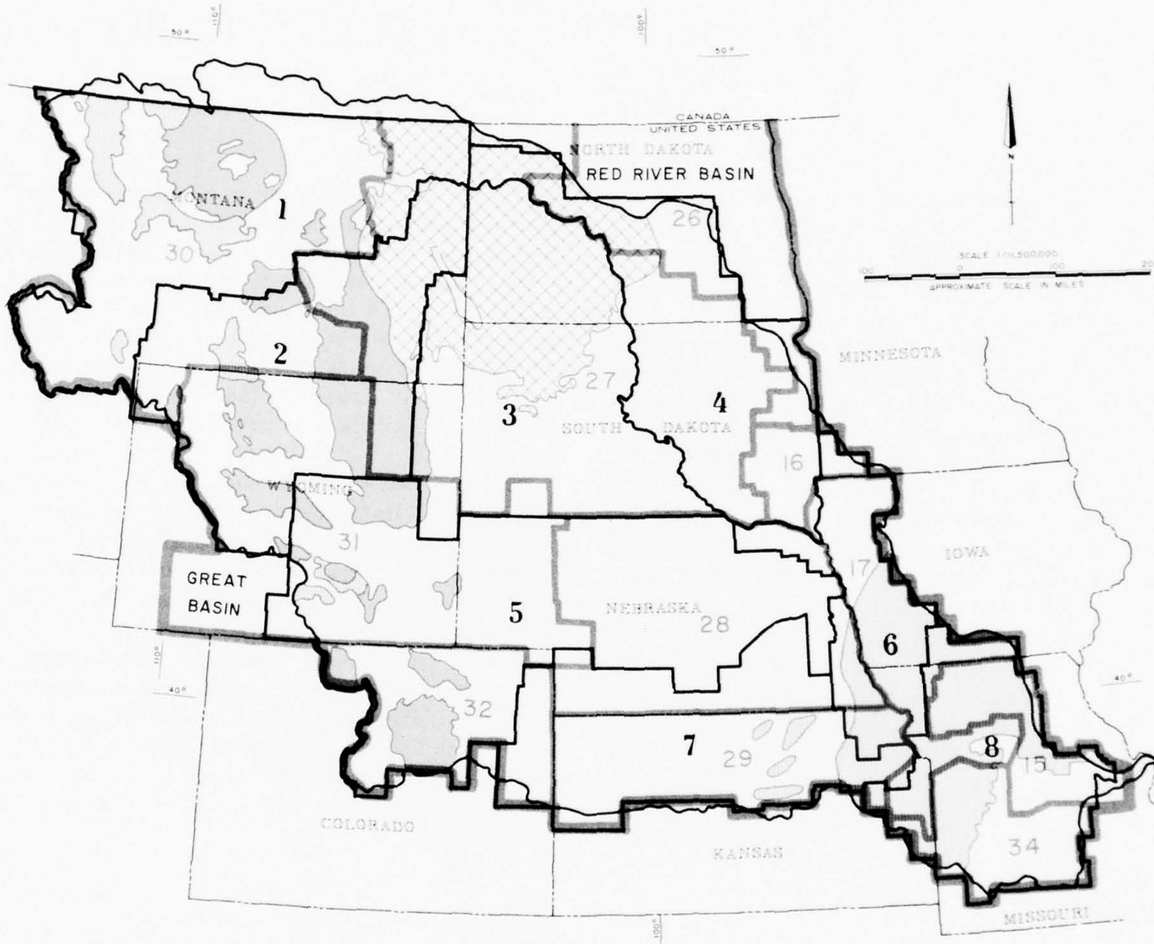
Basin Economy as Related to Power

Electric energy consumption is related primarily to population and to use for development of natural resources. Increased population requires increased use of electricity in the home, in commercial establishments, and in recreational and other activities. A rising standard of living results in increased use per customer. Development of available natural resources imposes increased electric energy demands in the mine, factory, mill, and on the farm; however, without the incentive of available electric power, the development of natural resources and the related population growth will diminish. Thus, the availability of economical electric energy is a key element in the economy of a region and, in turn, the power industry is directly affected by the economic climate.

Manufacturing within the Missouri River Basin is concentrated primarily in the processing of agricultural

FIGURE 21

POWER SUPPLY AREAS AND COAL FIELDS



LEGEND

BASIN BOUNDARY

STATE OR NATIONAL BOUNDARY

ECONOMIC SUBREGION BOUNDARY

POWER REGION BOUNDARY

30 FEDERAL POWER COMMISSION POWER SUPPLY AREA AND NUMBER

BITUMINOUS COAL AREA

SUBBITUMINOUS COAL AREA

LIGNITE COAL AREA

SUBREGIONS

1 UPPER MISSOURI RIVER TRIBUTARIES
2 YELLOWSTONE RIVER
3 WESTERN DAKOTA TRIBUTARIES
4 EASTERN DAKOTA TRIBUTARIES
5 PLATTE-NIOBRARA RIVERS
6 MIDDLE MISSOURI RIVER TRIBUTARIES
7 KANSAS RIVER
8 LOWER MISSOURI RIVER TRIBUTARIES

products. In addition to the food product industries, which are widely distributed, other industries such as petroleum refineries, paper and allied products, primary metals, and chemical products have been growing extensively within the region. This is due to the wealth of natural resources, including minerals, coal, oil, and some natural gas.

Of particular significance to the production of electric power is the supply of fossil fuels, which is not expected to impose quantitative limitations on the use of coal, gas, and oil in the producing and contiguous areas between now and 1980. However, in following decades, the development of economical nuclear and lignite plants, coupled with a reduction in oil and gas reserves, should result in substantial amounts of electric power generation utilizing nuclear and lignite fuels rather than the conventional fossil fuels. Ninety-eight percent of the national lignite reserves are in western North Dakota and eastern Montana. In addition, extensive deposits of bituminous and subbituminous coal are found in Montana, Wyoming, and Colorado. Figure 21 shows the location of coal fields of all types in the basin.

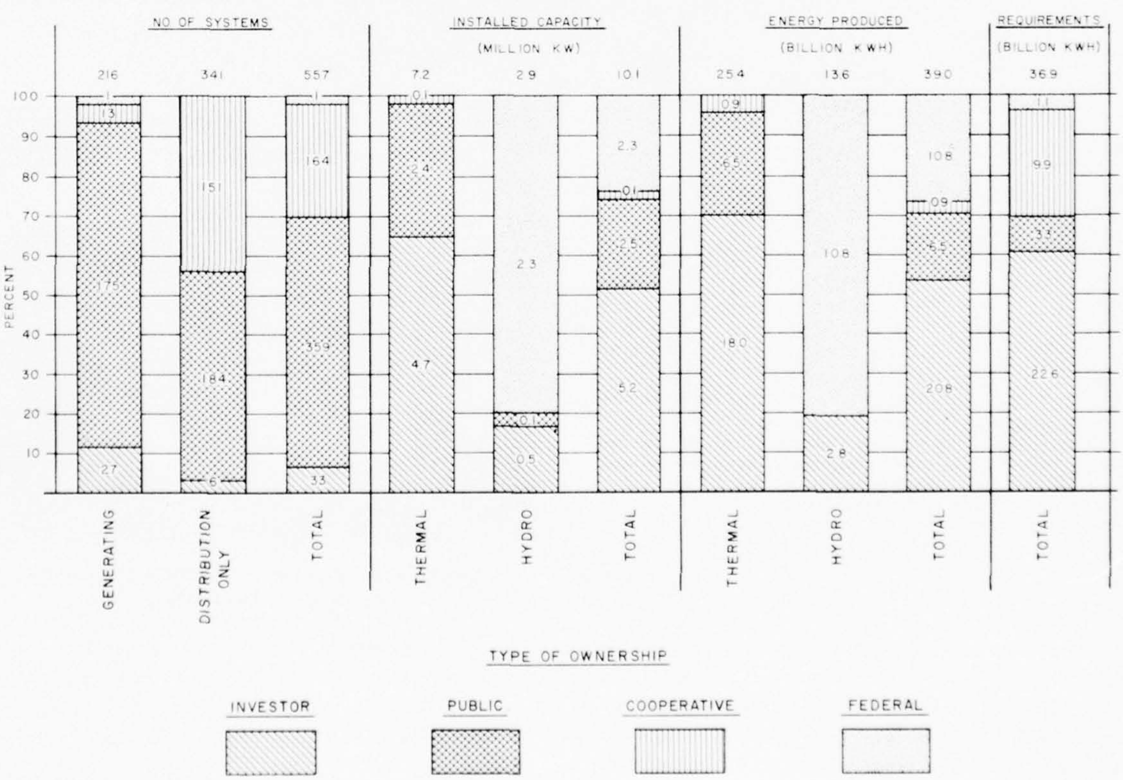
Organization of the Electric Power Industry

The Missouri River Basin Power Region in 1965 contained 578 electric utility systems. Of these, 33 were investor-owned systems, 369 were municipal and other publicly owned systems, 175 were cooperative systems, and one was the Federal hydroelectric system. The composition of the 1965 power supply is shown in figure 22 as the Missouri River Power Region minus the Red River Basin. Operations of some of the utilities included in the figure extend outside of the study area, but only that portion of the load and capacity of these utilities within the MRB Power Region boundary is here considered.

Investor-owned utilities comprise about 50 percent of the generating capacity and have 60 percent of the energy requirements. The remaining installed capacity is about evenly divided between the Federal and publicly owned systems. However, the Federal system generates about 70 percent more than the publicly owned system, supplying most of the requirements of the cooperatives in the basin, which produce less than one percent of their own needs.

FIGURE 22
COMPOSITION OF 1965 POWER SUPPLY

(MISSOURI RIVER POWER REGION MINUS RED RIVER BASIN)



About one-half of the public systems, which for the most part are quite small, have generating equipment whose production often is supplemented by external purchases. The cooperative group is comprised of a few generating and transmission systems and numerous distribution cooperatives varying considerably in size.

Recognition should be given to the nonutility supply which is composed almost entirely of industrial generation. In 1965, the nonutility generating capacity was about 156,000 kilowatts, compared with utility capacity of 10.3 million kilowatts. The nonutility generation was about 660 million kilowatt-hours compared with utility generation of 39,330 million kilowatt-hours. Because of the relatively minor impact of the nonutility supply on the total current supply, and because of uncertainties of the future, consideration of this source of supply and its negligible effects on water requirements have been omitted from the projected supply utilized in this analysis.

In perspective, the electric power requirements of the MRB Power Region in 1965, aggregating 38.6 billion kilowatt-hours, were approximately 3.6 percent of the national total. The total generating capacity was 10.3 million kilowatts, representing 4.4 percent of the national total. The 1965 annual peak loads and energy requirements by PSA's are shown in table 86.

Table 86 – MISSOURI BASIN POWER REGION 1965 ANNUAL PEAK LOADS AND ENERGY REQUIREMENTS

PSA	Annual Peak Load	Annual Energy Requirements	Annual Load Factor**
	(Mw)*	(Million kwh)	%
15	345	1,541	51.0
16	165	822	56.9
17	1,907	8,540	51.1
26	340	1,645	55.2
27	627	3,471	63.2
28	1,444	5,957	47.1
29	847	3,712	50.0
30	439	2,582	67.1
31	443	2,668	68.8
32	995	5,176	59.4
34	542	2,516	53.0
Total	8,094***	38,630	54.5

*Mw. (megawatts) – 1,000 kilowatts (kw.)
**Annual energy requirements divided by product of the annual peak load and the number of hours in the year (L. F. = Energy / Pk. Ld. x No. hrs. in yr.)
***Non-coincident

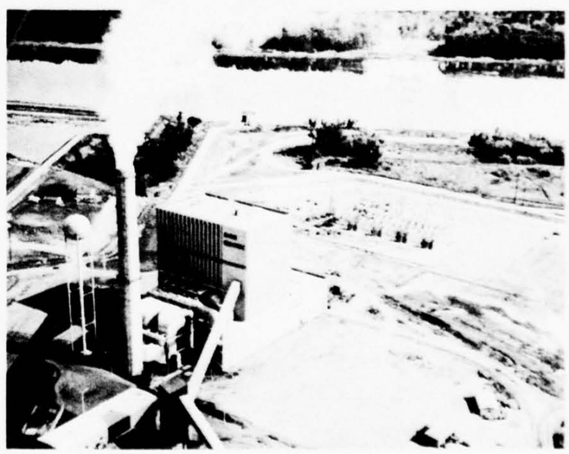
Generation

Steam plants using coal and gas as fuels generate the major portion of electric energy in the MRB Power Region, with hydroelectric plants contributing substantially to the power supply. There are numerous small diesel plants, but these account for an insignificant portion of the total. The gas turbine is becoming popular in some areas as a source of peaking and emergency power, but this application is expected to remain relatively small.

Estimated energy and capacity requirements of the MRB Power Region were determined by analysis of reports and service area maps filed with the Federal Power Commission by electric utilities serving the area. These requirements were estimated to be 38,630 million kilowatt-hours and 10,119 megawatts in 1965. Subtracting the requirements from the supply (see table 87) indicated a net excess of 700 million kilowatt-hours and 224 megawatts which were transferred out of the power region.

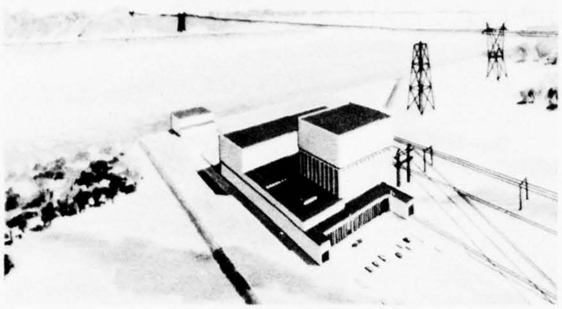
The MRB Power Region exported only a relatively small amount of energy and capacity in 1965. This is short-term power which will vary in direction of flow such that at times there will be a net import of power and, at others, a net export. The overall, long-time effect is for the transfers to cancel to zero, and they have been so considered in projecting the future power-supply requirements.

There are several small thermal-generating plants utilizing lignite as a boiler fuel for steam-electric generation. Currently, two large lignite plants in the order of 200 megawatts are in operation in the lignite fields of North Dakota. A third unit is under construction and a construction schedule has been established for a fourth unit of 400 megawatts. In addition, a subbituminous plant of 200 megawatt magnitude has been installed in Montana.



Lignite-Fired 200-Megawatt Steam-Electric Plant near Stanton, North Dakota

Another recent development influencing the type of power supply in the basin is the breakthrough of the nuclear powerplant cost-barrier. About 2,500 megawatts of nuclear generating capacity is scheduled for installation in the basin by early 1970.



Nuclear Generating Station, 800 Megawatts, Scheduled for 1972 – near Brownville, Nebraska

As shown in table 87 hydroelectric plants in the MRB Power Region accounted for 28 percent of the 1965 generating capacity and produced 35 percent of the energy. This hydro capacity is concentrated mainly on the main stem of the Missouri River. Federal plants constitute the bulk of the hydroelectric supply, accounting for approximately 80 percent of the total.

Table 88 lists the generating plants of 10 megawatts and over installed in the basin as of June 30, 1965, and their types of ownership.

Transmission

The technological development of higher transmission voltages has made practical the moving of larger blocks of electric power over long distances. This has encouraged a trend toward integration of utilities into larger operating systems to permit lower capital and operating costs. An extensive 230-kilovolt transmission network has been constructed to connect the major hydroelectric plants and to distribute the large blocks of power produced at the Federal plants.

Smaller capacity transmission lines also serve the basin with voltages generally in the order of 115-, 138-, and 161-kilovolts. These lines are owned by the other segments of the power industry in the basin (investor, public, and cooperative) as well as by the Federal Government. The primary functions of the lines are transmission of the power generated at the owners'

Table 87 – MISSOURI BASIN POWER REGION 1965 INSTALLED GENERATING CAPACITY AND PRODUCTION

PSA	Capacity in Mw			Net Generation in Million Kwh		
	Thermal	Hydro	Total	Thermal	Hydro	Total
15	238	176	414	757	582	1,339
16	104	---	104	216	---	216
17	1,790	---	1,790	5,596	---	5,596
26	219	---	219	376	---	376
27	414	1,874	2,288	1,283	8,432	9,715
28	1,308	138	1,446	4,000	548	4,548
29	826	2	828	2,851	12	2,863
30	69	318	387	170	2,507	2,677
31	583	209	792	1,859	867	2,726
32	1,096	186	1,282	4,416	698	5,114
34	788	5	793	4,149	11	4,160
Total	7,435	2,908	10,343	25,673	13,657	39,330

Gavins Point Dam and Hydroelectric Plant on Missouri River near Yankton, South Dakota

Yellowtail-Custer 230-Kilovolt Transmission Line, Montana

Table 88 – EXISTING GENERATING PLANTS – MISSOURI BASIN
10 MW AND OVER
(AS OF JUNE 30, 1965)

PLANT LIST – COLORADO

No. & Name of Plant	MW Capacity & Type	Owner Code
2 Arapahoe	250.5 St	PSCO
5 Boulder	20.0 Hy	PSCO
7 Cabin Creek	300.0 Hy*	PSCO
9 Cherokee	420.5 St	PSCO
12 Estes	45.0 Hy	USBR
13 Flatiron	71.5 Hy[1]	USBR
14 Fort Collins	11.0 St	FOCO
23 Pole Hill	33.2 Hy	USBR
28 Valmont	281.8 St	PSCO
30 Zuni	115.2 St	PSCO

*Pumped Storage; Under Construction
[1]Includes 8.5 MW Pumped Storage

OWNERSHIP LIST

FOCO	MUN	Fort Collins
PSCO	PRI	Public Service Co. of Colorado
USBR	FED	U. S. Bureau of Reclamation

PLANT LIST – IOWA

No. & Name of Plant	MW Capacity & Type	Owner Code
2 Atlantic	10.0 St	ATLA
	4.2 IC	ATLA
4 Big Sioux	41.0 St	IOPS
11 Council Bluffs	130.6 St	IOPL
17 George Neal	147.0 St	IOPS
24 Kirk	17.5 St	IOPS
38 Spencer	17.5 St	SPEN
39 Summit Lake	22.5 St	SOFP
	5.8 IC	SOFP
44 Wisdom, Earl	37.5 St	COBP

OWNERSHIP LIST

ATLA	MUN	Atlantic
COBP	COOP	Corn Belt Pwr. Coop.
IOPL	PRI	Iowa P. & L. Co.
IOPS	PRI	Iowa Pub. Serv. Co.
SOFP	COOP	S. W. Fed. Pwr. Coop.
SPEN	MUN	Spen

PLANT LIST – KANSAS

No. & Name of Plant	MW Capacity & Type	Owner Code
1 Abilene	33.8 St	KAPL
5 Clay Center	14.2 St	CLAY
7 Colby	12.0 St	CEKP
13 Hays	19.0 St	CEKP
17 Kaw Station	161.3 St (Insert Map)[1]	KACY
18 Lawrence	210.2 St	KAPL
23 Ottawa	6.5 St	OTTA
	7.3 IC	OTTA
25 Quindaro	104.5 St (Insert Map)[1]	KACY
	76.5 St*	KACY
28 Ross Beach	12.7 St	CEKP
	25.0 St	SUNC[2]
29 Russell	15.8 IC	RUSS
30 Tecumseh	346.1 St	KAPL

[1]Figure 23
[2]Leased to and operated by Central Kansas Pwr. Co.
*Under Construction

OWNERSHIP LIST

CEKP	PRI	Central Kansas Pwr. Co.
CLAY	MUN	Clay Center
KACY	MUN	Kansas City
KAPL	PRI	Kansas P. & L. Co.
OTTA	MUN	Ottawa
RUSS	MUN	Russell
SUNC	COOP	Sunflower Elec. Coop.

PLANT LIST – MINNESOTA

No. & Name of Plant	MW Capacity & Type	Owner Code
44 Worthington	16.5 St	WORT

OWNERSHIP LIST

WORT	MUN	Worthington

PLANT LIST – MISSOURI

No. & Name of Plant	MW Capacity & Type	Owner Code
3 Blue Valley	115.0 St (Insert Map)[1]	INDN
6 Chamois	59.0 St	CEEP
7 Chillicothe	15.0 St	CHIL
8 Clinton	15.5 St	MIPU
9 Columbia	59.3 St	COLM
	11.5 GT	COLM
10 Edmond St.	33.5 St	SAJL
11 Fulton	11.5 St	FULT
12 Grand Ave.	126.8 St (Insert Map)[1]	KACP
13 Green, Ralph J.	49.5 St	MIPU
15 Hawthorne	363.0 St (Insert Map)[1]	KACP
17 Dodgion St.	15.0 St (Insert Map)[1]	INDN
19 Jefferson City	12.7 St	MILC
21 Lake Road	60.6 St	SAJL
	90.0 St*	SAJL
22 Marshall	14.0 St	MARM
25 Missouri City	40.0 St	NOEP
26 Montrose	563.1 St	KACP
28 Northeast	156.0 St (Insert Map)[1]	KACP
29 Osage	176.2 Hy	UNEC
32 Sedalia	11.5 St	MIPU
33 Sibley	100.0 St	MIPU
36 Springfield	23.5 St	SPRM

*Under Construction
[1]Figure 23

OWNERSHIP LIST

CEEP	COOP	Central El. Pwr. Coop.
CHIL	MUN	Chillicothe
COLM	MUN	Columbia
FULT	MUN	Fulton
INDN	MUN	Independence
KACP	PRI	Kansas City P. & L.
MARM	MUN	Marshall
MILC	PRI	Missouri P. & L.
MIPU	PRI	Missouri Pub. Serv. Co.
NOEP	COOP	N. W. El. Pwr. Coop.
SAJL	PRI	St. Joseph L. & P. Co.
SPRM	MUN	Springfield
UNEC	PRI	Union Electric Co.

PLANT LIST – MONTANA

No. & Name of Plant	MW Capacity & Type	Owner Code
1 Bird, Frank	69.0 St	MOPO
2 Black Eagle	16.8 Hy	MOPO
3 Canyon Ferry	50.0 Hy	USBR
4 Cochrane	48.0 Hy	MOPO
5 Fort Peck	165.0 Hy	USAR
6 Hauser Lake	17.0 Hy	MOPO
7 Holter	38.4 Hy	MOPO
10 Lewis & Clark	50.0 St	MODU
11 Morony	45.0 Hy	MOPO
12 Mystic Lake	10.0 Hy	MOPO
14 Rainbow	35.6 Hy	MOPO
15 Ryan	48.0 Hy	MOPO
17 Yellowtail	250.0 Hy*	USBR

*Under Construction

OWNERSHIP LIST

MOPO	PRI	Montana Power Company
USAR	FED	U. S. Army
USBR	FED	U. S. Bureau of Reclamation

Table 88 – (continued)

PLANT LIST – NEBRASKA

No.	Name of Plant	MW Capacity & Type	Owner Code
1	Alliance	16.5 St	ALLI
2	Bluffs	42.2 St	COPD
3	Burdick, C. W.	39.5 St	GRIS
4	Canaday	108.8 St	CENP
5	Columbus	39.9 Hy	LORP[1]
6	Fairbury	8.7 St	FABU
		12.5 St*	FABU
7	Falls City	10.0 IC	FACY
8	Fremont No. 1	44.0 St	FREM
9	Fremont No. 2	21.0 St	FREM
10	Gavins Point	100.0 Hy	USAR
11	Hastings	32.0 St	HAST
12	Pine Street	17.5 St	GRIS
13	Jeffrey Canyon	18.0 Hy	CENP
14	Johnson Canyon No. 1	18.0 Hy	CENP
15	Johnson Canyon No. 2	18.0 Hy	CENP
16	Jones Street	173.5 St	OMPP
17	Kramer	112.5 St	NEPP
18	Lincoln - K Street	31.7 St	COPD[1]
19	Nebraska City	10.6 IC	NECU
20	North Omaha	427.1 St	OMPP
21	North Platte	26.1 Hy	PLVP[1]
22	Ogallala	7.5 St	COPD
		3.7 IC	COPD
23	Sheldon	108.8 St	COPD
24	South Omaha	20.0 St	OMPP

[1] Leased to Nebraska P.P.S.
*Under Construction

OWNERSHIP LIST

ALLI	MUN	Alliance
CENP	STATE	Central Nebr. P.P. & Irr. Dist.
COPD	STATE	Consumers P.P. Dist.
FABU	MUN	Fairbury
FACY	MUN	Falls City
FREM	MUN	Fremont
GRIS	MUN	Grand Island
HAST	MUN	Hastings
LORP	STATE	Loup River P.P. Dist.
NECU	MUN	Nebraska City
NEPP	STATE	Nebraska P.P. System
OMPP	STATE	Omaha P.P. Dist.
PLVP	STATE	Platte Valley P.P. & Irr. Dist.
USAR	FED	U. S. Army

PLANT LIST – NORTH DAKOTA

No.	Name of Plant	MW Capacity & Type	Owner Code
1	Beulah	13.5 St[1]	MODU
2	Bison	10.0 St	NOSM
3	Devils Lake	12.5 St	OTTP
4	Fargo	20.0 St	NOSM
		2.8 IC	NOSM
5	Garrison	400.0 Hy	USAR
6	Grand Forks	16.0 St	NOSM
7	Heskett	100.0 St	MODU
8	Kidder	20.5 St	OTTP
9	Neal, Wm. J.	38.5 St	CEPE
10	Olds, Leland	200.0 St*	BAEP
11	Stanton	172.0 St*	UNPA
12	Williston	2.0 St	MODU
		8.0 GT	MODU
13	Wood, Franklin P.	21.5 St	MIPI
		10.8 IC	MIPI

[1] 7.5 MW leased to MODU by Dakotas El. Coop., Inc.
*Under Construction

OWNERSHIP LIST

BAEP	COOP	Basin El. Coop.
CEPE	COOP	Central Pwr. El. Coop., Inc.
MIPI	COOP	Minnkota Pwr. Coop., Inc.
MODU	PRI	Montana-Dakota Util. Co.
NOSM	PRI	Northern States Power Co.
OTTP	PRI	Otter Tail Power Co.
UNPA	COOP	United Power Assoc.
USAR	FED	U. S. Army

PLANT LIST – SOUTH DAKOTA

No.	Name of Plant	MW Capacity & Type	Owner Code
1	Aberdeen	13.5 St	NOPS
2	Big Bend	234.0 Hy	USAR
		234.0 Hy*	USAR
3	Fort Randall	320.0 Hy	USAR
4	French, Ben	22.0 St	BLHP
		10.0 IC	BLHP
5	Huron	12.5 GT	BLHP
6	Kirk	31.5 St[1]	RUEP
7	Lawrence	48.0 St	NOSM
8	Mitchell	15.0 St	NOPS
9	Mobridge	8.5 St	MODU
		3.4 IC	MODU
10	Oahe	595.0 Hy	USAR
11	Pathfinder	66.0 St*	NOSM
12	Sioux Falls	15.5 St	NOSM

[1] 16.5 MW leased to Black Hills P. & L.
*Under Construction

OWNERSHIP LIST

BLHP	PRI	Black Hills P. & L.
MODU	PRI	Montana-Dakota Util. Co.
NOPS	PRI	Northwestern Pub. Serv. Co.
NOSM	PRI	Northern States Pwr. Co.
RUEP	COOP	Rushmore El. Pwr. Coop.
USAR	FED	U. S. Army

PLANT LIST – WYOMING

No.	Name of Plant	MW Capacity & Type	Owner Code
1	Acme	12.0 St	MODU
2	Alcova	36.0 Hy	USBR
3	Boysen	15.0 Hy	USBR
4	Cheyenne	10.0 IC	CHLF
6	Fremont Canyon	48.0 Hy	USBR
7	Glendo	24.0 Hy	USBR
8	Johnston, Dave	456.7 St	PAPL
9	Kortes	36.0 Hy	USBR
11	Osage	23.0 St	BLHP
		11.5 St	RUEP[1]
12	Rock Springs	25.0 St	PAPL
13	Seminoe	32.4 HY	USBR

[1] 11.5 MW leased to Black Hills P. & L.

OWNERSHIP LIST

BLHP	PRI	Black Hills P. & L.
CHLF	PRI	Cheyenne Light, Fuel & Power Co.
MODU	PRI	Montana-Dakota Utilities
PAPL	PRI	Pacific P. & L. Co.
RUEP	COOP	Rural El. Co.
USBR	FED	U. S. Bureau of Reclamation

TYPE OF OWNERSHIP

PRI	Private
COOP	Cooperative
MUN	Municipal
STATE	State
FED	Federal

POSSIBLE FUTURE HYDRO

	Name of Plant	MW Capacity
	(Montana)	
A	Allenspur	250.0
B	Buffalo Rapids	30.0
C	Fort Benton	300.0
D	Low Rocky Point	94.0
E	High Cow Creek	720.0
F	Lombard	25.0
G	Ennis	58.0
H	Hardy	19.0
I	Hebgen	12.0
J	Gibson	11.0
K	Tiber	10.0
	(Missouri)	
A	Richland	30.0
B	Rich Fountain	40.0
C	Pattonsburg	35.0
D	Pomme de Terre	16.8
E	Stockton	45.2*
F	Kaysinger Bluff	151.3[1]*

[1] Pumped Storage
*Under Construction

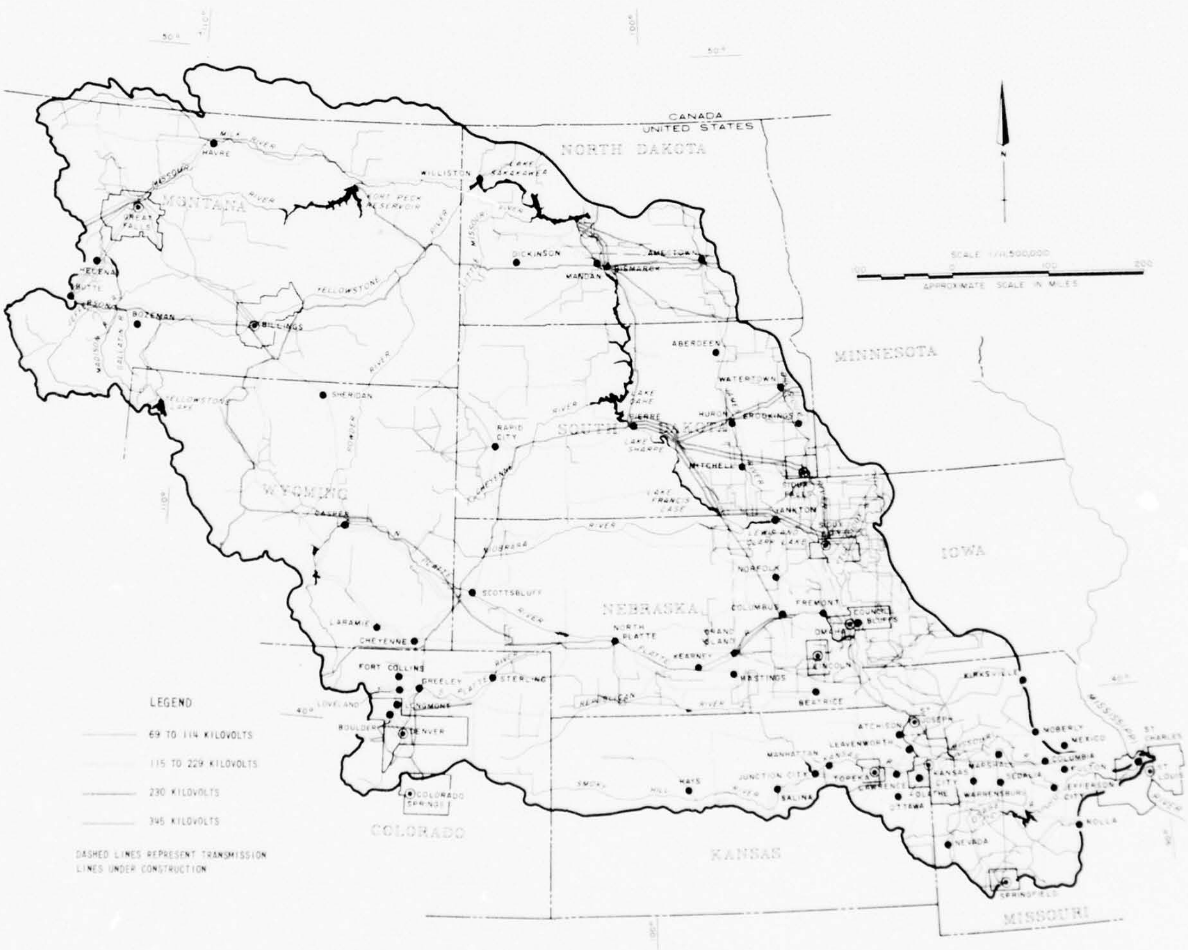
	Name of Plant	MW Capacity
	(Colorado)	
A	Elkhorn	27.4
B	Empire	28.5
C	Grant	20.0
D	Crossons	26.0
E	Resort Creek	52.0
F	Two Forks	116.0
G	Poudre	12.6
H	Sheep Creek	13.5
I	Canyon	19.8
J	Big Hill	18.6
K	Elk	13.0
L	Singleton	19.0
M	Shawnee	11.4
N	Insmont	14.2
	(Wyoming)	
A	Bald Ridge	23.0
B	Sheridan	25.0
C	Hunter Mountain	14.4
D	Thief Creek	125.2
E	Sunlight	14.9
F	Big Goose No. 2	15.0
G	Paintrock No. 2	12.0
H	Seminoe Additions	10.8
I	Pedro Mountain	18.0
J	Guernsey Additions	10.0
	(Nebraska)	
A	Kingsley	22.5
B	Northport	10.0

plants to their loads, wheeling of power from the Federal system to some of its customers, and coordination of operations of the power sources of all entities serving the basin.

As a result of coordinated planning of transmission facilities and power supplies, the first 345-kilovolt line in the Missouri River Basin was built from Kansas City to Wichita and energized at 138-kilovolts in 1967 and at 345-kilovolts in early 1968. In addition, 345-kilovolt lines from St. Louis to Kansas City were energized in the spring of 1968. A 345-kilovolt line from Kansas City to Omaha is scheduled to be energized in 1969. A line from Omaha to Sioux City and Minneapolis should be energized early in 1970. Another line is being built from the Cooper Nuclear Station on the Missouri River to Grand Island; and from Grand Island to Fort Thompson. Figure 23 shows the major transmission lines existing and under construction in the basin as of July 1969, including the 345-kilovolt lines under construction.

FIGURE 23

PRINCIPAL ELECTRIC TRANSMISSION LINES
(As of July 1969)



POWER PLANNING COORDINATION

Early in 1963, the Bureau of Reclamation and representatives of over 100 preference power systems executed the Missouri Basin Systems Group Pooling Agreement, which led to the formation of a power planning group called the Missouri Basin Systems Group (MBSG). Its planning committee conducted the first power survey of the Eastern Division of the Missouri River Basin Project power system. The results were released in late 1964 and given wide distribution.

Another power planning group, the Mid-Continent Area Power Planners (MAPP) composed of investor-owned utilities, public power districts, cooperatives, and municipals overlapping a large part of the MBSG area, has also studied the power needs of the area. A new study of broader scope has been initiated. Guidelines have been established by the MAPP-MBSG Joint Engineering Committee for conducting a reliability study for the 1970-78 period to be run concurrently with a long-range planning study for the 1975-90 period. In addition to systems within the Missouri River Basin, these studies will include adjacent systems. The objectives will be to determine what generating and transmission facilities will be needed to provide an adequate supply of low-cost power, and when and where such facilities should be located.

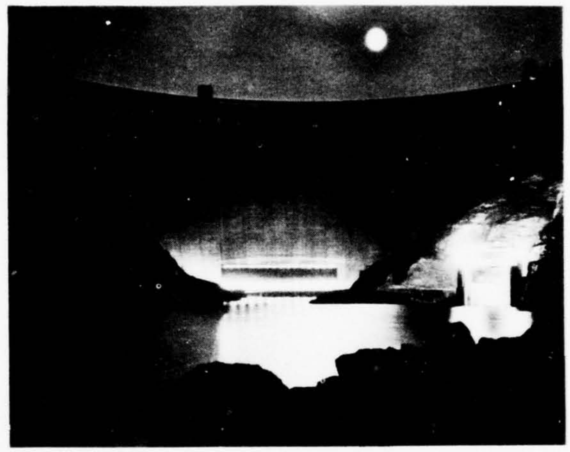
HYDROELECTRIC POWER

Present Stage

As of 1965, the hydroelectric power supply within the basin consisted of about 80 plants. These plants generated 13.7 billion kilowatt-hours, or 35 percent of the total energy requirements, and had an installed capacity of 2908 megawatts, which was 28 percent of the basin total. Of the total hydroelectric capacity existing in 1965, about 79 percent represented Federal plants which generated 75 percent of the total energy. The remaining hydroelectric power was primarily from plants of investor-owned utilities.

Disposition of power generated at Federal hydroelectric developments in the Missouri River Basin is governed by legislation and administered by the Secretary of the Interior. The Bureau of Reclamation is marketing agent for the power generated at the projects which it operates, as well as for power generated at reservoirs of the Corps of Engineers in the middle and upper Missouri River Basin. Southeastern Kansas and the State of Missouri lie within the general marketing area of the Southwestern Power Administration, and that agency has been assigned marketing responsibility for hydroelectric power from Corps' projects under construction in that general area.

The Federal hydroelectric system in the Missouri River Basin is known as the Missouri River Basin Project Power System. The system is divided into two marketing areas called the Eastern and Western Divisions. In 1965, the generating capacity of the system consisted of 22 existing plants with three others under construction. All of the authorized hydro-power plants on the main stem have been completed. The six main-stem plants, plus the Yellowtail and Canyon Ferry plants, produce the bulk of the Federal supply. Table 89 lists the names of these plants, their installed capacity, and owners. By the end of 1966, with all units in operation, the total Federal nameplate capacity in the basin was 2,720 megawatts.



Yellowtail Dam and Hydroelectric Plant, Bighorn River, Montana

In order to dispose of the large block of power produced, a large-capacity transmission system is required, connecting the major Federal power plants and interconnecting with the other major power systems within and adjacent to the marketing area. This system permits full coordination of water releases and plant generation at the several dams and the maximum output of power. It also permits integration of the hydroelectric output with the fuel-burning generating plants in the basin, so that large amounts of secondary energy are available which can be used effectively to save fuel. In addition, fuel plants can be used to supply the base load requirements of hydroelectric systems customers during adverse water years, thus effecting maximum power output and economies for the overall system.

About 9,120 miles of Federal transmission lines are completed and in service. The first Federal 345-kilovolt transmission line in the Missouri Basin is being constructed between Fort Thompson, S. Dak., and Grand Island, Nebr. This line will interconnect with another 345-kilovolt line to be built by Consumers Public Power District between Grand Island and Brownville, Nebr., and eventually will tie into a regional 345-kilovolt

Table 89 – MISSOURI BASIN POWER REGION HYDROELECTRIC PLANTS IN SERVICE AS OF DECEMBER 31, 1965

Federal – 10Mw and Over			Non-Federal – 10Mw and Over		
Plant Name	**Owner**	**Total Installed (Mw)**	**Plant Name**	**Owner**	**Total Installed (Mw)**
Big Bend	USAR	292	Black Eagle	MOPO	17
Fort Peck	USAR	165	Boulder	PSCO	20
Fort Randall	USAR	320	Cochrane	MOPO	48
Garrison	USAR	400	Columbus	LORP	40
Gavins Point	USAR	100	Hauser Lake	MOPO	17
Oahe	USAR	595	Holter	MOPO	38
Subtotal	USAR	1,872	Jeffrey Canyon	CENP	18
			Johnson Canyon #1	CENP	18
Alcova	USBR	36	Johnson Canyon #2	CENP	18
Boysen	USBR	15	Morony	MOPO	45
Canyon Ferry	USBR	50	Mystic Lake	MOPO	10
Estes	USBR	45	North Platte	PLVP	26
Flatiron	USBR	72	Osage	UNEC	176
Fremont Canyon	USBR	48	Rainbow	MOPO	36
Glendo	USBR	24	Ryan	MOPO	48
Kortes	USBR	36			
Pole Hill	USBR	33			
Seminoe	USBR	32			
Subtotal		391			
Total		2,263	Total		575
	Under 10 mw			Under 10 mw	
Miscellaneous		31	Miscellaneous		39
Total Federal		2,294[1]	Total Non-Federal		614

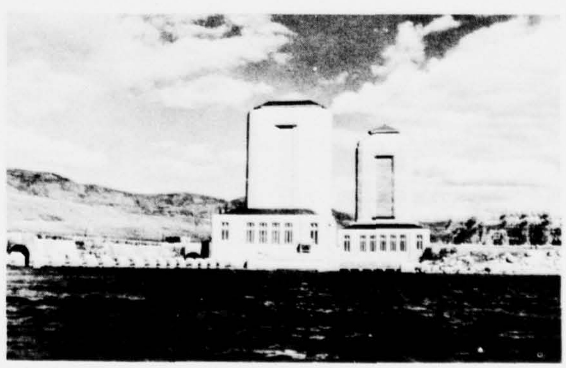
Ownership Code

CENP – State-Central Neb. P.P. & I.D.
LORP – State-Loup River P.P. Dist.
MOPO – Private-Montana Power Co.
PLVP – State-Platte Valley P.P. & I.D.
PSCO – Private-Pub. Service Co. of Colo.
UNEC – Private-Union Electric Co.
USAR – Federal-U.S. Army, Corps of Engineers
USBR – Federal-U.S. Bur. of Reclamation

[1] Additional 176 megawatts installed at Big Bend and 250 megawatts at Yellowtail plant in service during 1966. Total capacity in 1966 was 2,720 megawatts.

network. The objectives of this line are to implement long-term plans to market Federal peaking power in conjunction with installation of thermal generation by non-Federal entities, and to enhance the reliability of the Bureau's transmission network. Additional lines in the order of 345 kilovolt and possibly 500-kilovolt, are contemplated for future development. These lines would enable large lignite plants to economically distribute their output to loads scattered throughout the basin, and would also serve to reduce required reserves and to increase reliability.

The power marketing area of the Eastern Division of the Missouri River Basin Project power system includes all or parts of the States of Montana, North Dakota, South Dakota, Iowa, Nebraska, and Minnesota. The Federal power facilities in the Eastern Division consist of 6,112 circuit-miles of transmission line, the Bureau's Canyon Ferry and Yellowtail powerplants, and the Corps of Engineers' main-stem powerplants. The power marketing area of the Western Division includes those parts of Colorado and Wyoming in the Missouri River Basin and part of Nebraska. Within the basin, the Federal power facilities in the Western Division include 3,000 circuit-miles of transmission line; Kortes, Glendo, and Boysen Powerplants; and the integrated Colorado-Big Thompson, Kendrick, North Platte, Shoshone, and Riverton Project Powerplants.



Fort Peck Hydroelectric Plant, Missouri River, Montana

The coordination of the generation and operation of the powerplants in the Eastern Division is controlled by the Bureau of Reclamation's Central Power System Operations Office at Watertown, S. Dak. An extensive communication system and automatic control equipment regulate power generation and distribution to customers throughout the Eastern Division marketing area. System dispatchers at Watertown, S. Dak., Jamestown, N. Dak., and Fort Peck, Mont., coordinate the operation of the power system and are in constant touch with their counterparts in adjacent power systems, coordinating activities to achieve maximum efficiency in operations.

Close coordination is maintained between the Bureau of Reclamation's Power System Operations Office at Watertown and the Corps of Engineers' Reservoir Control Center in Omaha. The control center in Omaha establishes the water releases to be made from each reservoir, taking into account firm power loads and marketing opportunities for nonfirm power in order to insure maximum efficiency in power generation compatible with the other multiple-purpose operations of the reservoirs. The Bureau of Reclamation's Control Center in Billings establishes the water releases to be made from the Canyon Ferry and Yellowtail plants.

System operation for the Western Division is coordinated at the Upper Platte System Dispatching Office at Flatiron near Loveland, Colo. The power systems of the Colorado-Big Thompson, Kendrick, Riverton, Shoshone, and North Platte projects are integrated with the Missouri River Basin Project power system for the purpose of marketing the power produced from these projects, with the Western Division acting as the marketing agent.

Potential Utilization

Several studies have been made to consider the coordination of the hydroelectric plants with large lignite-fueled plants being planned for development in the area. The thermal plants would firm up the hydroelectric plants, permitting use of a portion of the hydroelectric power for peaking. Under this plan summer peaking power is being sold to Nebraska and winter peaking power to northern cooperatives. This takes advantage of the seasonal diversity potential which exists between the northern and the southern portions of the basin. Because of the detailed analyses required for testing the feasibility of expanding this type of arrangement, plans for further integration of hydro and thermal resources are beyond the scope of this study.

The potential future hydroelectric projects assumed herein would increase the total hydroelectric supply to about 6,000 megawatts, with average annual generation of 23 billion kilowatt-hours by 1980, although planning studies may show some of this to be impracticable of development. Estimates of future projects were based strictly on past studies and are therefore tentative. These assumed projects were used only to ascertain the amounts of thermal energy required in the future for the purpose of estimating water needs for thermal power production. This determination was made by deducting the estimated hydroelectric production from the projected total energy requirements. The amount of hydroelectric power involved is small in relation to total requirements and has only a minor effect on future water requirements for the thermal-electric generation. The total of the existing and assumed potential hydroelectric power supply for 1980 through 2020 is shown by PSA's in table 90.

Table 90 – MISSOURI BASIN POWER REGION HYDROELECTRIC POWER SUPPLY 1980 THROUGH 2020

PSA	Installed Capacity (Mw)	Average Annual Energy (Million Kwh)
15	251	590
16	---	---
17	---	---
26	---	---
27	2,080	8,878
28	138	576
29	3	12
30	2,067	7,134
31	510	2,313
32	878	2,957
34	248	419
Total	6,175	22,879

PROJECTED ELECTRIC POWER REQUIREMENTS AND SUPPLY

Composition of Supply and Projected Requirements

Thermal-electric plants now comprise about 70 percent of all the electric generating capacity in the MRB Power Region, and that proportion is expected to increase by 1980. Predictions of the patterns of generation beyond 1980 or 1985 are complicated by several factors, not the least of which is the accuracy of predicted total requirements for energy beyond these dates. The electric power industry is one of the most dynamic in the United States, having experienced an annual growth rate of between 6 and 7 percent for a number of years. The technology of electric generation and supply is changing rapidly with the advent of larger and larger units made possible by the rapid growth, the increasing reliance on extra high-voltage transmission, the construction of mine-mouth generation, the utilization of unit-type coal trains, and the large increase in the number of scheduled nuclear-fueled plants. New methods of generating power could eliminate the conventional heat cycle and thus eliminate the need for cooling water. Among the most promising of these are MHD or magnetohydrodynamics; EGD or electrogasdynamics; thermionic generation; and the fuel cell.

Projections of future power requirements through 1990 in the power region were completed by Regional Advisory Committees appointed to assist the Federal Power Commission in updating the National Power Survey. Thus, these projections are not based on material included in the Economic Base Survey for the Missouri River Basin, although similar basic information was used in making the projections. In general, the Regional Advisory Committees, which are composed of representatives from all segments of the utility industry in the respective regions, relied, for the most part, on projections made by and with the advice of the major utilities operating in the region. These estimates were supplemented as necessary to achieve full regional coverage, and the individual estimates and totals were rechecked with the industry utilities and were ultimately agreed upon. The energy and load data were checked for consistency, and the energy projections were also tested with population projections of the Census Bureau. Estimates for the period 1990 to 2020 were completed by the FPC staff, based on the Regional Advisory Committee estimates to 1990.

As stated previously, the potential future hydroproduction was determined by a subcommittee on hydroelectric power. Economic feasibility has not been established for the potential projects, and consequently the amounts of hydropower deduced from the total power requirements may be different than the amount ultimately found feasible of development.

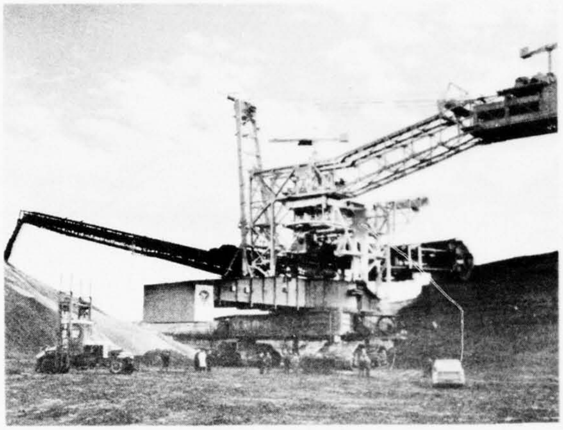
Table 91 shows the thermal requirements and supply by FPC power supply areas for the years 1965, 1980, 2000, and 2020. It reflects the approved (1968) load projections by the FPC's Regional Advisory Committee and shows the amounts of thermally generated power which will be required in each power supply area. The plant locations cannot conform entirely to this geographic pattern of requirements, because the surplus of hydroelectric and fossil fuel resources in some areas may be utilized in others. For instance, the installed capacity in PSA 27 is considerably larger than load requirements, because power from the Federal hydroelectric plants is marketed in several other PSA's. In addition, vast reserves of lignite lie close to the surface in the western half of North Dakota and in several counties of eastern Montana and Wyoming. This fuel can be strip-mined at low cost and exhibits great promise as a boiler fuel. It is probable that large developments of lignite-fueled

Table 91 – MISSOURI BASIN POWER REGION EXISTING AND PROJECTED THERMAL REQUIREMENTS AND SUPPLY

Capacity	PSA 15	16	17	26	27	28	29	30	31	32	34	Total
						Thermal Capacity (Mw)						
						1965						
Required	295	201	2,585	482	(1,090)[1]	1,642	993	281	345	1,136	565	7,435
Installed	238	104	1,790	219	414	1,308	826	69	583	1,096	788	7,435
						1980						
Required	1,037	570	6,110	840	86	4,867	2,597	(882)[1]	1,180	2,352	1,712	20,469
Installed	1,037	314	3,804	577	3,600	3,083	2,597	338	1,055	2,352	1,712	20,469
						2000						
Required	3,715	1,808	17,865	2,854	4,768	14,394	5,717	1,663	4,710	8,412	5,092	70,998
Installed	3,715	1,448	13,512	2,042	13,100	11,587	5,717	1,663	4,710	8,412	5,092	70,998
						2020						
Required	7,376	3,584	34,126	6,250	11,282	28,075	9,257	8,013	8,370	15,922	9,172	141,427
Installed	7,376	2,787	23,777	4,781	32,700	19,272	9,257	8,013	8,370	15,922	9,172	141,427
						Thermal Energy (Million Kilowatt-Hours)						
						1965						
Required	864	832	11,152	1,730	(4,960)[1]	5,264	2,675	388	1,801	4,455	1,472	25,673
Installed	757	216	5,596	376	1,283	4,000	2,851	170	1,859	4,416	4,149	25,673
						1980						
Required	4,310	2,800	25,000	2,500	622	17,524	10,038	(834)[1]	6,517	12,673	7,581	88,731
Installed	4,310	1,885	17,100	2,500	15,637	10,774	10,038	266	5,967	12,673	7,581	88,731
						2000						
Required	14,610	8,900	78,700	11,400	21,222	52,524	26,688	13,866	25,417	43,843	22,381	319,551
Installed	14,610	7,185	64,600	7,300	52,037	41,624	26,688	13,866	25,417	43,843	22,381	319,551
						2020						
Required	29,110	17,500	154,000	27,800	50,022	103,424	44,188	46,866	45,537	83,743	41,581	643,771
Installed	29,110	15,200	130,600	23,500	105,037	78,409	44,188	46,866	45,537	83,743	41,581	643,771

[1] Surplus hydro

thermal plants will be realized between 1980 and 2020. In consequence, large amounts of power from lignite-fueled plants in PSA 27 may be transmitted to other areas.



Giant Mining Wheel in Operation Near Stanton, N. Dak. Used Here To Remove Overburden From Lignite Beds

The subsequent tables showing installed capacity by PSA's and subbasins were predicated on the above assumptions of utilization of lignite and hydroelectric resources at distant load areas; however, recent studies by an FPC Regional Advisory Committee indicate that more nuclear generating capacity may be installed in PSA 28 than shown herein. This would reduce the lignite development projected in PSA 27. Because the studies are not completed, the tables represent the best data available at this time. Preliminary findings of the committee indicate that there would not be any material effect on the basin.

Before determination of the thermal power required, an allowance was made for importation of power from the proposed Nelson River Hydroelectric Power Project in Manitoba, Canada. This development is under active consideration and, therefore, imports of 300 megawatts in 1980 and 400 megawatts in 2000 have been included. Also, it has been assumed that by 2020 the net import will be zero, inasmuch as the power may then be required for markets within Canada.

Because the thermal-electric plant cooling requirements differ somewhat with different types of fuel, estimates were made of the amounts of power in kilowatt-hours to be produced by each type of thermal plant shown in table 92. The projected composition of the future thermal-electric power supply shown in this table reflects the consensus of the advisory group which was appointed to render assistance on this and other related matters. The trend toward the increasing number of nuclear generating plants has been taken into account in the projection of the future power supply. An allowance was made for development of new "exotic" types not requiring condensing water, of which MHD (magnetohydrodynamics) appears the most promising. Included in the "noncondensing" category are internal combustion plants, many of which were installed early in the development of the power industry. Expansion of transmission systems and increasing coordination among utilities should permit utilization of larger and more efficient steam units. This would result in the phasing out (by obsolescence) of the small internal-combustion plants. This accounts for the reduction in the non-condensing type of plant from 1965 to 1980. In subsequent years, MHD and gas turbines constitute the plants shown as "noncondensing type" in the table.

Tables 93 and 94 present by PSA's and subbasins the existing and projected thermal-electric generation requiring condenser cooling water by type of cooling system. Tables 95 through 98 summarize the existing and projected power requirements and supply in each PSA and subbasin.

Table 92 – COMPOSITION OF THE THERMAL ELECTRIC POWER SUPPLY IN THE MISSOURI BASIN POWER REGION

Type of Generation	1965			1980			2000			2020		
	Energy Production	Capacity Factor	Capacity	Energy Production	Capacity Factor	Capacity	Energy Production	Capacity Factor	Capacity	Energy Production	Capacity Factor	Capacity
	(Million Kwh)		(Mw)	(Million Kwh)		(Mw)	(Million Kwh)		(Mw)	(Million Kwh)		(Mw)
PSA 15												
Noncondensing types	40	0.09	53	None	---	---	None	---	---	6,000	0.80	850
Nuclear	None	---	---	None	---	---	7,100	0.81	1,000	19,000	0.72	3,000
Lignite	None	---	---	None	---	---	None	---	---	None	---	---
Bituminous coal and natural gas	717	0.44	185	4,310	0.47	1,037	7,510	0.31	2,715	4,110	0.13	3,526
Total	757	0.36	238	4,310	0.47	1,037	14,610	0.45	3,715	29,110	0.45	7,376
PSA 16												
Noncondensing types	2	0.01	20	None	---	---	None	---	---	None	---	---
Nuclear	None	---	---	None	---	---	4,600	0.79	660	13,000	0.76	1,950
Lignite	None	---	---	None	---	---	None	---	---	None	---	---
Bituminous coal and natural gas	214	0.29	84	1,885	0.68	314	2,585	0.37	788	2,200	0.30	837
Total	216	0.24	104	1,885	0.68	314	7,185	0.56	1,448	15,200	0.62	2,787
PSA 17												
Noncondensing types	89	0.07	140	None	---	---	4,200	0.80	600	30,000	0.76	4,500
Nuclear	None	---	---	5,600	0.80	800	52,000	0.76	7,800	91,000	0.76	13,600
Lignite	None	---	---	None	---	---	None	---	---	None	---	---
Bituminous coal and natural gas	5,507	0.38	1,650	11,500	0.44	3,004	8,400	0.19	5,112	9,600	0.19	5,677
Total	5,596	0.36	1,790	17,100	0.51	3,804	64,600	0.54	13,512	130,600	0.62	23,777
PSA 26												
Noncondensing types	1	---	49	None	---	---	None	---	---	None	---	---
Nuclear	None	---	---	None	---	---	4,600	0.75	700	18,500	0.78	2,700
Lignite	375	0.25	170	2,500	0.49	577	2,700	0.23	1,342	5,000	0.27	2,081
Bituminous coal and natural gas	---	---	---	None	---	---	None	---	---	None	---	---
Total	376	0.20	219	2,500	0.49	577	7,300	0.41	2,042	23,500	0.56	4,781
PSA 27												
Noncondensing types	53	0.07	85	None	---	---	None	---	---	None	---	---
Nuclear	None	---	---	None	---	---	None	---	---	None	---	---
Lignite	664	0.40	188	15,637	0.49	3,600	52,037	0.45	13,100	105,037	0.36	32,700
Bituminous coal and natural gas	566	0.46	141	None	---	---	None	---	---	None	---	---
Total	1,283	0.35	414	15,637	0.49	3,600	52,037	0.45	13,100	105,037	0.36	32,700
PSA 28												
Noncondensing types	235	0.18	147	None	---	---	4,200	0.80	600	20,000	0.76	3,000
Nuclear	None	---	---	5,700	0.50	1,300	36,300	0.50	8,300	52,900	0.41	14,540
Lignite	None	---	---	None	---	---	None	---	---	None	---	---
Bituminous coal and natural gas	3,765	0.37	1,161	5,074	0.32	1,783	1,124	0.05	2,687	5,509	0.36	1,732
Total	4,000	0.35	1,308	10,774	0.40	3,083	41,624	0.41	11,587	78,409	0.46	19,272
PSA 29												
Noncondensing types	234	0.18	146	None	---	---	None	---	---	None	---	---
Nuclear	None	---	---	3,550	0.81	500	13,350	0.76	2,000	37,000	0.77	5,500
Lignite	None	---	---	None	---	---	None	---	---	None	---	---
Bituminous coal and natural gas	2,617	0.44	680	6,488	0.35	2,097	13,338	0.41	3,717	7,188	0.22	3,757
Total	2,851	0.39	826	10,038	0.44	2,597	26,688	0.53	5,717	44,188	0.54	9,257
PSA 30												
Noncondensing types	None	---	---	None	---	---	None	---	---	None	---	---
Nuclear	None	---	---	None	---	---	None	---	---	23,200	0.80	3,300
Lignite	None	---	---	None	---	---	6,900	0.95	830	15,600	0.57	3,100
Bituminous coal and natural gas	170	0.28	69	266	0.09	338	6,966	0.95	833	8,066	0.57	1,613
Total	170	0.28	69	266	0.09	338	13,866	0.95	1,663	46,866	0.66	8,013
PSA 31												
Noncondensing types	47	0.13	42	None	---	---	None	---	---	None	---	---
Nuclear	None	---	---	None	---	---	None	---	---	20,000	0.76	3,000
Lignite	None	---	---	None	---	---	None	---	---	None	---	---
Bituminous coal and natural gas	1,182	0.38	541	5,967	0.64	1,055	25,417	0.61	4,710	25,537	0.54	5,370
Total	1,859	0.36	583	5,967	0.64	1,055	25,417	0.61	4,710	45,537	0.62	8,370
PSA 32												
Noncondensing types	9	0.06	18	None	---	---	5,000	0.71	800	20,100	0.79	2,900
Nuclear	None	---	---	2,480	0.81	350	14,000	0.80	2,000	43 300	0.77	6,400
Lignite	None	---	---	None	---	---	None	---	---	None	---	---
Bituminous coal and natural gas	4,407	0.47	1,078	10,193	0.58	2,002	24,843	0.50	5,612	20,343	0.35	6,622
Total	4,416	0.46	1,096	12,673	0.61	2,352	43,843	0.59	8,412	83,743	0.60	15,922
PSA 34												
Noncondensing types	44	0.21	25	None	---	---	None	---	---	None	---	---
Nuclear	None	---	---	None	---	---	None	---	---	20,000	0.76	3,000
Lignite	None	---	---	None	---	---	None	---	---	None	---	---
Bituminous coal and natural gas	4,105	0.39	763	7,581	0.50	1,712	22,381	0.50	5,092	21,581	0.38	6,172
Total	4,149	0.37	788	7,581	0.50	1,712	22,381	0.50	5,092	41,581	0.52	9,172
Total Power Region												
Noncondensing types	754	0.12	725	None	---	---	13,400	0.76	2,000	76,100	0.77	11,250
Nuclear	None	---	---	17,750	0.67	3,010	131,950	0.67	22,460	337,900	0.67	56,990
Lignite	1,039	0.33	358	18,137	0.49	4,177	61,637	0.46	15,272	125,637	0.38	37,881
Bituminous coal and natural gas	23,880	0.43	6,352	52,844	0.45	13,282	112,564	0.41	31,266	104,134	0.34	35,306
Total	25,673	0.39	7,435	88,731	0.49	20,469	319,551	0.51	70,998	643,771	0.52	141,427

Table 93 – MISSOURI BASIN POWER REGION THERMAL-ELECTRIC GENERATION BY TYPE OF COOLING BY PSA'S

PSA	Flow Through	Cooling Pond	Wet Cooling Tower	Dry Cooling Tower	Total
			(Million Kwh)		
			1965		
15	586	---	131	---	717
16	40	---	174	---	214
17	4,695	---	812	---	5,507
26	205	38	132	---	375
27	660	---	570	---	1,230
28	3,330	63	372	---	3,765
29	63	---	2,554	---	2,617
30	170	---	---	---	170
31	1,812	---	---	---	1,812
32	851	---	3,556	---	4,407
34	644	3,274	187	---	4,105
Total	13,056	3,375	8,488	---	24,919
			1980		
15	3,130	---	1,180	---	4,310
16	710	---	1,175	---	1,885
17	6,300	3,200	7,600	---	17,100
26	950	150	1,400	---	2,500
27	6,157	4,000	5,480	---	15,637
28	5,210	---	5,564	---	10,774
29	---	1,200	8,838	---	10,038
30	266	---	---	---	266
31	2,967	900	2,100	---	5,967
32	1,183	3,200	8,280	---	12,673
34	780	3,351	3,450	---	7,581
Total	27,663	16,001	45,067	---	88,731
			2000		
15	4,550	---	10,060	---	14,610
16	2,800	885	3,500	---	7,185
17	6,600	3,500	50,300	---	60,400
26	3,000	---	4,300	---	7,300
27	8,460	17,000	26,577	---	52,037
28	7,874	9,000	20,550	---	37,424
29	---	4,838	21,850	---	26,688
30	7,066	---	6,800	---	13,866
31	3,072	2,615	14,130	5,600	25,417
32	678	10,665	27,500	---	38,843
34	1,700	9,681	11,000	---	22,381
Total	45,800	58,184	196,567	5,600	306,151
			2020		
15	5,500	---	17,610	---	23,110
16	6,250	750	8,200	---	15,200
17	8,000	4,000	88,600	---	100,600
26	4,640	---	18,860	---	23,500
27	9,675	34,000	61,362	---	105,037
28	9,579	14,000	34,830	---	58,409
29	---	3,588	40,600	---	44,188
30	7,166	6,000	33,700	---	46,866
31	3,675	8,000	24,152	9,710	45,537
32	---	13,043	50,600	---	63,643
34	1,500	20,181	19,900	---	41,581
Total	55,985	103,562	398,414	9,710	567,671

Table 94 — MISSOURI BASIN POWER REGION THERMAL-ELECTRIC GENERATION BY TYPE OF COOLING, BY SUBBASINS

Subbasin	Flow Through	Cooling Pond	Wet Cooling Tower	Dry Cooling Tower	Total
	(Million Kwh)				
	1965				
Upper Missouri	---	---	---	---	---
Yellowstone	531	---	---	---	531
Western Dakota	324	---	461	---	785
Eastern Dakota	81	---	280	---	361
Platte-Niobrara	3,374	---	3,866	---	7,240
Middle Missouri	4,190	---	597	---	4,787
Kansas	80	63	2,554	---	2,697
Lower Missouri	4,312	3,274	598	---	8,184
Missouri Basin	12,892	3,337	8,356	---	24,585
Red River	164	38	132	---	334
Power Region	13,056	3,375	8,488	---	24,919
	1980				
Upper Missouri	1,337	800	1,096	---	3,233
Yellowstone	3,491	1,650	2,694	---	7,835
Western Dakota	2,463	1,600	2,192	---	6,255
Eastern Dakota	1,659	475	2,188	---	4,322
Platte-Niobrara	4,760	3,650	11,785	---	20,195
Middle Missouri	6,418	1,840	6,986	---	15,244
Kansas	---	960	9,225	---	10,185
Lower Missouri	7,060	4,951	8,201	---	20,212
Missouri Basin	27,188	15,926	44,367	---	87,481
Red River	475	75	700	---	1,250
Power Region	27,663	16,001	45,067	---	88,731
	2000				
Upper Missouri	4,518	3,400	8,035	---	15,953
Yellowstone	8,314	6,408	19,119	2,800	36,641
Western Dakota	3,384	6,800	10,630	---	20,814
Eastern Dakota	4,586	2,408	7,608	---	14,602
Platte-Niobrara	2,761	15,572	45,617	2,800	66,750
Middle Missouri	11,187	6,494	34,263	---	51,944
Kansas	---	5,671	23,164	---	28,835
Lower Missouri	9,550	11,431	45,981	---	66,962
Missouri Basin	44,300	58,184	194,417	5,600	302,501
Red River	1,500	---	2,150	---	3,650
Power Region	45,800	58,184	196,567	5,600	306,151
	2020				
Upper Missouri	4,801	9,200	25,752	---	39,753
Yellowstone	9,628	17,800	50,118	4,855	82,401
Western Dakota	3,870	13,600	24,545	---	42,015
Eastern Dakota	8,287	4,000	22,126	---	34,413
Platte-Niobrara	1,250	22,643	81,256	4,855	110,004
Middle Missouri	14,829	8,467	62,245	---	85,541
Kansas	---	5,671	41,361	---	47,032
Lower Missouri	11,000	22,181	81,581	---	114,762
Missouri Basin	53,665	103,562	388,984	9,710	555,921
Red River	2,320	---	9,430	---	11,750
Power Region	55,985	103,562	398,414	9,710	567,671

Table 95 – MISSOURI BASIN POWER REGION SUMMARY OF EXISTING AND PROJECTED POWER REQUIREMENTS

PSA	1965	1980	2000	2020
		Annual Peak Load (Mw)		
15	345	1,130	3,510	6,810
16	165	500	1,600	3,200
17	1,907	5,360	15,810	30,470
26	340	1,000	2,880	5,580
27	627	1,900	6,060	11,930
28	1,444	4,390	12,860	25,190
29	847	2,280	5,060	8,270
30	439	1,040	3,300	9,000
31	443	1,480	4,620	7,930
32	995	2,830	8,220	15,000
34	542	1,720	4,730	8,410
Total[1]	8,094	23,630	68,650	131,790
		Annual Energy Requirements (Million Kwh)		
15	1,541	4,900	15,200	29,700
16	822	2,800	8,900	17,500
17	8,540	25,000	78,700	154,000
26	1,645	4,600	14,200	27,800
27	3,471	9,500	30,100	58,900
28	5,957	18,100	53,100	104,000
29	3,712	10,050	26,700	44,200
30	2,582	6,300	21,000	54,000
31	2,668	8,830	27,730	47,850
32	5,176	15,630	46,800	86,700
34	2,516	8,000	22,800	42,000
Total	38,630	113,710	345,230	666,650

[1]Non-coincident

Table 96 – MISSOURI BASIN POWER REGION SUMMARY OF EXISTING AND PROJECTED POWER SUPPLY

PSA	Installed Capacity (Mw)				Energy Produced (Million Kwh)			
	1965	1980	2000	2020	1965	1980	2000	2020
15								
Hydro	176	251	251	251	582	590	590	590
Thermal	238	1,037	3,715	7,376	757	4,310	14,610	29,110
Total	414	1,288	3,966	7,627	1,339	4,900	15,200	29,700
16								
Hydro	---	---	---	---	---	---	---	---
Thermal	104	314	1,448	2,787	216	1,885	7,185	15,200
Total	104	314	1,448	2,787	216	1,885	7,185	15,200
17								
Hydro	---	---	---	---	---	---	---	---
Thermal	1,790	3,804	13,512	23,777	5,596	17,100	64,600	130,600
Total	1,790	3,804	13,512	23,777	5,596	17,100	64,600	130,600
26								
Hydro	---	---	---	---	---	---	---	---
Thermal	219	577	2,042	4,781	376	2,500	7,300	23,500
Total	219	577	2,042	4,781	376	2,500	7,300	23,500
27								
Hydro	1,874	2,080	2,080	2,080	8,432	8,878	8,878	8,878
Thermal	414	3,600	13,100	32,700	1,283	15,637	52,037	105,037
Total	2,288	5,680	15,180	34,780	9,715	24,515	60,915	113,915
28								
Hydro	138	138	138	138	548	576	576	576
Thermal	1,308	3,083	11,587	19,272	4,000	10,774	41,624	78,409
Total	1,446	3,221	11,725	19,410	4,548	11,350	42,200	78,985
29								
Hydro	2	3	3	3	12	12	12	12
Thermal	826	2,597	5,717	9,257	2,851	10,038	26,688	44,188
Total	828	2,600	5,720	9,260	2,863	10,050	26,700	44,200
30								
Hydro	318	2,067	2,067	2,067	2,507	7,134	7,134	7,134
Thermal	69	338	1,663	8,013	170	266	13,866	46,866
Total	387	2,405	3,730	10,080	2,677	7,400	21,000	54,000
31								
Hydro	209	510	510	510	867	2,313	2,313	2,313
Thermal	583	1,055	4,710	8,370	1,859	5,967	25,417	45,537
Total	792	1,565	5,220	8,880	2,726	8,280	27,730	47,850
32								
Hydro	186	878	878	878	698	2,957	2,957	2,957
Thermal	1,096	2,352	8,412	15,922	4,416	12,673	43,843	83,743
Total	1,282	3,230	9,290	16,800	5,114	15,630	46,800	86,700
34								
Hydro	5	248	248	248	11	419	419	419
Thermal	788	1,712	5,092	9,172	4,149	7,581	22,381	41,581
Total	793	1,960	5,340	9,420	4,160	8,000	22,800	42,000
Total Power Region								
Hydro	2,908	6,175	6,175	6,175	13,657	22,879	22,879	22,879
Thermal	7,435	20,469	70,998	141,427	25,673	88,731	319,551	643,771
Total	10,343	26,644	77,173	147,602	39,330	111,610	342,430	666,650

Table 97 – MISSOURI BASIN POWER REGION SUMMARY OF EXISTING AND PROJECTED POWER REQUIREMENTS BY SUBBASINS

Subbasin	1965	1980	2000	2020
		Annual Peak Load (Mw)		
Upper Missouri	290	800	2,160	3,800
Yellowstone	262	760	2,250	4,340
Western Dakota	292	770	2,120	3,850
Eastern Dakota	655	1,680	4,560	8,200
Platte-Niobrara	1,906	6,620	21,090	43,570
Middle Missouri	1,272	3,180	8,490	15,230
Kansas	881	2,300	6,190	10,960
Lower Missouri	2,176	6,470	18,780	35,980
Missouri Basin	7,734	22,580	65,640	125,930
Red River	360	1,050	3,050	5,860
Power Region	8,094	23,630	68,690	131,790
		Annual Energy Requirements (Million Kwh)		
Upper Missouri	1,384	3,830	10,840	19,200
Yellowstone	1,252	3,660	11,320	21,930
Western Dakota	1,395	3,720	10,630	19,470
Eastern Dakota	3,127	8,100	22,920	41,460
Platte-Niobrara	9,102	31,860	106,060	220,400
Middle Missouri	6,068	15,280	42,710	77,060
Kansas	4,209	11,070	31,140	55,460
Lower Missouri	10,393	31,140	94,250	182,000
Missouri Basin	36,930	108,660	329,870	636,980
Red River	1,700	5,050	15,360	29,670
Power Region	38,630	113,710	345,230	666,650

Table 98 – MISSOURI BASIN POWER REGION SUMMARY OF EXISTING AND PROJECTED POWER SUPPLY BY SUBBASINS

Subbasin	Installed Capacity (Mw) 1965	1980	2000	2020	Energy Produced (Million Kwh) 1965	1980	2000	2020
UpperMissouri								
Hydro	472	1,722	1,722	1,722	3,979	6,282	6,282	6,282
Thermal	---	855	3,285	9,745	---	3,233	15,953	39,753
Total	472	2,577	5,007	11,467	3,979	9,515	22,235	46,035
Yellowstone								
Hydro	38	798	798	798	270	3,335	3,335	3,335
Thermal	150	1,811	7,288	18,803	532	7,835	36,640	82,400
Total	188	2,609	8,086	19,601	802	11,170	39,975	85,735
Western Dakota								
Hydro	1,014	1,189	1,189	1,189	4,536	4,594	4,594	4,594
Thermal	228	1,440	5,240	13,080	785	6,255	20,815	42,015
Total	1,242	2,629	6,429	14,269	5,321	10,849	25,409	46,609
Eastern Dakota								
Hydro	595	595	595	595	1,800	2,455	2,455	2,455
Thermal	246	900	3,489	7,891	415	4,322	14,602	34,414
Total	841	1,495	4,084	8,486	2,215	6,777	17,057	36,869
Platte-Niobrara								
Hydro	503	1,267	1,267	1,267	1,896	4,555	4,555	4,555
Thermal	2,100	4,234	15,519	27,938	7,374	20,195	73,430	138,104
Total	2,603	5,501	16,786	29,205	9,270	24,750	77,985	142,659
Middle Missouri								
Hydro	100	100	100	100	566	631	631	631
Thermal	1,408	3,717	12,824	22,006	4,924	15,245	55,725	108,542
Total	1,508	3,817	12,924	22,106	5,490	15,876	56,356	109,173
Kansas								
Hydro	5	5	5	5	18	18	18	18
Thermal	904	2,695	6,891	11,260	2,961	10,184	29,674	51,031
Total	909	2,700	6,896	11,265	2,979	10,202	29,692	51,049
Lower Missouri								
Hydro	181	499	499	499	592	1,009	1,009	1,009
Thermal	2,211	4,529	15,441	28,314	8,348	20,212	69,062	135,762
Total	2,392	5,028	15,940	28,813	8,940	21,221	70,071	136,771
Missouri Basin								
Hydro	2,908	6,175	6,175	6,175	13,657	22,879	22,879	22,879
Thermal	7,247	20,181	69,977	139,037	25,339	87,481	315,901	632,021
Total	10,155	26,356	76,152	145,212	38,996	110,360	338,780	654,900
Red River								
Hydro	---	---	---	---	---	---	---	---
Thermal	188	288	1,021	2,390	334	1,250	3,650	11,750
Total	188	288	1,021	2,390	334	1,250	3,650	11,750
Power Region								
Hydro	2,908	6,175	6,175	6,175	13,657	22,879	22,879	22,879
Thermal	7,435	20,469	70,998	141,427	25,673	88,731	319,551	643,771
Total	10,343	26,644	77,173	147,602	39,330	111,610	342,430	666,650

WATER REQUIREMENTS

Criteria for Cooling Water

The principal demand imposed upon water supply by steam-electric generating plants is for condenser cooling purposes. Water introduced into the boilers is converted into steam to drive the turbogenerator units. Steam leaving the turbines at less than atmospheric pressure is passed through the condensers where it is cooled and condensed. The condensate is pumped back into the boilers in a closed-circuit system. Thus, the only consumptive use in the boiler circuit is the feedwater make-up required to replace water losses. Losses are quite small and the requirement for a 1,000 megawatt plant operating at full load is estimated to be only 0.5 cubic foot per second; however, a large separate flow through the condensers is required to carry away the waste heat of condensation. Essentially no water is used consumptively in the condensers but some losses occur when condenser flows are returned to the source bodies of water at higher temperatures, or are passed through cooling towers.

Withdrawals of water for cooling at steam-electric plants currently constitute the largest nonagricultural diversion of water. Either fresh or saline water can be used for this purpose and, in some cases, sewage treatment plant effluents are used. The amount of water required through the condensers depends upon the type of plant, its efficiency, and the designed permissible temperature rise within the condensers. The temperature rise of cooling water in the condenser is usually in the range of 10 to 20 degrees Fahrenheit. Currently, a large nuclear steam-electric plant requires about 50 percent more condenser water for a given temperature rise than a fossil-fueled steam-electric plant of equal size. By 1980, this added requirement is expected to decrease substantially. Such higher requirements result from the lower throttle steam temperatures and the resultant lower operating efficiencies of nuclear plants.

Steam-Electric Plant Heat Requirements

Condenser cooling water use is considered in two categories — first, the amount of water which is required to flow through a condenser to produce an acceptable high vacuum; and second, the amount of cooling water which evaporates as a result of the increase in its temperature. Either or both of these requirements could be critical in designing, and selecting the site, for a powerplant.

For the purpose of analysis, heat requirements of steam-electric plants are divided into the following elements:

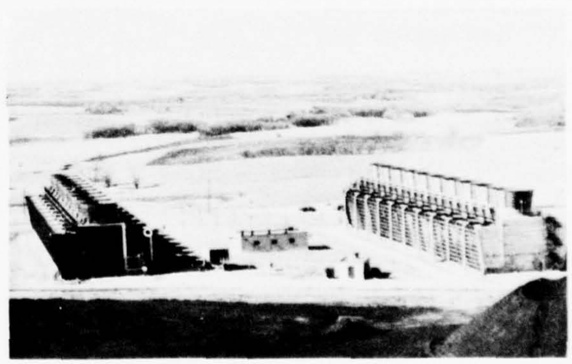
Heat loss from boiler furnace (negligible for nuclear plants)
Heat loss from electric generator
Heat equivalent of electric generator output
Heat energy remaining in steam leaving the turbine

The total fuel energy required per kilowatt-hour generated is determined by dividing the heat equivalent of 1 kilowatt-hour (3413 Btu) by the thermal efficiency of the plant. The heat energy which must be discharged to the condenser per kilowatt-hour generated is then determined by deducting the sum of the heat equivalent of 1 kilowatt-hour plus the boiler furnace heat loss from the total fuel energy required per kilowatt-hour. Because the total fuel energy required is normally given as a net heat rate, the heat equivalent of 3650 Btu/net kilowatt-hour (which includes a nominal 7 percent plant use) is deducted from the fuel energy rather than the 3413 Btu figure.

Factors Utilized in Determination of Water Requirements and Consumptive Use

Because thermal-electric plant cooling water requirements vary inversely with the plant efficiency, estimates have been made of the net heat rates for each type of thermal plant expected to be installed in the basin. These following heat rates reflect the consensus of an advisory group appointed to render assistance on this and other related matters:

Type of Plant	Heat Rates in Btu/Net Kwh			
	1965	1980	2000	2020
Coal- or Gas-Fueled Plants	11,900	9,500	8,500	8,000
Lignite-Fueled Plants	14,400	10,500	9,500	9,000
Nuclear-Fueled Plants	---	9,500	8,000	7,500



Cooling Towers At A 225-Megawatt Steam-Electric Station

Eighteen major electric utilities which operate in the Missouri River Basin and Upper Mississippi Basin furnished information relative to current practice and experiences in steam condensing at thermal-electric plants. These utilities reported their own experience and, in several instances, furnished copies of technical papers on the subject. They revealed wide differences in operating experience, especially in the water consumption rate of cooling towers.

Because of the wide variance in the consumptive use of water by cooling towers and ponds, as indicated by the reports, an advisory subcommittee was requested to recommend typical factors for use in calculating future condensing-water requirements.

The subcommittee's recommendations resulted in the use of the following as typical factors:

1. Flow rate of cooling water
   ---550 gallons per minute per megawatt for fossil fuel; 650 g/m/mw for nuclear fuel at a specified heat rate of 9,500 Btu per kilowatt-hour. This flow rate holds true for a cooling water temperature rise of 18°F.
2. Water consumption[1] by condensers at a specified heat rate of 9,500 Btu per kilowatt-hour:

Type of Cooling	Water Consumption: Fossil Fuel Lbs. Per Kwh	Fossil Fuel Acre-Feet Per Million Kwh	Nuclear Lbs. Per Kwh	Nuclear Acre-Feet Per Million Kwh
Cooling Tower, Wet (Blowdown Loss Included)	4.0	1.47	4.8	1.76
Cooling Pond	3.0	1.10	3.6	1.32
Flow-Through from Stream Source	2.5	0.92	3.0	1.10

3. Investment cost of cooling system above cost of flow-through type:

Type	Dollar per kw[2]
Cooling tower, wet	3.50
Cooling pond	2.50
Cooling tower, dry	15.00

[1] Consumption is water withdrawn from supply with apparent loss of water from the basin; essentially, the amount of cooling water which evaporates due to increase in its temperature.

[2] Figures are not necessarily current costs, but represent relative incremental expense of supplemental type cooling systems.

Cooling Water Requirements, Streamflow Diversions, and Consumptive Use

Water is a necessary factor in the production of all electric power now generated. Hydroelectric plants convert the energy of falling water to electricity, while steam-electric plants require relatively small amounts of extremely pure water for use in the boilers, and much larger amounts of untreated cooling water for circulation through the condensers. Internal combustion reciprocating engines and gas turbines require little or no water for the production of power. All plants require small amounts of water for station services, including fire protection. Within the basin the bulk of the power is produced by steam-electric and hydroelectric plants. Small amounts are produced in plants having internal combustion engines of the reciprocating or turbine types.

Firm planning for future generating capacity is usually not completed until shortly before the need becomes a reality. Accordingly, estimates of water requirements and consumptive use for cooling water for the year 2000 or 2020 can be only rough guides which should be reviewed periodically as new situations develop. With this in mind, it may be estimated that the basin's thermal-electric capacity will be about 92 percent of its total electric generating capacity in 2000, and about 96 percent of the total by 2020. A forecast of future water requirements by thermal-electric plants has been predicated on this basis; however, as is evident from other discussions in this report, there are alternatives to the demands for cooling water of good quality. For example, brackish water or sewage treatment plant effluents can be utilized under certain conditions as cooling water for thermal-electric generation. On the other hand, with some added expenditure, the consumptive use (primarily evaporation) of cooling water can be almost entirely eliminated by the construction of radiator-type closed-circuit towers. With the advent of EHV, power can be transmitted over long distances from areas of adequate water supply to water-deficient regions.

The amounts of thermal-electric energy which are likely to be required in the future were determined by deducting the estimated hydroelectric production from predicted total energy requirements. The thermal-electric energy production thus determined for each study period was converted to condenser cooling water requirements, streamflow diversions, and cooling water consumption by PSA's and subbasins. These data are shown in tables 99 through 106.

It is to be noted that calculations of water requirements were predicated on an increase of 18°F. temperature rise in the condenser cooling water. This will result in increased stream temperature at the point of discharge when flow-through cooling is employed.

Normally, the rise in stream temperature is dissipated rapidly, so that the measurable effects are usually small at points only a few miles downstream from the point of discharge. The large powerplants of the future, however, will discharge heat energy in unprecedented quantities. The heat additions could affect the aquatic life of the water body receiving the discharged heat, its waste assimilation capacity, and the suitability of the water for municipal, industrial, and recreational uses. The increase in temperature in water supplies that are used for cooling the steam condensers of both fossil-fueled and

Table 99 – MISSOURI BASIN POWER REGION WATER REQUIREMENTS BY PSA'S

PSA	1965	1980	2000	2020
	(Acre-Feet per Year)			
	Condenser Cooling Water Requirements			
15	107,621	431,900	1,246,000	1,793,700
16	38,444	197,000	620,400	1,182,800
17	737,032	1,822,100	5,309,900	7,858,700
26	67,511	296,300	679,500	1,911,000
27	261,605	1,853,000	5,214,100	9,558,400
28	453,021	1,190,100	3,319,000	4,563,200
29	352,961	1,074,700	2,277,800	3,433,800
30	26,520	26,600	1,261,200	3,831,100
31	256,405	597,800	1,666,500	2,749,000
32	582,200	1,318,000	3,276,800	4,884,600
34	475,175	759,700	1,830,800	3,140,800
Total	3,358,495	9,567,300	26,702,000	44,907,100
	Required Stream Flow Diversions			
15	89,279	315,320	398,630	443,830
16	8,060	81,030	248,470	500,370
17	617,331	754,610	650,910	731,780
26	40,590	115,240	283,900	401,700
27	108,661	744,380	905,560	996,480
28	386,670	603,150	732,880	799,300
29	15,630	15,340	32,010	4[illegible]490
30	26,520	26,600	658,780	639,740
31	256,405	301,380	270,620	300,010
32	114,008	135,920	99,620	68,280
34	93,057	86,980	161,030	147,810
Total	1,756,211	3,179,970	4,442,410	5,078,790
	Cooling Water Consumption			
15	1,092	4,620	16,170	24,020
16	522	2,460	7,500	14,470
17	7,498	21,500	73,760	110,930
26	745	3,670	8,450	25,980
27	3,300	21,480	65,680	124,160
28	4,535	14,200	41,980	58,860
29	5,157	15,340	32,010	49,490
30	243	240	14,940	51,290
31	2,791	6,810	21,630	35,660
32	7,008	17,520	44,630	68,280
34	4,551	9,500	23,210	39,910
Total	37,442	117,340	349,960	603,050

Table 100 – MISSOURI BASIN POWER REGION WATER REQUIREMENTS, BY SUBBASIN

Subbasin	1965	1980	2000	2020
	(Acre-Feet Per Year)			
	Condenser Cooling Water Requirements			
Upper Missouri	---	381,200	1,547,200	3,444,400
Yellowstone	96,599	870,900	3,154,500	6,540,900
Western Dakota	174,480	741,300	2,085,600	3,823,400
Eastern Dakota	74,063	492,700	1,357,500	2,857,600
Platte-Niobrara	971,949	2,115,900	5,456,500	8,100,800
Middle Missouri	575,226	1,639,800	4,562,300	6,677,900
Kansas	367,921	1,097,800	2,486,100	3,659,600
Lower Missouri	1,039,059	2,079,500	5,712,600	8,847,000
Missouri Basin	3,299,297	9,419,100	26,362,300	43,951,600
Red River	59,198	148,200	339,700	955,500
Power Region	3,358,495	9,567,300	26,702,000	44,907,100
	Required Stream Flow Diversions			
Upper Missouri	---	159,460	444,560	455,150
Yellowstone	96,599	390,070	802,220	874,910
Western Dakota	49,145	297,810	362,240	398,630
Eastern Dakota	16,775	198,480	431,350	700,740
Platte-Niobrara	454,314	528,180	300,390	201,740
Middle Missouri	480,288	753,330	1,040,140	1,237,300
Kansas	19,260	15,770	34,770	52,180
Lower Missouri	607,553	779,250	884,790	957,290
Missouri Basin	1,723,934	3,122,350	4,300,460	4,877,940
Red River	32,277	57,620	141,950	200,850
Power Region	1,756,211	3,179,970	4,442,410	5,078,790
	Cooling Water Consumption			
Upper Missouri	---	4,400	19,100	45,350
Yellowstone	928	9,990	39,490	85,620
Western Dakota	2,304	8,590	26,250	49,660
Eastern Dakota	1,000	5,960	16,790	36,990
Platte-Niobrara	11,302	26,940	73,790	111,780
Middle Missouri	5,815	19,330	59,530	89,340
Kansas	5,359	15,770	34,770	52,180
Lower Missouri	10,065	24,520	75,990	119,140
Missouri Basin	36,773	115,500	345,710	590,060
Red River	669	1,840	4,250	12,990
Power Region	37,442	117,340	349,960	603,050

Table 101 – MISSOURI BASIN POWER REGION CONDENSER COOLING WATER REQUIREMENTS BY PSA'S BY TYPE OF COOLING

PSA	Flow Through	Cooling Pond	Cooling Tower	Total
		(Acre-Feet Per Year)		
		1965		
15	89,006	---	18,615	107,621
16	7,608	---	30,836	38,444
17	615,484	---	121,548	737,032
26	40,213	9,870	17,428	67,511
27	106,379	---	155,226	261,605
28	385,680	11,500	55,841	453,021
29	10,580	---	342,381	352,961
30	26,520	---	---	26,520
31	256,405	---	---	256,405
32	108,000	---	474,200	582,200
34	89,326	351,909	33,940	475,175
Total	1,735,201	373,279	1,250,015	3,358,495
		1980		
15	313,600	---	118,300	431,900
16	79,300	---	117,700	197,000
17	739,900	320,600	761,600	1,822,100
26	112,600	17,800	165,900	296,300
27	729,600	474,000	649,400	1,853,000
28	594,400	---	595,700	1,190,100
29	---	120,200	954,500	1,074,700
30	26,600	---	---	26,600
31	297,300	90,200	210,400	597,900
32	119,500	320,700	877,800	1,318,000
34	78,200	335,800	345,700	759,700
Total	3,091,000	1,679,300	4,797,000	9,567,300
		2000		
15	386,000	---	860,000	1,246,000
16	243,200	72,400	304,800	620,400
17	582,500	286,300	4,441,100	5,309,900
26	278,000	---	401,500	679,500
27	847,700	1,703,400	2,663,000	5,214,100
28	697,300	800,100	1,821,600	3,319,000
29	---	395,800	1,882,000	2,277,800
30	649,800	---	611,400	1,261,200
31	251,300	213,900	1,201,300[1]	1,666,500[1]
32	55,500	872,400	2,348,900	3,276,800
34	139,100	791,900	899,800	1,830,800
Total	4,130,400	5,136,200	17,435,400[1]	26,702,000[1]
		2020		
15	423,700	---	1,370,000	1,793,700
16	490,400	54,400	638,000	1,182,800
17	626,600	290,400	6,941,700	7,858,700
26	379,200	---	1,531,800	1,911,000
27	880,400	3,094,000	5,584,000	9,558,400
28	747,300	1,101,800	2,714,100	4,563,200
29	---	260,500	3,173,300	3,433,800
30	593,900	466,100	2,771,100	3,831,100
31	266,800	580,800	1,901,400[2]	2,749,000[2]
32	---	946,900	3,937,700	4,884,600
34	108,900	1,532,300	1,499,600	3,140,800
Total	4,517,200	8,327,200	32,062,700[2]	44,907,100[2]

[1] Includes 45,800 acre-feet dry-type cooling.
[2] Includes 75,400 acre-feet dry-type cooling.

Table 102 – MISSOURI BASIN POWER REGION REQUIRED STREAMFLOW DIVERSIONS BY PSA'S BY TYPE OF COOLING

PSA	Flow Through	Cooling Pond	Cooling Tower	Total
	(Acre-Feet Per Year)			
		1965		
15	89,006	---	273	89,279
16	7,608	---	452	8,060
17	615,484	---	1,847	617,331
26	40,213	119	258	40,590
27	106,379	---	2,282	108,661
28	385,680	170	820	386,670
29	10,580	---	5,050	15,630
30	26,520	---	---	26,520
31	256,405	---	---	256,405
32	108,000	---	6,008	114,008
34	89,326	3,232	499	93,057
Total	1,735,201	3,521	17,489	1,756,211
		1980		
15	313,600	---	1,740	315,340
16	79,300	---	1,730	81,030
17	739,900	3,530	11,180	754,610
26	112,600	200	2,440	115,240
27	729,600	5,230	9,550	744,380
28	594,400	---	8,750	603,150
29	---	1,320	14,020	15,340
30	26,600	---	---	26,600
31	297,300	990	3,090	301,380
32	119,500	3,530	12,890	135,920
34	78,200	3,700	5,080	86,980
Total	3,091,000	18,500	70,470	3,179,970
		2000		
15	386,000	---	12,630	398,630
16	243,200	790	4,480	248,470
17	582,500	3,150	65,260	650,910
26	278,000	---	5,900	283,900
27	847,700	18,760	39,100	905,560
28	697,300	8,820	26,760	732,880
29	---	4,360	27,650	32,010
30	649,800	---	8,980	658,780
31	251,300	2,350	16,970	270,620
32	55,500	9,610	34,510	99,620
34	139,100	8,720	13,210	161,030
Total	4,130,400	56,560	255,450	4,442,410
		2020		
15	423,700	---	20,130	443,830
16	490,400	600	9,370	500,370
17	626,600	3,200	101,980	731,780
26	379,200	---	22,500	401,700
27	880,400	34,080	82,000	996,480
28	747,300	12,140	39,860	799,300
29	---	2,870	46,620	49,490
30	593,900	5,140	40,700	639,740
31	266,800	6,390	26,820	300,010
32	---	10,430	57,850	68,280
34	108,900	16,880	22,030	147,810
Total	4,517,200	91,730	469,860	5,078,790

Table 103 – MISSOURI BASIN POWER REGION COOLING WATER CONSUMPTION BY PSA'S BY TYPE OF COOLING

PSA	Flow Through	Cooling Pond	Cooling Tower	Total
		(Acre-Feet Per Year)		
		1965		
15	819	---	273	1,092
16	70	---	452	522
17	5,651	---	1,847	7,498
26	368	119	258	745
27	1,018	---	2,282	3,300
28	3,545	170	820	4,535
29	107	---	5,050	5,157
30	243	---	---	243
31	2,791	---	---	2,791
32	1,000	---	6,008	7,008
34	820	3,232	499	4,551
Total	16,432	3,521	17,489	37,442
		1980		
15	2,880	---	1,740	4,620
16	730	---	1,730	2,460
17	6,790	3,530	11,180	21,500
26	1,030	200	2,440	3,670
27	6,700	5,230	9,550	21,480
28	5,450	---	8,750	14,200
29	---	1,320	14,020	15,340
30	240	---	---	240
31	2,730	990	3,090	6,810
32	1,100	3,530	12,890	17,520
34	720	3,700	5,080	9,500
Total	28,370	18,500	70,470	117,340
		2000		
15	3,540	---	12,630	16,170
16	2,230	790	4,480	7,500
17	5,350	3,150	65,260	73,760
26	2,550	---	5,900	8,450
27	7,820	18,760	39,100	65,680
28	6,400	8,820	26,760	41,980
29	---	4,360	27,650	32,010
30	5,960	---	8,980	14,940
31	2,310	2,350	16,970	21,630
32	510	9,610	34,510	44,630
34	1,280	8,720	13,210	23,210
Total	37,950	56,560	255,450	349,960
		2020		
15	3,890	---	20,130	24,020
16	4,500	600	9,370	14,470
17	5,750	3,200	101,980	110,930
26	3,480	---	22,500	25,980
27	8,080	34,080	82,000	124,160
28	6,860	12,140	39,860	58,860
29	---	2,870	46,620	49,490
30	5,450	5,140	40,700	51,290
31	2,450	6,390	26,820	35,660
32	---	10,430	57,850	68,280
34	1,000	16,880	22,030	39,910
Total	41,460	91,730	469,860	603,050

Table 104 – MISSOURI BASIN POWER REGION CONDENSER COOLING WATER REQUIREMENTS BY SUBBASIN, BY TYPE OF COOLING

Subbasin	Flow Through	Cooling Pond	Cooling Tower	Total
		(Acre-Feet Per Year)		
		1965		
Upper Missouri	---	---	---	---
Yellowstone	96,599	---	---	96,599
Western Dakota	47,275	---	127,205	174,480
Eastern Dakota	15,921	---	58,142	74,063
Platte-Niobrara	447,569	---	524,380	971,949
Middle Missouri	478,869	---	96,357	575,226
Kansas	14,040	11,500	342,381	367,921
Lower Missouri	603,028	351,909	84,122	1,039,059
Missouri Basin	1,703,301	363,409	1,232,587	3,299,297
Red River	31,900	9,870	17,428	59,198
Power Region	1,735,201	373,279	1,250,015	3,358,495
		1980		
Upper Missouri	156,500	94,800	129,900	381,200
Yellowstone	383,600	187,300	300,000	870,900
Western Dakota	291,900	189,600	259,800	741,300
Eastern Dakota	194,300	56,300	242,100	492,700
Platte-Niobrara	505,900	365,700	1,244,300	2,115,900
Middle Missouri	740,800	184,400	714,600	1,639,800
Kansas	---	96,200	1,001,600	1,097,800
Lower Missouri	761,700	496,100	821,700	2,079,500
Missouri Basin	3,034,700	1,670,400	4,714,000	9,419,100
Red River	56,300	8,900	83,000	148,200
Power Region	3,091,000	1,679,300	4,797,000	9,567,300
		2000		
Upper Missouri	429,400	340,700	777,100	1,547,200
Yellowstone	769,800	618,000	1,766,700[1]	3,154,500[1]
Western Dakota	339,100	681,400	1,065,100	2,085,600
Eastern Dakota	418,400	228,200	710,900	1,357,500
Platte-Niobrara	228,700	1,299,400	3,928,400[1]	5,456,500[1]
Middle Missouri	989,700	556,800	3,015,800	4,562,300
Kansas	---	476,700	2,009,400	2,486,100
Lower Missouri	816,300	935,000	3,961,300	5,712,600
Missouri Basin	3,991,400	5,136,200	17,234,700	26,362,300
Red River	139,000	---	200,700	339,700
Power Region	4,130,400	5,136,200	17,435,400[2]	26,702,000[2]
		2020		
Upper Missouri	413,600	805,200	2,225,200	3,444,000
Yellowstone	796,600	1,498,300	4,246,000[3]	6,540,900[3]
Western Dakota	352,200	1,237,600	2,233,600	3,823,400
Eastern Dakota	669,900	353,000	1,834,700	2,857,600
Platte-Niobrara	90,800	1,678,000	6,332,000[3]	8,100,800[3]
Middle Missouri	1,158,600	648,900	4,870,400	6,677,900
Kansas	---	428,800	3,230,800	3,659,600
Lower Missouri	845,900	1,677,400	6,323,700	8,847,000
Missouri Basin	4,327,600	8,327,200	31,296,800	43,951,600
Red River	189,600	---	765,900	955,500
Power Region	4,517,200	8,327,200	32,062,700[4]	44,907,100[4]

[1]Includes 22,900 acre-feet dry-type cooling.
[2]Includes 45,800 acre-feet dry-type cooling.
[3]Includes 37,700 acre-feet dry-type cooling.
[4]Includes 75,400 acre-feet dry-type cooling.

Table 105 – MISSOURI BASIN POWER REGION REQUIRED STREAM FLOW DIVERSIONS BY SUBBASIN, BY TYPE OF COOLING

Subbasin	Flow Through	Cooling Pond	Cooling Tower	Total
	(Acre-Feet Per Year)			
		1965		
Upper Missouri	---	---	---	---
Yellowstone	96,599	---	---	96,599
Western Dakota	47,275	---	1,870	49,145
Eastern Dakota	15,921	---	854	16,775
Platte-Niobrara	447,569	---	6,745	454,314
Middle Missouri	478,869	---	1,419	480,288
Kansas	14,040	170	5,050	19,260
Lower Missouri	603,028	3,232	1,293	607,533
Missouri Basin	1,703,301	3,402	17,231	1,723,934
Red River	31,900	119	258	32,277
Power Region	1,735,201	3,521	17,489	1,756,211
		1980		
Upper Missouri	156,500	1,050	1,910	159,460
Yellowstone	383,600	2,060	4,410	390,070
Western Dakota	291,900	2,090	3,820	297,810
Eastern Dakota	194,300	620	3,560	198,480
Platte-Niobrara	505,900	4,030	18,250	528,180
Middle Missouri	740,800	2,030	10,500	753,330
Kansas	---	1,060	14,710	15,770
Lower Missouri	761,700	5,460	12,090	779,250
Missouri Basin	3,034,700	18,400	69,250	3,122,350
Red River	56,300	100	1,220	57,620
Power Region	3,091,000	18,500	70,470	3,179,970
		2000		
Upper Missouri	429,400	3,750	11,410	444,560
Yellowstone	769,800	6,810	25,610	802,220
Western Dakota	339,100	7,500	15,640	362,240
Eastern Dakota	418,400	2,510	10,440	431,350
Platte-Niobrara	228,700	14,310	57,380	300,390
Middle Missouri	989,700	6,130	44,310	1,040,140
Kansas	---	5,250	29,520	34,770
Lower Missouri	816,300	10,300	58,190	884,790
Missouri Basin	3,991,400	56,560	252,500	4,300,460
Red River	139,000	---	2,950	141,950
Power Region	4,130,400	56,560	255,450	4,442,410
		2020		
Upper Missouri	413,600	8,870	32,680	455,150
Yellowstone	796,600	16,500	61,810	874,910
Western Dakota	352,200	13,630	32,800	398,630
Eastern Dakota	669,900	3,890	26,950	700,740
Platte-Niobrara	90,800	18,490	92,450	201,740
Middle Missouri	1,158,600	7,150	71,550	1,237,300
Kansas	---	4,720	47,460	52,180
Lower Missouri	845,900	18,480	92,910	957,290
Missouri Basin	4,327,600	91,730	458,610	4,877,940
Red River	189,600	---	11,250	200,850
Power Region	4,517,200	91,730	469,860	5,078,790

Table 106 – MISSOURI BASIN POWER REGION COOLING WATER CONSUMPTION BY SUBBASIN, BY TYPE OF COOLING

Subbasin	Flow Through	Cooling Pond	Cooling Tower	Total
		(Acre-Feet Per Year)		
		1965		
Upper Missouri	---	---	---	---
Yellowstone	928	---	---	928
Western Dakota	434	---	1,870	2,304
Eastern Dakota	146	---	854	1,000
Platte-Niobrara	4,557	---	6,745	11,302
Middle Missouri	4,396	---	1,419	5,815
Kansas	139	170	5,050	5,359
Lower Missouri	5,540	3,232	1,293	10,065
Missouri Basin	16,140	3,402	17,231	36,773
Red River	292	119	258	669
Power Region	16,432	3,521	17,489	37,442
		1980		
Upper Missouri	1,440	1,050	1,910	4,400
Yellowstone	3,520	2,060	4,410	9,990
Western Dakota	2,680	2,090	3,820	8,590
Eastern Dakota	1,780	620	3,560	5,960
Platte-Niobrara	4,640	4,030	18,270	26,940
Middle Missouri	6,800	2,030	10,500	19,330
Kansas	---	1,060	14,710	15,770
Lower Missouri	6,990	5,460	12,070	24,520
Missouri Basin	27,850	18,400	69,250	115,500
Red River	520	100	1,220	1,840
Power Region	28,370	18,500	70,470	117,340
		2000		
Upper Missouri	3,940	3,750	11,410	19,100
Yellowstone	7,070	6,810	25,610	39,490
Western Dakota	3,110	7,500	15,640	26,250
Eastern Dakota	3,840	2,510	10,440	16,790
Platte-Niobrara	2,100	14,310	57,380	73,790
Middle Missouri	9,090	6,130	44,310	59,530
Kansas	---	5,250	29,520	34,770
Lower Missouri	7,500	10,300	58,190	75,990
Missouri Basin	36,650	56,560	252,500	345,710
Red River	1,300	---	2,950	4,250
Power Region	37,950	56,560	255,450	349,960
		2020		
Upper Missouri	3,800	8,870	32,680	45,350
Yellowstone	7,310	16,500	61,810	85,620
Western Dakota	3,230	13,630	32,800	49,660
Eastern Dakota	6,150	3,890	26,950	36,990
Platte-Niobrara	830	18,490	92,460	111,780
Middle Missouri	10,640	7,150	71,550	89,340
Kansas	---	4,720	47,460	52,180
Lower Missouri	7,760	18,480	92,900	119,140
Missouri Basin	39,720	91,730	458,610	590,060
Red River	1,740	---	11,250	12,990
Power Region	41,460	91,730	469,860	603,050

nuclear powerplants is commonly referred to as "thermal pollution," although the heating is not pollution in the usual sense. Concern over the damaging effects of thermal pollution is growing among many water users and at all levels of government. Effective action was taken at the Federal level by the passage of the Water Quality Act of 1965, requiring water quality standards to be set and implemented for all interstate and coastal waters. If it is determined upon establishment of the standards that thermal pollution would occur from generating plants projected herein, such condition could probably be eliminated by the use of supplemental cooling systems, but at increased cost.

The procedure used herein to calculate cooling-water flow requirements and consumption are illustrated by the following development of estimated quantities for coal-fired electric generating stations in the year 1980. Typical factors recommended by the advisory subcommittee were used.

Sample Calculation
Cooling Water Requirements & Losses[1]

Operating Conditions:

Assumed over-all plant efficiency	36%
Assumed generator efficiency	97.5%
Heat equivalent of one kwh	3414 Btu
Fuel energy required (net plant heat rate)	9500 Btu/kwh
Heat loss from boiler furnace[2]	950 Btu/kwh
Energy delivered to turbine	8550 Btu/kwh
Heat loss from generator[3]	94 Btu/kwh
Generator output (including 7% plant use)	3650 Btu/kwh
Energy removed in condenser (Energy delivered to turbine minus generator output)	4900 Btu/kwh

Cooling Water Required:

$$\text{Acre-ft/kwh} = \frac{\text{Energy removed in condenser}}{\text{Heat Absorption Rate of Water}^4 \times {}^{\circ}\text{F temp. change in cooling water}}$$

$$= \frac{4900 \text{ Btu/kwh}}{2{,}718{,}144 \text{ Btu/acre-ft/}^{\circ}\text{F temp. change} \times {}^{\circ}\text{F temp. change in cooling water}}$$

$$= \frac{.001803}{{}^{\circ}\text{F temp. change in cooling water}^5}$$

[1] Cooling water required is the amount of water needed to pass through the condensing unit and is independent of the type of cooling. . .flow-through, pond, or tower. Losses are the consumptive water use and are essentially the amount of cooling water evaporated. Losses are dependent on the type of cooling employed.

[2] Negligible for nuclear plants.

[3] Generator cooling usually part of cooling water load.

[4] 1 Btu/lb. water/°F temp. change in the water; 2,718,144 lbs. of water = 1 acre-ft.

[5] Note that the quantity of cooling water required varies inversely with permitted temperature rise of cooling water.

Cooling Losses (acre-feet per kwh)[6]***:***

Flow-through = 0.92×10^{-6}
Cooling pond = 1.10×10^{-6}
Cooling tower (Wet) = 1.47×10^{-6}

[6] Established by Missouri River Basin Advisory Subcommittee for fossil-fuel plants @ 9500 Btu/kwh. For other heat rates, adjust in proportion to energy removed in condenser.

The preceding tables indicate that the consumptive use is only about one percent of the total water required for cooling. Analysis of the data gathered for this study leads to the conclusion that cooling water requirements of thermal-electric generating plants in the Missouri River Basin will impose an important demand on the future water supply. Several factors concerning these figures should be borne in mind:

1. The cooling water required is not necessarily the amount of water required to be withdrawn continuously from a water source. This is true only in a flow-through plant.

   The supply water required for cooling in wet-tower and cooling-pond plants is only that needed for makeup, which is equivalent to their consumptive use, since the diverted water is recirculated.

   Water withdrawn from a water source for cooling use may be reused (except for the consumption) again and again in downstream plants, or for other purposes such as municipal and irrigation. The only limitation is that the downstream distance be great enough to allow the warm discharge water to return to normal stream temperature.

   It is apparent that diversion figures, rather than the condenser cooling water requirements, represent the amount of water required to be withdrawn from the supply. The actual depletion of water from the supply is equal to the consumptive use. Any application of the foregoing in determining the adequacy of the water supply to support generation should be in relation to a specific plant site.

2. The amount of water consumed can be varied at the discretion of designers by changing the parameters which control the amount of cooling water use, the two most important ones being the type of cooling and the permissible temperature rise of the water. The type of cooling employed has an important effect on water consumption, being greatest for wet type cooling towers and negligible for dry type. Consumption by the flow-through and cooling-pond methods is intermediate between that of wet and dry type cooling towers.

   The relatively high cost of dry type cooling towers is at present a deterrent to increased use of that method; however, as demands for water approach more closely the available supply, and more stringent water standards are enacted, this cost differential will become less significant.

3. The condenser cooling water requirements, consumptive use, and streamflow diversion figures shown in tables 99 and 106 are for an 18° F. change in temperature of the cooling water. If lower water discharge temperature standards are established by legislation in accordance with the Water Quality Act of 1965 (P.L. 98-234), more supplemental type cooling may be required, possibly altering the values determined.

Water Use by Hydroelectric Plants

The amount of power produced in a hydroelectric plant is directly proportional to the rate of flow through the plant and the fall, or head, through which the water is used. The design flow through the plant depends upon the firm and average streamflows available at the site and the characteristics of the power load in which the plant output is to be utilized. Thus, in effect, the plant is designed for the site conditions and utilizes the streamflows that are available or may be provided through regulation. Periodic deficiencies in the available streamflows through changes in the storage regulation or consumptive uses usually can be accommodated by serving the customers from another power source when a portion of the power load cannot be served by the plant's output. Except for the initial filling of the reservoir, hydroelectric power production does not involve the permanent withdrawal of water from rivers and streams.

Most new hydroelectric plants are designed to operate at low plant factors to serve the peak portions of the load. Hydroelectric plants are particularly well suited for such use, for providing spinning reserve capacity, and for load regulation. This is because they have the ability to start quickly and to make rapid changes in the rate of plant output.

Except for the evaporation that may be associated with the reservoirs, hydroelectric plants do not use water consumptively. The only significant thermal effects are those relating to stratification within the reservoirs and the subsequent releases of stored water. Releases from

Highest Head and Highest Elevation Pumped-Storage Plant In The United States Is Cabin Creek, Pumped-Storage Hydroelectric Project deep reservoirs may lower summer temperatures in the stream, but such stored water may be deficient in dissolved oxygen. In some cases, multiple level intake structures are used to obtain an "average" flow. Such uniformity helps to preserve or enhance fish and wildlife values and provide downstream water-temperature benefits. In other instances, downstream reregulating reservoirs are constructed to smooth out the varying releases from hydroelectric plants for the benefit of fish and wildlife as well as for recreation and other uses of the stream.

Pumped-storage developments produce power by releasing water from an upper reservoir through a powerplant to a lower reservoir after all or part of the water has previously been pumped into the upper reservoir. Most developments use reversible pumping-generating equipment. Although there are many possible arrangements for pumped-storage developments, they fall generally into two broad categories. In the combined type development, reversible units are installed in the normal type of hydroelectric project, consisting of a reservoir on a stream with a downstream reregulating reservoir, or afterbay. Such developments provide for in-stream use of the water. Pumped-storage projects normally include a hilltop upper reservoir and a lower pool which may be a reservoir or other body of water of substantial size, or a pond on a small stream, and consist only of reversible generating equipment. In such developments the water is recirculated between the upper and lower pools and only enough make-up water is needed to cover the evaporation and other losses.

By utilizing high heads, large pumped-storage installations are possible with relatively small amounts of water and small reservoirs. A requirement for such developments is an adequate supply of off-peak pumping energy which is usually generated in steam-electric plants. Pumped-storage developments are best adapted for providing low plant-factor peaking and reserve capacity. The trend toward the construction of very large steam-electric units which can operate most efficiently and economically in the base portions of the load has accelerated the planning and construction of conventional hydroelectric and pumped-storage developments for low plant-factor-use. Two recent pumped-storage developments in the basin are the 151,300-kilowatt Kaysinger Bluff project under construction in Missouri, and the 300,000-kilowatt Cabin Creek project in Colorado which was completed in 1967. The Cabin Creek project, constructed by the Public Service Company of Colorado, is the highest head and highest elevation pumped-storage plant in the United States. The power house is located at elevation 10,000 feet, with an operating head of 1,200 feet.

SUMMARY

All in all, the basin now is about self sufficient, powerwise. The needs in 1980, 2000, and 2020 are likely to increase substantially, but the water resources of the basin appear to be adequate to support the thermal-electric plants which seem likely in meeting the future requirements. No great electric power export is envisioned. Thermal pollution of water sources will be recognized and alleviated by appropriate design.

The rapid pace of technological advances in the power industry makes imperative periodic review and analysis of the electric power resources of the basin to ascertain that the direction being taken is in accord with the overall development of the basin and the other needs therein. Such analyses should assure the adequacy, timeliness, and most economical installation of the future power supply, consistent with aesthetic and ecological constraints.

Son-Dad Fishing in Controlled Waters.

CHAPTER 5

FISH AND WILDLIFE

Fish and wildlife resources are important throughout the Nation. Historically, the Indians, trappers, explorers, and early settlers depended heavily on them for food, clothing, and shelter. Their value was almost solely utilitarian. Today, wild animals, birds, and fish are equally important to millions of people — even though in a vastly different sense than in former years. Fishermen, hunters, and other outdoor recreationists have the most obvious interest in these resources; also there is a growing number of both professional and amateur scientists. The trades and businesses associated with serving the seekers of fish and wildlife are increasing both locally and nationally. Certain fur animals and many kinds of fish have significant commercial value. The Missouri Basin supports an unusual variety of fish and wildlife species, some in a pristine environment. It is doubtful if any other major drainage area in the country is more important nationally in this regard.

Much Of The Fishing In The Mountains Is Of National Importance And Should Be Preserved

EXISTING RESOURCES AND USES

Land and Water Use

Fish and wildlife resources and land and water use have undergone a series of major changes during settlement of the Missouri River Basin. When man inhabits a region and densely populates some areas, he converts much of the virgin grasslands and timberlands to cropland and to use for domestic livestock, industry, highways, and cities. Major changes in the ecological balance of fish and wildlife communities result. Consequently, a major problem is the use and management of land, water, and plant resources to maximize their production for both agriculture and fish and wildlife and still provide for other goods and services. The search for, and implementation of, land use and management practices to accomplish this goal have been a continuing problem.

Use of wildlife by fur traders and buffalo hunters was an initial change directly affecting this resource. Utilization of free-grass corridors without restraint by cattlemen en route to the transcontinental railroad and establishing homesteads by settlers also had their effects. These were not as direct but they were no less important.

The free-range cattle industry resulted in concentrated areas of unregulated use extending over a period of more than half a century. Initial homesteads of 160 acres were not large enough to provide a livelihood, thus creating conditions resulting in improper use of the land. Later homesteads of 640 acres resulted in similar misuse where areas unsuited for a cultivation type agriculture were broken and planted.

The drought of the thirties represented a natural phenomenon that also had various effects upon fish and wildlife resources. Ways and means of preventing recurring droughts may never be developed, but land use programs and practices are doing much to offset their more disastrous effects.

Settlers of the basin frequently viewed the forests, grasslands, potholes, and wetlands as enemies to be vanquished rather than producers of the wildlife they utilized. Nevertheless, while the changes they wrought caused the loss of some habitats, they created others.

Today, private and public land use programs and practices are giving increased recognition to fish and wildlife resources, and some lands and waters are developed and managed primarily for this purpose.

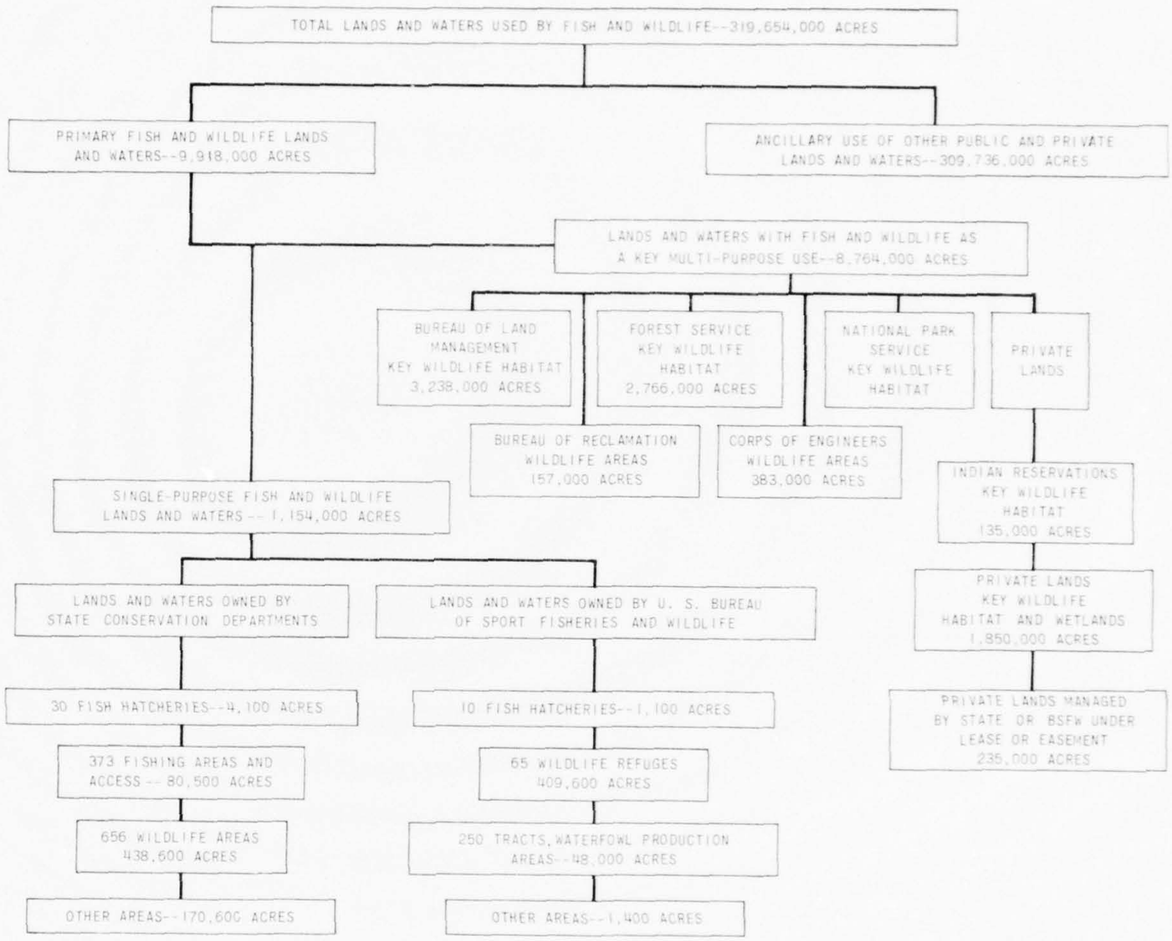
The Missouri Basin encompasses an area of almost 329 million acres, the majority of value to fish and wildlife. For the purpose of this study, the total land and water area used by fish and wildlife is divided into two broad categories: (1) lands and waters devoted to fish and wildlife as a primary use; and (2) lands and waters where fish and wildlife are ancillary users. Primary fish and wildlife lands and waters are further subdivided: (1a) single-purpose fish and wildlife lands and waters owned and managed by the several State Conservation Departments and by the Bureau of Sport Fisheries and Wildlife; and (1b) multipurpose publicly owned or privately owned lands and water where fish and wildlife management is one of the principal uses. Figure 24 illustrates this breakdown.

Pronghorn antelope hunting unsurpassed anywhere in the West characterizes large acreages of public and private lands in the Missouri Basin. Such lands need only preservation and proper use for maximum wildlife benefits of nationwide importance.

The figure reveals that 97 percent of the lands and waters important to fish and wildlife falls into the category of ancillary use. This includes almost all of the private lands and a substantial portion of the public lands. On most of this acreage agriculture predominates, and wildlife exists because of its compatibility with current farming and ranching practices and because of the land owners recognition and protection. However, because of the tremendous acreage involved, these lands and waters support most of the basin's fish and wildlife and offer most of the substantial opportunities for further enhancement of these resources. Only 0.3 percent of the total basin is devoted to fish and wildlife as a single-purpose or dedicated use, but on an additional 2.7 percent of the basin, fish and wildlife is one of the primary or key considerations of multipurpose management. This latter category includes lands owned by several Federal agencies and numerous small areas of privately owned land.

A substantial portion of the lands and waters in the National Parks and in some State Parks is known to be of great importance to fish and wildlife. At present, data are not available to classify these lands and waters on the same basis as the other items shown on figure 24. Accordingly, National Parks are noted as an item, but

FIGURE 24
OWNERSHIP AND USE OF LANDS AND WATERS IMPORTANT TO FISH AND WILDLIFE



the acreages of primary importance to fish and wildlife have not been estimated.

Private lands and waters account for about 20 percent (2,220,000 acres) of the area considered of primary importance to fish and wildlife. The State Conservation Departments and the Bureau of Sport Fisheries and Wildlife lease or hold easement rights on nearly 250,000 of these acres. The bulk of the easement lands is under Bureau of Sport Fisheries and Wildlife control for wetland preservation purposes in the eastern Dakotas. More State easements are for fishing or hunting access.

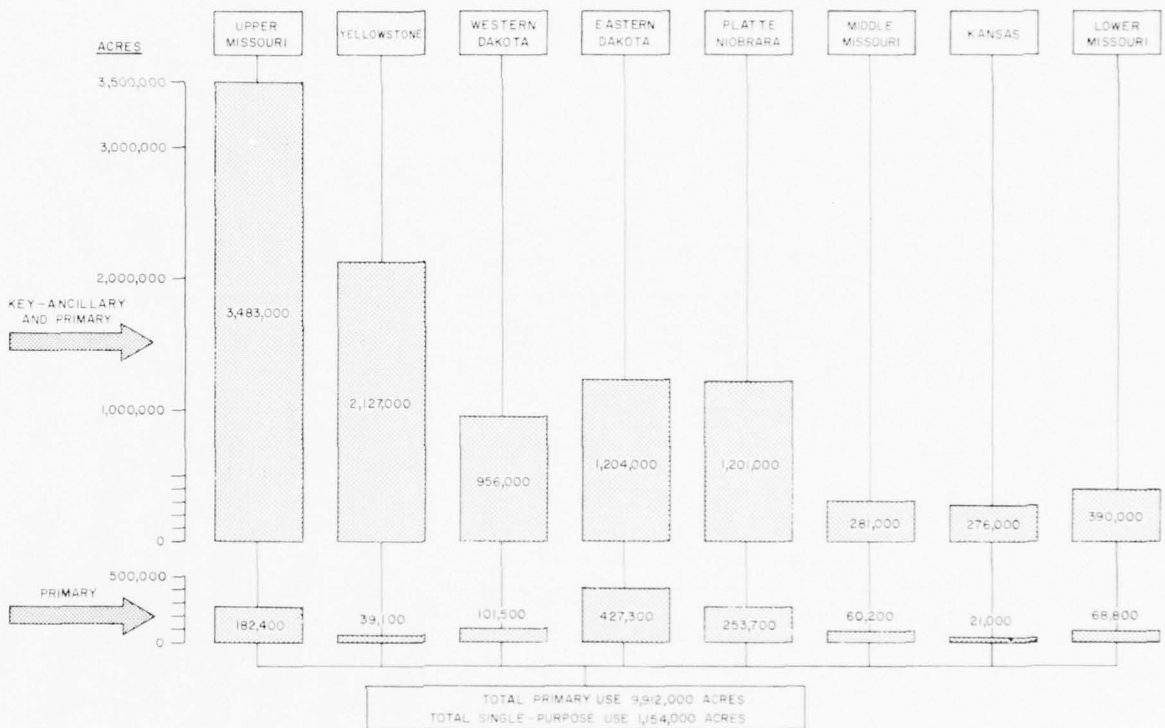
Over half of the total acreage on which fish and wildlife is a primary use lies in the Upper Missouri and Yellowstone subbasins, although these drainages include only 30 percent of the total basin area (figure 25). This is due to the availability of the large amount of public land, especially the National Forests and the Public Domain, for fish and wildlife management. However, these subbasins contain only about 20 percent of the single-purpose fish and wildlife lands and waters in the Missouri Basin. On the other hand, the Middle Missouri, Kansas, and Lower Missouri subbasins contain the smallest acreages of lands and waters on which fish and wildlife management is the primary use. As one would expect, these are the areas in which agricultural use of the land is most extensive.

In general, those subbasins containing the most public land also have most of the land and water devoted primarily to fish and wildlife. The Eastern Dakota Subbasin, a notable exception, contains a significant portion of the Nation's small marshes, and Bureau of

FIGURE 25

DISTRIBUTION OF SINGLE-PURPOSE AND PRIMARY (KEY) FISH AND WILDLIFE LANDS AND WATERS, BY SUBBASINS

(SINGLE-PURPOSE IS INCLUDED IN PRIMARY)



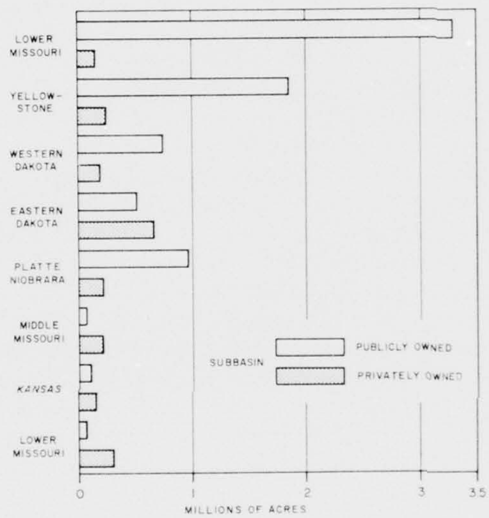
A large segment of the basin is typified by semi arid prairies, much of which is public domain. Plant regeneration is slow and overgrazing a chronic hazard.

Sport Fisheries and Wildlife Waterfowl Production Areas account for a substantial portion of the primary use acreages. In South Dakota meandered lands (lakes and lakebeds omitted from original government surveys and held in trust for the people of the State) are managed by the Department of Game, Fish, and Parks. These lands together with several National Wildlife Refuges, contribute substantially to the large single-purpose wildlife acreage in that subbasin.

Diversified agriculture in the lower subbasins provides excellent hunting for deer and small game; however, widespread clearing frequently depreciates wildlife values.

Figure 25 shows the distribution of both primary and single-purpose fish and wildlife lands and waters among the eight subbasins. Figure 26 indicates that the Upper Missouri and Yellowstone subbasins contain almost 70 percent of the public land on which fish and wildlife management is the primary use. The lion's share of the private lands and waters in this category is found in the Eastern Dakota Subbasin. Most of this latter acreage is under easement to the Bureau of Sport Fisheries and Wildlife for wetland preservation.

FIGURE 26
OWNERSHIP OF LAND AND WATER AREAS ON WHICH FISH AND WILDLIFE MANAGEMENT IS THE PRIMARY USE



Apart from the lands and waters primarily used for fish and wildlife, certain areas where such use is ancillary to other uses deserve special mention because of the large acreages involved. These include Indian reservations and State school lands, in particular.

Indian reservations encompass in excess of 16 million acres, or about 5 percent of the Missouri Basin. Although all land within the reservations is not Indian owned, 12 million acres, or almost 4 percent of the land in the basin is in Indian ownership. Of this total, 7 million acres are owned by individual Indians, and 5 million acres are in tribal ownership. On most reservations there is minimal management of fish and wildlife resources. The large management potential of the tribally owned lands in particular is practically untouched; however, in recent years the Bureau of Sport Fisheries and Wildlife has provided technical assistance in this field upon request.

There are about 12,250,000 acres of State school lands in the Missouri River Basin segments of Colorado, Montana, Nebraska, North Dakota, South Dakota, and Wyoming, but none remain in Iowa, Kansas, Minnesota or Missouri. Typically, these lands are leased mostly to farmers and ranchers. State laws make no special provisions for fish and wildlife management on school lands. For such lands, the fish and wildlife managment potential is great.

Water surface areas are included in the data presented in figures 24, 25, and 26. About 13 percent of the primary use acreage and 35 percent of the single-purpose acreage are wetlands or open water. The single-purpose water areas total over 410,000 acres. Based on a net average evapotranspiration rate of 1.60 acre-feet per *surface-acre over the entire* basin, the annual consumptive use of water on single-purpose fish and wildlife areas is estimated at about 660,000 acre-feet (table 107). Evapotranspiration losses on 1,270,000 surface-acres of water in the primary use category are not included. These areas also serve other important purposes, such as stock water, municipal and industrial water, hydropower generation, navigation, irrigation, and general recreation, and the annual water loss would not be measurably reduced if the fish and wildlife purposes were eliminated.

Table 107 – ESTIMATED CONSUMPTIVE WATER USE ON SINGLE-PURPOSE FISH AND WILDLIFE AREAS, BY SUBBASIN

Subbasin	Surface Acres		Average Annual Acre-feet per Surface-Acre Evaporation and Transpiration[1]	Acre-feet Consumed
	Land	Water		
Upper Missouri	142,000	40,250	2.00	80,500
Yellowstone	31,000	2,960	2.00	5,930
Western Dakota	92,000	9,420	1.83	17,260
Eastern Dakota	162,000	265,290	1.50	397,930
Platte-Niobrara	220,000	34,100	2.50	85,230
Middle Missouri	25,000	35,510	1.17	41,560
Kansas	15,000	5,750	2.50	14,370
Lower Missouri	51,000	17,560	1.00	17,560
Missouri Basin	738,000	410,840	1.60	660,340

[1] Based on "Evaporative Estimates for the Missouri River Basin" Work Group on Hydrologic Analyses and Projections.

Distribution and Status of Fish

An inventory and classification has been made of 43,500 miles of streams and 1,420,000 acres of ponded waters (lakes and reservoirs) for fishing, of a total 2,524,000 acres of water surface. Along the eastern slope of the Rocky Mountains, from Colorado to Montana, there are many nationally known trout streams. Numerous mountain lakes also provide outstanding fishing and other recreational opportunities. In the foothills and out on the plains, man-made impoundments dominate the fishing scene.

In the Dakotas, the large Missouri main stem reservoirs, including several high quality tailrace or afterbay fisheries, are very prominent. Also important are over 100,000 acres of natural lakes of glacial origin, mostly in northeastern South Dakota, and a number of good quality trout streams in the Black Hills.

Farther south, through the plains States of Nebraska and Kansas, stream fishing tends to be of local significance, while artificial impoundments ranging from farm ponds to large multipurpose reservoirs support the bulk of the fishing. Some 22,000 acres of natural sandhill lakes are important in Nebraska. They are the result of local closed drainages and groundwater exposures in the northcentral and northwestern part of the state.

In northwestern Iowa and the southwestern corner of Minnesota there are several glacial lakes of high fishery value. Only in the extreme lower end of the basin, in the Ozarks of Missouri, does stream fishing quality again approach the significance it has in the western mountain region. A number of spring-fed Ozark streams are renowned for floating, affording unique scenery and fine fishing.

For purpose of this study, fishing waters have been separated into the categories of streams, natural lakes, and reservoirs (figure 27). Reservoirs have been further divided into large (those over 1,000 acres) and small categories (those less than 1,000 acres, including farm ponds). Within these categories, waters and adjacent surroundings were classified on the basis of quality characteristics as to their relative importance – National, State, local. Figure 28 shows, in a general way, the location and nature of those waters identified as of National or Statewide importance for sport fishing.

An effort was made to identify waters that have suffered degradation as fisheries by man's activity. However, data on pollution, water withdrawal, channelization, increased siltation, and limited information on shoreline encroachment could not be related directly to fish propagation and quality of experience. Surface waters of the basin receive nutrients from treated domestic and industrial waste and from agricultural runoff. For the most part nutrient concentrations are higher in the lower or eastern part of the basin due to greater population densities and more intensive land use. Oxygen sag or reduction occurs occasionally on the lower main stem and can be correlated with intensive rainfall and floods on tributary streams.

Degradation of fishing waters is not limited to the eastern part of the basin. The South Platte River and many of its tributaries around Denver have been essentially destroyed for fishing by pollution and by dewatering for beneficial uses. Very serious stream pollution occurs in the Black Hills where miles of trout streams are wholly or partially degraded. Even in the sparsely populated States of Montana and Wyoming, stream pollution is often of critical concern. This includes many miles of the Yellowstone River, some of it just north of Yellowstone National Park.

Dewatering of streams by diversion is also widespread over much of the basin. This practice is most damaging to trout fishing in the irrigated areas of the western states. Hundreds of miles of otherwise good trout streams have been almost totally dewatered by irrigation diversions and by the operation of impoundments for irrigation, electric power production, and other purposes. Warm water stream fisheries also have suffered in the Plains States from these same factors. In these areas, dewatering is often complicated by widely fluctuating natural stream flows. Not even in the eastern tip of the basin, where water supplies are much greater, can dewatering be disregarded as a factor limiting stream fisheries. There are, however, examples where developments and impoundments have improved reaches of streams for fishery habitat through stabilization of the flow regimen, better temperature control, and sediment reduction.

Proper land use practices and good watershed conditions are essential to management of small prairie impoundments.

Man's use of the land is a factor in the acceleration of soil erosion and the production of sediment. Cultivation for the production of row crops and small grains resulted in added soil erosion and sediment delivery to streams.

FIGURE 27
DISTRIBUTION OF FISHING WATERS
BY SUBBASINS

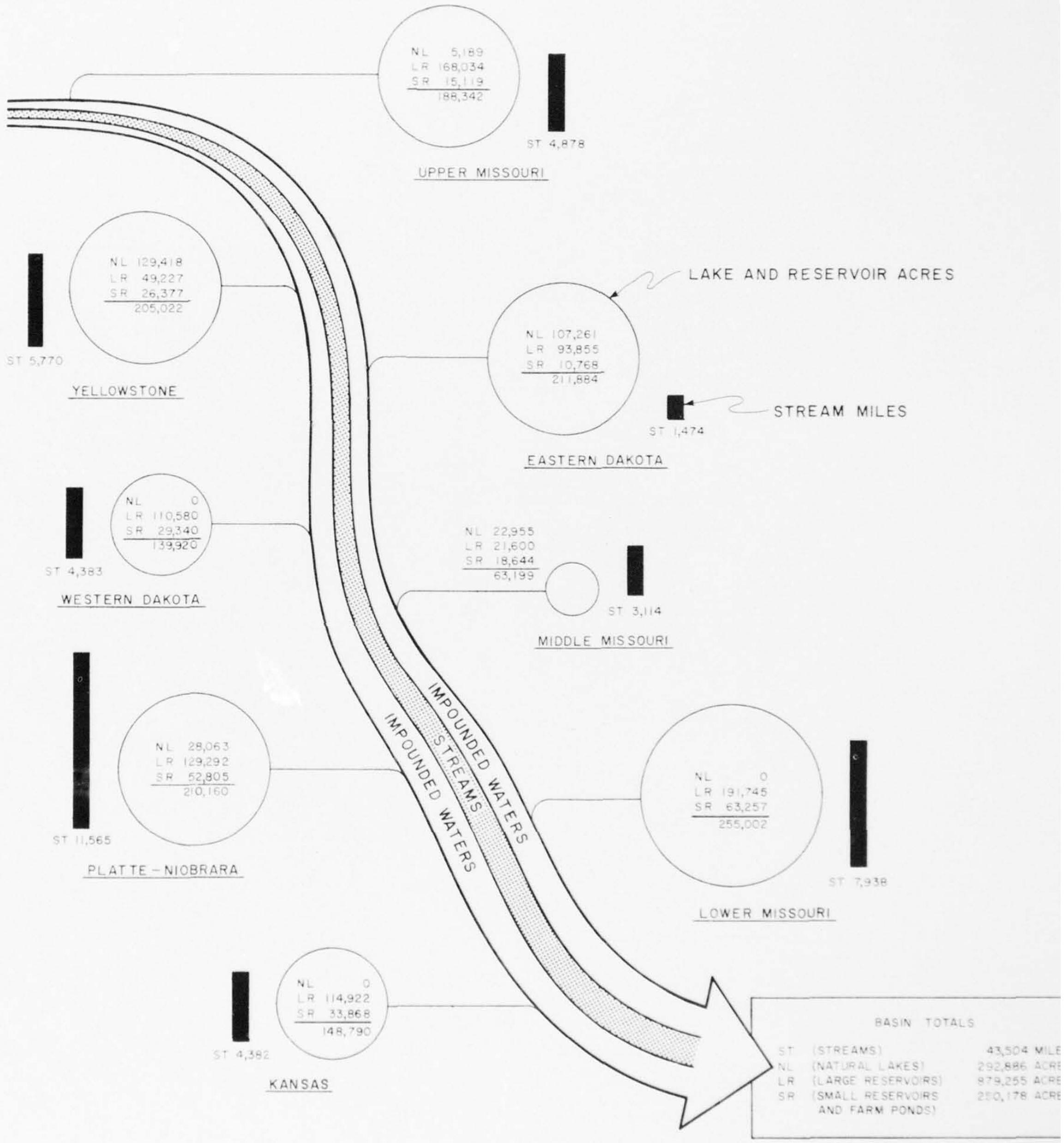
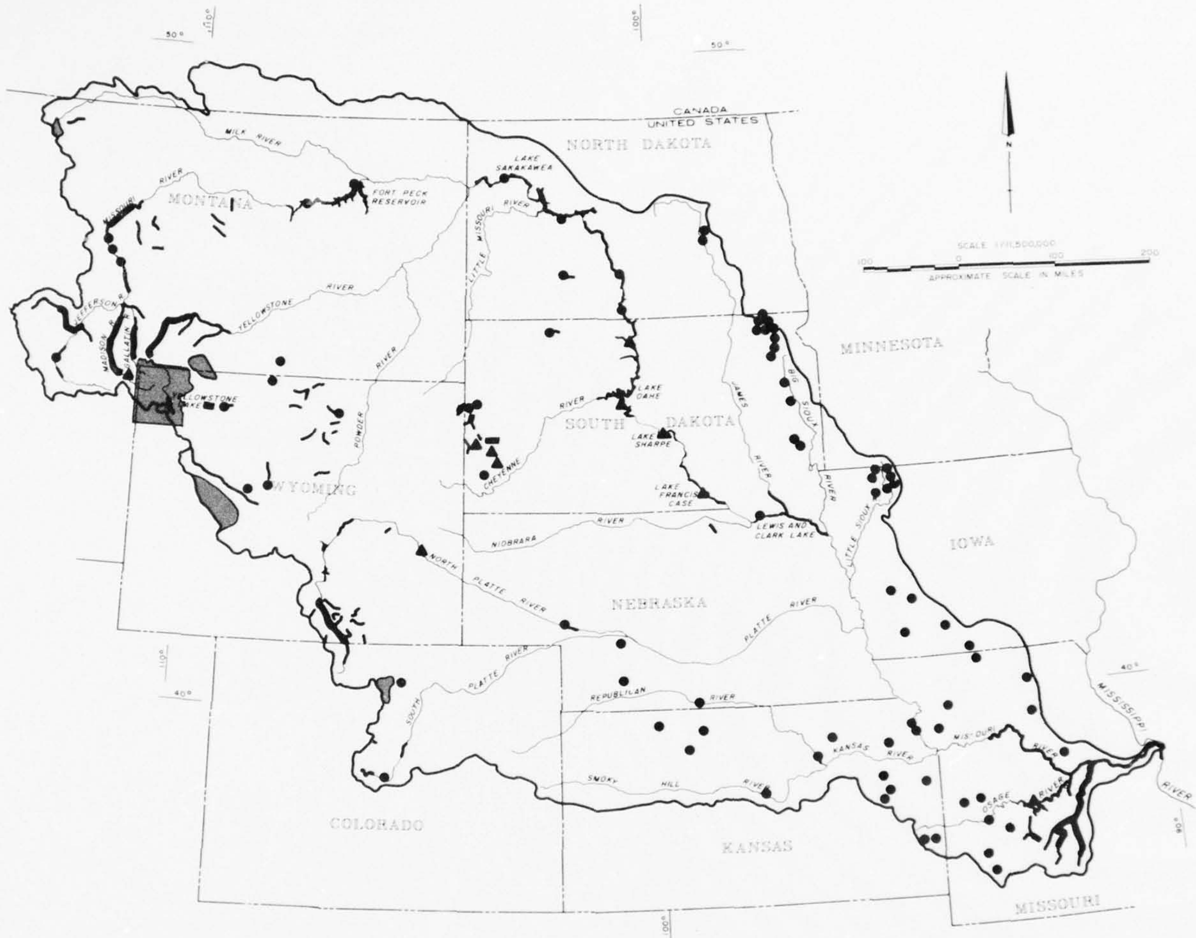


FIGURE 28

STREAM AND LAKE FISHERIES



LEGEND

STREAMS

CLASS I (864 MILES)
Waters of Nationwide Importance

CLASS 2 (2,194 MILES)
Waters of Statewide Importance

LAKES

CLASS I (161,514 ACRES) Waters of Nationwide Importance (This includes only 20% of the area of Main Stem Reservoirs; the area considered to have significant sport fishing value.)

CLASS 2 (508,770 ACRES) Waters of Statewide Importance (This includes only 20% of the area of Main Stem Reservoirs, except Lewis and Clark Lake; the area considered to have significant sport fishing value.)

The unique nature of fishing waters within the enclosed areas are considered to be of National significance, although individual waters are not shown in Class I totals. This includes all waters within the boundaries of Yellowstone, Glacier, and Rocky Mountain National Parks, plus the mountain lake complexes of the Bear Tooth Plateau (Montana and Wyoming) and Wind River (Wyoming) areas.

The removal of streamside vegetation and bank erosion, road construction, strip mining, and in some areas, logging, also contribute to increased sediment production. These sediment loads have increased turbidities and accelerated the sedimentation of lakes and streams with serious adverse effects on fish. The application of conservation practices, proper grazing, and changed use of some highly erosive soils from cultivation to permanent vegetation, have reduced the problem to some extent. The construction of water impoundments has served to trap sediment with adverse effects on the impoundment. This has in turn lowered the turbidity of streamflows below these structures. However, a serious sediment problem still exists in many of the rivers, streams and lakes in the basin.

Channelization of stream courses has resulted in significant degradation of associated fisheries in many instances. Many tributaries have been channelized to speed flood runoff, especially in their lower reaches. Road construction has resulted in much channel modification. Rerouting of streams often increases gradients and flow velocities; destroys meanders, vegetation, pools, riffles, and undercut banks; and reduces fishable stream mileage.

From data available on the degrading factors listed, about 2,410 miles of streams and about 4,300 acres of relatively small impoundments were identified as totally degraded for fishing. It is certain that additional waters would be so classed if the data were more complete. Certainly most waters in the basin have suffered some damage from one or more of the enumerated factors.

There are about 1,857,000 acres of water in the basin having significant commercial fishing potential. This includes all water bodies exceeding 1,000 surface-acres, plus the Missouri River. The 1,004,000 acres of main stem impoundments constitute most of the total. Other impounded waters, including natural lakes, provide an additional 758,000 acres. The Missouri River represents about 95,000 acres of water suitable for commercial fishing.

In the mountainous west, rainbow trout and brown trout constitute the main sport fish populations. Brook, cutthroat, and lake trout are also important, with Kokanee, silver salmon, and golden trout locally significant. The Arctic grayling and greenback cutthroat trout, considered as rare and endangered, respectively, by the Committee on Rare and Endangered Species, also occur.

On the plains, the northern pike is a popular trophy species. In the Dakotas, this species, with the walleye, provides the backbone of the main stem fishery, along with sauger, burbot, paddlefish, and catfish. Channel catfish provide the most popular stream fishing throughout the plains area. Trout are very important locally, particularly in the Black Hills and in relatively small, State-managed recreational lakes. Largemouth bass, crappie, sunfish, yellow perch, bullheads, and some species already mentioned, are locally important in natural lakes and small reservoirs.

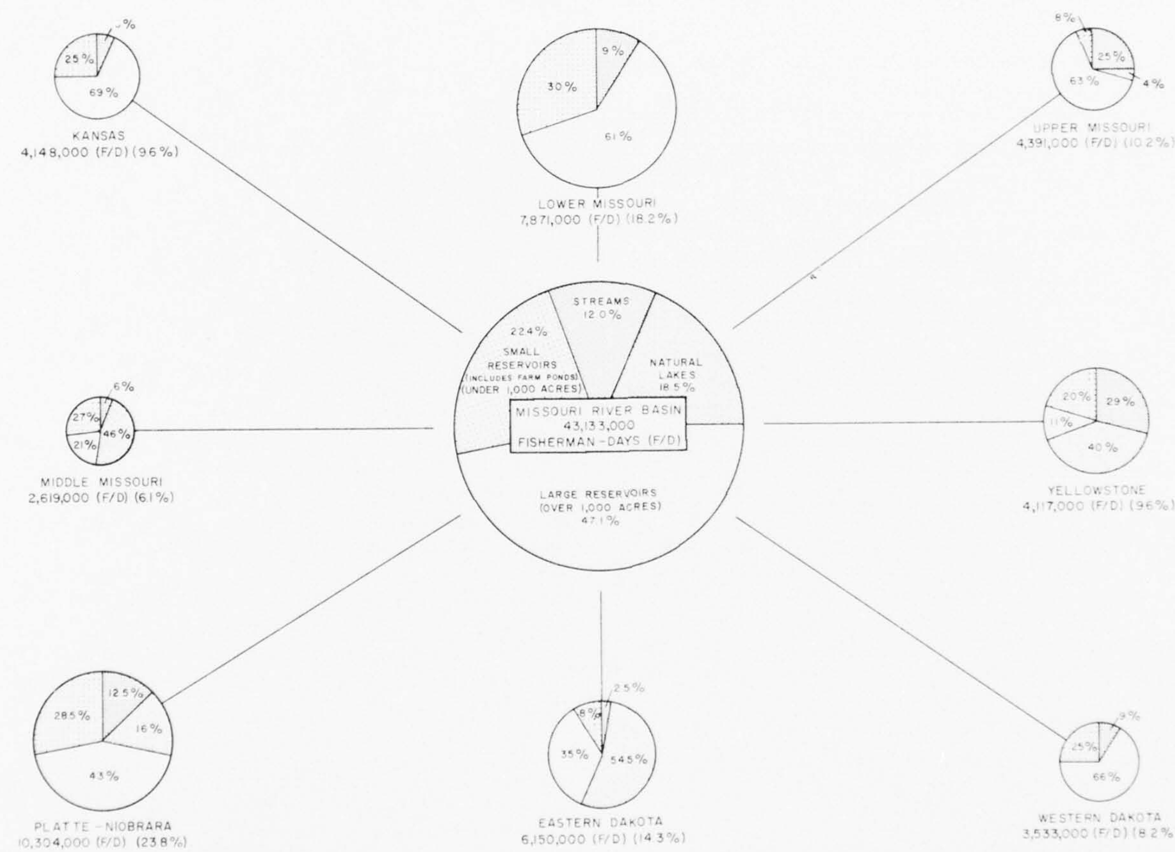
Northern pike, such as these from Oahe Reservoir, are "trophy" fish of outstanding value. A shortage of physical access developments limits fishing. Future research and improved management may perpetuate the future of this resource in these reservoirs.

In the lower part of the basin, largemouth bass, crappie, bullheads, and especially the channel catfish, become increasingly important. White bass and carp are significant in many areas from the Dakotas to Missouri. The smallmouth bass is highly prized in Ozark streams. Important put-and-take trout fisheries are located below a few large springs in the Ozarks.

About 30 species of fish, not including minnows caught commercially for sport fishing bait, can be considered as having commercial fishing value. Of primary importance to the existing commercial fishery are carp, buffalo, and catfish. These fish are moderately to highly abundant across the Missouri Basin and presently provide the bulk of production. Carp stand out in abundance, being adaptable to the varying water quality found across the basin. Buffalo are found in most of the basin's large rivers, lakes, and reservoirs. Catfish are relatively abundant throughout rivers and reservoirs of the basin, and, where regulations permit their harvest, are the most important commercial fish. Other species sometimes caught commercially include river carpsucker, paddlefish, sturgeon, bullhead, goldeye, suckers, blue and flathead catfish, and freshwater drum.

The capability of the classified fishing waters in the Missouri Basin to supply sport fishing has been estimated at about 43,133,000 fisherman-days (f-d) annually. Estimates are based upon "good" quality fishing defined as 3 fish, or 1 to 2 pounds, per fisherman day for both warm-water and cold-water fishing. Capability or capacity, as used here, is an estimate of fishing that could be realized if all habitat were used at a high level. The total basin capability is the sum of estimated individual capabilities for the multitude of habitat components comprising the fishery resource. It is shown divided into segments by subbasin and habitat categories in figure 29. Basinwide, natural waters including streams and lakes together provide just over one-third of all

FIGURE 29
DISTRIBUTION OF FISHING CAPACITY
BY SUBBASINS



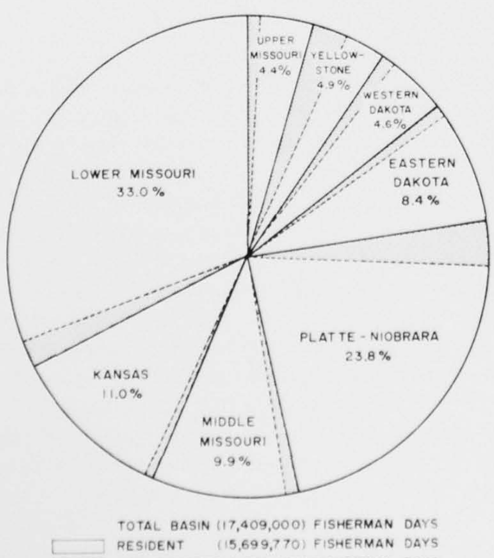
capacity, artificial reservoirs of 1,000 acres and over provide nearly half, and small reservoirs, including farm ponds, supply the remainder.

As seen in figure 29, streams and natural lakes contribute significantly to the total fishing capacity in and near the mountainous western end of the basin where associated aesthetic qualities are of a high order. Artificial impoundments provide the vast bulk of capacity in other areas, although natural waters do contribute significantly, notably the streams of the Ozark Plateaus in Missouri, the glacial lake complexes in the Dakotas and Iowa, and streams of the Black Hills in South Dakota and Wyoming, and the sandhill lakes of Nebraska. The status of most of these high quality fishing waters is tenuous, and must be protected to preserve the unique recreational and aesthetic values. Substitution of gross increases in fishing capacity, as through reservoir construction, in the past has obscured the loss of unique and irreplaceable stream fishing resources, especially in areas of the basin where available fishing capacity has exceeded that needed to meet demand.

Sport fisherman use in the basin has been estimated at 17,409,000 fisherman-days in 1960 or about 40 percent of the total capacity as shown in figure 30. Nonresident use represented about a tenth of the total.

Trout are so abundant in some of the scenic high mountain lakes that fishing such as this is commonly enjoyed. Preservation, improved public access, and intensive management are basic needs for many of these waters.

FIGURE 30
FISHERMAN USE
(IN PERCENT BY SUBBASIN)



About one-third of all use was in the Lower Missouri Subbasin, nearly a fourth in the Platte-Niobrara Subbasin, and about a tenth in the Middle Missouri Subbasin. These three subbasins support some 70 percent of the population in the Missouri Basin, and it is in these areas that the most serious shortages of fishable waters occur, or are in prospect. By contrast, less than a tenth of all use occurred in the Upper Missouri and Yellowstone subbasins combined. Over half of the fishing in these two subbasins was on streams, largely trout waters.

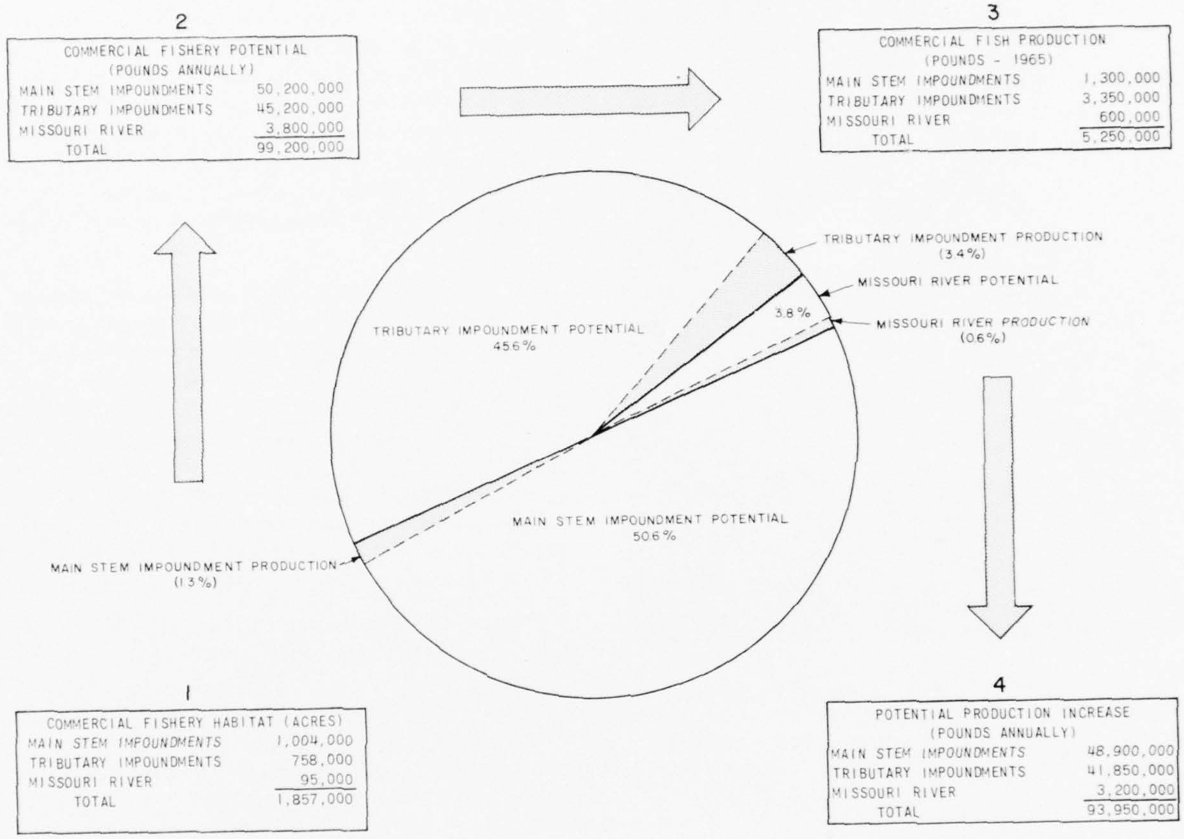
The overall supply of sport fishing in the Missouri Basin appeared adequate in 1960, based on a comparison of use and capacity (figures 29 and 30). However, many factors tend to discourage use or limit realization of the available capacity. A major problem is the geographical distribution of people versus fishing waters. In the Missouri Basin, much fishing is too far from the potential fisherman. Legal and physical access to fishable waters is another important consideration. For example, there may be relatively little fishing on a prime trout stream if access is actually or in effect denied.

Physical limits on access, such as the lack of roads into mountainous and other undeveloped areas, are frequently important. Very large impoundments present inherent difficulties which often restrict use. Big reservoirs require large personal investments in equipment and present hazardous fishing conditions. Aesthetic qualities are frequently low, especially where extensive lake drawdowns are common, and developed access areas, other than at tailraces and public recreation sites, are often inadequate or unattractive. These and other factors have depressed actual use of fishing waters in the Missouri Basin in the past and will continue to do so in the future.

The capacity of classified fishing waters to support sport fishing is projected as unchanged for the years 1980, 2000, and 2020. Routine construction of impoundments combined with fishery management sophistication will undoubtedly increase the capacity. On the other hand, gradual degradation of existing habitat through stream channelization, water quality deterioration, sedimentation of stream beds and reservoir basins, and other factors, will tend to offset many of the gains. No reasonable basis exists for quantifying the net trend; thus fishing capacity is projected as level from the present to 2020.

The capacity of waters in the basin to sustain a commercial fishery is estimated to be about 99.2 million pounds annually of which the main stem impoundments would provide over one-half (figure 31). Actual production for marketing in 1965 was only about 5.2 million pounds, or just over 5 percent of the estimated available supply because of the low demand.

FIGURE 31
COMMERCIAL FISHING POTENTIAL AND DISTRIBUTION



The commercial fishery potential of the basin is largely undeveloped, generally confined to scattered one or two-man operations on the Missouri River.

Distribution and Status of Wildlife

Wildlife habitat and populations are as varied as the wide range of habitat that supports them. About 60 species of big game, small game, and waterfowl are sought by hunters and about 20 of the species are important for their fur.

For purposes of this report, only those animals of value for hunting, as fur animals, or those having outstanding significance for some other reason, are discussed. The values of wildlife for recreational purposes other than hunting are treated more fully in chapter 6.

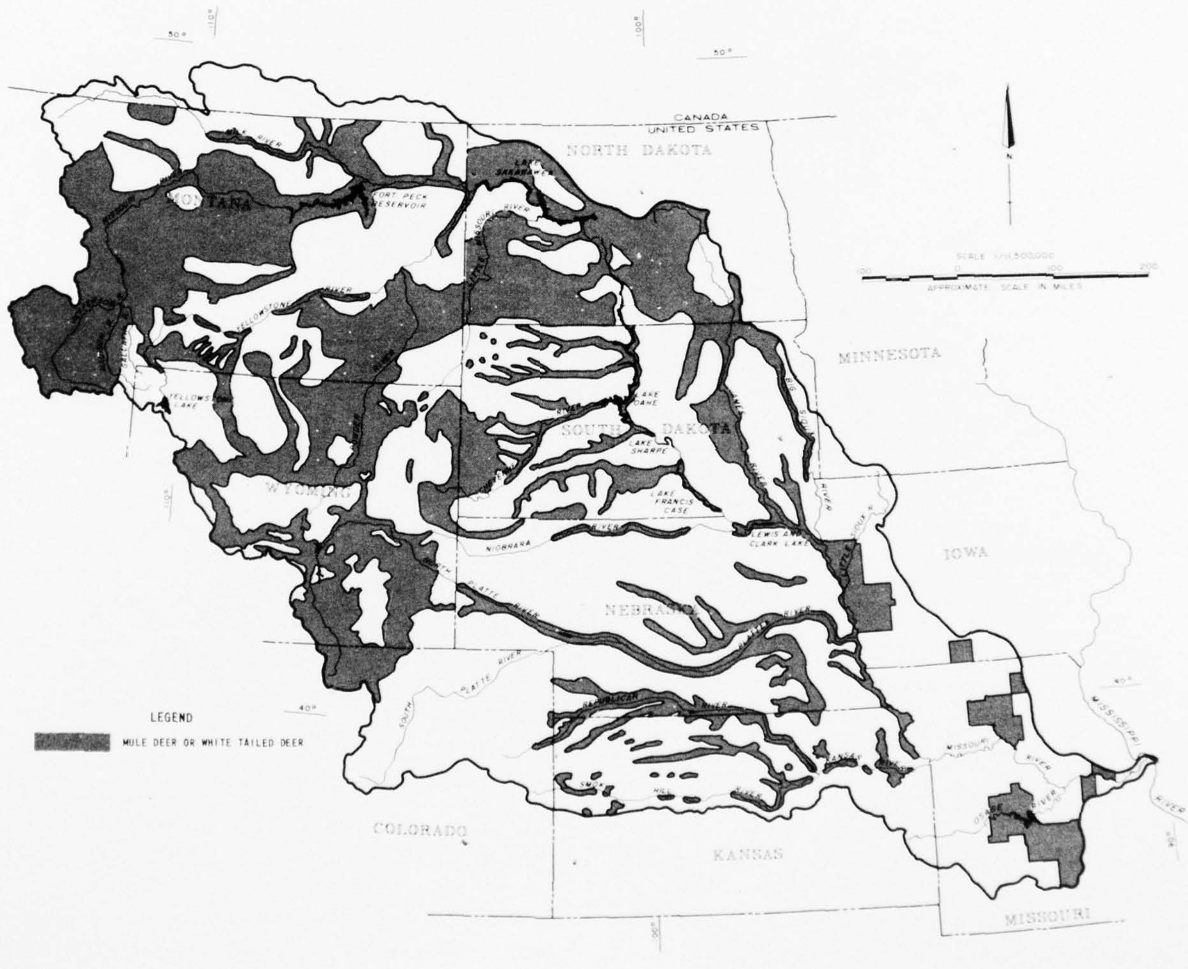
Some animals of special note occur in the basin; these are the rare or endangered species as recognized by the Committee on Rare and Endangered Wildlife Species of the Bureau of Sport Fisheries and Wildlife. Birds and mammals considered to be near extinction or endangered include the black-footed ferret, Eskimo curlew, grizzly bear, and whooping crane. Those categorized as rare are the American peregrine falcon, black-tailed prairie dog, greater sandhill crane, northern greater prairie chicken, and western burrowing owl. Programs have been initiated to perpetuate these species.

Deer are the most abundant and important of big game, and because of their wide distribution they form the backbone of big game hunting in the basin. Although both mule and white-tailed deer are abundant, whitetails are more widely distributed, with mule deer restricted to the western portion of the basin. White-tailed deer prefer the more heavily timbered areas and brushy drainages, whereas mule deer typically inhabit the open prairie and mountain lands with a more scattered arrangement of woody cover. In much of the western portion of the basin both species can be found together. Since there is considerable overlap of their ranges, the high quality habitat for both is illustrated in figure 32.

FIGURE 32

DEER HABITAT

HIGH QUALITY



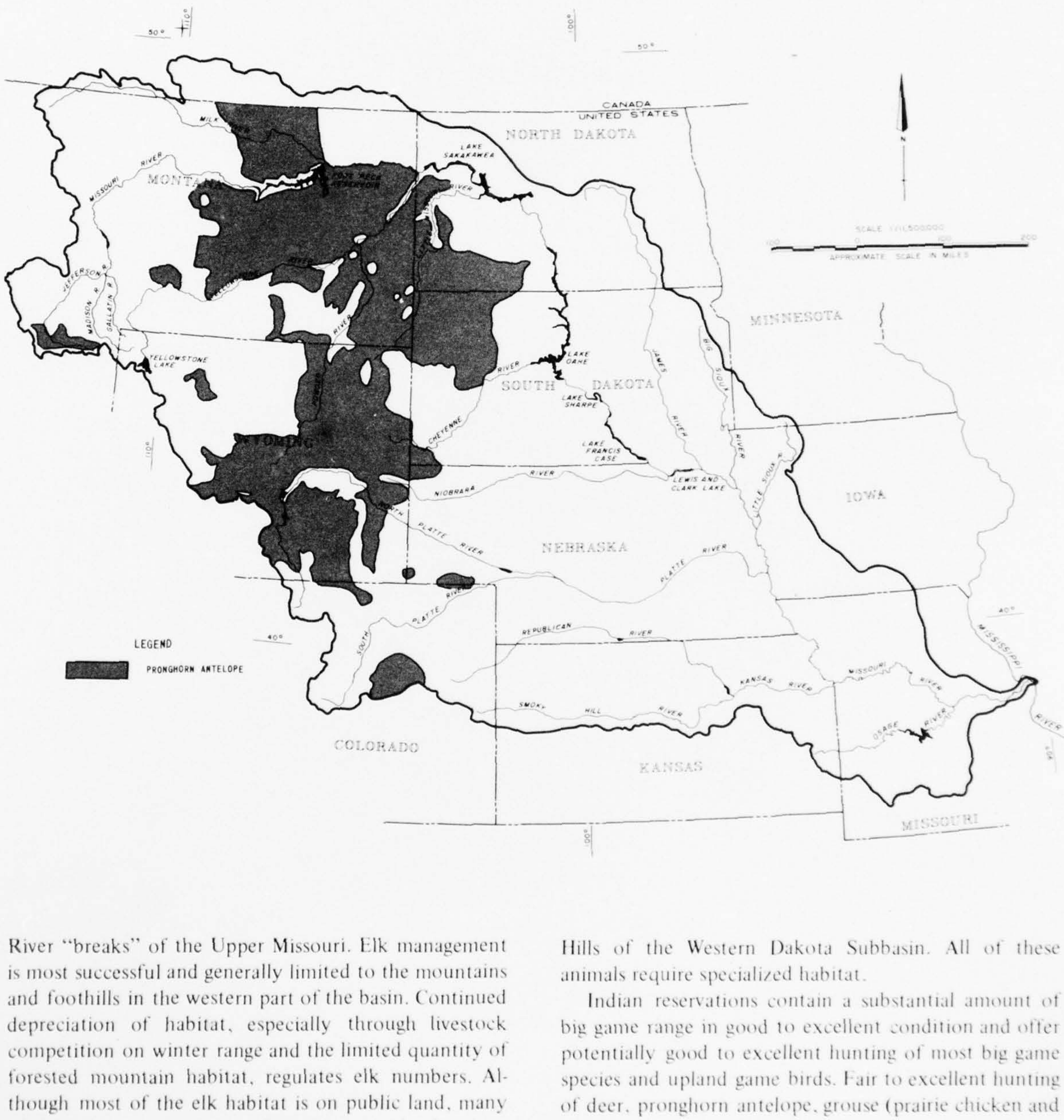
Pronghorn antelope is most abundant in the prairie sections of the Upper Missouri, Yellowstone, Western Dakota, and Platte-Niobrara subbasins (figure 33). In terms of annual big game kill, it ranks second only to deer. The pronghorn is dependent on the condition of open rangeland, and this habitat has been deteriorating — largely as a result of fencing, overgrazing, sagebrush eradication, and conversion of native mixed habitat to grass ranges. In some areas along the eastern edge of the existing pronghorn range, transplanting and re-establishment programs are being carried out to extend distribution.

Elk are located mainly in the timbered mountain portions of the Upper Missouri, Yellowstone, and Platte-Niobrara subbasins. Small herds are also found in the Black Hills of the western Dakotas and the Missouri

FIGURE 33

ANTELOPE HABITAT

HIGH QUALITY



River "breaks" of the Upper Missouri. Elk management is most successful and generally limited to the mountains and foothills in the western part of the basin. Continued depreciation of habitat, especially through livestock competition on winter range and the limited quantity of forested mountain habitat, regulates elk numbers. Although most of the elk habitat is on public land, many of the winter ranges are on adjoining private land and are used to capacity by livestock during other times of the year.

Moose, bighorn sheep, black bear, grizzly bear, and mountain goats are other "trophy" species that are associated in general, with the more remote areas of the Upper Missouri, Yellowstone, and Platte-Niobrara subbasins. There are also a few sheep and goats in the Black Hills of the Western Dakota Subbasin. All of these animals require specialized habitat.

Indian reservations contain a substantial amount of big game range in good to excellent condition and offer potentially good to excellent hunting of most big game species and upland game birds. Fair to excellent hunting of deer, pronghorn antelope, grouse (prairie chicken and sharp-tail), pheasants, and dove exists on some of the reservations today.

The pheasant is the most important upland game species from the standpoint of harvestable numbers, man-days of hunting, and wide distribution. High quality habitat associated with cropland is scattered throughout the basin (figure 34). Populations in the Eastern Dakota and Platte-Niobrara subbasins can be considered of

Range for elk and other big game is in critical supply where herds come into the foothill grasslands in competition with livestock for winter feed. Winter range should be balanced with the abundant summer range for maximum benefits to wildlife.

More hunting effort is devoted to pheasant in the basin than any other wildlife species. These Kansas hunters are enjoying the fruits of high quality habitat developed and managed by the State on lands around Lovewell Reservoir. All future water development projects should be planned to achieve similar benefits wherever possible.

national importance, and large numbers of hunters travel considerable distances to hunt them. Pheasants in the more arid sections of the basin are usually associated with irrigated river valleys where environmental conditions, especially at the lower elevations, are favorable. Pheasant numbers are greatest in the Eastern Dakota, Platte-Niobrara, and Middle Missouri subbasins, but populations there and elsewhere have declined in recent years as a result of land use changes, drainage, intensified agriculture, and environmental limitations which are not completely explainable.

The bobwhite quail is the second most important game bird in the basin in terms of kill and man-days of hunting. Although high value habitat is found only in the southeastern part of the basin, huntable populations do extend into the Eastern and Western Dakota subbasins (figure 34) and a few areas farther west. Reduction of habitat by improved farming methods, urban development, highway construction, and weed control is rapidly lowering quail populations and the quality of quail hunting, especially in the Middle and Lower Missouri subbasins. The adverse effects upon quail habitat are being relieved in small measure by planting of farm hedgerows and shrubs and development of habitat on isolated areas.

Several species of grouse are widely distributed throughout the basin except in the southeast. High quality habitats for sharp-tailed grouse, sage grouse, mountain grouse (blue, Franklin's, and ruffed) and greater prairie chicken are shown in figure 35. Distribution of all grouse since 1900, with the possible exception of the mountain grouse, has been diminished due to reduction of habitat by overgrazing, cultivated agriculture, and other changes in land use. For example, the only remaining high quality prairie chicken habitat of any extent is confined to relatively small areas in the Platte-Niobrara and Western Dakota subbasins. The sharptail is the most widely distributed and likewise the most important to hunting. Some of the best populations in the Nation are found in western North Dakota and South Dakota; however, here also much habitat is depreciated. Unfortunately, numerous sagebrush-control efforts are continuing to severely reduce sage grouse habitat.

Hungarian partridge habitat is well distributed throughout the northern portions of the basin, and good populations of this exotic bird are present (figure 34). It is well adapted to the northern Great Plains where extensive grain production occurs. This bird is subject to wide population fluctuations, which greatly complicate its management. Chukar partridges now are well established in many foothill areas in the western part of the basin.

Mourning dove habitat is also well distributed throughout the basin, and tremendous numbers are produced annually. Agricultural practices have generally benefited mourning doves. In late summer and fall many more migrate through, and large concentrations are common. Only Colorado, Kansas, Missouri, and South Dakota currently permit dove hunting. It is a protected bird in the other Missouri Basin States despite the fact that it is the number-one game bird in the Nation in terms of numbers taken by hunters.

FIGURE 34

PHEASANT, PARTRIDGE, AND QUAIL HABITAT

HIGH QUALITY

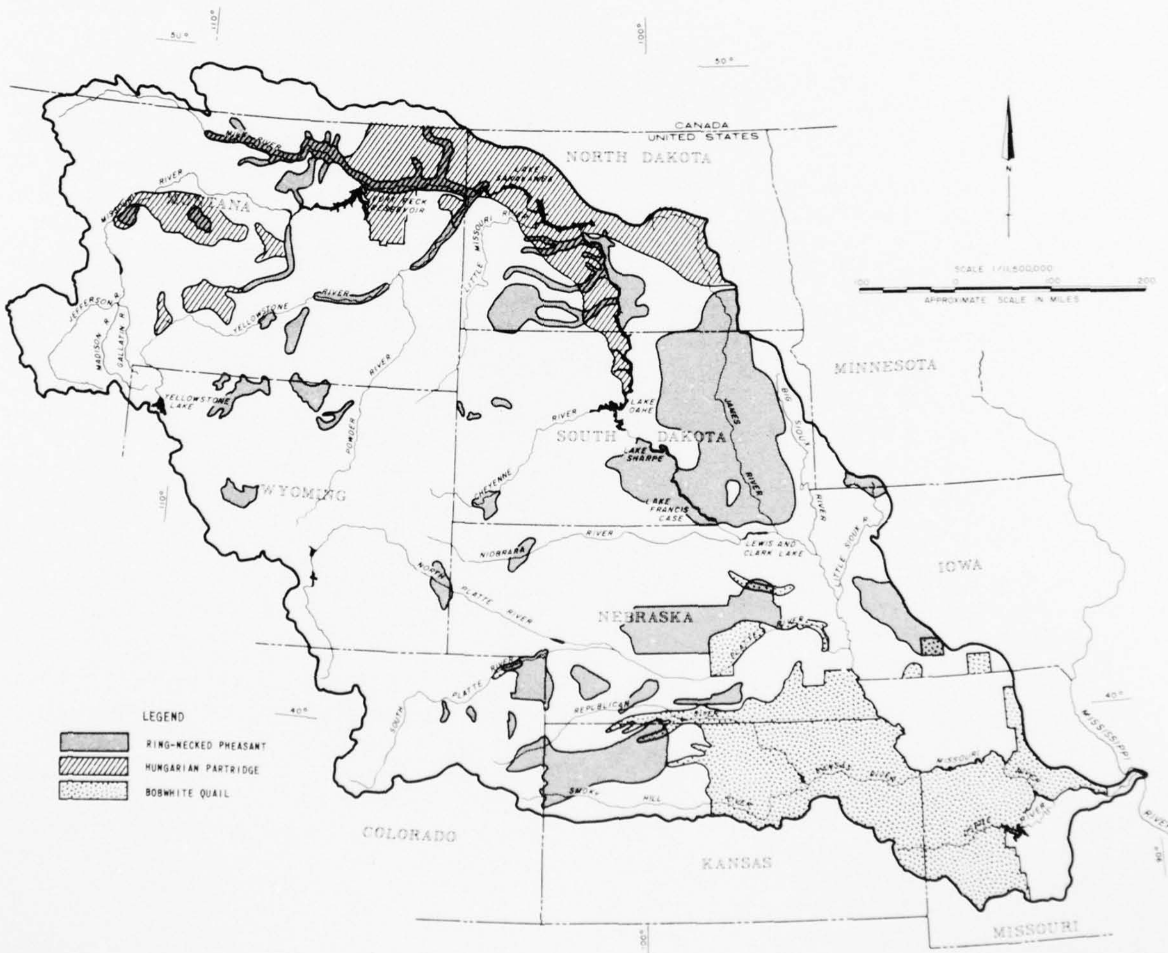
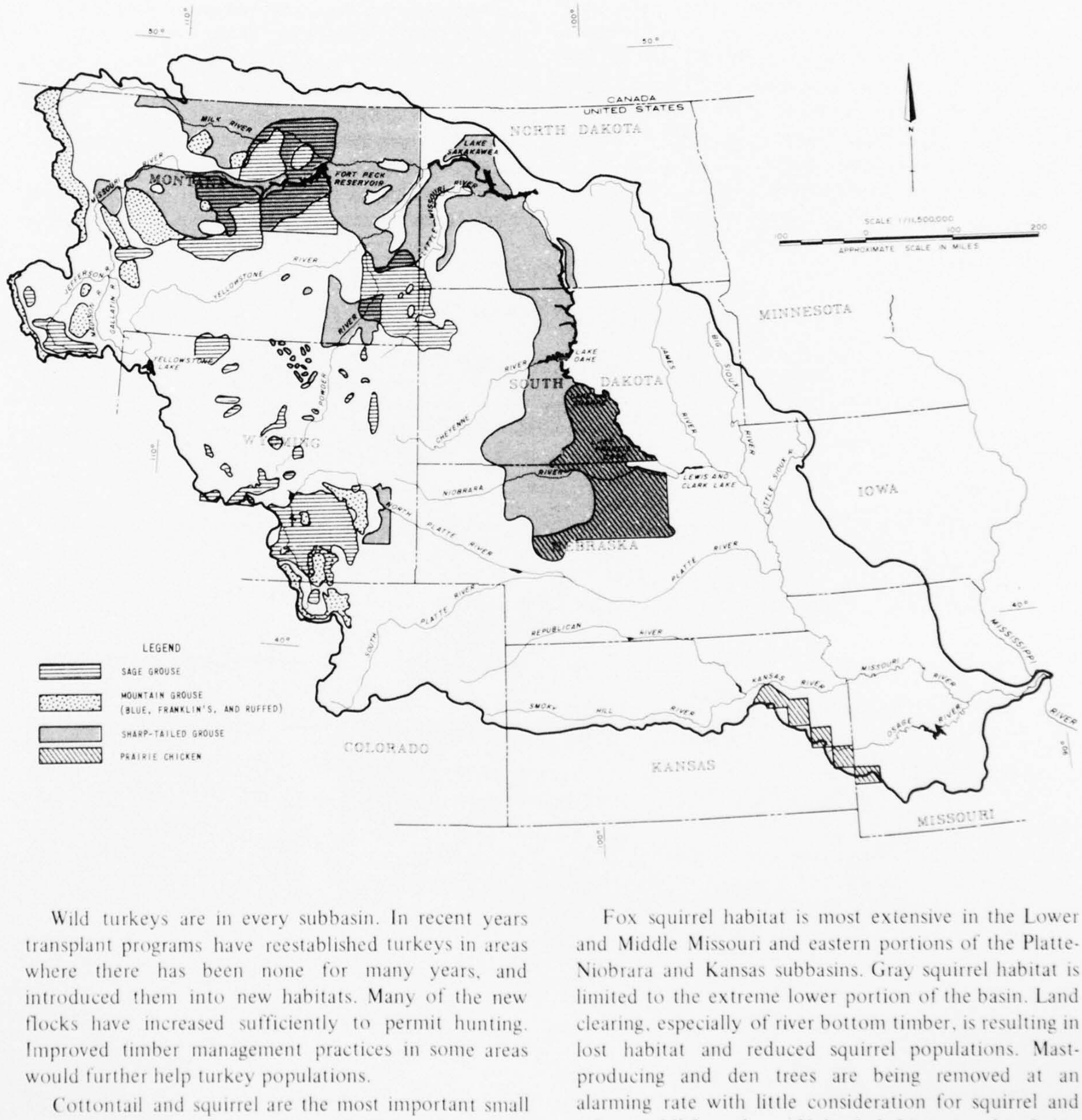


FIGURE 35

GROUSE HABITAT

HIGH QUALITY



Wild turkeys are in every subbasin. In recent years transplant programs have reestablished turkeys in areas where there has been none for many years, and introduced them into new habitats. Many of the new flocks have increased sufficiently to permit hunting. Improved timber management practices in some areas would further help turkey populations.

Cottontail and squirrel are the most important small game mammals in the basin. Cottontail hunting is second only to pheasant hunting in terms of man-days expended. High quality cottontail habitat is found in all subbasins, but better populations occur in the lower four. In these lower subbasins, cottontail habitat is decreasing as a result of changes in land use and intensified agriculture.

Fox squirrel habitat is most extensive in the Lower and Middle Missouri and eastern portions of the Platte-Niobrara and Kansas subbasins. Gray squirrel habitat is limited to the extreme lower portion of the basin. Land clearing, especially of river bottom timber, is resulting in lost habitat and reduced squirrel populations. Mast-producing and den trees are being removed at an alarming rate with little consideration for squirrel and other wildlife values. Upland habitat is also being degraded by lack of adequate consideration for wildlife in management of timber stands. Some slight compensation is resulting from the acquisition of small timbered tracts by urban people seeking rural retreats. Much of the land acquired by these people is being permitted to revert to woody cover by natural plant succession. Farm shelterbelts, windbreaks, and forest plantings have helped to expand the fox squirrel range and establish new populations.

Muskrat, mink, and beaver are the most important fur species throughout the basin from the standpoint of fur value. The muskrat is the most widely distributed and most commonly trapped. Raccoons, foxes, coyotes, skunks, badgers, bobcats, weasels, martens, jackrabbits, and snowshoe hares are common, although not distributed basinwide. Land clearing and intensive agricultural use, including drainage, continue to reduce fur animal habitat, particularly muskrat habitat. Farm ponds, marsh improvements, and other water developments have provided some replacement habitat.

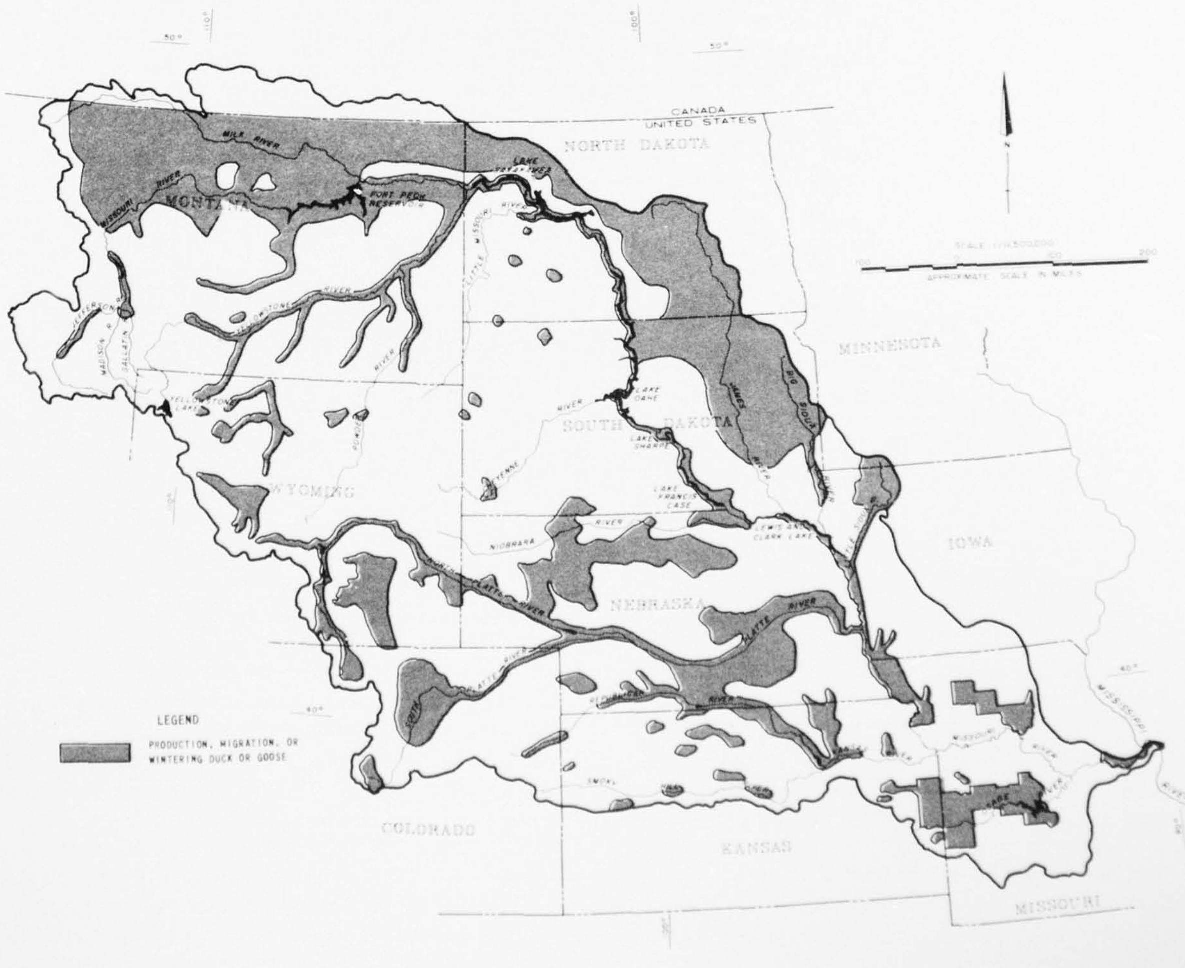
Waterfowl habitat is extremely varied and very unevenly distributed. In the northern part of the basin, large expanses of dryland grain farms and grasslands interspersed with prairie potholes or marshes, especially in the Dakotas, provide migration and breeding habitat for great numbers of waterfowl. Farther south, the habitat is typically stream bottoms, lakes, reservoirs, and various other wetlands. These areas are more important for migration and wintering. In the western parts of the basin, the beaver ponds, lakes, streams, and marshes of the Rocky Mountains and the irrigated lands in the valleys, are valuable for the full range of waterfowl activities. Figure 36 indicates the habitat considered of high waterfowl value.

There are an estimated 2.5 million acres of wetlands valuable to waterfowl in the basin. Of this, about

FIGURE 36

DUCK AND GOOSE HABITAT

HIGH QUALITY



66 percent or 1,650,000 acres, is located in the Eastern Dakota, in the heart of the duck-producing area of North America (figure 37). About 2 million acres consist of type 3, 4, and 5 wetlands, for the most part natural marshes or potholes. In addition, about 400,000 acres of farm and ranch ponds are valuable to waterfowl. Continued stock pond development has played a significant role in waterfowl production, especially in the western part of the basin. Of the total acreage of such ponds in the basin, about 52 percent, or an estimated 210,000 acres, are located in the Upper Missouri, Yellowstone, and Western Dakota subbasins.

Probably no other group of wildlife is affected by so many factors as waterfowl. Foremost is the availability and condition of wetlands. Periods of drought, such as occurred in the northern plains during the late 1950's and early 1960's severely reduced aquatic habitat.

Normal winter migration has been interrupted where water developments create unseasonal open water areas and attract heavy concentrations of ducks and geese.

Geese concentrated at the Squaw Creek National Wildlife Refuge in Missouri. As goose populations continue to increase, additional migration and wintering habitat will be needed to help distribute the flocks and hunting pressures.

The welfare of migratory waterfowl is of international concern involving the conservation and development of production, migrating, and wintering habitat. In some places all three habitat functions are supplied on the same area, compounding the complexity of waterfowl management. A summary of wintering and breeding waterfowl by the various subbasins is shown in tables 108 and 109. The status and future of breeding waterfowl especially ducks and their associated habitat, is a major concern in the basin. The Upper Missouri leads in the production of geese, and the Eastern Dakota is the major producer of ducks. The Lower Missouri winters the largest numbers of both ducks and geese. About 2.4 million breeding waterfowl were present in the basin in the middle 1960's. During the same years wintering waterfowl in the basin totaled almost 2 million.

Various programs have been initiated or accelerated to preserve and develop habitats and associated waterfowl populations in the major production areas. However, in several areas where significant waterfowl production potentials exist, no action or only token action has been taken to stimulate wetland preservation, development, and management.

Draining, filling, burning, polluting, and overgrazing are still rapidly decreasing valuable wetland habitat. In the major waterfowl producing areas where wetland drainage with Federal cost-sharing assistance has been curtailed, extensive drainage has continued through private initiative. In addition, Federal, State, and local water development projects, and land treatment programs that include drainage, continue to reduce wetlands of prime value to waterfowl and other forms of fish and wildlife.

Wetland drainage is one of the major wildlife problems in the basin. This drainage ditch will destroy the marsh in the background and with it the wildlife forms dependent on the wetlands.

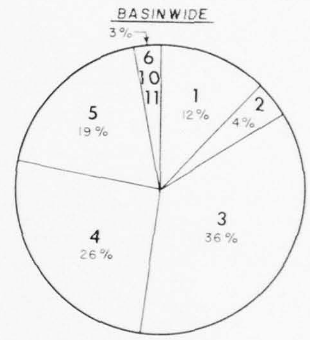
Remaining natural wetlands in the three-state pothole area are being drained at a current rate of 1.73 percent per year almost entirely to improve farm lands for agricultural purposes. Recent surveys in North Dakota

FIGURE 37
DISTRIBUTION OF WETLANDS AND RELATED WATERS FOR WILDLIFE

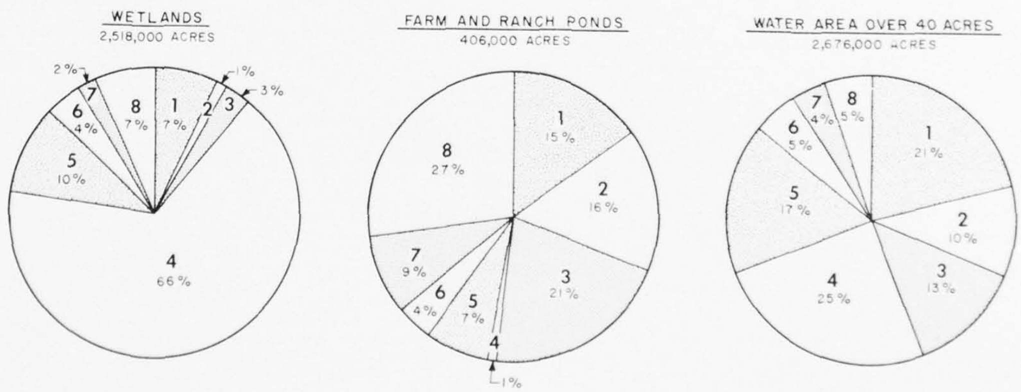
WETLAND TYPES

TYPES

1 SEASONALLY FLOODED BASINS
2 INLAND FRESH MEADOWS
3 INLAND SHALLOW FRESH MARSHES
4 INLAND DEEP FRESH MARSHES
5 INLAND OPEN FRESH WATER
6 SHRUB SWAMPS
10 INLAND SALINE MARSHES
11 INLAND OPEN SALINE WATER



DISTRIBUTION BY SUBBASIN



SUBBASINS

1 UPPER MISSOURI
2 YELLOWSTONE
3 WESTERN DAKOTA
4 EASTERN DAKOTA
5 PLATTE-NIOBRARA
6 MIDDLE MISSOURI
7 KANSAS
8 LOWER MISSOURI

Table 108 – SPECIES AND ESTIMATED NUMBERS OF WATERFOWL BREEDING AND WINTERING IN THE MISSOURI BASIN (1960-65 AVERAGE)

Species	Subbasins								
	Upper Missouri	Yellow-stone	Western Dakota	Eastern Dakota	Platte-Niobrara	Middle Missouri	Kansas	Lower Missouri	Total
Wintering Waterfowl									
Canada Goose	1,200	1,600	6,300	11,700	24,100	5,000	13,940	140,020	203,860
Blue-Snow Geese	0	0	0	0	10	25,000	0	10,030	35,040
Mallard	84,900	56,300	84,200	224,700	356,900	175,000	263,050	600,000	1,845,050
Pintail	0	1,000	*	*	3,030	0	520	9,600	14,150*
Teals	200	4,000	*	*	3,300	0	810	3,380	11,690*
Shoveler	0	1,000	*	*	100	0	*	780	1,880*
Gadwall	10	1,000	*	*	140	0	40*	700	1,890*
Wigeon	100	3,000	*	*	1,100	0	410*	1,480	6,090*
Wood Duck	0	0	0	0	0	0	0	4,000	4,000
Other Ducks	1,200	2,900	1,720	5,020	40,400	0	1,930	15,600	68,770
Totals	87,610	70,800	92,220	241,420	429,080	205,000	280,700	785,590	2,192,420
Breeding Waterfowl									
Canada Goose	10,000	1,200	60	810	2,500	400	210	400	15,580
Mallard	265,200	160,000	129,200	233,890	103,400	4,200	5,850	100	901,840
Pintail	145,000	29,000	41,800	132,140	21,850	0	1,560	0	371,350
Teals	35,800	26,000	83,300	309,400	74,700	8,400	13,400	200	551,200
Shoveler	24,100	10,100	21,800	95,200	10,600	0	170*	0	161,970*
Gadwall	49,900	22,400	19,200	74,000	18,000	0	60*	0	183,560*
Wigeon	24,200	10,200	12,200	19,000	5,600	0	40*	0	71,240*
Wood Duck	0	0	0	0	0	3,750	4,100	12,300	20,150
Other Ducks	19,000	8,100	13,450	57,400	11,700	2,100	5,190	0	116,940
Totals	573,200	267,000	321,010	921,840	248,350	18,850	30,580	13,000	2,393,830

*Some included in other ducks.

Table 109 – DISTRIBUTION OF BREEDING AND WINTERING WATERFOWL IN MISSOURI BASIN (1964-65)

Subbasin	Percent			
	Geese		Ducks	
	Breeding	Wintering	Breeding	Wintering
Upper Missouri	64	*	24	4
Yellowstone	8	*	11	4
Western Dakota	*	3	14	4
Eastern Dakota	5	5	39	12
Platte-Niobrara	16	10	10	21
Middle Missouri	3	13	1	9
Kansas	1	6	1	14
Lower Missouri	3	63	*	32
Missouri Basin	100	100	100	100
Total Number of Waterfowl	15,600	239,100	2,378,000	1,954,000

*Less than 1 percent.

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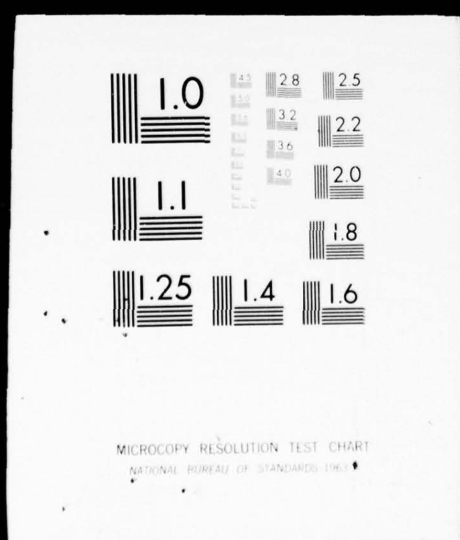
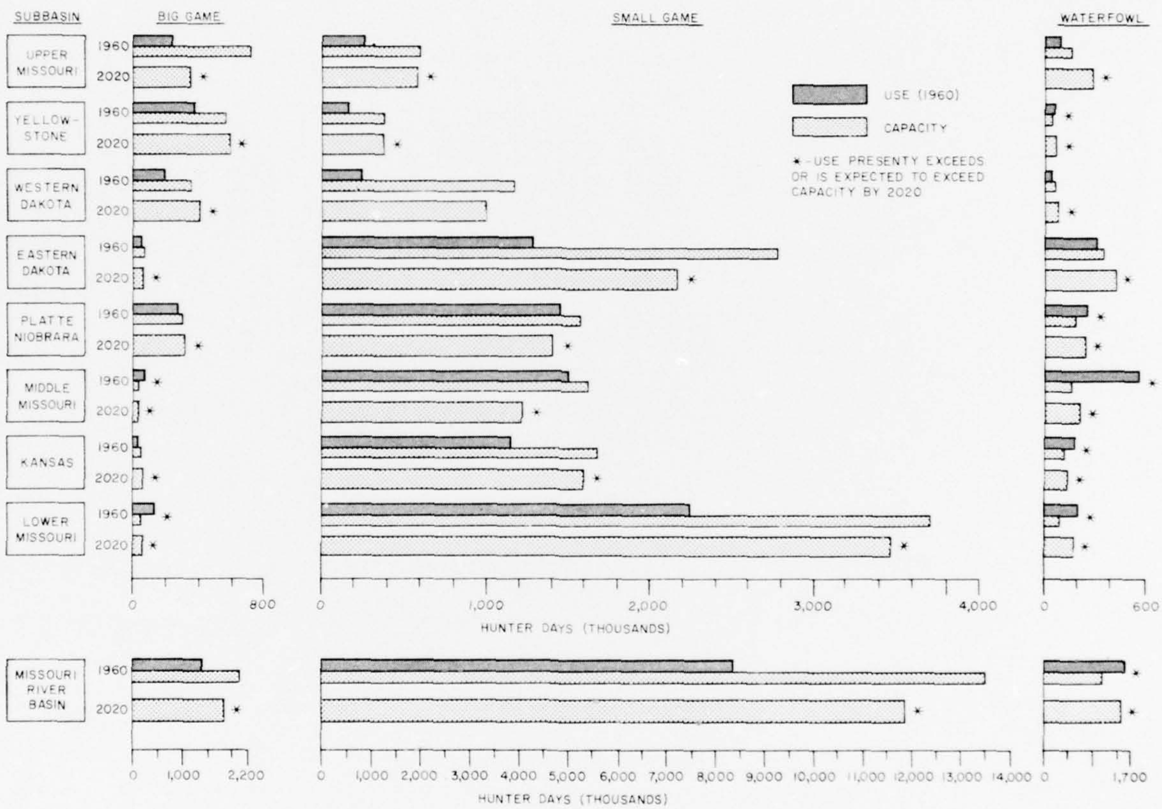

1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963

revealed 1965-67 drainage losses to be almost 45,000 acres of semi-permanent and permanent wetlands (Types 3 and 4). In the Eastern Dakota Subbasin where over 50 percent of the original wetlands were drained before 1950, drainage currently of remaining wetlands is approximately 1.25 percent per year representing about 4,500 acres.

The wildlife resources and habitat in the Missouri Basin have the capacity to support an estimated 16.8 million man-days of "good" quality hunting annually (figure 38). Present use already exceeds 11.4 million man-days, about 75 percent of which is small game hunting and the remaining 25 percent equally divided between big-game and waterfowl hunting.

FIGURE 38
USE AND CAPACITY OF WILDLIFE RESOURCE



Measurement of the present use is a rather straightforward estimate based on time spent hunting and the success in terms of numbers of game bagged. Success is defined as the kill per unit of effort, or the number of man-days expended for each bird or other animal bagged. In this study, present use is based on the levels of hunter success currently prevailing in each subbasin. The estimate of the capability of the habitat to produce wildlife and support hunting is based on a level of success believed to reflect "good" quality hunting. The "good" level is defined as follows:

Species	*Number Harvested*	*Hunter-Days Expended*
Deer	1	5
Antelope	1	2
Any Other Big Game	1	10
Turkey, Goose	1	2
Pheasant, Grouse,) Duck, Quail, Partridge,) Dove, Cottontail,) Squirrel, Racoon,) Fox (or Coyote))	2	1
Jackrabbit	4	1
Woodchuck	2	1

While the present total capacity of wildlife resources and habitat to support hunting appears to be somewhat greater than the present use, the three major components of that use (small-game hunting, big-game hunting, and waterfowl hunting) are not well balanced with the habitat capability. For example, the currently excess hunting capacity in the Missouri Basin is primarily related to small game. Waterfowl hunter-use is already greater than the capacity of the birds and the habitat to support it at the "good" quality level, and big-game hunter use is near that capacity.

The contributions of the several subbasins to these three categories also vary. Big-game hunter demand exceeds capacity in the Middle and Lower Missouri subbasins and even with continued restrictions, will exceed capacity in all subbasins well before 2020. Small-game hunter use is below the capacity of the habitat to support it in all subbasins, but by 2020 use is expected to exceed capacity in all subbasins except the Western Dakota. Waterfowl hunter use is already greater than capacity in the Yellowstone, Platte-Niobrara, Middle Missouri, Kansas, and Lower Missouri subbasins, and long before 2020 the demand for waterfowl hunting will exceed supply in all subbasins.

Two species of deer, the only big game hunted basinwide, support most of the big game hunting. Over 225,000 deer are killed annually – roughly three-fourths of the almost 300,000 big game animals of all species killed each year as shown in table 110. While deer supply the big-game hunting base, antelope, elk, bear, and "trophy" big game are extremely important in some parts of the basin.

The Upper Missouri, Yellowstone, and Western Dakota subbasins account for over 70 percent of the total big-game kill. Another 20 percent is taken in the Platte-Niobrara Subbasin, mostly in the western portion (table 111). About half the total hunter-days in the Upper Missouri, Yellowstone, and Western Dakota subbasins is spent on big game. In contrast, 5 percent or less of the hunting effort is expended on big game in the eastern subbasins.

Small game habitat is the base for 80 percent of the capability of the Missouri Basin to provide hunting. Only in the Platte-Niobrara and Middle Missouri subbasins is current use near the capacity. All species considered, almost 15 million small game birds and mammals are harvested annually by hunters, and almost one-third of these are pheasants (table 110). The cottontail ranks

Table 110 – AVERAGE ANNUAL HARVEST OF GAME ANIMALS IN THE MISSOURI BASIN

Species	Estimated Number Killed								Missouri Basin Total[1]
	Upper Missouri	Yellow-stone	Western Dakota	Eastern Dakota	Platte-Niobrara	Middle Missouri	Kansas	Lower Missouri	
Deer	58,000	61,000	39,000	11,000	43,000	5,000	3,000	8,000	227,000
Antelope	8,000	17,000	14,000	50	15,000	0	300	0	55,000
Elk	3,700	5,000	200	0	2,000	0	0	0	11,000
Moose	200	200	0	0	0	0	0	0	400
Bighorn Sheep	50	100	0	0	20	0	0	0	200
Mountain Goat	100	50	0	0	0	0	0	0	150
Bear	600	300	0	0	100	0	0	0	1,000
Pheasant	143,000	130,000	230,000	1,941,000	904,000	653,000	704,000	44,000	4,749,000
Sage Grouse	27,000	32,000	1,000*	0	27,000	0	0	0	87,[illegible]
Sharptailed Grouse	34,000	20,000	105,000*	35,000*	51,000*	0	0	0	245,000
Prairie Chicken	0	0	*	*	*	200	6,000	6,000	12,000
Mountain Grouse	29,000	3,000	- - -	0	4,000	0	0	0	36,000
Bobwhite Quail	0	0	- - -	- - -	159,000	312,000	680,000	2,256,000	3,407,000
Hungarian Partridge	41,000	19,000	22,000	50,000	0	5,000	0	0	137,000
Chukar Partridge	0	10,000	- - -	0	300	0	0	0	10,000
Turkey	100	400	1,000	50	1,000	5	50	100	3,000
Mourning Dove	0	0	0	0	74,000	29,000	239,000	330,000	672,000
Cottontail	- - -	18,000	42,000	164,000	282,000	690,000	231,000	2,300,000	3,727,000
Squirrel	0	0	0	- - -	82,000	336,000	124,000	632,000	1,173,000
Raccoon	- - -	- - -	- - -	- - -	- - -	34,000	1,000	110,000	146,000
Fox-coyote	- - -	- - -	- - -	- - -	10,000	16,000	- - -	11,000	38,000
Jackrabbit	- - -	- - -	- - -	- - -	124,000	12,000	- - -	- - -	136,000
Woodchuck	0	0	0	0	0	- - -	- - -	130,000	130,000
Ducks	56,000	33,000	36,000	245,000	189,000	90,000	116,000	73,000	837,000
Geese	7,000	1,000	4,000	65,000	10,000	27,000	7,000	21,000	142,000

[1] Totals are rounded hence the sum of the subbasins may not exactly equal the Missouri Basin total.

*Data for these individual species cannot be completely separated; therefore the number of sharptailed grouse may include some sagegrouse and some prairie chicken.

- - - No data available. For the most part, the numbers missing are not large.

Table 111 – HUNTER EFFORT EXPENDED ON WILDLIFE IN THE MISSOURI BASIN

Species	Percent of Total Hunter-Days Expended								
	Upper Missouri	Yellow-stone	Western Dakota	Eastern Dakota	Platte-Niobrara	Middle Missouri	Kansas	Lower Missouri	Missouri Basin
Deer	26	39	36	3	10	3	2	5	9
Antelope	3	7	6	*	2	0	*	0	1
Elk	16	17	1	0	2	0	0	0	2
Moose	*	*	0	0	0	0	0	0	*
Bighorn Sheep	*	*	0	0	*	0	0	0	*
Goat	*	*	0	0	0	0	0	0	*
Bear	1	*	0	0	*	0	0	0	*
Big Game	47	64	43	3	14	3	2	5	13
Pheasant	16	15	26	68	43	34	42	1	32
Sage Grouse	2	5	*	0	2	0	0	0	1
Sharptailed Grouse	3	2	12	1	2	0	0	0	1
Prairie Chicken	0	0	---	---	---	*	1	*	*
Mountain Grouse	5	*	---	0	*	0	0	0	*
Bobwhite Quail	0	0	0	0	5	7	19	26	10
Hungarian Partridge	16	4	9	4	0	0	0	0	2
Chukar Partridge	0	2	---	0	*	0	0	0	*
Turkey	*	*	*	*	*	*	*	*	*
Mourning Dove	0	0	0	0	2	*	5	3	2
Cottontail Rabbit	---	1	3	4	13	20	13	34	16
Squirrels	0	0	0	---	2	15	5	10	6
Other Small Game	*	*	*	*	4	5	*	12	4
Small Game	42	30	50	77	74	81	85	87	74
Ducks	8	5	6	12	9	8	8	6	8
Geese	3	1	1	8	3	8	5	2	5
Waterfowl	11	6	7	20	12	16	13	8	13
All species	100	100	100	100	100	100	100	100	100

*Less than 1 percent.

second with almost 4 million killed, and the bobwhite third with a take of about 3.4 million.

The kill of various species is noticeably irregular from subbasin to subbasin, but the bulk of small game is taken in the eastern portion of the Missouri Basin where small game populations and hunting pressures are the greatest. Almost half of the pheasants are taken in the Eastern Dakota Subbasin. Over half of the quail and cottontails are killed in the Lower Missouri. More than 75 percent of the hunter-days in the Eastern Dakota, Middle Missouri, Kansas, and Lower Missouri subbasins are spent hunting small game, and almost 70 percent of the activity in the Eastern Dakota Subbasin is expended on pheasants alone (table 111).

About 1 million waterfowl have been bagged annually in the basin in recent years (table 110). In the early 1950's the kill was about twice as heavy, but a series of poor water years and continued habitat destruction have necessitated smaller bag limits and reduced seasons in order to keep annual harvest rates in balance with production. Since 1962 duck populations have been making a modest comeback.

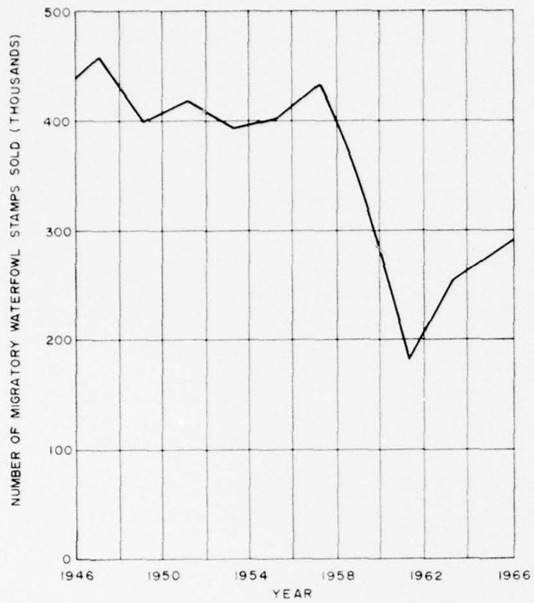
The number of geese, unlike most of the ducks, has been more stable. In general, their nesting areas are farther north and not affected as much by drouth conditions or man's activities. In fact, through improved management, the number of geese as well as hunting has been increasing in recent years.

Since use is related to the number of hunters as well as availability of game, figure 39 provides an indication of recent trends in waterfowl hunting. The bulk of the waterfowl hunting occurs in the eastern portion of the basin. This is partially because of the greater emphasis on big game hunting in the western states.

Of almost 800,000 wild fur pelts harvested annually in the basin, over one-half are muskrat and one-fourth are raccoon (table 112). Aquatic fur animals are the most important from both the standpoint of numbers taken and total fur value.

In general, the more valuable fur-animal populations are declining gradually with the decline in available habitat. Aquatic fur animals have been especially affected by drainage of wetland areas. For various reasons, mostly economic, trapping is also steadily declining. Surplus fur animals occur in most subbasins, and barring radical changes in demand for fur, these surpluses will persist. Although populations of various fur animals will fluctuate from time to time, the long-term trends suggest a rather static relationship between use and capacity.

FIGURE 39
DUCK STAMP SALES IN MISSOURI BASIN STATES
(EXCEPT MINNESOTA)



* THE NUMBERS SHOWN ARE FOR THE TOTAL STATE SALES; NOT THE NUMBER SOLD WITHIN THE MISSOURI BASIN.

Table 112 – ANNUAL FUR ANIMAL HARVEST IN MISSOURI BASIN, 1960-1965 AVERAGE

Species	Number
Muskrat	407,000
Beaver	49,000
Mink	35,000
Otter	30
Raccoon	179,000
Opossum	33,000
Fox	52,000
Coyote	8,000
Skunks	8,000
Badger	6,000
Bobcat (and Lynx)	4,000
Weasel	2,000
Marten	250
Jackrabbit (includes other hares)	Unknown
Missouri Basin	783,280

One of the better indicators of quality relative to the hunting of any one species is the success of the hunters, since the success in taking game is generally the factor most influencing use of the resources. Table 113 presents the hunting success for selected game species in recent years. Since these data were compiled from a variety of sources collected through different sampling methods, it should be used only as a rough index to success in the Missouri Basin. A basinwide average and an indication of departure from this average by each subbasin are included.

PROJECTED DEMANDS

Hunting and Fishing

Sport fishing and hunting have increased dramatically in the last three decades. The upward trend was greatest in the years immediately following World War II, and has become more gradual in recent years. According to the *National Surveys of Fishing and Hunting*, fishing activity increased over 25 percent and hunting about 10 percent nationwide between 1955 and 1965. Over the same period, the population of the United States increased by about 15 percent. Hunting and fishing in the Missouri Basin has generally conformed with the national trends. In the future, the demand for fishing and hunting recreation will continue to increase as population, leisure time, ease of travel, and general affluence continue on the upswing. The spectacular increases percentagewise, because of the nature of the resource base relative to the demand, will be in fishing while hunting in contrast, is expected to show a percentage of population participation decline.

Fishing and hunting demand consists of two essential components: (1) "expressed" demand – the actual present use; and (2) "latent" or unfulfilled demand – the use over and above expressed demand that would occur if the opportunity to fish and hunt were optimum. Expressed demand is readily obtainable through fishing and hunting license sales or similar sources and for the purposes of this study is synonymous with present fishing and hunting use. Latent demand is nonetheless real, and since it can be at least partially satisfied in the future by development and management of resources, it must be considered in estimating future demand on the resources.

Considerable changes in the ratio of expressed to latent demand over short periods of time can be expected, since latent demand is exceedingly ephemeral. The latent demand for hunting and fishing may be currently expressed in alternate uses of leisure time; however, it has been amply demonstrated that if fishing is provided in an area devoid of fishing, many people who are spending their leisure time pursuing other recreational activities will begin to fish.

Demand for fishing and hunting is measured in terms of man-days of use and is the product of the number of users, times the days they spend hunting and fishing. An examination of several sources suggests that in recent years increases in man-days spent fishing and hunting have resulted not so much from increases in activity by present users, as from increases in the actual number of users in the population. In short, progressively larger numbers of people in the United States are fishing and hunting.

Therefore, demand is based primarily on changes in population throughout the study period. It has been

Table 113 – HARVEST PER MAN-DAY OF EFFORT FOR SELECTED GAME SPECIES, MISSOURI BASIN

Species	Subbasin								Missouri Basin Average
	Upper Missouri	Yellow-stone	Western Dakota	Eastern Dakota	Platte-Niobrara	Middle Missouri	Kansas	Missouri	
Deer	.35	.26	.23	.23	.21	.08	.12	.06	.22
Antelope	.47	.40	.52	.44*	.40		.77*		.44
Elk	.04	.05	.06*		.05				.05
Pheasant	1.43	1.50	1.82	1.80	1.00	1.03	1.19	1.24	1.34
Sage Grouse	1.75	1.18	.60*		.84				1.14
Sharptailed Grouse	1.94	1.46	1.84	1.79	1.10				1.59
Bobwhite Quail					1.61	2.25	2.66	3.33	2.91
Hungarian Partridge	.42	.85	.50	.80					.60
Turkey	.11	.15	.48	.28	.20	.20*	.05	.05	.20
Mourning Dove	0	0	0	0	2.35	4.02	3.84	4.04	3.68
Cottontail Rabbit	Unknown	3.00	2.99	2.73	1.02	1.90	1.30	2.62	2.10
Squirrel				Unknown	1.61	1.23	1.70	2.46	1.80
Duck	1.13	1.10	1.34	1.34	.99	.59	1.12	.50	.95
Goose	.28	.16	.46	.51	.16	.36	.10	.33	.28

*Based on a relatively small sample.
Blanks indicate that huntable populations are not available or hunting has not been permitted.

Missouri Basin Average		
Below Average	Average ± 10%	Above Average

calculated using methods set forth in reports of the Outdoor Recreation Resources Review Commission, modified to account for persons coming into the various subbasins to fish or hunt. In almost every case the assumption has been made that residents of any given subbasin who leave the subbasin to fish or hunt elsewhere in their home state are balanced by incoming state residents of other subbasins. Where considerable bias due to this assumption was suspected, corrections were made to compensate.

Fishermen and hunters have been divided into two groups—residents and nonresidents (persons holding nonresident licenses). All nonlicensed users are considered residents, because, for all practical purposes, no state has any provision for nonresidents to fish or hunt without a license. Treatment of resident and nonresident demands separately does not take into account the overlap from residents of one state of a multi-state subbasin participating as a nonresident in another state of the same subbasin. This leads to a bias in estimating the number of fishermen or hunters but does not seriously affect man-days of demand.

All latent demands have been attributed to the resident segment, no realistic estimate of latent nonresident demand being possible with available data. The nonresident demand for big game hunting is often limited legally by the states, especially in the mountainous west. Elimination of these restrictions would undoubtedly result in substantial increases in applications for nonresident hunting of certain big game species. Unlike big game hunting licenses, there have been no limits set by the States on the sale of resident and nonresident fishing licenses.

Fishing and hunting demands in the Missouri Basin are presented in figures 40 and 41. Demand as it stands alone is not very meaningful; therefore, capacity is also presented to provide the basis for an analysis of the demand-supply relationship. Capacity, discussed earlier, is a relative term, and for purposes of this study is based on the level of success rated "good."

The total Missouri Basin demand for fishing is presently below the capacity of the habitat to sustain good fishing, but will exceed that capacity shortly before 1990. In the Middle and Lower Missouri subbasins demand already exceeds capacity and will do so in the Platte-Niobrara and Kansas subbasins by 1980. Fishing demand in the upper four subbasins is well below total capacity at present, and is not expected to

FIGURE 40
ESTIMATED SPORT FISHING DEMAND AND CAPACITY

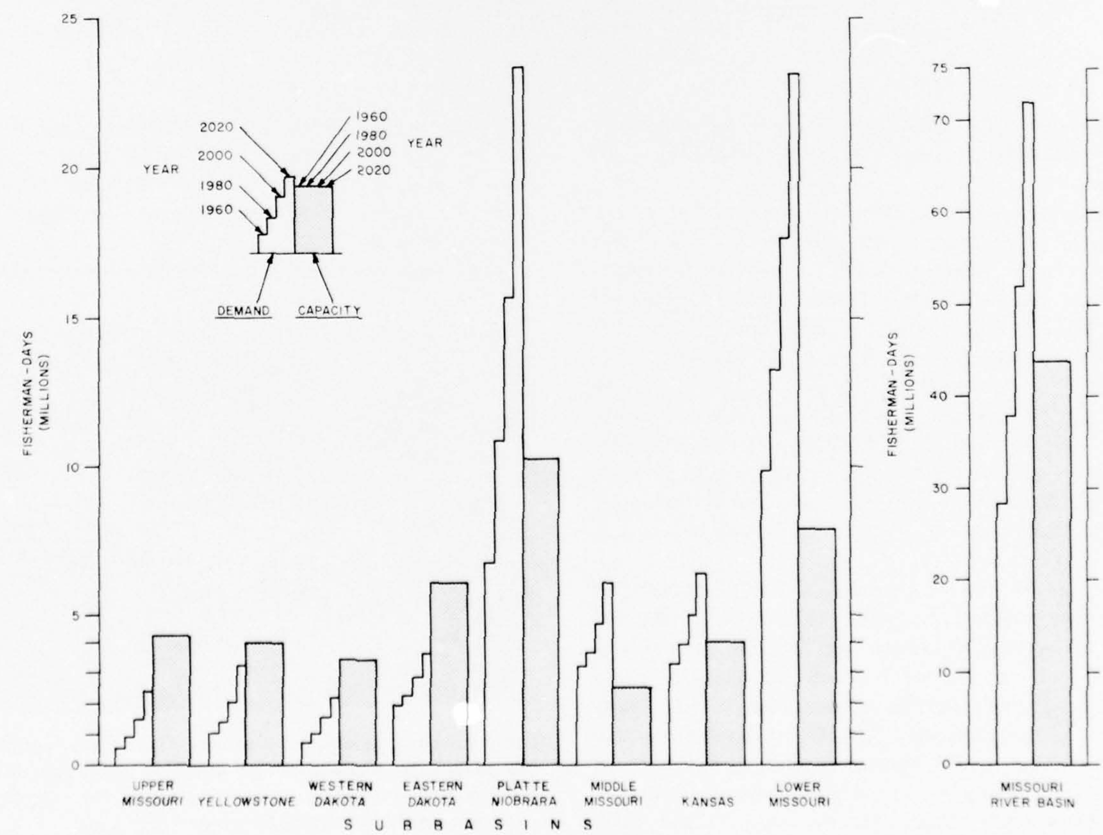
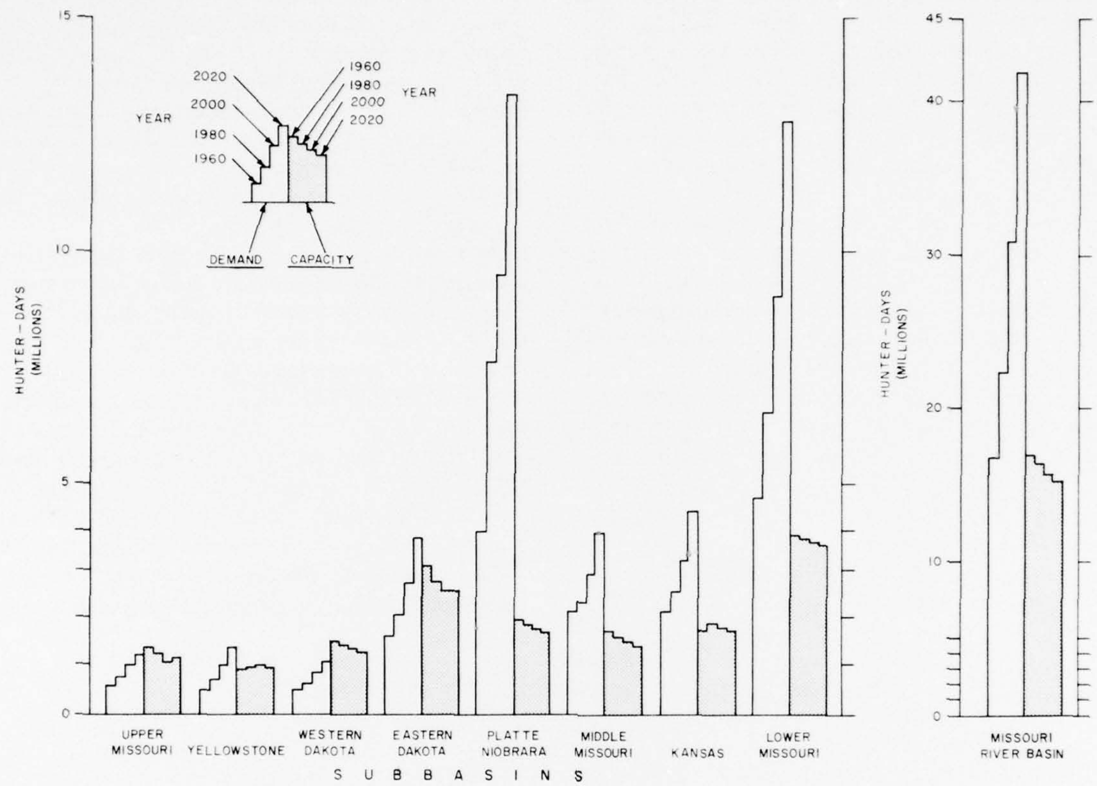


FIGURE 41
ESTIMATED HUNTING DEMAND AND CAPACITY



equal capacity by 2020. However, nonresident demand will be of vital importance here, as explained later in this section.

Hunting shows a generally similar pattern (figure 41). Demands in the upper subbasins are below capacity, but in all of the lower subbasins including the Platte-Niobrara, Middle Missouri, Kansas, and Lower Missouri subbasins, hunting demand exceeds capacity. By 2020 all subbasins except the Western Dakota will face a demand for hunting in excess of the capacity of the resources and habitat to support it at a "good" quality level. For the total Missouri Basin, demand essentially equaled capacity in 1960. Aggravating the problem is a marked downward trend in amount and quality of wildlife habitat resulting in an equivalent decrease in projected capacity.

Figures 40 and 41 represent the total demands of fishermen and hunters on the entire resource base and do not necessarily reflect the demand on any one segment of the resource. For example, demands placed on the big game and waterfowl resources are already near or greater than capacity in almost all subbasins, and the remaining surplus hunting capacity is based almost entirely on small game. In the Western Dakota Subbasin, fishing demands placed on the streams and small reservoirs in the Black Hills are greater than their capacity; yet, the bulk of the total subbasin fishing capacity is represented by the large main stem Missouri River reservoirs where demands do not begin to approach capacity.

The upper portion of the basin is characterized

Good habitat can support a variety of wildlife. A mixed bag of grouse, pheasants, and ducks is often common. Habitat preservation is a primary need for the perpetuation of this excellent hunting.

generally by demands below gross capacities. In the lower portion, demand in the Platte-Niobrara, Middle Missouri, Kansas, and Lower Missouri subbasins is presently near or greater than capacity. Actual fisherman and hunter-day use is naturally somewhat below the demand estimates. The excess of demand over use is substantially greater in the lower basin, indicating much latent, or unfulfilled demand. Over 80 percent of the Missouri Basin population is found in the lower part of the basin. Since demand tends to vary directly with the population, and good quality fishing and hunting opportunities vary inversely with the population, these latent demands are understandable.

The fish and wildlife capacities indicated are estimates based on calculations related to an inventory of fish and wildlife resources. For a variety of reasons, substantial segments of the capacity are not actually available to satisfy demands. Foremost among these are: (1) a disproportionate distribution of the population relative to the available resources, and (2) limited access to fishing and hunting areas. In addition there is a pronounced preference of fishermen and hunters for certain types of fishing and hunting, such as big game hunting and trout fishing. These factors must be adequately considered in any analysis of the hunting and fishing demand-supply situation for the basin.

This concentration of fishermen on a small lake near Omaha emphasizes the need to increase fishing opportunity in the heavily populated parts of the Missouri Basin.

Poor distribution of the supply relative to demand is probably the most important factor limiting full use of the capacity. The population centers of Denver, Omaha-Lincoln, Kansas City, and St. Louis create very severe demand-supply problems. These same areas are those most in need of expanded outdoor recreation. Urbanized populations tend to grow more rapidly than those in rural areas. Lands around these urban areas become more and more intensively used. The result is progressively less room for fish and wildlife, and progressively greater latent demands.

Denver is a good example of this situation. The Platte-Niobrara Subbasin, which includes Denver, is well endowed with fishing and hunting opportunity; however, the sheer magnitude of the demands generated by Denver greatly overrides the capacity in the Colorado portion of the subbasin. A large share of the Denver area demands is satisfied in parts of Colorado outside the Missouri Basin, and in other States, especially Wyoming and Nebraska. A substantial portion of the potential demand is not satisfied at all, and thus is "latent."

The complexities of distribution are not confined to the larger cities. They affect urban areas in general. In the upper basin the effect of unbalanced resource-population distribution is noticeable in such areas as Great Falls in the Upper Missouri, Billings in the Yellowstone, Rapid City, Dickinson, and Mandan in the Western Dakota, and Bismarck, Aberdeen-Huron, and Sioux Falls in the Eastern Dakota subbasins.

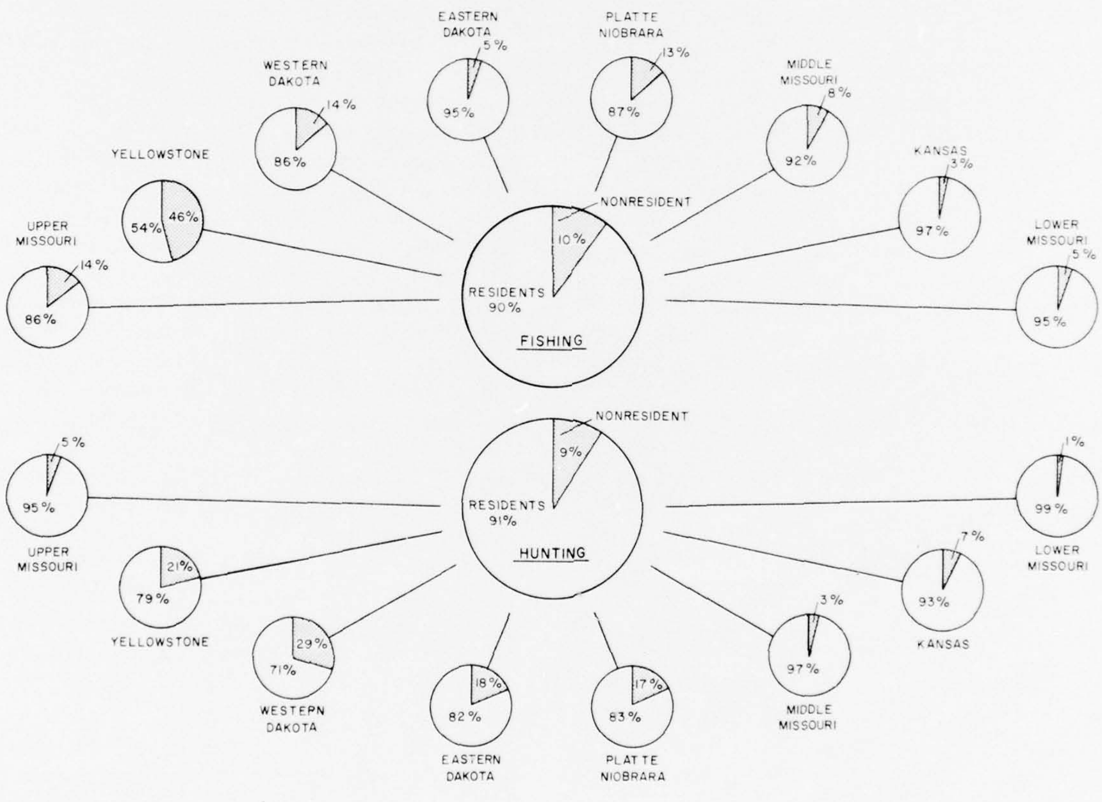
Lack of access is a limitation on use second only to population distribution. Access tends to be most restricted near urban areas, yet the deficiency is by no means confined to such places. Even in the sparsely populated Upper Missouri and Yellowstone subbasins substantial acreages of private lands are, for all practical purposes, completely closed to public entry for hunting and fishing. Over 84 percent of the basin land is in private and state ownership, including Indian lands held in trust by the United States. Access to much of this land for fishing and hunting continues to be available but all of it is subject to closure at any time. Lack of right-of-way across privately owned land prevents access to large blocks of public land. This condition is especially serious in the western states but also occurs around reservoirs and along rivers in other areas.

In addition to legal access, fishing and hunting capacity is also limited by physical access difficulties. Lack of roads, trails, facilities, or proper equipment prevent full use of sizeable segments of the basin's capacity. Typically, lack of physical access is most prominent in the sparsely populated and mountainous regions and is of minor importance in comparison with legal access difficulties.

Demand for big game and waterfowl hunting and trout fishing tends to soon absorb the supply, i.e., reach capacity quickly. Utilization of these more desirable kinds of fishing and hunting will approach the usable capacity much more rapidly and more closely than for the lower quality or less satisfying activities. As demands increase and the higher quality fishing and hunting opportunities become less available or degraded and less attractive, people will be forced to make more use of the lower quality opportunities or quit fishing and hunting entirely. To a significant extent, this accounts for the high latent demands prevalent in the lower portion of the basin.

The nonresident who fishes or hunts outside his home state plays a significant role in the Missouri Basin. About one of every ten fishermen or hunters is a nonresident (figure 42). Data are not available to permit a detailed evaluation of movement of fishermen and hunters into and out of the Missouri Basin. It is assumed from good circumstantial evidence that movement into the basin is substantially greater than the outflow. Typically, nonresident participants in any segment of a subbasin either live in an adjacent state, or are from California, Missouri, Minnesota, Texas, or Illinois. The greatest movements out of the basin occur from Denver and from population centers of the Middle Missouri and Lower Missouri subbasins.

FIGURE 42
RESIDENT AND NONRESIDENT FISHERMAN AND HUNTER USE
(PERCENTAGE BASED ON MAN-DAY USE)



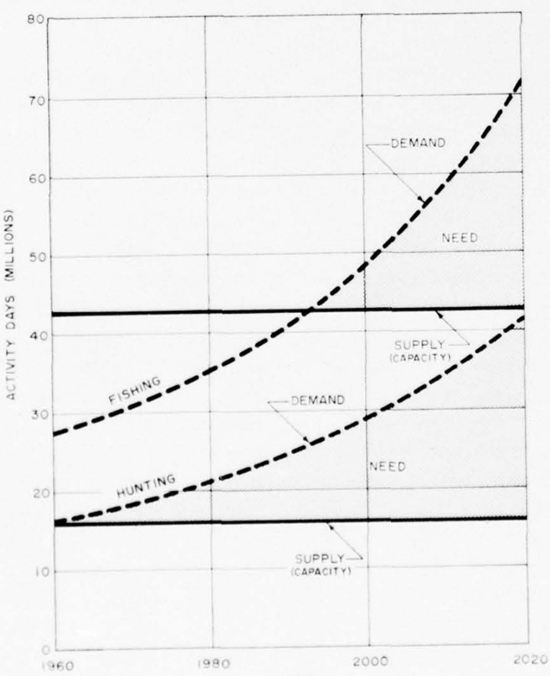
In the Yellowstone Subbasin, almost half of the fishermen are nonresidents, and in the Upper Missouri about 14 percent are nonresidents. These subbasins, along with the Black Hills of the Western Dakota and segments of the Platte-Niobrara and Lower Missouri are very important nationwide as summer recreation areas. For example, an estimated 180,000 fishermen from every State in the Union make use of Yellowstone National Park fishing waters each year. Glacier and Rocky Mountain National Parks also account for large numbers of nonresident fishermen. In the Lower Missouri Subbasin large numbers of fishermen from Illinois and other areas outside the Missouri Basin travel to the Ozarks for recreation.

The Yellowstone, Upper Missouri, Western Dakota, Eastern Dakota, and Platte-Niobrara subbasins accommodate very substantial numbers of nonresident hunters who are limited only by the capacity of the resources to provide hunting and the attendant necessity to restrict license sales for several species. The Yellowstone and Western Dakota subbasins attract big-game hunters nationwide for deer and antelope. Upland game hunting, particularly for pheasants, is the attraction in the Eastern Dakota and Platte-Niobrara. The Upper Missouri is well known for a wide variety of high quality big-game hunting; however, only 5 percent of the hunters are nonresidents. Responsibility for this small percentage includes distance from population centers, but just as important are the restrictive regulations on nonresident hunting.

Nonresident hunting will probably not increase to any extent in the future. Although demand for hunting in general, and the more desirable types in particular will continue to grow, the latter increasingly will be reserved for residents. Restrictions on nonresident hunters are bound to increase unless very fundamental changes occur in the attitudes of resident hunters which will influence legislatures and state management programs. This seems unlikely.

In the future, demands of nonresidents for fishing will increase substantially, especially in the mountainous upper reaches of the basin. This region has the capacity to satisfy very large demands for high quality fishing, but careful maintenance of this "high quality" capacity will be required if these demands are to continue to be met in the Missouri Basin (*figure 43*).

FIGURE 43
DEMAND FOR HUNTING AND FISHING
AS RELATED TO THE PRESENT AND FUTURE SUPPLY



Commercial Fish

Estimates of present and future commercial demand for freshwater fish within the Missouri Basin are based primarily on nationwide trends in the use of such products for human food and for industrial purposes (table 114). Basic assumptions are made that: (1) elements of demand projections valid nationwide are also valid for the Missouri Basin; and (2) disregarding fish from the Great Lakes, freshwater fish consumption represents 1.5 percent of total U. S. production. The latter relationship is assumed to be constant for the study period.

Table 114 – PROJECTED DEMAND FOR FRESHWATER FISHERY PRODUCTS WITHIN THE MISSOURI BASIN[1]

Subbasin	Year			
	1960	1980	2000	2020
	(1,000 Pounds)			
Upper Missouri	123	193	318	454
Yellowstone	112	184	332	518
Western Dakota	125	187	312	459
Eastern Dakota	279	407	671	979
Platte-Niobrara	688	1,397	2,760	4,718
Middle Missouri	662	973	1,596	2,310
Kansas	375	555	913	1,310
Lower Missouri	928	1,566	2,760	4,299
Missouri Basin	3,292	5,462	9,662	15,047

[1]Does not include demand for fish produced live for the bait-minnow and fee-pond industries.

As suggested by the national trends, the increasing demands for the future are a reflection of an increasing population and of increasing per capita consumption of fishery products. The estimated demands do not necessarily reflect demands for fishery products produced within the basin; rather, they reflect demands to be filled by a combination of in-basin production and imports.

Most of the commercial type of fish produced in the Missouri Basin in 1965 was shipped to wholesale food markets outside the basin; while most of the in-basin type of fish demand was filled by imports. Therefore, while future demand for the basin has been estimated, there is no good method of estimating the role of in-basin production in filling basin demand. It is assumed that some part of the future increase in basin demand will be filled by increasing in-basin production; however, in-basin demand cannot be expected to provide much impetus for development of the Missouri Basin commercial fishery. Production in 1965 was about 5 million pounds. As seen in the table, total basin demand estimated for 1980 barely exceeds the 1965 production figure, and even in the year 2020 total demand will be less than three times current production. Since 1965 production was only about 5 percent of the basin capacity, it is clear that any stimulation of full development of the basin's commercial fishery must come from outside markets.

In turn, export market demand will be more influenced by nationwide marketing and technological developments rather than those of regional or basin scope. Acceleration of programs to overcome existing marketing and technological constraints could result in an increase of demand for commercial fish greater than indicated in these projections. The future of commercial fishery production in the Missouri Basin therefore will be closely related to these outside developments and to the industry's ability to participate and compete in export markets.

There is a large existing demand in the United States for industrial fishery products, primarily for use in the poultry and other animal feed industries. Presently this demand is being supplied principally by foreign sources. Although development of fish-meal plants poses no insurmountable technological problems, none of the basin's fishing companies finds it economically feasible to supply sufficient quantities of fish at a competitive price for large scale fish-meal plant production. Unless these limitations are overcome, there is no large scale development of an industrial fishery foreseen in the Missouri Basin, at least before the year 2000.

Two additional aspects of commercial fishing in the Missouri Basin are important. First is the stable but relatively small market in the basin for rough fish, primarily carp, which are processed for mink food and canned pet food. This demand is presently filled primarily by existing in-basin production and is not expected to increase significantly. Second is the demand for pond-propagated minnows and fish used in the bait and fee-pond fishing industries. The in-basin demands in table 114 do not reflect this use, nor does the 1965 commercial fish production of about 5 million pounds include pond fish produced for this purpose. Existing information does permit quantifying fee fishing basin-wide, but it is expected that it will grow significantly, corresponding to sport fishing as a whole.

Fur Animals

Trapping has provided substantial income to the rural economy, but in recent years there has been a steadily declining interest, due principally to low fur prices. Yet, trapping is still popular in some areas (table 112).

Generally, fur animals are significantly under-harvested. The economic situation and the supply of animals both have been depressing influences on commercial trapping. Several factors are recognized as influencing demands for wild fur. These include: (1) the extent and efficiency of commercial fur farms; (2) the development of synthetic replacements; and (3) the fashion whims of the public. Since "fashion" is perhaps the most dominating aspect of fur demand, meaningful projections of wild fur demands are obviously impossible.

In addition to the commercial aspects of demand, a significant recreation demand for fur animals by "hobby" trappers exists. However, trends suggest that interest in trapping as a form of outdoor recreation will continue to decrease.

Several species, notably fox, raccoon, coyote, bobcat, and jackrabbit, are assuming more importance for their hunting values and less for trapping. As demand for outdoor recreation increases, these species will be relied upon to make up some of the shortages. Overall demand for such animals will probably not increase to any extent.

LAND NEEDS, WATER NEEDS, AND PROBLEMS

The more significant fish and wildlife problems, whether physical, legal, or institutional, include: (1) poor distribution of fishing and hunting demand relative to the supply; (2) legal and physical restrictions on public access; (3) loss of game habitat associated with land use; (4) lagging ability of fish and game use to compete with other economic uses; (5) water pollution and siltation, stream channelization, and dewatering; (6) the lack of, or inadequate, legal status of water used to benefit fish and wildlife; (7) legal restraints on use of some species; (8) depleted populations in some areas; (9) undeveloped commercial fishery; and (10) failure of the economic system to adequately reflect fish and wildlife values. Many of these problems cannot be fully resolved; however, much can be done to offset or minimize them.

Overall hunting demand about equaled supply in 1960, while fishing demand will not reach capacity until about 1990 (figure 43). As a practical matter, this oversimplification, while it makes an impressive illustration, is misleading because of the maldistribution of the supply relative to the demand. Access limitations are also a major adverse factor. In the upper basin, where the amount of available hunting and fishing significantly exceeds demand, resources not only are capable of providing continuing good hunting and fishing for residents, but have the potential, at least for fishing, to absorb large segments of nonresident demand through an expanding tourist industry. This will offset in some measure (especially for the higher quality aspects) shortages of fishing and other outdoor recreation in other parts of the Nation. This trend is to be encouraged.

The overall supply-demand picture should not be permitted to obscure the fact that in much of the lower and eastern parts of the basin, hunting and fishing demands already exceed supplies. In that part of the basin, especially within close proximity to heavily populated areas, extensive development of the resource base will be necessary if significant portions of expanding demands are to be met. The major opportunity for increasing fishing lies in the construction and use of small reservoirs. Generally, single-purpose fishing lakes of 100 to 300 acres, located within easy range of population centers, will best serve the need. Such lakes can be efficiently managed for maximum production, fishing quality, and public use. Multipurpose reservoirs also offer opportunities. Planning of such impoundments must be fully coordinated among concerned agencies to insure that fishery enhancement features are adequately considered in project formulation.

Only a limited number of resource development potentials exist for increasing hunting near the major population centers. Preservation, enhancement, or development of wildlife habitat in conjunction with urban-related development should receive a high priority in planning. In the Lower Missouri Subbasin, where demand is especially great, development of the Missouri River with maximum emphasis on wildlife and related recreation has an outstanding potential.

While there will be much less need for fish and wildlife development in the upper basin to supply resident demand, considerable development will nevertheless be required. In many local situations, wildlife management areas and reservoirs to supply hunting and fishing will be needed, particularly in the Black Hills and on the plains near several smaller metropolitan areas.

Overgrazing is a basinwide problem, affecting not only the associated wildlife habitat but also water runoff and quality downstream.

The Missouri Basin contributes very significantly to waterfowl production; therefore, perpetuation and use of this resource both within and without the basin is heavily dependent on habitat within the basin. As a national need, waterfowl preservation and enhancement should have a high priority.

Meeting the growing need for assured public access for hunting and fishing is highly important if these activities are to survive as mass recreational pursuits. The existence of a fine smallmouth bass stream in the Ozarks or heavy pheasant populations on Dakota farms is of small tangible value to sportsmen if little or no use can be made of the resources. At present, private ownership of lands, particularly as farms and ranches, denies effective use of large segments of the game supply, just as private ownership of many thousands of acres of impounded waters and of land along streams results in exclusion of public fishing. Public use of these resources is permissive by owners; a prerogative that certainly, in most cases, should not be changed. Nevertheless, a deliberate, coordinated effort to provide and improve public access to fish and wildlife resources associated with private lands is necessary, as is a corollary effort to improve the attitude of sportsmen seeking the use of these resources.

High quality wetlands form the backbone of duck production and afford valuable habitat for fur animals. Drainage and filling of marshland has reduced waterfowl habitat.

Landowner and recreationist education is important, but there is an accelerating need for public acquisition of legal access through fee purchase, or negotiated lease, and easement rights on privately owned lands and waters. Acquiring land for public hunting and fishing, never a particularly popular idea in most of the basin, often is prohibitive because of the high cost.

Despite this, many fishing access sites should be acquired outright. Recent trends suggest that vastly increased profit incentives to landowners through development of fee hunting and fishing or through tax relief and other meaningful measures hold considerable promise of increasing access to hunting and fishing areas.

Where water and related land resource development involves public funds, increased attention to the development and enhancement of fishing and hunting is often needed. In some areas, physical access to existing public land and waters is inadequate, notably in mountainous areas and around many large multipurpose reservoirs. More and better roads will be required in the future. Access, physical or otherwise, to publicly controlled areas for hunting and fishing should be unlimited except to the extent actually needed to be consistent with the purposes for which the areas are managed (i.e., timber production, livestock production, flood control, power production, water production, wilderness preservation, or fish and wildlife management). In many cases, additional or improved facilities of publicly owned areas could easily be justified on the basis of high current demand. High demand levels will develop for most areas in the future.

The Department of Agriculture's Cropland Adjustment Program, recently established on a limited basis, is a step toward resolving access problems and stabilizing high quality habitat.

While lack of access and maldistribution of hunting and fishing opportunities limit the realization of optimum use of the resources, major problems also exist that directly affect the resource base. Those of primary importance involve habitat destruction due to changes in land use and poor land management. In fact, the overriding need in areas of "surplus" hunting or fishing is to preserve the quality of existing resources. This need is particularly apparent along the eastern slope of the Rocky Mountains where outstanding trout waters and big-game herds are found. "Quality" resources of these types are fast dwindling nationwide. It is time to fully recognize and protect their unique national values and to prevent unwise or short-term exploitation. The need to preserve hunting and fishing habitat is not confined to the west; it is a vital element of the effort to meet the demand in the rest of the basin.

The failure of wildlife interests, land management interests, and farmers to develop a mutually beneficial program to promote wildlife on farms and ranches remains at the root of the problem facing conservationists today. The economic problems related to the preservation and creation of wildlife habitat on private lands largely have not been solved.

In some cases the losses to wildlife might have been averted by appropriate planning. In others, the derived benefits to wildlife or other interests were so limited

Improper land use results in increased runoff and sedimentation of downstream waters. If stabilized and protected from overgrazing, this landscape could eventually support excellent wildlife cover.

that the conversion proved to be economically marginal and later was discontinued. Many wildlife losses resulting from conversion to marginal cropland would not occur if landowners were able to capture the economic and environmental benefits important to and enjoyed by society. As the general public's interest in the total environment broadens, there are increasing pressures for the use of multiple judgments in the use of land so as to further consider the values of natural areas and wildlife resources. Ways and means must be found to provide an equitable distribution of the costs of such programs between the landowners and society. This is necessary if fish and wildlife, natural beauty, environmental quality, and all other socially desirable and intrinsically valued uses are to be made a part of a multiobjective decision-making process. Such action would conserve the use of our scarce natural resources in such a way as to maximize social benefits to the public.

The trampled and unvegetated shoreline of this unprotected stock pond reduces the value to wildlife and shortens the pond's useful life.

A well-protected stock pond on a National Grassland. Note watering gap for livestock. An accelerated program like this for both private and public lands would be extremely valuable to wildlife, especially waterfowl.

One of the costliest aspects of land conversion, from the wildlife standpoint, is the loss of natural wetlands through drainage and filling. Programs that have helped to counter the loss include the Federal refuge system, State wildlife management area developments, and wetlands acquisition and preservation. Preservation and development plus the creation of new wetlands as currently sponsored by the various State, Federal, and local governmental agencies are continuing needs.

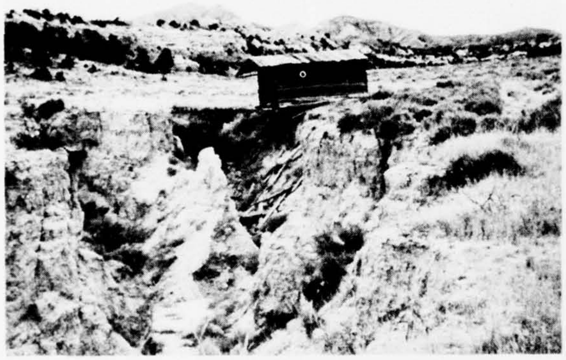
Level ditching, a cost-shared ACP practice, has vastly improved the production capabilities of this marsh without affecting the water table or increasing flood threats in the watershed. About 40 ducks were on the water when this photo was taken.

Technological changes in cropping culture, including the use of chemical biocides and fertilizers, have adversely affected habitat for pheasant, quail, and cottontail.

The current land conversion trend from the standpoint of basinwide acreage totals is away from cropland and toward more grassland and woodland. Programs profitable to the farmer and aimed at aiding wildlife need to be further developed and implemented. A variety of wildlife opportunities can be identified on agricultural lands but has not been adequately implemented. Many of the needs of wildlife can be realized through small watershed development if adequate consideration is given to planning and development, particularly by the local people.

Losses of bottomland timber and associated wildlife continue to occur. Development of flood control reservoirs and the loss of woodland habitat caused by inundation in such reservoirs is compounded by downstream clearing made possible by the reduced flood hazard. Replacement of bottomland habitat is needed and could be realized by the conversion of marginal cropland to woodland. Losses are countered to some degree by upland plantings of forest trees, shelterbelts, and farmstead and field windbreaks.

Bottomland timber removal and wildlife habitat losses increase steadily as flood threats are reduced by upstream dams, levees, and similar structures.



Rangeland erosion degrades land value for livestock and wildlife, contributes sediment loads into valuable fishing streams and reservoirs, and depreciates the beauty of the landscape.

The land base available to wildlife in the basin continues to be depleted by urban expansion, airports, industrial and military installations, highway and road construction, strip mining, and a variety of other land occupations. On the positive side, highway construction and strip mining accomplished with adequate consideration of wildlife often reduce habitat damages and in some cases offer excellent opportunities for enhancement.

Intensive agricultural practices, along with land abuse, contribute substantially to habitat degradation. Correction of overgrazing, erosion, and siltation resulting from unfavorable land use practices should be accelerated on both public and private lands. About 123 million acres of private land in the basin are classified as Types V through VIII (cropland and rangelands) according to the *Conservation Needs Inventory* of 1958. These lands are not suited for cultivation. About 4 percent is not suited for grazing. Some lands are suffering degradation and are a contributing source of silt loads of nearby streams. Those areas which are best suited for wildlife should be preserved or converted to that use.

Erosion from irrigation waste water often degrades downstream fisheries. Silt, warmed waters, and assorted agricultural wastes are damaging influences.

Pollution of surface waters from a wide variety of sources is a particular threat to fishing. Water quality

Partially treated organic materials, heavy nutrient loads, and assorted wastes resistant to standard treatment techniques combine to degrade the stream below this outfall from a sewage treatment plant.

standards sufficient to preserve valuable fisheries have been adopted and must be effectively implemented. Broad standards applied over large geographical areas, with little regard to varying ecological conditions, often will prove inadequate. To protect desirable sport fisheries, standards must be designed to meet the specific tolerances of the ecological unit, often perhaps a single body of water or reach of stream. Standards must be inclusive enough to cover the wide array of potential depreciating influences, including the more obscure menaces such as pesticides and increased nutrients in runoff waters from chemical fertilizers and feedlots. Threatened increases in turbidities and siltation must be controlled.

Dewatered streams for irrigation and other needs support few fish.

Constant vigilance against newly developing threats is essential. For example, much of eastern Montana and Wyoming, along with the northern part of North Dakota, are underlain with extensive lignite deposits. More favorable economic conditions in the future may bring about large scale mining of this resource. If so, a threat to fishing waters might develop through concentrated development of thermal-electric generation plants along the Missouri River and several tributaries. Heated cooling-water discharges from these plants, as well as from similar fossil fuel or from thermo-nuclear plants in various places in the basin, are capable of seriously altering downstream aquatic environment. Provisions to assure maintenance of suitable water quality for fish and other aquatic organisms must be included from the time of the earliest planning efforts if optimum results are to be attained.

Physical loss of fishery habitat through road building, channeling of streams, and other activities, must be watched vigilantly, with maximum effort given to measures that will reduce or compensate for the losses. The only alternative is a continuing and accelerating reduction in fishing waters, particularly of the already limited stream and natural lake resources.

Interrelated with the need to protect fishery resources is the need to restore, within practical limits, those waters where degradation has already occurred. Pollution abatement, reduction of sedimentation, restoration and maintenance of adequate minimum stream flows, and several measures of more limited application are usually within technological limits. Implications of this problem go far beyond the need for fishing; benefits derived from restoration of clean water, for example, accrue to large segments of society. These benefits contrast sharply with the short range advantages, often to special interests, at the social cost of a deterioration of water quality often associated as a by-product of "development".

A primary fish and wildlife need, related to habitat protection and restoration, is that of establishing in each state a legal basis for the use of water for fish and wildlife. In many parts of the Missouri Basin, at present, natural stream flows or impounded waters stored for fish and wildlife purposes can be easily and legally diverted to other uses. For example, such waters released through dams to sustain fish during drought periods or supply water for downstream wildlife management often are legally diverted from the stream by irrigators or other users having recognized legal rights. Legislation and policy changes are needed if this condition is to be overcome. It is one that threatens to become ever more acute in water-short regions.

Well-developed habitat plantings are important to wildlife and enhance soil and water conservation.

Paradoxically, while use of the game resource exceeds recognized capacity in many areas, a significant portion of the capacity in these same areas is not legally available to the hunter. Mourning dove hunting, for example, if legalized everywhere, would provide many thousands of additional man-days of hunting. The commercial fishing potential, represented by impressive areas of productive habitat well stocked with many fish species, is for all practical purposes, unused.

A very substantial portion of wildlife resources in the basin is supported by valuable bottomland along meandering streams. Such habitat should be preserved. Streamside vegetation is also important to fisheries by shading the water, providing cover, and reducing sedimentation.

At the other extreme, big game is scarce to non-existent on much high quality habitat, especially on Indian reservations. More rigid protection and enlightened management are needed to restore and maintain productive populations. The needs for developing fish and wildlife management plans, with particular emphasis on harvesting regulations on Indian reservations, are gaining the recognition and cooperation of the various tribes. The problem of jurisdiction on Indian reservations containing both Indian trust and non-Indian owned fee lands necessitates the cooperation and coordination of the respective State Fish and Game Departments to develop workable regulations. This cooperation needs to be expanded to provide for public access across Indian lands to public hunting and fishing in many areas of the Missouri Basin.

It is difficult to quantify the true value of fish and wildlife to man. Aside from the obvious importance in providing hunting and fishing recreation, these resources are valuable to the birdwatcher, photographer, vacationer and sightseer, scientist, historian, armchair reader, student, and those who simply love the out-of-doors and the creatures that live there. To date, no adequate system has been devised to measure the worth of these resources in terms which can be compared with other human values.

Some of the major land and water requirements of fish and wildlife identifiable within reasonable limits are shown in table 115. The entries represent summarized requirements from single-purpose development opportunities or potentials, as identified during the course of this study. The inventory of these potentials is not complete nor does the table reflect land and water requirements that may be added in planning future multipurpose water resource developments. Not included are estimates of land and water resources which will be needed to mitigate future wildlife losses resulting from habitat inundation, channelization and other measures, and resources needed to realize wildlife enhancement opportunities related to water resource development. Realization of all fish and wildlife developments covered in table 115 would very significantly enhance fish and wildlife resources, but the total needs for the Missouri Basin as a whole would not be met.

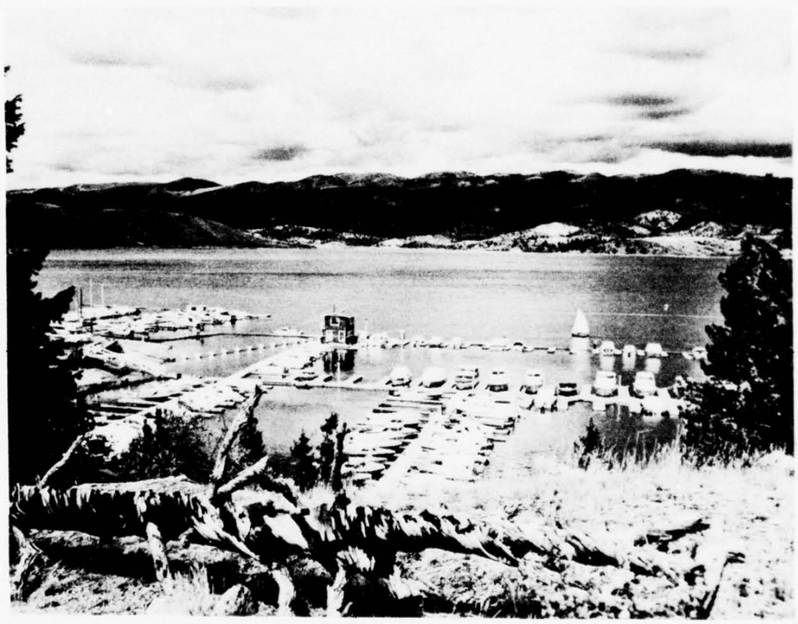
All in all, the future outlook to maintain an adequate basinwide ratio of supply to demand for fishing is good. For wildlife, the prospects are good for the next 10 or

15 years. But, by 2000, the ratio will be difficult to maintain for fishing and almost impossible for wildlife unless basin residents do some aggressive planning during the next 20 years.

Table 115 – IDENTIFIED LAND AND WATER NEEDS FOR FISH AND WILDLIFE[1]
MISSOURI BASIN

Category	Land and/or Water	Identified Needs All Subbasins (Acres or Stream Miles)
Private Land Habitat Enhancement	Both	9,086,000[2]
Public Land Habitat Enhancement	Both	2,515,000[3]
High Quality Upland Habitat Preservation	Land	35,000
High Quality Wetland Habitat Preservation	Land	263,000
	Water	1,066,000[4]
Wildlife Habitat Development	Land	1,824,000
	Water	295,000
Access for Fishing	Land	49,000[5]
Reservoir Construction (Single-Purpose)[6]	Land	47,000
	Water	23,000
Dewatered Stream Restoration[7]	Water	4,620
Polluted Stream Restoration[8]	Water	2,410

[1]Land and water acreages shown would be acquired by public agencies, in fee or by lease, except as otherwise noted.
[2]Land would remain in private ownership, but a primary use would be for wildlife enhancement.
[3]Acreage represents only a fraction of public lands where increased emphasis should be given to wildlife management.
[4]Only 256,000 of these acres are to be acquired in fee. The remainder consists of easements providing for preservation.
[5]Only 6,680 acres need to be acquired in fee; easements for fishing on remainder.
[6]None in Upper Missouri or Yellowstone subbasins.
[7]Stream mileage dewatered for irrigation or other requirements. Dependable minimum flows are desirable to support stream fisheries.
[8]Stream mileage polluted, to varying extent, by industrial, municipal, and agricultural wastes where abatement could result in needed sport fishing restoration.



Canyon Ferry Reservoir Boating Marina Near Helena, Montana.

CHAPTER 6

OUTDOOR RECREATION

From the sculptured mountains and alpine lakes of Glacier National Park to the densely wooded hills and meandering streams of the Ozark Plateaus, the Missouri Basin offers a myriad of varying scenes and opportunities to the recreationist. Some of the best known recreation areas in the United States are situated within the 519,000 square-mile basin, including Yellowstone, Glacier, and Rocky Mountain National Parks, the Black Hills region, Custer Battlefield National Monument, and Lake of the Ozarks. The basin contains several nationally known streams and rivers and a number of very important and sizeable lakes, including a chain of six large Corps of Engineers reservoirs on the upper and middle reaches of the Missouri River that account for more than a million surface-acres of water. But most of the water resources of the basin are not especially well known to nonresidents.[1]

Rocky Mountain National Park, in a particularly beautiful and rugged portion of the Rocky Mountains, is one of the best known recreation areas in the Missouri Basin.

The basin's recreation resources fall into three major geographic and climatic types, namely: the Rocky Mountains and Black Hills region, the plains and prairies, and the Ozark Plateaus of southern Missouri. The plains and prairies are found in every basin state and constitute the preponderance of the total land. While the Rocky Mountain, Black Hills, and Ozarks regions have long been known as summer play and vacation target areas, the plains country has been better known for its corn and wheat fields, cattle ranching, and vast open spaces. National attention to the recreation resources of the Great Plains has been largely lacking. However, this pattern is beginning to change with development of more and better opportunities, facilities, and promotional activities. In addition, crowding at some of the more popular national and regional attractions is beginning to turn recreationists to natural, historic, archaeologic, and water attractions found in plains recreation areas. This chapter deals with outdoor recreation associated with land and water resources. Although emphasis has been placed on water related activities, needs, and problems, the analysis includes estimates of the land and water needs for all outdoor recreation endeavors except hunting and fishing. Land and water requirements specifically for hunting and fishing are treated in Chapter 5, "Fish and Wildlife."

[1] Nonresident recreationists are those living outside the subregion in which they recreate, regardless of whether they live within or outside the Missouri Basin.

EXISTING RECREATION RESOURCES AND USES

Resources and Developments

Outdoor recreation resources in the Missouri Basin have been classified as scenic, historic, and natural (type I); land-oriented (type II); or water-oriented (type III). Summarized information on recreation acreages, developments, and uses by types is presented in tables 116, 117, and 118. The recreation area location pattern can be seen in plates 6 and 7.

In total, 139 Type I areas, 3,091 Type II areas, and 1,964 Type III areas were inventoried. No tally was made of the number of private recreation areas, but the private sector has been estimated to account for well over 800,000 acres of land and water. The above figures include a combination of areas of greatly varying size and type. For example, a two-acre roadside park and

Table 116 – TYPE I (HISTORIC, SCENIC, AND NATURAL) RECREATION AREA INVENTORY SUMMARY, MISSOURI BASIN

Number of Areas:	139
Acres	
Land	3,042,229
Marsh	12,200
Water	124,694
TOTAL	3,179,123
Activities (by popularity rank)	
Driving and sightseeing	1
Picnicking	2
Camping	3
Developments	
Developed Acreage[1]	6,582
Percentage of Acreage Developed	0.22%
Annual Visitation[2]	11,773,000

[1]"Developed" land is land occupied with or immediately adjacent to recreation facilities or substantially modified from a natural condition for recreation purposes. Other recreation land area is considered to be "undeveloped".

[2]Total shown is that for available recent visitation data only. Actual current use is believed to be significantly higher than 11,773,000 annual visits.

Table 117 – TYPE II (LAND-ORIENTED) RECREATION AREA INVENTORY SUMMARY, MISSOURI BASIN

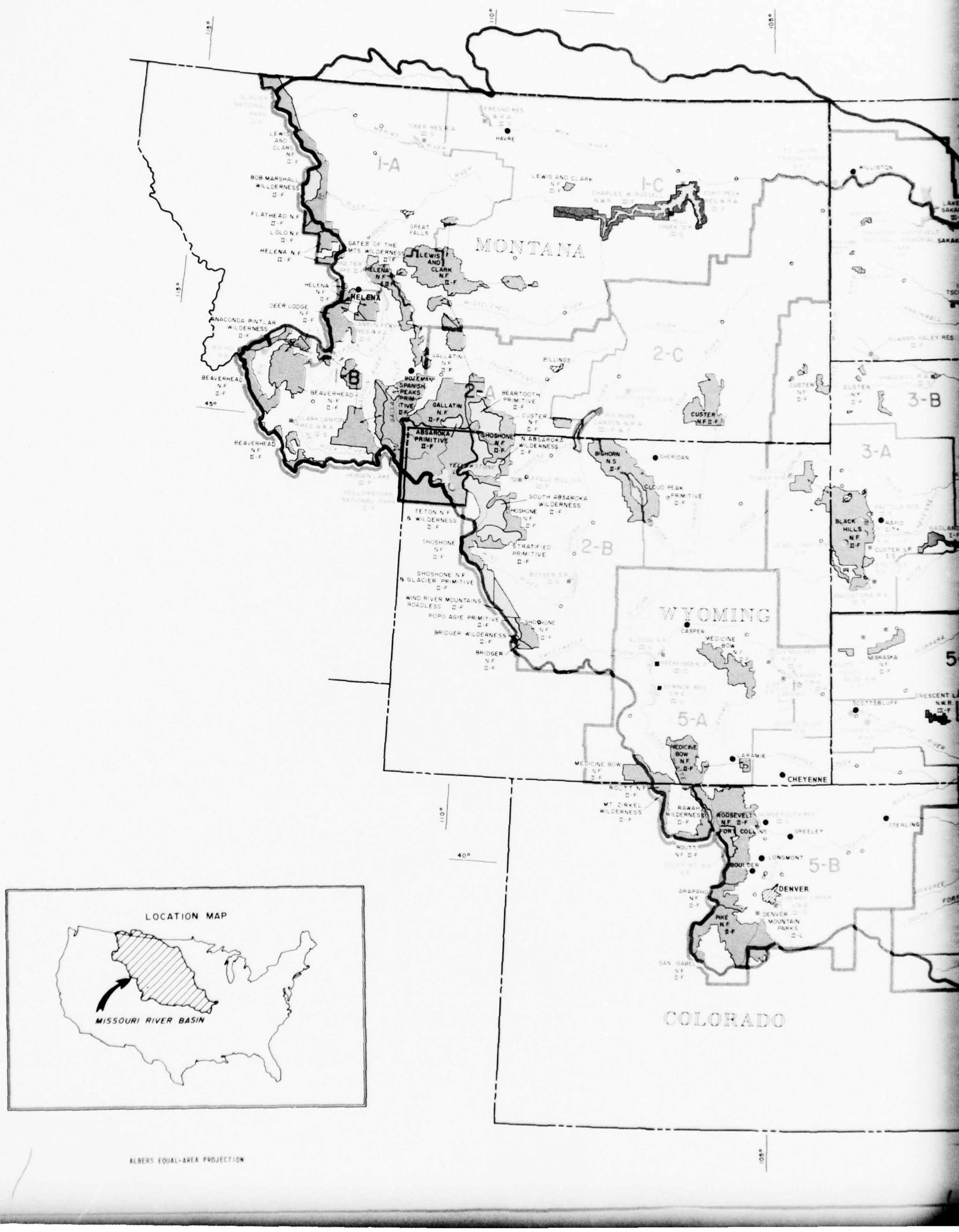
Item	Local Parks	State Parks (Roadside)	State Parks and Recreation Areas	State Fishing and Hunting Areas and Fish Hatcheries	State Forest Lands	National Wildlife Refuges and Fish Hatcheries	Indian Reservations	National Forests and Grasslands	Bureau of Land Management Lands	Miscellaneous Federal Lands	Private Sector	Total
AREAS AND ACREAGES												
Areas (No.)	2,193	493	40	221	5	6	43	35	35	20	NA	3,091
Land (Acres)	65,655	2,816	31,974	249,073	42,826	21,660	6,849,058	18,814,309	14,957,069	134,839	456,616	41,625,895
Marsh (Acres)	6	---	25	259	120	---	1,339	7,170	160	---	---	9,079
Water (Acres)	3,108	---	118	581	62	926	7,762	54,731	1,780	98	31,943	101,109
Total (Acres)	68,769	2,816	32,117	249,913	43,008	22,586	6,858,159	18,876,210	14,959,009	134,937	488,559	41,736,083
ACTIVITIES (By Popularity Ranking)												
Driving and Sightseeing	3	5	3	2	1	2	7	1	2	5	---	1
Swimming	5	4	6	---	---	---	---	---	---	1	4	6
Fishing	9	---	4	7	---	---	6	2	3	6	1[2]	7
Picnicking	1	1	1	4	4	4	1	4	4	2	6	2
Nature Study	4	2	7	6	3	1	8	6	6	---	8	4
Hunting	---	---	8	1	2	---	3	3	1	7	1[2]	8
Camping	6	3	2	5	5	---	2	5	5	3	5	5
Hiking and Walking	8[3]	6	5	3	---	3	5	---	7	---	7	9
Playing Games & Sports	2	7	9	---	---	---	4	---	---	4	3	3
DEVELOPMENTS												
Developed Acreage	31,055	2,629	3,177	200	2	24	1,998	15,102	300	935	46,483	101,905
% of Area Intensively Developed	45%	93%	10%	.08%	.05%	.1%	.03%	.08%	.002%	7%	10%	0.24%
VISITATION												
Annual Recreation Visits Reported (In Thousands)	17,189[1]	2,667[1]	1,637[1]	385[1]	24[1]	51	113[1]	13,615	2,873	173[1]	3,000[1]	41,727[1]
Latest Year or Years Available or Used	1963-65	1964-65	1963-65	1959+ 1963-66	1963-66	1965	1964-66	1963-66	1964-65	1964-65	1965	1959+ 1963-66

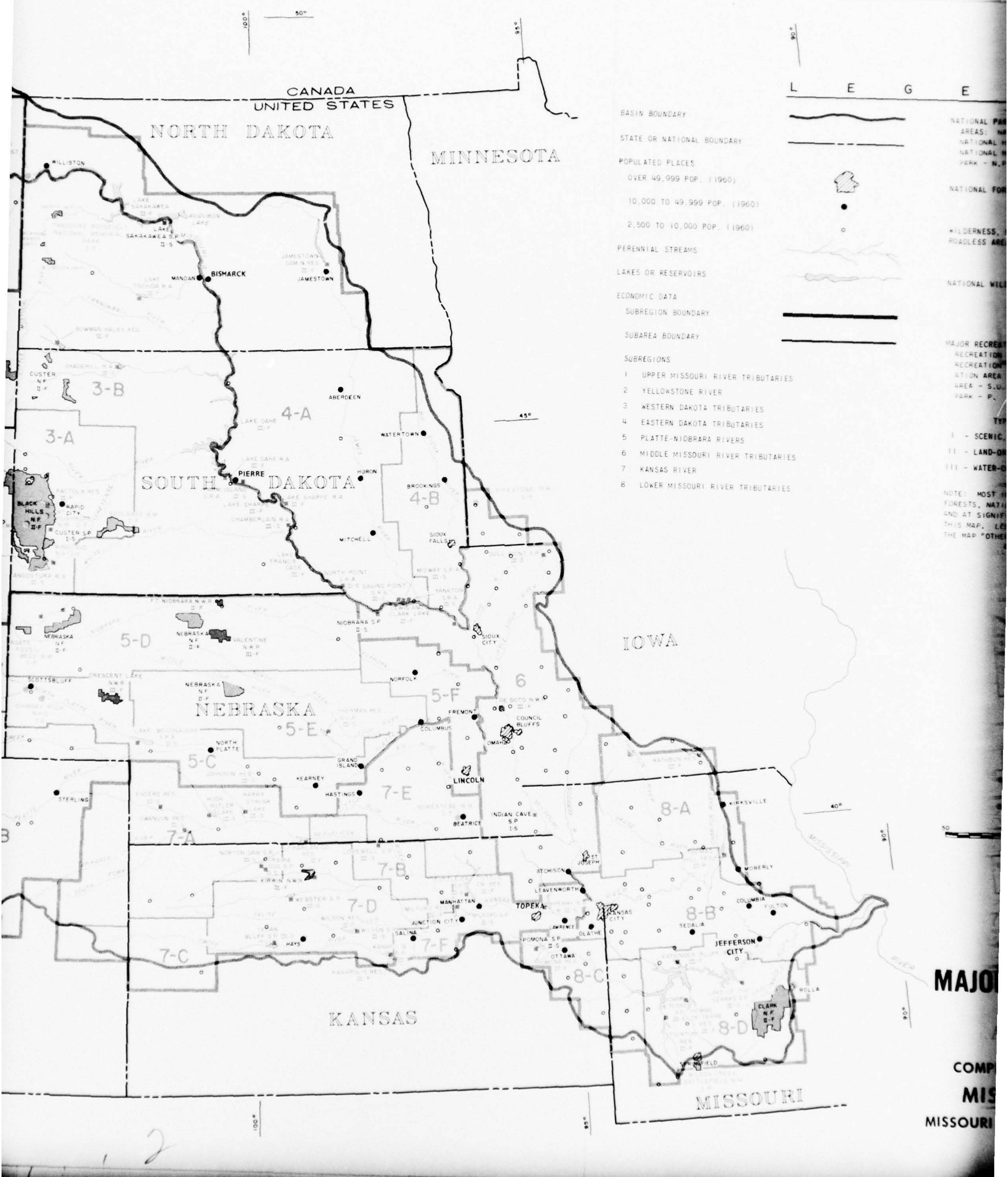
[1]Figures available are incomplete and therefore lower than actual use.
[2]Fishing and Hunting are about equal.
[3]Viewing outdoor sports was the 7th ranked activity.

Table 118 – TYPE III (WATER-ORIENTED) RECREATION AREA INVENTORY SUMMARY, MISSOURI BASIN

Item	Local Parks	State Parks and Recreation Areas	State Fishing and Hunting Areas and Fish Hatcheries	State Parks (Roadside)	National Wildlife Refuges	Federal Reservoirs (Net)[5]	Indian Reservations	Bureau of Land Management Lands	Private Sector	Missouri River Access	Total
AREAS AND ACREAGES											
Areas (No.)	672	188	776	7	78[1]	113	59	4	NA	67	1,964[2]
Land (Acres)	61,922	148,219	256,013	64	1,402,505	952,936	25,254	447	116,313	660	2,964,333
Marsh (Acres)	731	1,081	30,250	0	33,594	2,000	7,146	0	0	0	74,802
Water (Acres)	58,374	314,505	97,985	35	391,203	1,078,320	18,961	0	211,206	127,400	2,297,989
Total (Acres)	121,027	463,805	384,248	99	1,827,302	2,033,256	51,361	447	327,519	128,060	5,337,124
ACTIVITIES (By Popularity Ranking)										3	
Driving and Sightseeing	6	3	4	---	1	1	---	---	---	---	1
Swimming	2	5	---	4	6	6	5	3	---	---	3
Water Skiing	---	8	8	---	---	8	6	---	---	---	---
Fishing	3	2	1	5	4	2	1	2	1	---	4
Picnicking	1	1	3	1	5	4	2	---	3	---	2
Nature Study	---	---	7	---	2	---	---	---	---	---	---
Boating	5	6	6	2	---	3	4	---	2	---	5
Hunting	---	7	2	---	3	7	---	1	4	---	7
Camping	---	4	5	3	7	5	3	---	---	---	6
Playing Games or Sports	4	---	---	---	---	---	---	---	---	---	---
DEVELOPMENTS											
Developed Acreage	22,965	12,734	1,552	51	715	19,743	202	0	7,909	10	65,861
% of Area Intensively Developed	37%	9%	1%	80%	.05%	2%	1%	---	7%	2%	2%
VISITATION											
Annual Recreation Visits Reported (In Thousands)	13,725[4]	23,292[4]	2,408[4]	70[4]	1,507[4]	15,421[4]	127[4]	NA	NA	NA	56,550[4]
Latest Year(s) Available or Used	1963-65	1959+ 1963-66	1963-66	1965	1964-66	1965-66	1965	---	---	---	1959+ 1963-66

[1]Several entries consist of numerous tracts.
[2]Does not include private areas.
[3]Data not available to rank activities.
[4]Figures available are incomplete and therefore lower than actual use.
[5]Land and water acreage figures for State-administered waters, State parks, National wildlife refuges, and other such areas situated at Federal reservoirs are included under other categories.


MONTANA
WYOMING
COLORADO
1-A
1-B
1-C
2-A
2-B
2-C
3-A
3-B
5-A
5-B
HAVRE
HELENA
GREAT FALLS
BILLINGS
BOZEMAN
SHERIDAN
CASPER
LARAMIE
CHEYENNE
FORT COLLINS
GREELEY
LONGMONT
BOULDER
DENVER
STERLING
WILLISTON
RAPID CITY
SCOTTSBLUFF
LEWIS AND CLARK N.F. II-F
GALLATIN N.F. II-F
ABSAROKA PRIMITIVE II-F
SHOSHONE N.F. II-F
BLACK HILLS N.F. II-F
MEDICINE BOW N.F. II-F
ROOSEVELT N.F. II-F
PIKE N.F. II-F
CUSTER N.F. II-F
BIGHORN N.S. II-F
LOCATION MAP
MISSOURI RIVER BASIN
ALBERS EQUAL-AREA PROJECTION



CANADA
UNITED STATES
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
IOWA
NEBRASKA
KANSAS
MISSOURI
WILLISTON
LAKE SAKAKAWEA
LAKE SAKAKAWEA S.P.
MANDAN
BISMARCK
JAMESTOWN
ABERDEEN
WATERTOWN
PIERRE
HURON
BROOKINGS
MITCHELL
SIOUX FALLS
RAPID CITY
BLACK HILLS N.F.
CUSTER S.P.
SIOUX CITY
NORFOLK
FREMONT
COLUMBUS
COUNCIL BLUFFS
OMAHA
LINCOLN
GRAND ISLAND
KEARNEY
HASTINGS
NORTH PLATTE
SCOTTSBLUFF
STERLING
BEATRICE
KIRKSVILLE
MOBERLY
ST. JOSEPH
ATCHISON
LEAVENWORTH
TOPEKA
KANSAS CITY
LAWRENCE
OLATHE
MANHATTAN
JUNCTION CITY
SALINA
HAYS
OTTAWA
SEDALIA
COLUMBIA
FULTON
JEFFERSON CITY
ROLLA
CLARK N.F.
SPRINGFIELD
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3-B
4-A
4-B
5-C
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6
7-A
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100°
95°
90°
45°
40°
L E G E
BASIN BOUNDARY
STATE OR NATIONAL BOUNDARY
POPULATED PLACES
OVER 49,999 POP. (1960)
10,000 TO 49,999 POP. (1960)
2,500 TO 10,000 POP. (1960)
PERENNIAL STREAMS
LAKES OR RESERVOIRS
ECONOMIC DATA
SUBREGION BOUNDARY
SUBAREA BOUNDARY
SUBREGIONS
1 UPPER MISSOURI RIVER TRIBUTARIES
2 YELLOWSTONE RIVER
3 WESTERN DAKOTA TRIBUTARIES
4 EASTERN DAKOTA TRIBUTARIES
5 PLATTE-NIOBRARA RIVERS
6 MIDDLE MISSOURI RIVER TRIBUTARIES
7 KANSAS RIVER
8 LOWER MISSOURI RIVER TRIBUTARIES
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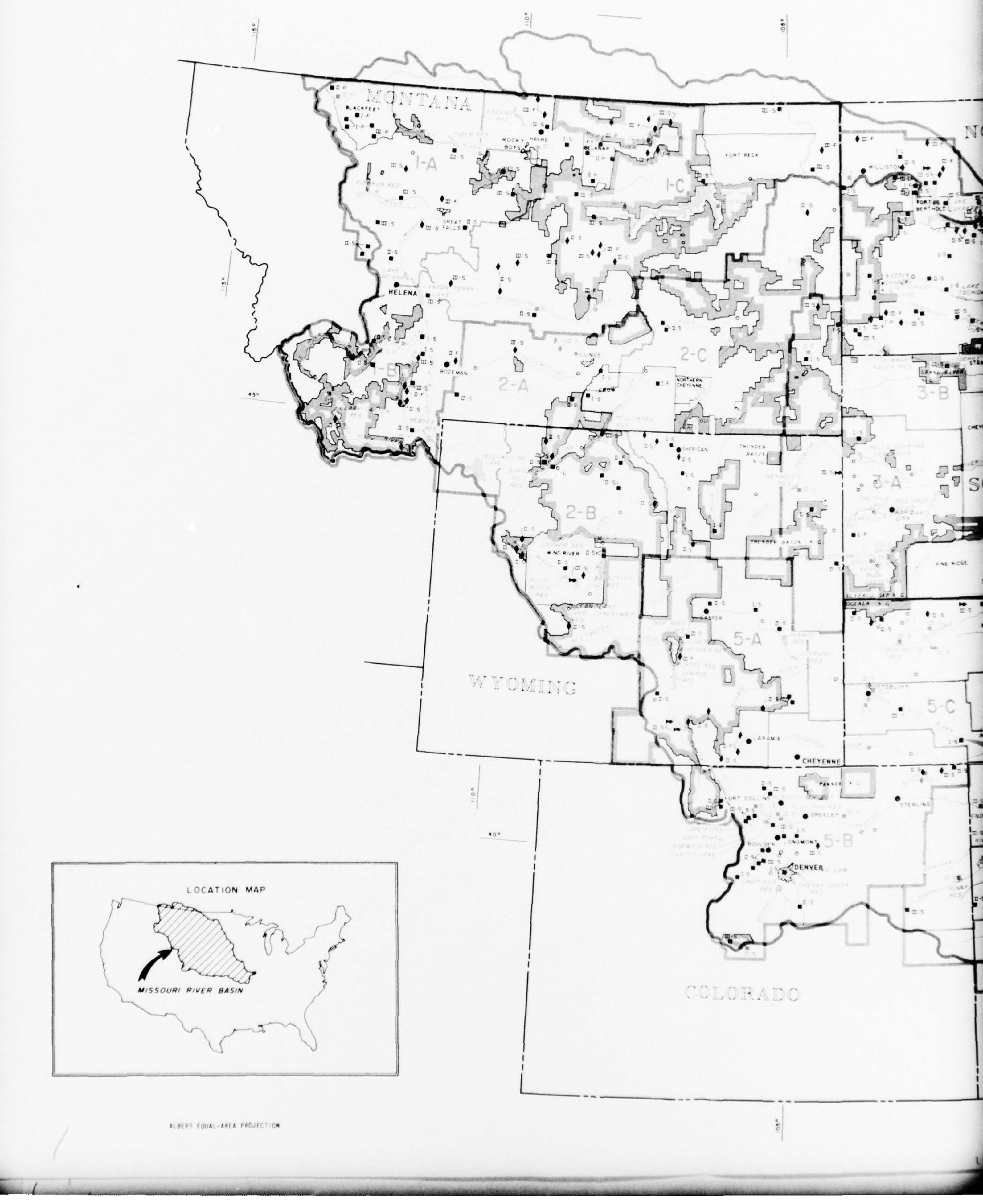
MAJOR RECREATION AREAS

COMPREHENSIVE FRAMEWORK STUDY

MISSOURI RIVER BASIN

MISSOURI BASIN INTER-AGENCY COMMITTEE

PLATE 6



MONTANA
WYOMING
COLORADO
1-A
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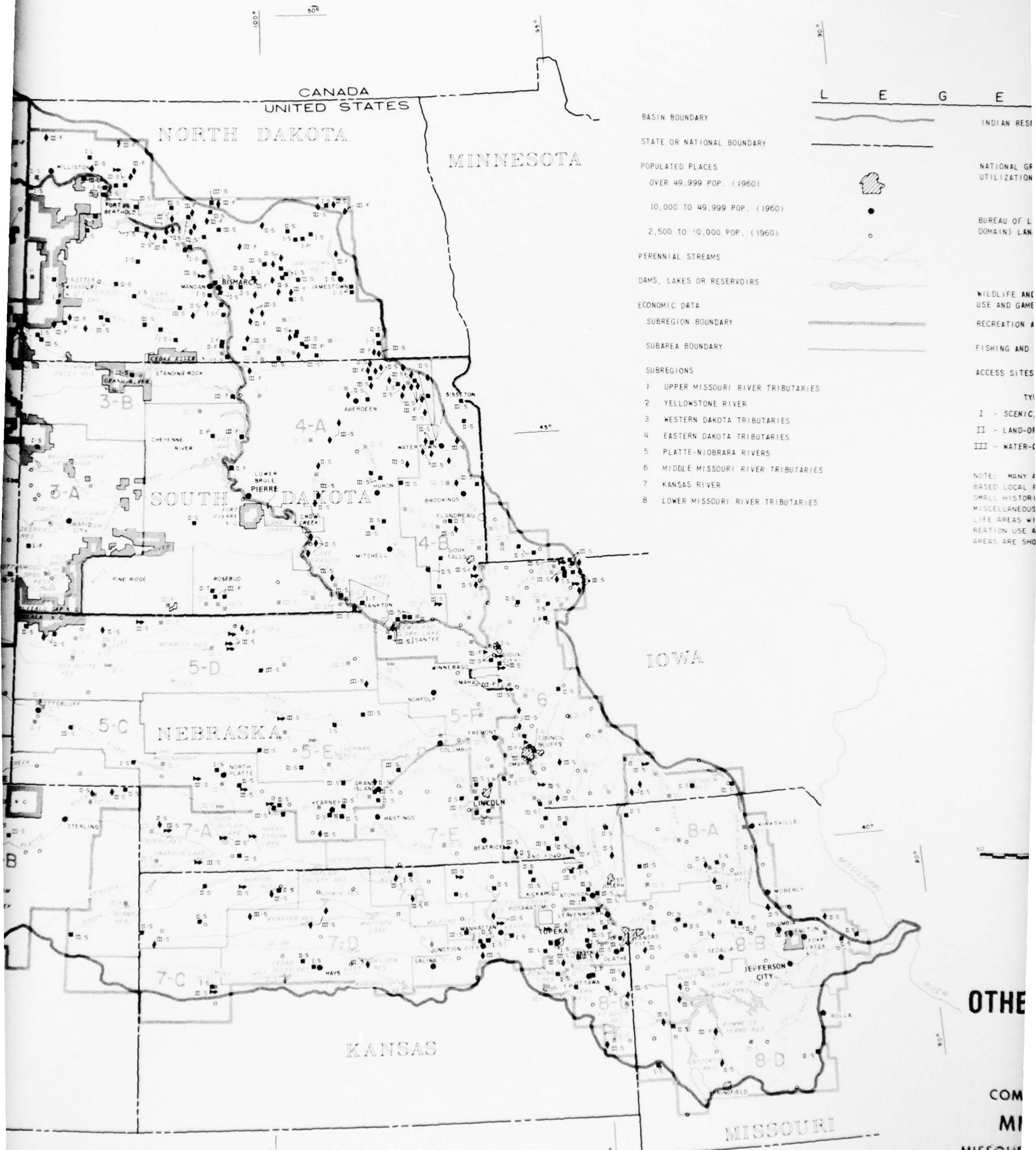
BLACKFEET
ROCKY BOYS
HAVRE
FORT PECK
GREAT FALLS
HELENA
BOZEMAN
BILLINGS
CROW
NORTHERN CHEYENNE
WILLISTON
SHERIDAN
THUNDER BASIN N.G.
RAPID CITY
PINE RIDGE
WIND RIVER
CASPER
SCOTTSBLUFF
LARAMIE
CHEYENNE
FORT COLLINS
GREELEY
STERLING
BOULDER
LONGMONT
DENVER
115°
110°
105°
45°
40°
LOCATION MAP
MISSOURI RIVER BASIN
ALBERS EQUAL-AREA PROJECTION



CANADA
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BASIN BOUNDARY
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OVER 49,999 POP. (1960)
10,000 TO 49,999 POP. (1960)
2,500 TO 10,000 POP. (1960)
PERENNIAL STREAMS
DAMS, LAKES OR RESERVOIRS
ECONOMIC DATA
SUBREGION BOUNDARY
SUBAREA BOUNDARY
SUBREGIONS
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2 YELLOWSTONE RIVER
3 WESTERN DAKOTA TRIBUTARIES
4 EASTERN DAKOTA TRIBUTARIES
5 PLATTE-NIOBRARA RIVERS
6 MIDDLE MISSOURI RIVER TRIBUTARIES
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WILLISTON
FORT BERTHOLD
MANDAN
BISMARCK
JAMESTOWN
CEDAR RIVER
STANDING ROCK
ABERDEEN
SISSETON
CHEYENNE RIVER
WATERTOWN
LOWER BRULE
PIERRE
HURON
BROOKINGS
CROW CREEK
FLANDREAU
MITCHELL
SIOUX FALLS
PINE RIDGE
ROSEBUD
YANKTON
SANTEE
WINNEBAGO
SIOUX CITY
OMAHA
NORFOLK
SCOTTSBLUFF
FREMONT
COLUMBUS
COUNCIL BLUFFS
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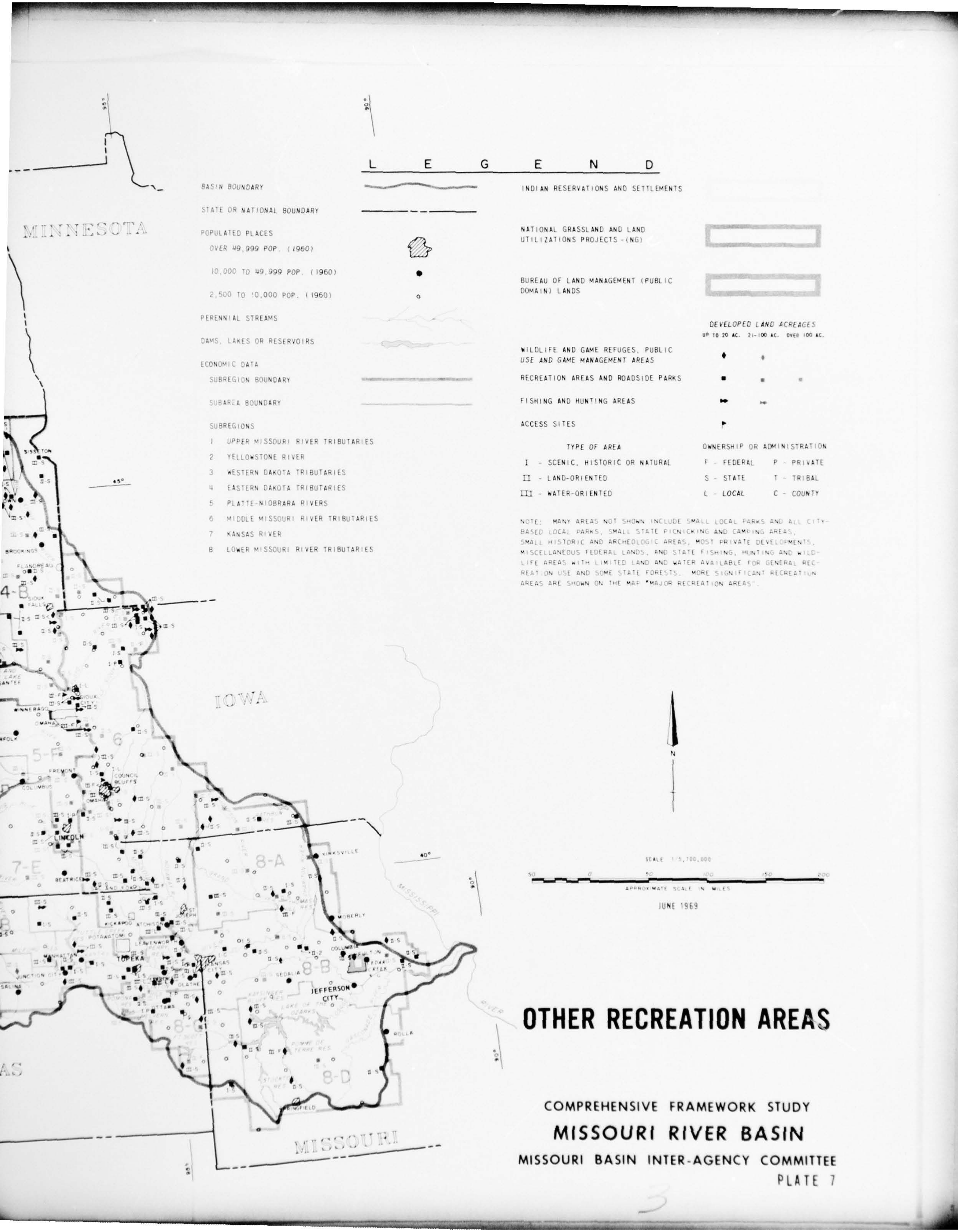


OTHER RECREATION AREAS

COMPREHENSIVE FRAMEWORK STUDY

MISSOURI RIVER BASIN

MISSOURI BASIN INTER-AGENCY COMMITTEE

PLATE 7

two million-acre Yellowstone National Park have both been inventoried as individual recreation areas. Large Federal and State areas, notably national forests and national parks, contain many recreation "sites" as large or larger than many individual recreation areas. If all identifiable recreation sites and separate developments were counted, the total number would undoubtedly exceed 10,000. It is also important to recognize that many large and basically land-oriented areas, such as national forests and Indian reservations, contain a number of water-oriented enclaves and sites. To some extent, the reverse situation is also true, but Type III sites within Type II areas predominate and distort statistical comparisons slightly. Recreation lands comprise 15.2 percent of the total basin.

Four national parks, nine national monuments, and five other National Park Service-administered areas, including several national memorial parks, comprise 97 percent of the Type I acreage. The large Yellowstone, Glacier, and Rocky Mountain National Parks account for the bulk of this category. The magnificent scenery, wildlife and other unique natural features of these parks attract visitors from many distant places. Other natural, historic, and scenic recreation areas include Custer State Park in South Dakota, Chimney Rock National Historic Site in Nebraska, and a number of public and private historic and archaeologic monuments, parks, national landmarks, and shrines at both designated and undesignated sites. Although the 139 Type I areas comprise only 6 percent of the total recreation lands and waters and 4 percent of the total developed land (see figure 44), they include some of the most unique, interesting, and popular recreation attractions in the basin and sustain heavy total visitation. Smaller Type I areas are found throughout the Missouri Basin; however, the largest and most significant scenic and natural of these are situated in the western portion. Historical parks and sites predominate in the eastern half of the basin.

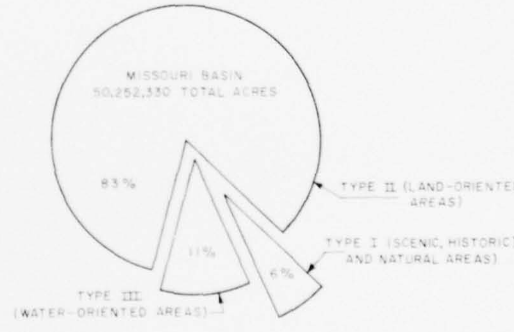
Badlands National Monument is one of the excellent natural recreation areas found in the Missouri Basin.

Some of the finest and more extensive natural environment areas in the Nation are found within Type I and II inventoried locations in the Missouri Basin. The best and most primitive of these are either now classified as true wilderness or will be studied for inclusion in the Nation's Wilderness System. Most, if not all, are in pristine condition and will no doubt be designated as wilderness. Eight existing wildernesses within the basin are located in Montana, Wyoming, and Colorado, and comprise a rugged 1,558,000 acres of land.[2] Six primitive areas, all situated within national forests as are wildernesses, are candidates for the wilderness system, three of which are in Montana and three in Wyoming. The 183,000-acre Wind River Mountains Roadless Area, situated within the Wind River Indian Reservation in Wyoming, will also be studied for wilderness designation.

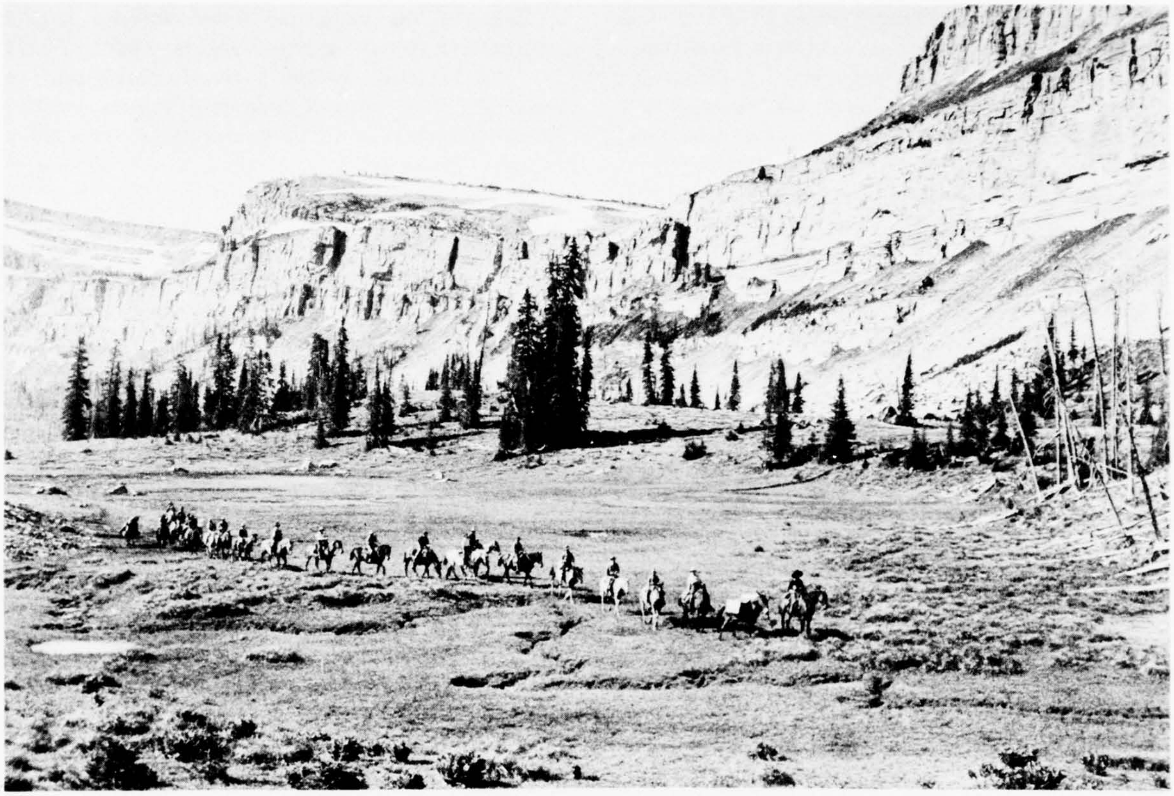
Although not specially designated, approximately 2,037,000 acres of land within Yellowstone, Glacier, and Rocky Mountain National Parks carry sufficient wilderness value to be officially identified and added to the wilderness system. All told, nearly 4.5 million acres of land and water have been specifically designated in the wilderness-type category and are now receiving wilderness preservation protection. Some of the finest horseback riding, fishing, and nature study experiences available anywhere can be enjoyed in these scenic Rocky Mountains, and the importance and use of basin wilderness-type lands are increasing steadily.

The bulk of the basin's recreation land is considered to be Type II, or *basically land-oriented*. More than 41 million acres of Type II land, excluding farm and ranch lands used in an extensive manner for hunting and fishing, have been inventoried as possessing significant recreation value. Only one-quarter percent of this is

FIGURE 44
PORTIONS OF TOTAL RECREATION LANDS AND WATERS REPRESENTED BY TYPE I, II, AND III AREAS

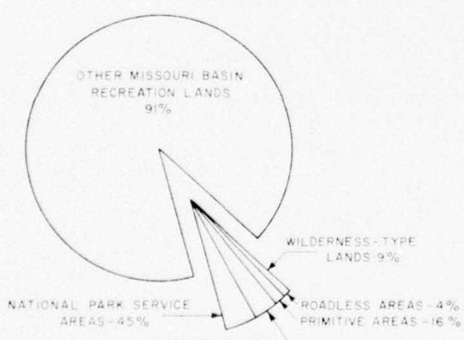


[2]Wilderness-type areas outside of national parks and monuments were not specifically inventoried in the Type I category. All so-called "wilderness areas" and "wild areas" are now *called wildernesses. All locations possessing significant* wilderness values and that are in or candidates for inclusion in the wilderness system have been collectively termed "wilderness-type areas".



The Bob Marshall Wilderness in northern Montana, the largest such area in the basin, provides outstanding back-country experiences.

FIGURE 45
RECREATION LANDS IN WILDERNESS-TYPE AREAS



actually developed. Despite the fact that land-oriented recreation areas include large blocks of extensive national forest, public domain, and other multiple-use lands, they support nearly as much visitation and recreation opportunity as water-oriented areas. This situation contrasts with that found in eastern and southern regions of the United States where huge public tracts of land are few, and most recreation takes place at water-based areas.

Chadron State Park in western Nebraska, illustrates a typical land-oriented recreation area.

National forests and grasslands with nearly 19 million acres, public domain with 15 million acres, and Indian reservations with almost 7 million acres of inventoried recreation lands, comprise 97.5 percent of the total Type II land and water. Nearly all of these sizeable units are situated in the western half of the basin. Combined with national parks and monuments and the private sector, these areas will continue to accommodate the

State parks situated at Federal reservoirs typify the water-oriented recreation areas found in the basin. Shown in this picture is a State facility of Milford Reservoir in Kansas.

majority of the extensive recreation activity, such as sightseeing, hiking, and hunting, in the western portion. In the eastern part of the basin, smaller variously administered and private water-oriented areas support most of the extensive recreation activity.

Since visitation figures are incomplete, the amounts of developed recreation lands provided by various agencies or "administrative categories" shown in table 117 headings provide a useful clue as to which agency or group provides the most facilities and supports the greatest total use. As indicated in figure 47, the private sector, local parks, and national forests provide the

FIGURE 46
DISTRIBUTION OF TYPE II (LAND ORIENTED)
RECREATION LANDS

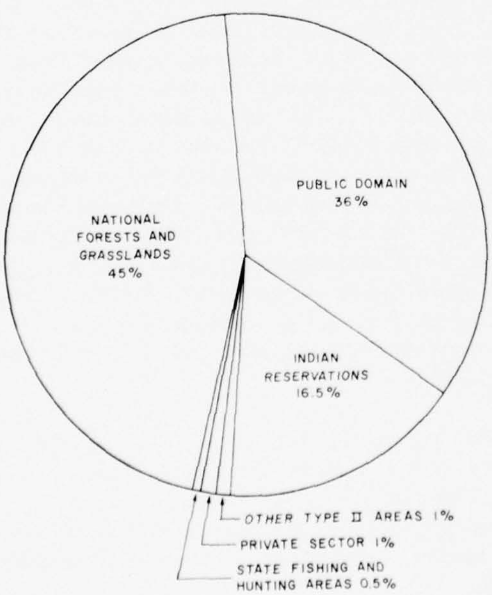
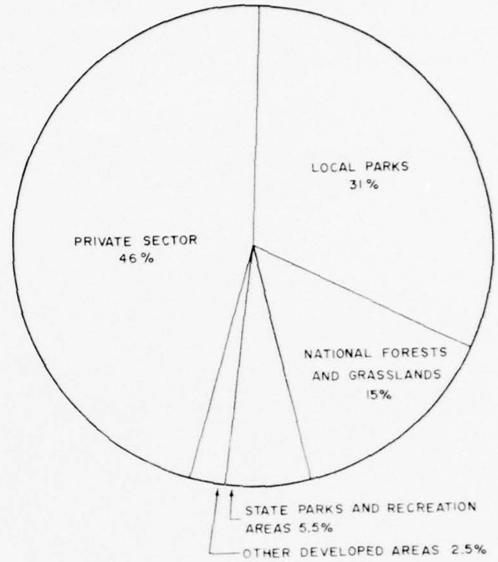


FIGURE 47
DISTRIBUTION OF TYPE II (LAND ORIENTED)
DEVELOPED RECREATION LANDS



majority of the Type II developed lands. On these lands excellent facilities are available for a variety of intensive uses. National forest developed sites are an especially important part of the recreation scene in the western part of the basin, while most of the local park developments are found in the more populous southern portion. In the latter, some important local recreation developments such as Denver's Mountain Parks are situated outside the cities. Relatively little developed acreage is provided in other locations, although land-oriented State and roadside parks do receive a significant percentage of the total visitation.

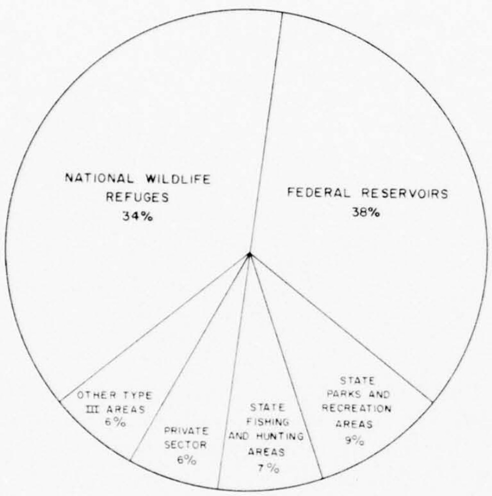
Type III recreation areas account for a relatively small part of the basin's total recreation land. However, water-oriented recreation lands contain nearly two-fifths of the total developed acreage, while they include or border on 3.3 million surface acres of recreational waters. The Type III areas found throughout the Missouri Basin support approximately half the total visitation. They provide the backbone of the recreation opportunities available in all of the eastern and most of the southern portions of the basin.

In general, water-oriented areas do not incorporate or require huge tracts of undeveloped or extensive lands, as do Type II areas. The 113 Federal reservoirs and 78 national wildlife refuges[3] are the only two "administrative categories" shown on table 118 that contain more than a half-million acres of recreation land and water. These two groups, which account for just over and just

[3]"National wildlife refuges" also include one national wildlife range, several national fish hatcheries and other management units.

under 2 million acres respectively, comprise 72 percent of the total Type III land and water acreage. As indicated by figure 48, State parks and recreation areas, State fishing and hunting areas, and private sector developments are also important in the overall water-oriented recreation picture.

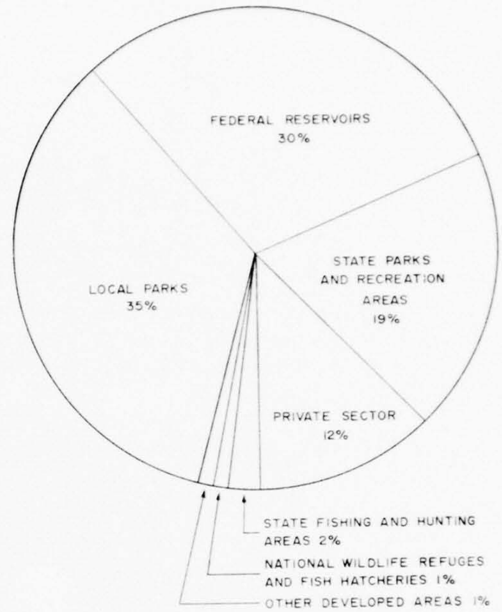
FIGURE 48
DISTRIBUTION OF TYPE III (WATER-ORIENTED) RECREATION, LAND AND WATER



The greatest concentration of recreation waters is found in five major reservoirs on the Missouri River main stem, in the Dakotas and northeastern Nebraska. In total, Lakes Sakakawea, Sharpe, Francis Case, and Lewis and Clark, and Oahe Reservoir contain 846,000 surface-acres of water. Upriver, Fort Peck Reservoir, the Canyon Ferry Reservoir, and several lesser impoundments account for another 259,000 surface-acres of water. The Missouri River itself provides an estimated 127,000 surface-acres of recreational water valued chiefly for boating, sightseeing, and its environmental aspects. The upper and middle reaches of the Missouri River have especially high aesthetic, historic, and wildlife values.

As illustrated by figure 49, local parks, Federal developments at Federal reservoirs, and State parks and recreation areas provide most of the developed Type III land. A large number of these State and local developments, however, have been established adjacent to and utilize the waters impounded at Bureau of Reclamation and Corps of Engineers reservoirs. Nearly all recreation lands and waters at Bureau of Reclamation reservoirs are managed by State and other agencies; however, in many cases initial facility development has been provided or aided by the construction agency. The private sector, which is especially important in the southeastern portion of the basin, also provides a significant portion of the Type III developed land. State fishing and hunting areas, national wildlife refuges and hatcheries, and Indian lands furnish extensive water-oriented recreation opportunities but relatively little development.

FIGURE 49
DISTRIBUTION OF TYPE III (WATER-ORIENTED) DEVELOPED RECREATION LANDS



The preceding discussion has compared recreation areas within the "type" classification. If the comparison were made of the overall importance of all areas providing recreation, regardless of type, the following conclusions can be made: National forests and grasslands, private sector developments, local parks, and Federal reservoirs provide the largest gross recreation acreage, developed acres, and estimated visitation in the basin. These would be followed by State parks and recreation areas, and National Park Service holdings, the latter along with local parks receiving the most intensive use. The third group would include public domain (Bureau of Land Management units) and Indian lands. The fourth group would consist of national wildlife refuges and State fishing and hunting areas which have been specifically established for fish and wildlife purposes.

This comparison does not consider important but hard-to-analyze aesthetic values, and development potential. Public domain, Indian lands, and national wildlife refuges provide large acreages which have major potential for additional recreational development in the Missouri Basin.

Table 119 – 1965 OUTDOOR RECREATION DEMANDS, MISSOURI BASIN

Activity	Rank	Activity-Days in Thousands		
		Resident	Nonresident[3]	Total
Swimming	2	35,246	17,260	52,506
Boating	6	15,707	5,705	21,412
Water Skiing	10	1,443	575	2,018
Picnicking	3	27,689	13,922	41,611
Camping	8	4,969	7,538	12,507
Sightseeing	1	55,465	68,032	123,497
Nature Walks	4	16,687	12,276	28,963
Hiking	9	2,078	1,372	3,450
TOTALS[1]		159,284	126,680	285,964

Other major recreation activities (as taken from data in the chapter on Fish and Wildlife.)

Hunting[2]	7	15,751	1,056	16,807
Fishing[2]	5	26,373	1,804	28,177

[1]Recreation-day figures for total Resident, Nonresident and Total Demand are, 63,714, 50,672, and 114,386 respectively. Based on 2.5 activities per average day of recreation.
[2]Figures considered to be applicable for 1960-65 period.
[3]Nonresident figures presented here are totals from those compiled separately for the eight Missouri Basin subregions. Nonresidents of individual subregions, who may be basin residents, are counted as nonresidents. It is estimated that an average of one in four nonresident recreationists in each subregion is a resident of another part of the basin. Based on this assumption, the actual Missouri Basin resident/nonresident demand ratio is 67/33 (190,964,000/95,000,000 activity-days).

Sparsely developed public domain lands include a vast amount of potentially important recreation acreage, whereas a large portion of national forest land, as seen in the background, provides numerous developed recreation areas.

Present Use and Demand

The available visitation figures recorded in tables 116, 117, and 118, total about 110 million; however, there are many gaps in the individual recreation site figures used to compile the data, especially for scenic, historic and natural (Type I), and land-oriented (Type II) categories. The total number of visits to Missouri Basin recreation areas in 1965 was estimated to have been approximately 200 million.

North Central region participation rates for various activities were obtained from the 1960-61 studies of the Outdoor Recreation Resources Review Commission and applied to subregion population projections. Factors were used in the calculations that took into account the influence of income, place of residence, and future increases in leisure time and mobility. The resulting calculated figures are termed "demands". Demands, as presented in table 119, are expressed in "activity-days" (an individual's participation in one recreation activity during any part of a day) and totals are shown in "recreation days" (an average day of recreation for an individual, considered normally to be 2.5 activity-days). Demands are also calculated and listed separately for resident and nonresident recreationists.[5]

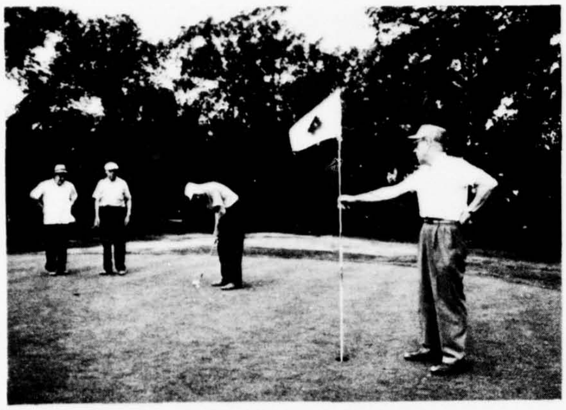
Demands have been calculated for the 10 activities most commonly associated with water. The activities considered are swimming, boating, water skiing, picnicking, camping, sightseeing, nature walks, hiking, fishing, and hunting. As can be seen in table 119, the first eight activities accounted for total 1965 basin demands amounting to 286 million activity-days or 114 million recreation-days. Fishing and hunting, studied separately, added another 45 million activity-days.[6] The resulting 331 million activity-days total should not be considered as the sum total of all the 1965 recreation activity in the basin, as no calculations were made of the demands for such activities as playing games and sports, skiing, and ice skating. A number of these "other" activities, however, have been treated in a general way in studies of the eight Missouri Basin Planning subregions.

Figure 50 supplements the data in table 119 by providing a comprehensive breakdown of 1965 recreation uses and activities by subregions. All uses so broken out are given in percentage terms to help show in one overall view which subregions and activities are the most popular. Additional information on this subject is presented under ***Projected Recreation Demands*** as well as in the material immediately following.

Nonresidents exert a very strong impact on basin recreation. Approximately 39 percent of the total demand (including fishing and hunting) can be attributed to nonresidents of Missouri Basin subregions in

[5]"Resident" demand within a particular subregion includes an estimate of that originating from SMSA's (Standard Metropolitan Statistical Areas) within 150 miles of the subregion (or basin) boundary.

[6]The Fish and Wildlife Chapter of this appendix treats fishing and hunting in detail. Demand figures have been extracted from that chapter and repeated here to provide a total recreation presentation; however, the figures have been counted only once in arriving at total demands and needs for the basin.

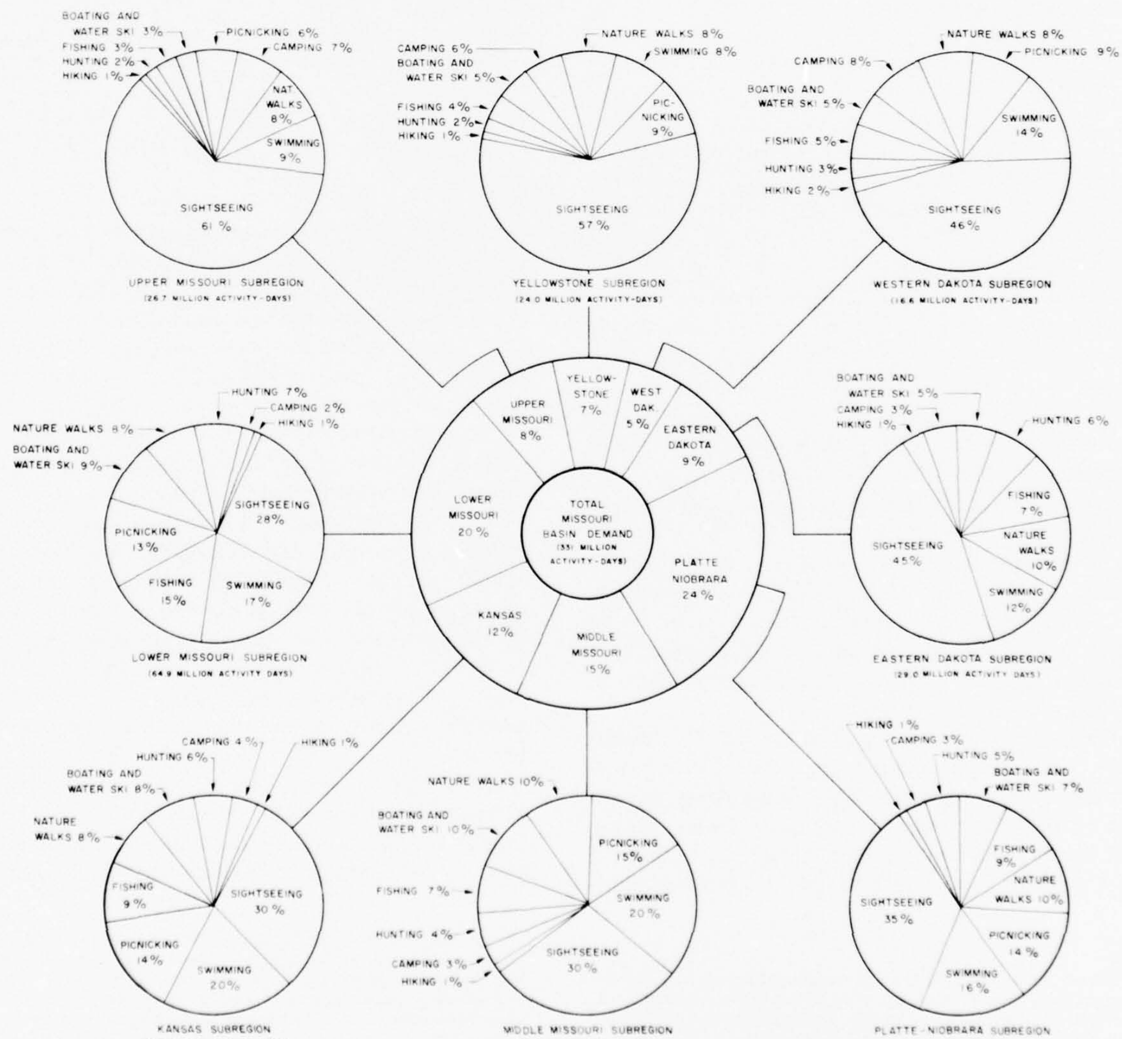


Golfing is one of the more popular "other" recreation activities for which demand has not been calculated.

which the demand is expressed and the use occurs. Since a number of nonresidents in each subregion actually live elsewhere in the basin, the percentage of nonresident demand for the basin as a whole is less than 39 percent. Taking a basinwide view, approximately 67 percent of the demand can be credited to residents and "nearby nonresidents" (those living in metropolitan centers within 150 miles) of the basin, while 33 percent can be attributed to nonresidents, mostly tourists.

As is true for much of the Nation, well over 90 percent of the nonresident recreation use occurs between May and late September, with the peak period between June 15 and August 25. The major vacation destination areas in the Missouri Basin are the Black Hills, Ozarks, and Rocky Mountains. The presence of

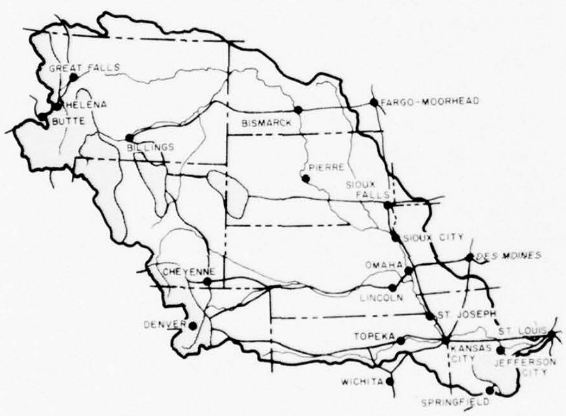
FIGURE 50
1965 RECREATION DEMANDS



such scenic and natural areas as Glacier and Yellowstone National Parks accounts for nonresidents who create 70 to 75 percent of the demand in the Yellowstone and Upper Missouri subregions. Even though most eastern and southern parts of the basin are not known as vacation areas, they are crossed by major travel routes carrying vacationists from eastern and Great Lakes' population centers. As a result, all Missouri Basin subregions enjoy the benefits of a significant amount of stop-over tourist use. Excluding those locations where exceptional or nationally known opportunities are provided, most of such use is now limited to very brief stays or overnight stops.

FIGURE 51

MAJOR VACATION-DESTINATION AREAS AND INTERSTATE HIGHWAYS



Well-known scenic attractions draw millions of nonresident visitors each year as at the St. Mary Entrance to Glacier National Park.

Residents or nearby nonresidents create most of the recreation impacts in the eastern and southern parts of the basin. Most major population centers in and near the basin are situated in these localities. Residents engage in outdoor recreation activities the year around; and in regions where good winter sports opportunities are available, such as near Denver, off-season use is substantial. However, the major recreation season even for residents extends from early May through October. In the southern part of the basin, especially, pleasant spring and fall weather can produce some surprising use figures. May visitation at several Federal reservoirs near Denver, for example, often surpasses that of August.

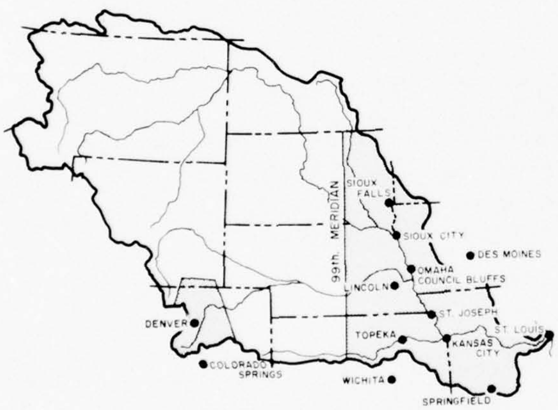
The most popular and seasonally crowded recreation areas in the basin are, in nearly all cases, either (1) in well known vacation target destinations, (2) in or near major population centers, and/or (3) in locales of limited recreation opportunity. Some of the most popular (and often congested) recreation areas in the basin include the following: Yellowstone National Park and environs, South Dakota portion of the Black Hills region, Lake of the Ozarks, Rocky Mountain National Park and environs, foothills and close-in mountain recreation areas west of Denver, Roosevelt National Forest in Colorado, Gallatin National Forest in Montana, and the Okoboji-Spirit Lakes area in northwestern Iowa. The most heavily used Federal reservoirs in the basin are: Lewis and Clark Lake in northeastern Nebraska and southeastern South Dakota, Oahe Reservoir in the Dakotas, Pomme de Terre Reservoir in Missouri, Cherry Creek Reservoir at Denver, and Tuttle Creek Reservoir in Kansas.

Intensive use at the Madison River Earthquake Area testifies to the great seasonal popularity of sightseeing.

Approximately 30 percent of the recreation demand studied is water-dependent. Heavy demand for water-based recreation opportunities, especially those that are reservoir-based, is strongly associated with one or more of the following four conditions: (1) the accessibility to large urban populations, (2) a shortage of alternate opportunities, within a reasonable travel distance, (3) climatic conditions associated with temperature, humidity, and length of season, and (4) economic conditions associated with disposable income. All of these factors create a heavy demand for water-based recreation in the populous portion of the basin. Large metropolitan areas were considered to create a demand within a 75-mile radius and the lessor urban areas with a 50-mile radius. Thus, large urban areas outside but near the basin boundary influence the demand for water-based recreation within the basin. Figure 52 shows the areas of heaviest water-based recreation demand, which are generally east of the 99th Meridian and in the area centering on Denver, between Colorado Springs and Cheyenne, Wyoming. The importance of water recreation within the localities is evidenced by the fact that every State park within the Kansas portion of the basin is reservoir-based.

FIGURE 52

AREAS OF HEAVIEST DEMANDS FOR WATER-BASED RECREATION



The situation relative to "water recreation" is quite different in the bulk of the northern and western parts of the basin. Pressure is relieved materially by the availability of land-based opportunities on large Federal and Indian holdings. The short summer season and lower water temperatures discourage use of reservoirs and lakes for body contact sports such as water skiing and swimming. Pressure on available facilities does not originate from the small and dispersed local population. Tourist use of impounded water areas is light due to (1) the availability of similar recreation opportunities nearer home, and (2) the inconvenience of transporting equipment such as boats, skis, etc., to a distant area that affords only limited opportunity.

As a result, reservoir-based demands in the north and most of the western part of the basin could be described as light to moderate — at least when compared with the area east of the 99th Meridian. Crowding occurs at a number of strategically located points on waters in the northwestern basin, but general congestion and severe shortage of opportunity or opportunity-alternatives, known to much of the southeast, have not yet been realized.

The oxbow lake at DeSoto National Wildlife Refuge is situated within the eastern area of "heaviest demand for water-based recreation".

The information presented on current use and demands has centered on a description of the form and magnitude of overall recreation pressures on the various segments of the basin. Following is a discussion of the specific recreation activities which have been studied.

Swimming is, by far, the most popular water sport in the basin and ranks second for all activities studied. Most swimming occurs at pools; as a result, the requirement for beaches and outdoor waters has not been commensurate with the high demand. However, the warm, humid climate and favorable reservoir and "sand-pit" lake development opportunities of that portion of the basin east of the 99th Meridian have promoted a considerable amount of beach swimming demand.

Lake of the Ozarks State Park contains one of the very popular beach swimming sites in the heavy water sports demand area east of the 99th Meridian.

Fishing and boating are the second and third most popular water sports and the fifth and sixth-ranked activities, overall. Most of the demands are associated with lakes and reservoirs. Stream and river activity is confined mostly to the western and northern parts of the basin. In the latter, especially in the mountains and highlands of Wyoming and Montana, are found some of the finest cold-water stream and boat fishing opportunities in the Nation. The Missouri River and Missouri River reservoirs above Sioux City also provide unique and generally underused possibilities for fishing and boat cruising. A very large portion of the basin demand for both activities, however, is met by a number of popular Federal and private power company reservoirs, especially those in Missouri, northern Kansas, southern Nebraska, northwestern Colorado, and at Lewis and Clark Lake on the Missouri River.

Boating is a popular activity with basin residents. Excellent opportunities are available on the basin's reservoirs such as the Lewis and Clark Lake.

Water skiing is the least popular of the 10 activities studied, but this is largely because of the special equipment and skill required. It has been one of the fastest growing recreation activities. The sport necessitates space, which is usually not available on lakes of less than about 200 surface acres. Water skiing is moderately popular throughout the basin, but about 90 percent of the demand is associated with reservoirs in the four southern subregions.

Sightseeing is the most popular of the activities studied. It is generally considered to consist of touring and observing attractions by car, but it can cover a multitude of closely related pursuits, including visiting historic sites and taking photographs. The activity has universal appeal throughout the basin and tourists spend an especially large percentage of their time pursuing this pastime. Approximately 52 percent of the basin sightseeing demand is associated with the three western subregions (Upper Missouri, Yellowstone, and Platte-Niobrara).

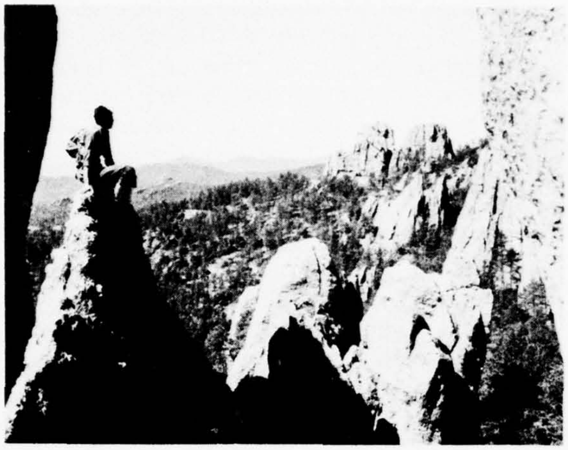
Picnicking ranks third in popularity, and it too enjoys a universal appeal throughout the basin. However, picnicking is strongly associated with areas of major urban population. Popular local parks and water-based recreation areas in the southern half of the basin absorb 80 percent or more of the total picnicking demand.

The fourth most popular basin recreation activity is nature walks (also known as nature study), closely identified with other activities, especially sightseeing. As the population of the Nation and the basin has gradually changed from basically rural to urban, an aggressive if not highly scientific pursuit of nature association and knowledge has evolved. Generally, too few opportunities for planned nature walks have been made available, but various agencies are now beginning to provide specialized facilities for the activity. The very high nature-study use of Yellowstone National Park and of DeSoto and Squaw Creek National Wildlife Refuges in the eastern end of the basin, attest to the growing popularity of this form of recreation. In a number of areas, the interest in and demand for nature study equal or exceed those for hunting and fishing.

Viewing and photographing big game in national parks, as in Yellowstone, is an especially popular form of nature study.

Hunting, the seventh most popular activity, is covered in considerably more detail in the chapter on Fish and Wildlife. Some of the best big-game, upland bird, and waterfowl hunting to be found in the Nation is available in the northern half of the basin, but approximately 67 percent of the total hunting demand is associated with the four subregions in the southern half of the basin where the human population is concentrated. Most of the hunting there is done on private lands.

The popularity of camping, the number eight activity, tends to be regionalized, although in part this is due to a shortage of opportunity in much of the plains. Camping demand, especially high in vacation-destination areas and along major travel routes, is strongly associated with tourists and other vacationers. The single most popular camping area in the basin is the Black Hills region. The three western subregions combined with the adjacent Black Hills absorb 54 percent of the total camping demand. The growth of camping in the past 20 years has been sifnificantly greater than for the average of all activities.



Demand is limited, but excellent opportunities for hiking and climbing exist in mountainous areas.

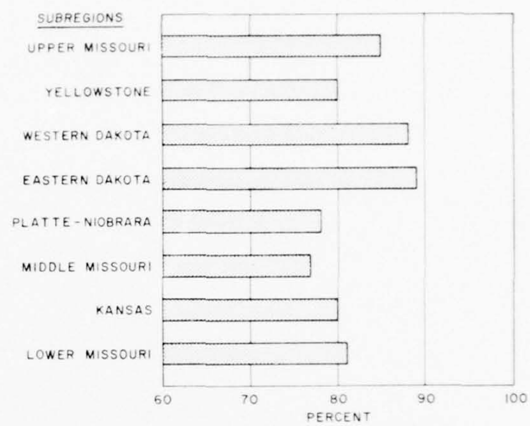
The total demand for hiking, the ninth-ranked activity, is relatively small, due to the fact that hiking, as opposed to "walking for pleasure," normally includes *the use of trails and toting of pack, tent, or provisions.* If the basin demand for walking for pleasure were calculated, it would probably surpass that for sightseeing. Hiking demand is distributed more or less commensurate with the distribution of population; however, much of the demand in the southern basin is unfulfilled due to a lack of good opportunity. The best opportunities for hiking are in the western, mountainous areas in national forests and national parks.

Other important basin recreation opportunities include driving for pleasure, playing games and sports, attending outdoor games, snow skiing, ice skating, sledding, snowmobiling, horseback riding, bicycling, and attending outdoor concerts and drama. All of the winter sports mentioned are especially important, and skiing and snowmobiling have enjoyed rather recent sharp increases in popularity both in and outside the basin. Opportunities for skiing are limited mostly to the Black Hills and Rocky Mountain regions. The bulk of the basin suffers from a shortage of good, close-in opportunities for most winter sports.

Adequacy of Present Recreation Facilities

The results of generalized analyses of the recreation facility supply/demand picture in each of the eight Missouri Basin subregions for 1965 are shown in figure 53. Although there are local recreation land and facility surpluses in some areas, every subregion shows an overall deficit of between 11 and 23 percent. The greatest current shortages are found in the four subregions representing the highly populous southern half of the basin and in the Yellowstone River drainage of northern Wyoming and southern Montana.

FIGURE 53
APPROXIMATE PERCENT OF 1965 RECREATION DEMAND MET BY EXISTING SUPPLY



Subregion data, averaged for the basin, indicate there are moderate to moderately severe shortages of adequate camping, boating, and water skiing facilities; moderate shortages of picnicking, swimming, and nature walk facilities; light to moderate shortages of fishing, sightseeing and informational, winter sports, and hiking facilities; and light shortages of roadside facilities. The adequacy of certain other facilities, such as those for games and sports, has not been analyzed.

In general, a combination of the highest and lowest quality facilities in the basin is found in the northern and western areas. In most of the southern and eastern

In general, the greatest current shortages of facilities are found in the more populous, southern part of the basin. In this scene, campers are literally jammed into a campground.

parts of the basin, facility quality is less variable and could be described generally as nearly adequate to good. There are excellent, as well as poorly located, developed and maintained recreation facilities in all parts of the basin, including the southern and eastern portions.

Trends in Programs

The Missouri Basin was the setting for the precedent-breaking establishment of the first of four major types of conservation-recreation areas. Yellowstone National Park, the first major scenic area to be set aside as a "public pleasuring ground", was established in 1872 and marked the real beginning of the far-flung national park system. Creation of the Yellowstone Timberland Reserve in 1891, later to become in part the Shoshone National Forest, signaled the beginning of a great national forest system. The first national monument, Devils Tower, was set aside in 1906. Finally, the Bob Marshall Wilderness Area in northwestern Montana, the first wildland to be so designated, was established in 1940. The first tract acquired by a State for park purposes in the basin was the site containing Forts Abraham Lincoln and McKeen, on the west bank of the Missouri River near Mandan, North Dakota. The State acquired this tract from the Federal Government in 1908.

Fort McKean

The Civilian Conservation Corps program in the late 30's provided an important impetus to outdoor recreation within national parks, state parks, and forests. Since World War II, the recreation programs have expanded significantly. Most of this growth has occurred since the early 1950's. A new awakening to the importance of recreation, and a realization of the development lag that began in 1940, surfaced in the mid-1950's. In 1956, the National Park Service initiated its Mission 66 Project, the U.S. Forest Service strengthened its recreation planning and development with the 1957 Operation Outdoors Program, and several basin states started their first real park systems. In addition, Congress established the Outdoor Recreation Resources Review Commission which led the way to a national comprehensive survey of recreation resources and needs.

Since 1960, the recreation planning, development, organizational improvement, and legislative action that has taken place in the basin has probably exceeded that of the previous 30 years. To a large degree this activity has been aided by inception of several new Federal assistance programs, including the Land and Water Conservation Fund program. Moreover, the demand for more and better recreation facilities and opportunities, especially those that could most logically be furnished by the State, local government, and private sectors, has increased greatly. Currently there is an increased tempo of municipal, industrial, water, and transportation development. This in turn is creating, modifying, and eliminating basin recreation lands at a relatively rapid rate, a situation which requires a keener awareness of recreation and natural beauty values at all levels of government.

In Montana, Wyoming, Colorado, and most of the Dakotas west of the Missouri River, Federal programs have been traditionally dominant. In these areas, facilities and opportunities provided by the National Park Service, the U. S. Forest Service, and Army Corps of Engineers are especially important. The Bureau of Reclamation indirectly supports major programs through providing a number of reservoir lands and waters administered, for the most part, by state and local agencies. Secondary or specialized opportunities are available on sizeable but largely undeveloped lands administered by the Bureau of Land Management, the Bureau of Sport Fisheries and Wildlife, and the Department of Defense, as well as on many private Indian and tribally owned lands. The Soil Conservation Service's small watershed program (P.L.566) provides opportunities for recreation on single- and multiple-purpose flood control facilities. Intensive recreation planning and/or development programs involving these programs are just getting underway. Local recreation programs in this western basin area have been relatively strong in larger cities and towns and generally weak in smaller communities, while a few counties support recreation activities or systems of any kind. Until recently, the investments in State park programs have been modest or nonexistent. All State park agencies within the basin are still seriously underfinanced and understaffed. This does not necessarily reflect on the magnitude or quality of the State park systems. All western states now have or are developing park and recreation systems. The private sector is increasingly significant through the many tourist enterprises that have been developed, while private fishing and hunting lands supplement those found within many Federal and State areas.

This family is utilizing one of the many Forest Service recreation sites.

In Nebraska, the eastern Dakotas, southwestern Minnesota, Iowa, Missouri, and Kansas, State recreation developments and programs are generally dominant. All States in this general area are maintaining large, well developed, and usually comprehensive park and recreation systems. However, Federal as well as State and private reservoirs provide many of the water impoundments where State recreation sites are located. The only Federal agency that provides and administers a substantial number of recreation facilities here is the Corps of Engineers. Again, local recreation programs are generally quite strong in the larger towns and cities, and range from strong to weak in smaller communities. Although the situation varies greatly from one place to another, a number of county park districts and boards have been established in the eastern half of the basin, and some are supporting major programs. In Iowa, only one county lacks an active county conservation board. The private sector plays a prominent role through making available millions of acres of farm and other lands for hunting and fishing.

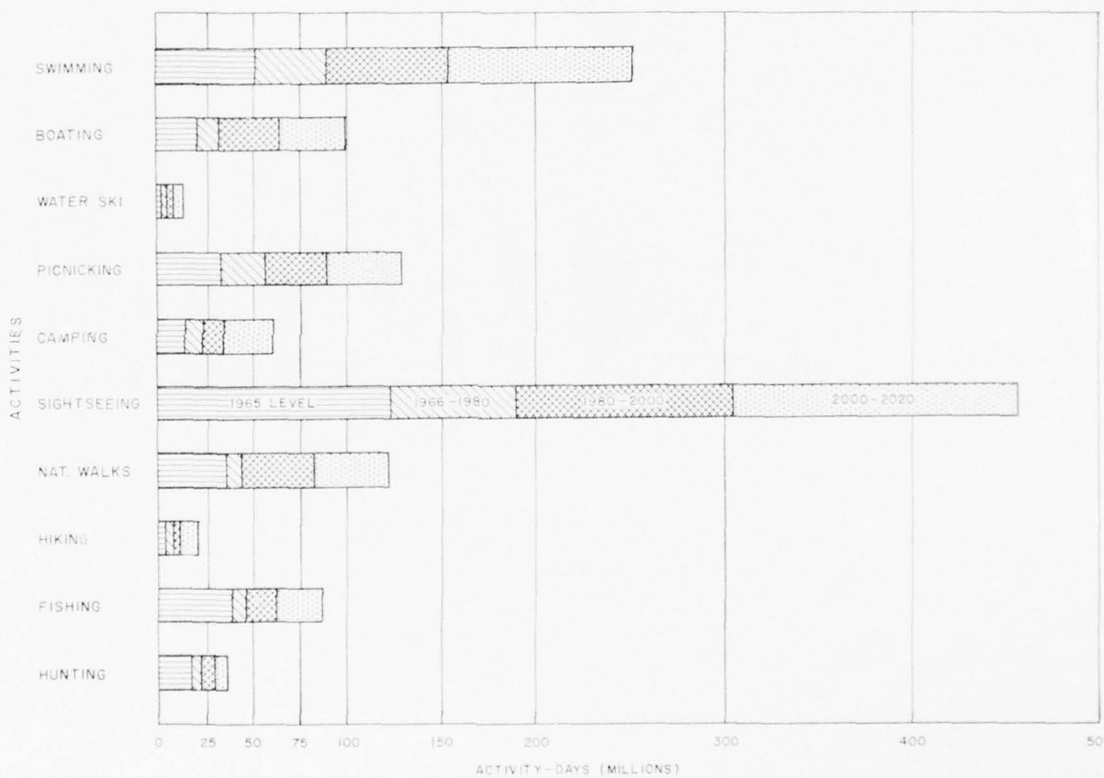
An excellent facility at a State recreation area.

PROJECTED RECREATION DEMAND

Future Recreation Trends

Many factors are constantly at work, gradually increasing or decreasing the popularity of certain sports, changing recreationists' vacation habits, and altering the resource that makes outdoor recreation possible. It is possible that high quality cold water trout fishing, readily available to the average Coloradoan in 1969, may require a reservation and a special license in 2000. All such factors, which are discussed herein as trends, help determine the amount and form of people's demands for outdoor recreation in future years. The appraisals expressed concerning basin trends should be considered as falling somewhere between strong possibility and reasonable probability. One overriding probability should be kept in mind; that is the upward trend foreseen for almost all recreation activities. Some of the more important trends are discussed herein and are illustrated by figure 54. Basinwide and subregion demand projections are treated separately under "Future Recreation Demands."

FIGURE 54
BASIN-WIDE RECREATION DEMAND BY ACTIVITIES



Sightseeing– This activity will continue to be the most popular of the 10 studied. Visiting historic places ranks as one of the top two or three visitor-pursuits according to several State tourist studies. The Missouri Basin enjoys a rich historical heritage. As evidence of intense interest is the fact the Lewis and Clark Trail, as well as several historic routes proposed for National designation, will be especially well developed and promoted by the plains states. Historically oriented sightseeing should increase accordingly.

Water-sports– Swimming is expected to be the number-one outdoor activity nationally by 1980; however, it will remain the number-two basin sport. Boating, now sixth in popularity, is gaining participants rapidly and should become the number-five basin activity before 2000. It should at least tie for fourth place by about 2020. Water skiing demand will continue to be quite limited, although it could be one of the very fastest popularity gainers. It requires a large amount of water surface per participant, and future activity will likely be curtailed in water-short areas. Fishing will continue to be very much in demand, but quality opportunities will probably be limited in a number of key locations. Demand projections prepared for this study show the sport should drop from fifth to sixth place before 2000. Because of the very strong relationship of water-dependent activity with urban populations and warm climates, the southern part of the basin will continue to furnish the preponderance of the water sports demand. Areas that could show great increases in such water use include the Missouri main stem and future reservoirs built near Denver, Kansas City, and Omaha.

Water skiing is a popular recreation activity on larger warm-water lakes and reservoirs.

Picnicking and Camping – Picnicking is expected to remain the third most popular basin activity, though the demand increase will be slightly below the average for all activities. Growing urbanization will help sustain the demand and increase the requirement for close-in facilities. The increase in camping demand will substantially exceed the average rate of increase for all activities, and camping should climb to seventh in popularity by about 1980. Increases in camping demand should be especially noticeable in the plains and near cities.

Nature walks, hiking, and biking – Nature walks should remain in the number-four popularity position, at least through the year 2000. Hiking should continue to be the number-nine activity, but both hiking and "walking for pleasure" should show unusually large increases in participation and, together, they will probably represent the most popular form of recreation in the basin. Bicycling by adults is an increasingly popular form of activity in and near urban areas. Interest in or plans for creating urban trails and bikeways is high in Denver, Omaha, and Kansas City, and should spur the future popularity of all three of these activities.

Hunting – Due primarily to growing shortages of good or sufficient opportunities, hunting is expected to slip from seventh to eighth place in popularity by 1980. However, the activity is still expected to show a demand increase of nearly 150 percent by 2020.

Winter sports – Skiing – and to lesser degrees snowmobiling, ice skating, sledding, inner-tubing, and even

Skiing and snowmobiling are both expected to show substantial increases in popularity.

Sightseeing, in its various forms, is the most popular of the 10 Missouri Basin recreation activities studied.

ski-watching, have increased dramatically in most snow areas of the country in the past 10 to 15 years. Between the 1954-55 and 66-67 seasons, visits to national forest winter sports areas within the Rocky Mountain Region increased 674%. Although the Missouri Basin does not include the most popular areas accounting for this increase, the figures give some indication of what could happen within the western portion of the basin as populations increase, transportation improves, and as nonresidents "discover" some of the better locally popular winter sports areas. Snowmobiling, in particular, could become extremely popular within Colorado, Wyoming, Montana, and the Dakotas. More than 4,000 snowmobile visits were made into Yellowstone Park from West Yellowstone alone during the 1966-67 winter season. This use is certain to increase substantially in future winters unless Park roads are kept open for winter auto travel.

Accommodations and vacation-destination areas– More and more, traveling recreationists expect to find and do more at their points of stay. This trend will particularly favor private-sector development, now exemplified by many of the 60 private campgrounds in the Black Hills region that offer swimming, showers, and even nightly entertainment. Deluxe resorts and recreation ranches could and probably will become much more common. Those that possess the proper transportation facilities and location, along with a range of popular recreation opportunities, should become vacation destinations – some in both winter and summer. Chain organizations offering this type of facility may develop.

Deluxe resorts that possess the proper recreation opportunities and transportation facilities are vacation targets for a significant number of recreationists.

Recreation transportation– The private automobile will continue to be the mainstay for the traveling recreationist for some time to come. However, a large upsurge in vacation air-travel and the use of rental cars can be expected. Bus touring may again become popular, especially in scenic, congested areas such as Yellowstone National Park. Rail travel and tours are now dying businesses, but basin vacationers may well rediscover train travel when the highways and air corridors become more congested and if faster and better rail equipment is provided. This may include auto-carrying trains between major cities and high volume departure points. Boat excursions on the Missouri River could become popular. Improving world affluence and transportation are certain to produce a sharp increase in the number of visitors from other countries.

For the next few years, interstate highways promise to have the greatest transportative influence on recreation. For the Missouri Basin, the influence should be positive, unless sufficient recreation facilities, signing, information stations, and branch-off tour roads are not provided near these travel routes. Substantial improvement of remote area and private land access will also have a significant bearing on future recreation use, especially in the northern and western portions of the basin.

Crowding and overuse– Yellowstone, Grand Teton, and Rocky Mountain National Parks, the Black Hills region, and certain other areas are being subjected to inexorably increasing use that may eventually necessitate limits on visitation. A "turn-away" situation is especially likely to develop at Yellowstone, and at Grand Teton National Park, just outside the basin. As a result, much greater pressures will be placed on such areas as the Big Horn Canyon National Recreation Area and nearby national forest lands. Also, there should be greater demands for and use of facilities within State parks, the public domain, Indian reservations, and other now-less-popular areas. Different, more complex patterns of travel and activity preference could also result. These probabilities become more important in light of State and Federal plans or potentials for developing new plains recreation areas, promoting the Lewis and Clark Trail, and establishing national and State scenic rivers and trails.

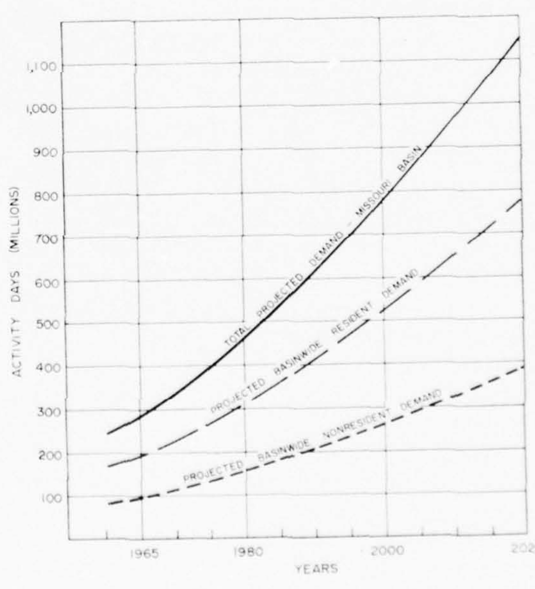
New water resource developments– In general, areas of high urban growth and population will be areas of high water-based demands. Urbanized locales in the southern and eastern parts of the basin, notably near Omaha and Kansas City, are now quite short on convenient water-based opportunities. Construction of desirable new reservoirs could cause instant popularity and mass use through conversion of a considerable amount of latent demand to actual use. On the other hand, development of new reservoirs in remote locations or areas of great existing supply or low demand, will result in use but relatively little change in total visitation.

Greatly increasing use at extremely popular areas may result in a "turn-away" of vacationists to other less well known attractions, such as Fort Robinson State Park in northwestern Nebraska.

Future Recreation Demands

Figure 55 shows the amount of total projected recreation demand between 1960 and 2020 in the Missouri Basin. Although demand has been calculated only for 1965, 1980, 2000, and 2020, the derived curve

FIGURE 55
PROJECTED RECREATION DEMANDS
(EXCLUDING HUNTING AND FISHING DEMANDS)

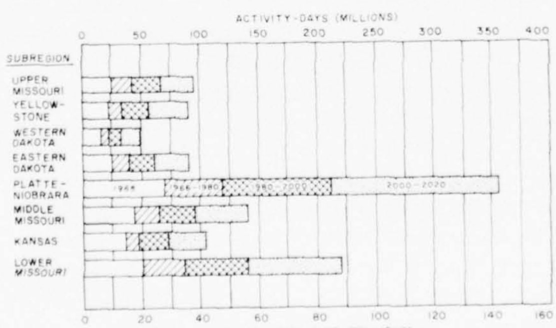


indicates approximate total demand in intervening years. Nonresident data are for only those recreationists who travel to, but do not live in, the basin. About one in four basin residents travels across subregion boundaries for recreation, which accounts for a higher recreation demand in some subregions than would be indicated by resident participation.

Excluding fishing and hunting as well as the several activities that were not intensively studied, total recreation demands increase from approximately 286 million activity days in 1965 to 1.14 billion in 2020. With fishing and hunting included, total demands grow from 331 million activity-days in 1965 to 1.26 billion in 2020, an overall increase of 280 percent (recreation-day figures may be computed by dividing by 2.5). It is apparent that the overall increase in recreation demand is greater than the projected increases in population. This is due to projections of increasing participation in recreation, resulting from increasing income, leisure time, mobility, and other socio-economic factors.

Figure 56 provides a comparison of the 1965, 1980, 2000, and 2020 levels of total recreation demand by each of the eight Missouri Basin subregions. The influence of population concentrations on subregion demand totals is readily apparent. The Platte-Niobrara, followed by the Lower Missouri, accounts for far more projected demand than any other subregions. The Platte-Niobrara Subregion contains the fast growing Denver and Lincoln Standard Metropolitan Statistical Areas. The subregion is also strongly influenced by residents of the Omaha-Council Bluffs SMSA. The Lower Missouri Subregion contains the Kansas City and Springfield, Mo., metropolitan areas and is significantly influenced by the nearby St. Louis and Topeka SMSA's.

FIGURE 56
RECREATION DEMANDS, BY SUBREGION
(EXCLUDING HUNTING AND FISHING DEMANDS)



The Middle Missouri Subregion, which includes the Omaha and Sioux City SMSA's, is third highest in total anticipated demand in the basin. All of the aforementioned subregions, including the Kansas, comprise what could be described as the southern half of the basin, which accounts for approximately 71 percent of the recreation demand studied.

The northern half of the basin, comprising the four northern subregions, records only 29 percent of the total projected recreation demand; however, a high percentage of this demand is felt within a 3-month summer period. In addition, there are many localized "pressure points" combined with many areas that will probably not be subjected to high recreation use through the year 2020. The Upper Missouri and Eastern Dakota subregions show the highest present and projected demand levels, with the Yellowstone following close behind.

The Platte accounts for more total recreation demand, both present and future, than any other subregion. Fremont State Recreation Area is a popular location at the eastern end of the Platte River Basin.

PROJECTED RECREATION LAND AND WATER NEEDS

Demand considers only the expected future impact on recreation resources, while need expresses the net or additional requirements for land, water, facilities, or management. For most framework river basin studies, the primary concerns are "acre needs" for both water surface and land.

Determination of recreation acre needs involves calculation of future use in terms of activity-days of expected recreation demand. Demands are then converted to "total requirements" for recreation land and water surface in acres. When, for any given target year, the known "supply" of this resource in acres is subtracted from total estimated requirements, the remainder is the need.

Figure 57 provides basinwide comparisons of total requirements, existing supply, and the indicated future needs for three resources: (1) recreation waters, (2) developed recreation lands, and (3) undeveloped recreation lands. Primary use, undeveloped recreation lands, are those set aside or used primarily for recreation and

FIGURE 57
BASIN SUPPLY AND FUTURE NEEDS FOR
RECREATION LAND AND WATER

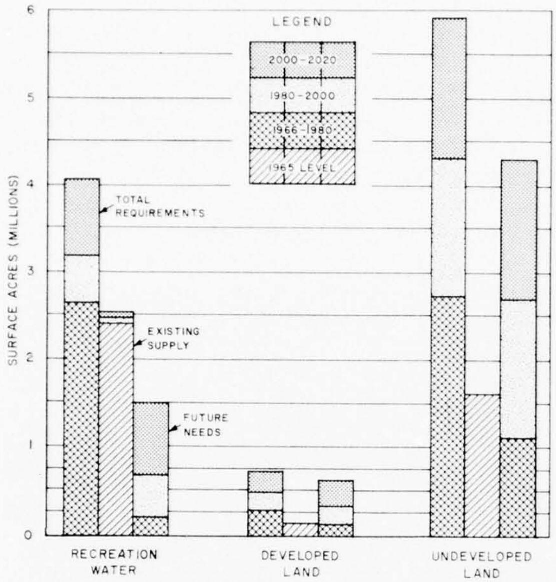
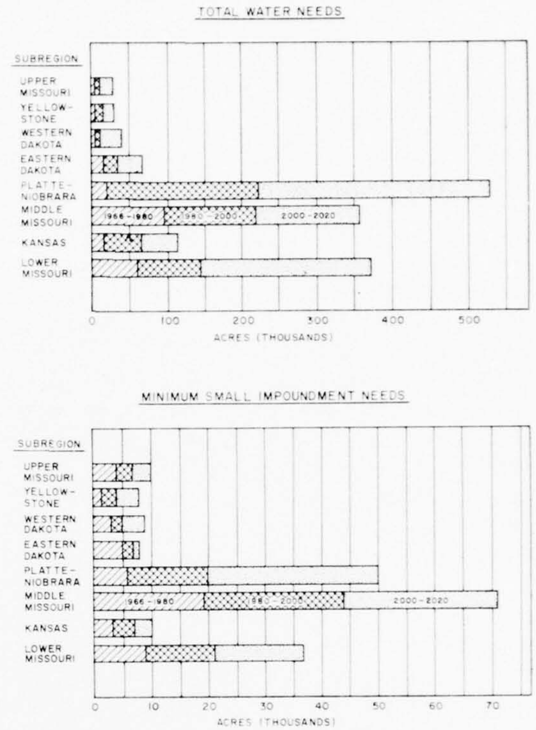


FIGURE 58
FUTURE RECREATION WATER NEEDS



fish and wildlife purposes. The existing supply of recreation waters may be noted to show a future increase which reflects an estimate of existing but ineffective waters due to pollution, lack of access or other problems but that can be made recreationally effective. Figure 58 shows total recreation water needs and estimated portions thereof which are required for small impoundments. Figure 59 portrays needs for developed and undeveloped recreation lands. Since ultimate needs involve much more than acres of water and land, expansion of the information provided in the figures is presented in the narrative following.

Water and Water-Based Needs

There will be substantial needs for additional recreational surface waters in all three target years. These estimated needs increase from about 227,000 surface acres in 1980, to 720,000 acres in 2000, and to 1,536,000 acres in the year 2020.

In many places, especially in and near urban areas, small impoundments of up to about 300 surface-acres will best meet the water needs. Minimum small impoundment needs, which are portions of the total figures, have been estimated at 41,000, 115,000, and 203,000 surface-acres for the years 1980, 2000, and 2020, respectively.

In effect, all of the water needs for the target years 1980 and 2000 result from a widespread supply/demand imbalance within the basin. Unfortunately, most of the recreation waters are located in areas of relatively low demand — areas too far from population concentrations to be effectively utilized. If it were possible to redistribute basin waters according to location of need, there would be a theoretical 1.5-million surface-acre surplus in 1980 and even a 0.75 million-acre surplus in the year 2000.

There is considerably supply/demand inequity within individual subregions. The overall imbalance can be illustrated best by a basin-wide statistic indicating that 66 percent of the year-2000 supply is situated within the four northern subregions, while 84 percent of the corresponding total requirement for recreation water is associated with the four southern subregions. As a result, 90 percent of the total need for additional recreation waters in the year 2000 should be met in the southern half of the basin. An indication of the strong relationship of water-need with urban-concentration can be seen by the fact that nearly 60 percent of the year 2000 needs for water surface should be met within the urbanized "subareas" covering the Denver, Lincoln, Omaha, Topeka, and Kansas City metropolitan areas.

Regions of high future water need (40,000 surface-acres or more by 2020) include those surrounding and strongly influenced by Sioux Falls, Denver, Lincoln, Omaha, Sioux City, St. Joseph, Kansas City, and Topeka. Locales of moderately high future water need include the Great Falls, Butte-Anaconda, Billings, Rapid City-Black Hills, Fort Collins-Greeley, Grand Island-Hastings-Kearney, and St. Louis-Columbia-Jefferson City influence areas.

Small impoundments normally offer more user benefits per acre than large reservoirs.

Strategically situated reservoirs will receive heavy use on summer weekends.

By activity, most of the water needs are for various forms of boating and fishing. Water skiing requirements are also significant. Outdoor waters for swimming are important, but the surface-acre requirement is relatively small. The water needs for sightseeing and aesthetic purposes are significant, but calculations consider these requirements only as they relate to small impoundments. Generally, sightseeing and related needs can be served by meeting those for other water-sports activities. In western portions of the basin, especially, streams help meet important demands for views of and experiences in a scenic highlands environment.

A final water-based need centers on the desirability of retaining the basin's scenic or primitive rivers and high quality trout stream resources, particularly those in the western basin. Especially important are the relatively few blue-ribbon streams in scenic locations. Rivers like the Madison and Upper Yellowstone in Montana are nationally known and contribute much to the reputation, drawing power, and environment of the region. Most such streams are situated in areas of limited population and low recreation-water-surface demand. There should be strong social and economic justification before converting any portion of scenic, outstanding river reaches, and blue-ribbon trout streams to major reservoirs or for causing severe stream degradation through pollution, road construction, and diversion. The western portion of the Missouri Basin possesses both extremely important scenic and wildlife resources along with many possibilities for future water resource development. Careful planning and appraisement of values will be a requisite to insure saving the outstanding natural scenic resources of this area.

Land and General Needs

Figures 57 and 59 show that the estimated basin needs for additional developed recreation land grow from 152,000 acres in 1980, to 369,000 acres in 2000 and to 601,000 in 2020. Undeveloped recreation land needs for the same target years will be about 1,192,000, 2,808,000, and 4,433,000 acres. Total land needs for the year 2020, then, are expected to be about 5 million acres, or only slightly more than one percent of the total land area of the subbasin.

Developed lands are those occupied with or immediately adjacent to any type of recreation facilities, or appreciably altered from a natural condition for recreation purposes. Undeveloped lands are those that serve as buffer and scenic backdrop, allow for extensive recreation activities, and generally insure a maximum quality environment. In computing needs for undeveloped lands, only the future requirements for "primary use" recreation areas, such as local and state parks and resorts, were considered. Hence, the needs are for lands on which recreation, in any of its various forms, will be a dominant use.

The basin location pattern for land needs is considerably more complex than that for water needs. There are significant differences in locations where developed land needs and undeveloped land needs can best be met.

As can be seen in figure 59, the greatest developed land needs will be associated with the Platte-Niobrara Subregion, with the Colorado Springs-Denver-Cheyenne population strip providing the greatest influence in this

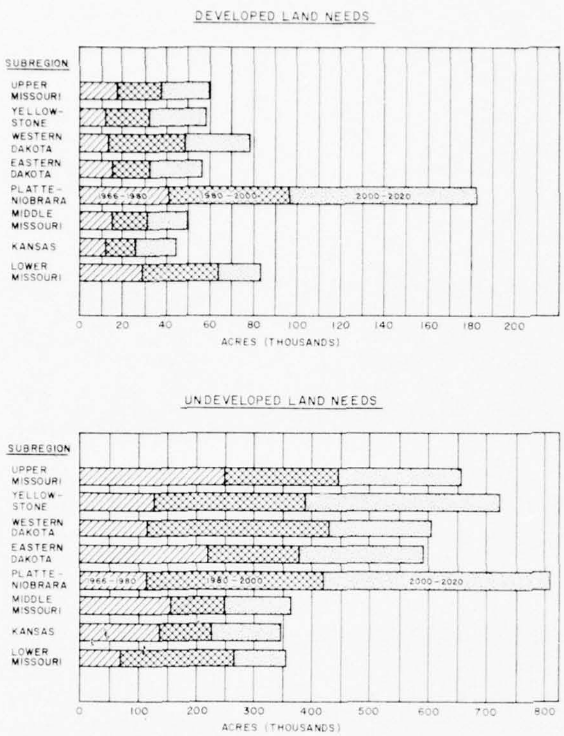
There is and will continue to be an important need to retain scenic rivers and blue-ribbon trout streams such as the Upper Yellowstone River.

The parking area, boat ramp, and other facilities identify "developed" adjacent to "undeveloped" re[illegible]ation lands.

area. The future development needs of this subregion far exceed those of any other. Next in magnitude are the developed land needs of the Lower Missouri and Western Dakota subregions, areas most influenced by Kansas City and the Black Hills region, respectively. Differences in developed land needs for other subregions are relatively small. For 1980, the Platte-Niobrara and Lower Missouri subregions account for 45 percent of the total such needs. Approximately 35 percent has been assigned to the major urban "subareas" covering the Denver, Lincoln, Omaha, Topeka, and Kansas City metropolitan areas. These percentages would be higher were it not for the fact that some of the concentrated needs have been "spread" into adjacent subareas, where the necessary developments are more apt to be accomplished.

Figure 59 shows that the major need for additional undeveloped recreation lands should be met in the Platte-Niobrara and in the four northern or "wide open space" subregions. This is not to imply that establishment of parks in the southern half of the basin will not

FIGURE 59
FUTURE RECREATION LAND NEEDS



be important, as this is where the most critical needs for all types of recreation lands will be. Nevertheless, most new, sizeable parks and recreation areas, especially those nationally designated, will probably have to be carved out of the more arid and rugged northern and western portions of the basin.

The most critical present and near-future needs for both developed and undeveloped land, but especially for developed land, are associated with urban, suburban, and outlying metropolitan influence areas. Additional lands will be needed for all of the recreation activities described in the section on trends. Probably the most important, and those requiring the most land, are the needs for preservation of high quality natural environment that can provide atmosphere for picnicking, walking and biking, nature studies, pleasure driving, winter sports, general relaxation, and enjoyment.

Important, though less critical now than those cited, are the needs that will be part of the nonurban or vacation and weekend recreation scene. Since many nonurban recreation areas contain considerable room for development expansion, their needs involve both existing and potential recreation areas. It will be especially desirable to continue to set aside and develop new vacation-weekend recreation areas as opportunities arise and needs dictate. This is because unique and irreplaceable resources will be threatened while growing shortages will be more difficult to detect them in urban situations. Nonurban recreation land needs will be greatest for sightseeing and general relaxation, camping, walking, hiking, horseback riding, nature study, hunting, winter sports, commercial lodging, and related facilities. The preservation of outstanding natural resources and maintenance of environmental control will be most important and will require considerable land. The demand for game and sports developments, such as golf courses, in vacation-weekend areas is becoming more noticeable and could also require a significant amount of land.

The scenic and primitive reach of the Missouri River below Virgelle, Montana is an outstanding nature resource.

The future will see an increasing need to establish "islands" of beauty in the cities. The South Platte River at Denver is an outstanding example of potential urban recreation resource.

Unique natural resource areas, such as this, will be needed to provide natural environment and new attractions for future enjoyment.

High quality or unique recreation opportunities, such as found or expected in the most popular national parks and monuments, will not be as readily available in the future as they are now. In addition, congested roads as well as creeping ugliness and social pressures will force establishment of islands of beauty and far better close-in recreation opportunities near our cities. This adds up to a need for finding, designating, enhancing, and promoting *new and alternate recreation attractions* — both in the city and in the country. At the same time, an attempt must be made to induce a greater number of recreationists to accept and use these alternate opportunities and attractions. This does not mean, for example, that Yellowstone National Park will not be available, but the average vacationer may have to combine a 1- or 2-day reserved stay there with a week at Oahe Reservoir, Nebraska's new Fort Robinson State Park, or Bighorn Canyon National Recreation Area.

Particular emphasis should be placed on the designation, planning, and development of flood plains within the basin for future recreation use. Too often in the past, unprotected flood plains have been the location of urban development, resulting in inevitable damage and financial losses during periods of flooding.

In addition to finding new attractions, the relatively few pieces of unprotected but unique natural and cultural resources which remain should be identified and, whenever possible, interpreted and protected. The supply of such areas in the Missouri Basin and in other regions of the country is dwindling rather rapidly. Finally, attention must be placed on maintaining, or more often, restoring and enhancing recreational resources — clean air and water, productive and unspoiled land, and mankind and his works — in harmony with his environment.

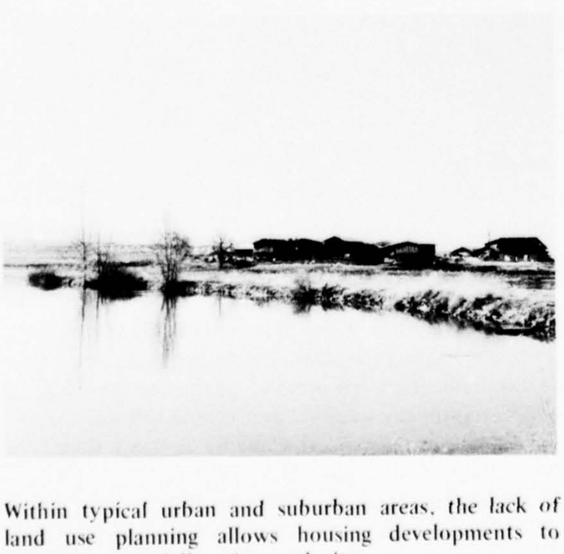
RECREATION PROBLEMS

One of the most serious and all-encompassing problems of the basin and the rest of the Nation is a lack *of sufficient concern to pay the full price* of maintaining and enhancing a quality recreation environment. This indifference, including local failure to fully appreciate local resource values, must be considered as an understandable but basic cause of many of the specific problems discussed below.

The loss of lands which probably could serve their highest use through dedication to recreation and aesthetic purposes becomes more important and frustrating each year. *The problems compound as pressures* for alternate uses mount, land prices escalate, and man's capability of modifying his environment increases. Generally, the conditions are most acute in and near fast growing urban areas where a single new housing development can swallow up potential park lands, a section or two at a time. The demands are great also for lands along rivers, streams, and lake shores, for both private uses and water resource developments. The shorelines of some popular lakes and reservoirs in the eastern and central parts of the basin, for example, are ringed with homes and cabins that leave little, if any, room for public access and development. Along the Missouri and other rivers, notably those spared from occasional flooding through development of channels and reservoirs, attractive woods are being gradually eliminated and converted to crop lands. In terms of current-value dollars, land price escalation alone will double the cost of potential recreation lands in a decade. Choice recreation lands that may not be needed today nevertheless should be acquired today, otherwise many will be unavailable a decade from now.

The increasing loss of quality natural environment is intertwined with the loss of quality recreation lands. In too few places throughout the Missouri Basin have major attempts been made to preserve or enhance an endangered quality environment. This is especially noticeable and difficult in larger cities of the basin, where forests of signs, powerlines, ugly buildings, and junked automobiles abound. To a large degree, urban troubles reflect a lack of good planning and adequate zoning; however, a general inability to recognize creeping ugliness, coupled with an absence of unified action to do anything about it, are also major factors. Many rightfully associate the problems with disagreeable industrial areas and older and poorer neighborhoods; however, some of the worst violations of good taste and greatest contrasts in beauty and ugliness are found in newer areas. The unappealing commercial developments that so frequently "shoestring" along travel routes on the edges of towns and cities is but one example.

Environmental problems are less serious in nonurban areas, but there is a potential for widespread and irreparable loss of aesthetic environment in many locales that could transcend the losses that have occurred in basin cities. Good land-use planning and controls, special recreation area zoning, and private owner cooperation will be essential. In some areas where one or more of these items has been weak, the natural environment has been altered to a point that it cannot be enjoyed by those seeking isolation and solitude as a condition of recreation enjoyment. Examples can be found at Lake of the Ozarks, the Black Hills, and the Denver foothills, even while these areas exhibit high popularity as demonstrated by visitation and recreational use. Proper zoning and development can provide for both isolation and heavy visitation if properly applied.



Within typical urban and suburban areas, the lack of land use planning allows housing developments to pre-empt potentially prime park sites.

Transportation and access bottlenecks produce major problems in certain parts of the basin and the situation could worsen. New highways and secondary roads, and public transportation facilities, do not and should not be designed to deliver the recreationist to the immediate vicinity of his ultimate destination. Transportation modes to recreation areas must arrange for retention and preservation of the scenic resource, even if time of travel is increased. Added leisure time for application to recreational pursuits may encourage recreationists to accept a slower pace as recreation areas are approached. The problem is one of public discipline which may prove challenging.

"Shoestring" commercial development signs along major travel routes add to the environmental problems.

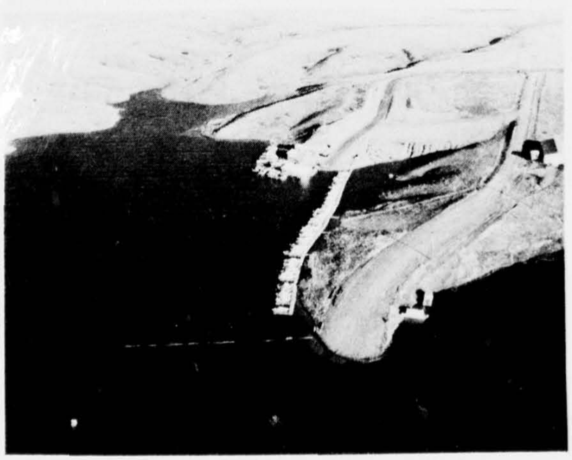
Inadequate funding of Federal, State, and local recreation programs has been a problem in the past and has intensified many of the problems facing recreation in the basin. The expanded Federal programs initiated in the 1960's are contributing to fulfillment of recreational needs but have not as yet accomplished the desired level of opportunity in all parts of the basin. The difficulties associated with applying for Federal assistance, restrictions, and rules relating to expenditure of Federal matching funds, have discouraged progress in many local communities. Also contributing to non-investment in recreational lands and facilities by local government is that the immediacy of action is not apparent in the less populated and slower growing communities. Past experience with the costs of operation, maintenance, and replacement of facilities also dampens the enthusiasm of local governmental officials to invest further in recreation programs.

In general, the State recreation agencies and the major cities have carried out creditable recreation programs even though hampered by inadequate funding and a shortage of qualified planners. The organization of regional planning groups has the potential to support and in some instances establish regionally oriented recreation development. The coordinated Federal, State, and local approach to solving recreation problems currently noticeable in smaller communities and low population counties, at areas managed by States with inadequately funded park programs, at many Federal and other multipurpose reservoirs, at certain national wildlife refuges, at most Indian reservation recreation areas, and at many privately operated campgrounds, trailer parks, and tourist attractions. New recreation developments are needed generally on public domain lands and at or near high-use locations within national forests and national parks and monuments. Most frequently found to be inadequate at existing recreation areas are site access roads, signs, and facilities for camping, parking, boating, swimming, hiking, vehicle control, and environmental health protection. Improper original planning and construction, along with insufficient maintenance arrangements, are often the cause of continuing problems. Site crowding and resultant ground and tree damage occur in a number of locations. Fortunately, some agencies or units of agencies in the basin have taken important steps to make major improvements in planning and facility development.

Many reservoirs and other recreation areas in the Great Plains lack adequate shade and screening. The plains portion of the basin is noted for numerous clear and hot days, so the need for trees is considerable. The requirement for more shade is not limited to existing recreation areas; additional tree planting should be undertaken now in areas of proposed future development when climatic and soil conditions are favorable.

The widespread lack of adequate access is most noticeable in the western high plains, mountains, and along the Missouri River and its reservoirs. Limited or fair-weather access is also a deterrent to public recreation use at many privately developed lakes in the eastern basin, on large tributary reservoirs, on farm lands used for hunting and fishing, and even at many designated public recreation areas. Thousands of miles of additional good access roads along the Missouri River are needed in Montana, the Dakotas, and Missouri in particular. This would help meet the goals set forth by the Lewis and Clark Trail Commission and provide an access and tourway system that will attract tourists and enable the great Missouri to be used effectively. Limited access is also a handicap on public domain and Indian lands. Access to and general public use of the Missouri River for recreation will require additional emphasis on water safety programs by all of the States and by the U.S. Coast Guard. Considerable county-State-Federal and private sector cooperative action will be needed to overcome these access limitations.

Related to the access deficiency is the fact of limited or nonexistent lands for recreation development at certain local and private reservoirs. Primarily involved are private-power-company and irrigation reservoirs in Montana, where water-tight reservoir "take-lines" were established that left no shoreline lands for placement of recreation facilities. Private, State, and local agencies have been reluctant to buy lands, provide good access, or assume administrative responsibilities under these conditions.



Limited shade and screening is a problem at many Great Plains reservoir recreation areas.

Inadequate facilities and management of use present problems at a number of recreation areas.

Water pollution, which is now receiving considerable State and Federal attention, is detrimental to many parts of the basin. In a few areas of population or industrial concentration and intensive agricultural and soil loss, the conditions are serious. The middle Missouri River, the South Platte River below Denver, a number of streams in the Black Hills, and the Nishnabotna River in Iowa are all examples of recreationally important or potentially important waterways that have serious pollution or

Inadequate access is a common problem and limits potential recreation use.

Vertical drawdown of the Gibson Reservoir can approach 100 feet.

siltation problems. In the eastern Dakotas and other areas where feedlots and intensive cultivation are common, runoff leaches fertilizers and nutrients and carries them into streams and lakes. The growth of annoying algae in recreation lakes is one of the complicating results. Several eastern basin lakes support numerous cabin developments with inadequate waste handling facilities, creating additional pollution problems. Lakes Poinsett and Kampeska and Big Stone Lake in South Dakota are examples of water bodies suffering from pollution.

In addition to pollution, road building, gouging, dumping, rechanneling, and dewatering through diversion have caused serious damage to quality streams and fisheries in many areas, especially in hilly and mountainous country. The Gallatin River in Montana, for example, has several reaches left literally dry during periods of heavy irrigation demand. Siltation or lack of sufficient inflow water occurs at new and old Missouri River oxbow lakes. Nearly all of the oxbows are important as potential recreation areas.

Water level fluctuation, an inherent necessity at most multipurpose projects, lessens recreation and aesthetic quality on many reservoirs. The drawdown is usually most severe at older reservoirs on major and secondary tributaries, but several of the Missouri River impoundments, including both Canyon Ferry Reservoir and Lake Francis Case, are affected. Significantly lowered water levels make boat launching and moorage difficult, result in business loss at marinas, damage fisheries, and cause highly unpleasant conditions. In severe cases, recreationist abandonment and business evacuation can occur. This drawdown situation can be very difficult to resolve, due to variable precipitation and the built in "conflict" of demands at multipurpose projects.

A number of past and current Congressional bills have proposed the establishment of a national system of "scenic", "wild," or a combination of similarly designated free-flowing rivers. The conceptual differences between the terms "wild" and "scenic" have changed with time and varied with the proposal, but most of the eight candidate Missouri Basin rivers have been included in a number of proposals as national scenic rivers. Many now consider a potential wild river to be limited to a free-flowing river within a designated or de facto wilderness. A scenic river area has been defined by the Assistant Secretary of the Interior as "a stream . . or river — and . . . adjacent land area — that possesses outstanding scenic, fish, wildlife, and outdoor recreation values, that is essentially free-flowing and unpolluted and that should be preserved in such condition, or restored thereto, in order to promote public use and enjoyment." Establishment of scenic and/or wild rivers will require acquisition or lease of certain adjacent lands for protection of aesthetics and development of public use areas. Eight Missouri Basin rivers or river reaches, with a total of 1,170 miles, or about 2½ percent of the total basin river and major stream mileage, have been considered in previous legislation for a national system of scenic and wild rivers. Recent Congressional action (P.L. 90-542) has designated a number of rivers and lands adjacent thereto as components of the National Wild and Scenic Rivers System. Although no rivers in the Missouri Basin have been included in the system, two of the basin rivers have been designated for potential addition to the Wild and Scenic Rivers System. They are the entire length of the Gasconade of 265 miles in Missouri, and a 185-mile stretch of the Missouri River between Fort Benton and Ryan Island in Montana. Several of the aesthetically unique candidate rivers, as well as excellent reaches of noncandidate rivers, are or will be endangered by proposed water resource developments. Most commonly, impoundment or channelization will be involved. Careful planning and thorough consideration of needs and alternatives will be essential in order to retain some of the more outstanding free-flowing rivers and fisheries of the Missouri Basin and the Nation.

There are many historic and archeologic sites, notably the remnants of once-bustling mining towns in Montana and Colorado, that eventually will be lost if sufficient interest and funding are not secured for acquisition or protection. A few areas, such as Bannack State Monument (former Montana Territorial Capitol), are partly in public ownership, but adequate protection and restoration are still lacking. Unfortunately, only limited Federal funding is available for restoration and protection purposes and, at present, public concern is generally absent.

Many of the vacation and other recreation areas in the basin lack high quality commercial service facilities or contain only marginal developments. In some areas, this is due to low use. But the problem exists even in high-use areas and is partly due to a short recreation season, often as little as 70 or 75 days. A combination of a longer profit season, together with owner organization and local government assistance and control could contribute much to a more healthy and attractive commercial service industry.

Additional recreation and aesthetic concerns within the basin include air pollution at major cities; river and reservoir bank erosion and wave and ice damage to recreation lands and facilities, especially on the Missouri main stem; Great Plains winds and climatic changes that can make boating and other water-use difficult at larger reservoirs; and State boundary disputes along the middle Missouri River, increasing the problem of developing oxbow lakes. There are also needs for greater promotion and public recognition of plains recreation resources, and for local government consolidation or inter-county agreements that will enable major recreation developments and acquisitions in multi-county suburban areas.

Reaches of aesthetically outstanding or unique rivers should be preserved.

Important historic areas, such as Bannack — Montana's first territorial capitol — are deteriorating due to a lack of protection and restoration funds.

CHAPTER 7

FLOOD AND RELATED EROSION PROBLEMS

The severity and intensity of flood and related erosion problems in the Missouri River Basin are as diverse as the basin's economy, climate, topography, and stream characteristics. Flood damages have varied widely throughout the basin because of the variations of rainfall and runoff patterns, the degree of flood plain development, and the effects of flood control improvements. Floods have been caused by snowmelt, general rains of long duration, intense local rains, and combinations of these. The extent of flooding has been influenced not only by the duration of the high flows, but also by ice-jam conditions.

Erosion is closely related to floods since the cutting of streambanks and the formation of gullies are accelerated during high-flow conditions. Because of soil characteristics, the erosion process is quite active in certain portions of the basin even during low-flow periods. Streambank erosion occurs along most reaches of the principal basin streams as well as many of the smaller tributaries. Gullies are often a part of the natural water disposal system, particularly in the more erosive soil areas of the basin. A great many have a reasonable degree of stability, with a good cover of grass, shrubs, or woody vegetation, and are used for grazing or wildlife habitat as well as waterways. Others are unstable, lack vegetative cover, and are degrading or headcutting at excessive rates. When these unstable gullies affect high value areas, such as cropland, the destruction or depreciation of these lands causes longterm economic losses to the land operator and sediment problems downstream.

The evaluation of the intensity and severity of flood and related erosion problem covers the three principal categories of floodwater damage, streambank erosion, and gully erosion. The evaluations and analyses contained herein are based primarily on data available from Federal and State agency files. Some field reconnaissance surveys were made, usually on a sample basis, in order to provide representative basic information for areas where data were lacking. The results of the flood damage study are expressed in terms of average annual flood damages and the area sustaining such damages. Flood damages were evaluated for the situation in 1965 and extended over the long term on the basis of economic projections for the Missouri Basin. Both base-year and future-damage levels are expressed on a constant-dollar basis referred to 1960 price levels.

Erosion conditions were necessarily generalized, although the extent of existing and future problems was identified. Estimates of annual erosion damage are limited to streambank and gully erosion. Continuing future studies of more detailed scope will be required to clearly define the continuing needs with respect to streambank erosion.

HISTORICAL FLOODS

A review of flood experience provides a valuable insight to the magnitude of the many and varied problems which remain to be solved. Many parts of the basin have suffered highly destructive floods. To illustrate, one has but to look back to such occurrences as the 1935 flood in the Republican River basin which devastated the valley, damaged 25 cities and towns, and took 110 lives; the many Missouri River floods in the 1940's and early 1950's, culminated by the great flood of 1952 which caused about $179 million of damage; the record floods of 1951 in Missouri and Kansas where 36 persons lost their lives and damages approached $1 billion; the significant floods of the 1950's and 1960's in such areas as the James River in North and South Dakota, the Elkhorn and Loup rivers in Nebraska, and the Nemaha Rivers, Salt Creek, the Blue River, and others in Nebraska and Kansas; and highly destructive floods in the upper Missouri basin in 1964 and on the South Platte River centering in the Denver metropolitan area in 1965. Others continued the toll through 1969.

Floods that occur in tributary or upstream watershed areas are not as spectacular as those which inundate the flood plains of the main stems of the Missouri Basin; however, in the tributary areas, floods occur more frequently and quite often annually. Damages are not large for any one flood occurrence, but the aggregate can be quite significant over a period of time. In the mountainous parts of the basin, overbank flooding occurs infrequently. Flows are ordinarily kept within the channel, but high flows cause significant damages to irrigation diversion and headgate or on-canal structures,

The Central Industrial District at Kansas City during the 1951 flood on the Kansas River

roads, bridges, trails, and sites such as picnic areas and scenic views.

Any analysis of historical floods must be tempered with a knowledge of the improvements installed by man to control floods and alleviate losses. In many of the areas described subsequently, the construction of major projects will greatly reduce the damages. Given a historical flood pattern and the timing of flood control improvements, the potential relative flood damage in various parts of the basin can be estimated.

THE EXISTING SITUATION

Existing Improvements

The magnitude and extent of flood and erosion losses at present are governed by the economic development located in the flood plains and the effectiveness of various programs and projects for reducing potential losses. Development within the flood plains varies throughout the general region, with the greatest concentrations being found in the lower half of the basin; however, some relatively well developed flood plains are found in localized areas of the upper half. It is impracticable to identify all improvements that have been made for the control of floods and erosion. Many of the improvements made by individuals or by relatively small groups in local areas have in fact greatly reduced losses, but such effects have for the most part been embodied in the historical flood experience and submerged in past statistics. For the larger projects and programs, having widespread and identifiable effects, sufficient data and information are available to assess their effectiveness and performance. Plate 8 identifies and locates these improvements. For purposes of evaluating current losses, improvements now under construction with completion assured in the very near future are considered to be in place and functioning.

Completed Floyd River channel improvement project at Sioux City, Iowa.

I. D. NO. PROJECT NAME

1. UPPER MISSOURI RIVER TRIBUTARIES SUBBASIN
   1. JAWBONE CREEK
   2. BOX ELDER CREEK

2. YELLOWSTONE RIVER SUBBASIN
   3. NORTH FORK OF POWDER RIVER

4. EASTERN DAKOTA TRIBUTARIES SUBBASIN
   4. MARNE CREEK
   5. TURKEY RIDGE CREEK
   6. UPPER DEER CREEK - LAKE HENDRICKS
   7. SILVER CREEK
   8. PATTEE CREEK
   9. GREEN CREEK
   10. SCOTT CREEK
   11. RICHLAND CREEK
   12. BRULE CREEK
   13. GANT CREEK

5. PLATTE-NIOBRARA RIVERS SUBBASIN
   14. ANTELOPE CREEK
   15. LONDON FLATS CREEK
   16. ANGELL DRAW
   17. ARNOLD DRAIN
   18. GERING
   19. WILDHORSE
   20. KIOWA CREEK
   21. WEST CHERRY
   22. FRANKTOWN-PARKER
   23. HOME SUPPLY
   24. COALBANK CREEK
   25. BRULE
   26. CURE
   27. SPRING CREEK (DAWSON)
   28. JONES CREEK
   29. BELLWOOD
   30. PILGER
   31. COTTONWOOD
   32. SWEDEBURG
   33. OAK-MIDDLE
   34. UPPER SALT
   35. TURTLE CREEK

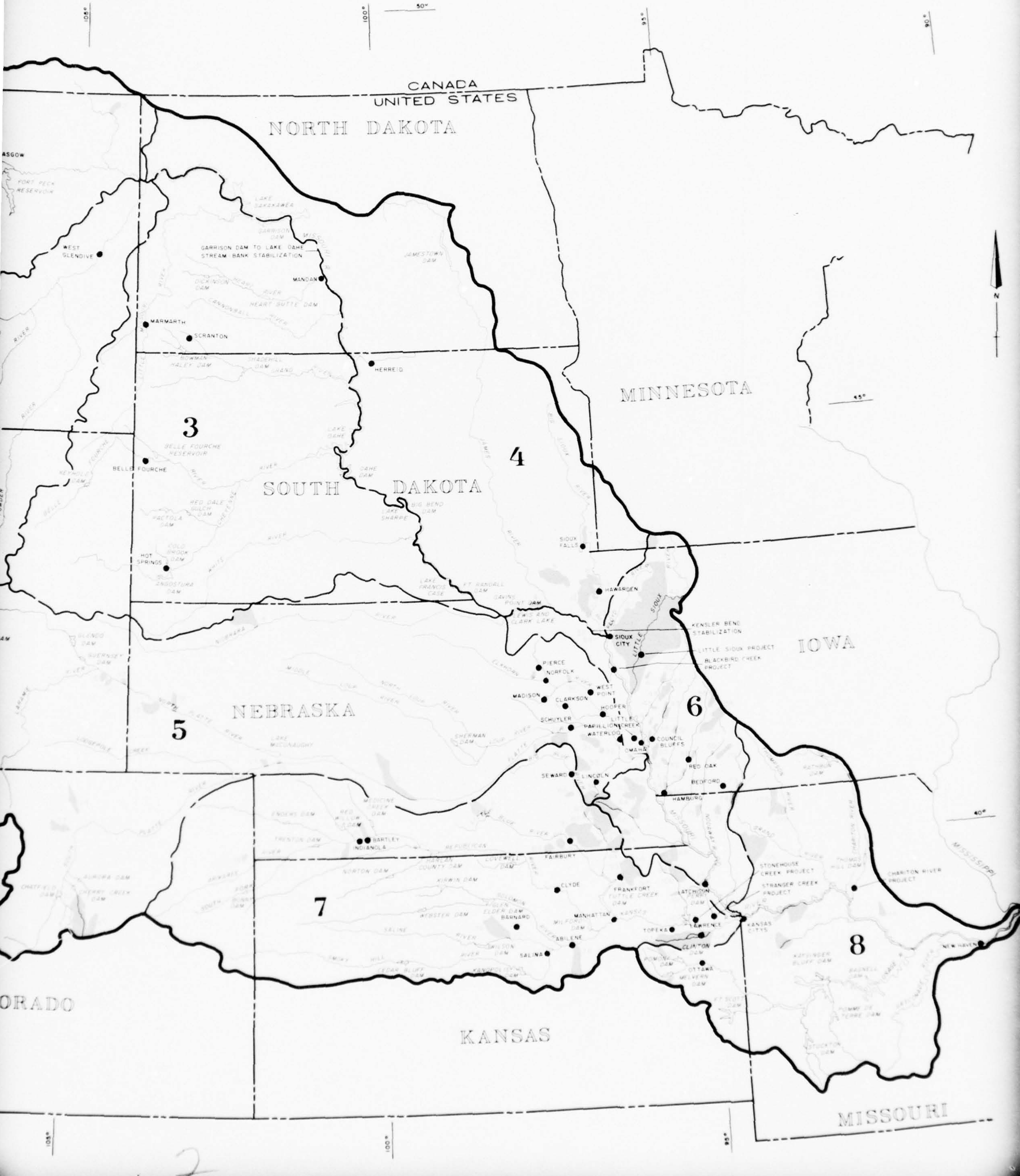
6. MIDDLE MISSOURI RIVER TRIBUTARIES SUBBASIN
   36. LAKES OKABENA AND OCHEDA
   37. NASSAU (UPPER PLYMOUTH)
   38. HELD
   39. SOUTH HUNGERFORD
   40. LITTLE SIOUX
   41. DAVIS-BATTLE CREEK
   42. DANE RIDGE
   43. BIG PARK
   44. MILL-PICAYUNE
   45. HARMONY
   46. NORTH PIGEON
   47. MOSQUITO OF HARRISON
   48. RYAN-HENSCHEL
   49. INDIAN CREEK
   50. PONY CREEK
   51. BEE-JAY
   52. MULE CREEK
   53. SIMPSON CREEK
   54. HAMBURG CREEK
   55. DAVIDS CREEK
   56. CROOKED CREEK
   57. TURKEY CREEK
   58. STENNET-RED OAK
   59. PIERCE CREEK II
   60. HOUND DOG CREEK
   61. PLATTSMOUTH
   62. WILSON CREEK
   63. BROWNELL
   64. ZIEGLER
   65. SPRING (JOHNSON)
   66. UPPER BIG NEMAHA
   67. ROCK (PAWNEE)
   68. WALNUT CREEK
   69. WEST DOUGLAS
   70. WALTERS CREEK
   71. HOOVER-FRANKUM
   72. 102 RIVER TRIBUTARIES
   73. BLOCKTON
   74. PLATTE RIVER TRIBUTARIES
   75. WHITE CLAY-BREWERY-WHISKEY CREEKS

I. D. NO. PROJECT NAME

7. KANSAS RIVER SUBBASIN
   76. SPILLMAN CREEK
   77. LOST
   78. TURKEY
   79. WRAY
   80. DRY CREEK SOUTH
   81. DRY CREEK
   82. STAMFORD
   83. THIRTY-TWO MILE CREEK
   84. BOWMAN SPRING BRANCH
   85. BUCKLEY CREEK
   86. DORCHESTER CREEK
   87. CLATONIA
   88. LITTLE INDIAN CREEK
   89. BEAR-PIERCE-CEDAR CREEKS
   90. MUD CREEK
   91. CUB CREEK
   92. BIG INDIAN
   93. PLUM CREEK
   94. MISSION CREEK
   95. SNIPE
   96. NORTH BLACK VERMILLION
   97. UPPER BLACK VERMILLION
   98. IRISH CREEK
   99. LITTLE DELAWARE-MISSION CREEKS
   100. LITTLE DELAWARE-MISSION CREEKS AND TRIBS.
   101. NEBO CREEK
   102. THOMPSONVILLE
   103. UPPER WAKARUSA
   104. LOWER WAKARUSA

8. LOWER MISSOURI RIVER TRIBUTARIES SUBBASIN
   105. GRINDSTONE-LOST-MUDDY CREEKS
   106. WELLINGTON-NAPOLEON
   107. TABO CREEK
   108. EAST FORK OF BIG CREEK
   109. PANTHER CREEK
   110. HONEY CREEK
   111. MOULTON
   112. EAST BRANCH OF S. FORK OF BLACKWATER RIVER
   113. SOUTH FORK OF BLACKWATER
   114. CALLAHAN
   115. SWITZER CREEK
   116. FROG CREEK

ALBERS EQUAL-AREA PROJECTION



CANADA
UNITED STATES
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
NEBRASKA
IOWA
KANSAS
MISSOURI
ORADO
3
4
5
6
7
8
105°
100°
95°
90°
45°
40°
50°
N
WEST GLENDIVE
GARRISON DAM TO LAKE OAHE STREAM BANK STABILIZATION
MANDAN
MARMARTH
SCRANTON
HERREID
BELLE FOURCHE
HOT SPRINGS
SIOUX FALLS
HAWARDEN
SIOUX CITY
KENSLER BEND STABILIZATION
LITTLE SIOUX PROJECT
BLACKBIRD CREEK PROJECT
PIERCE
NORFOLK
WEST POINT
MADISON
CLARKSON
HOOPER
SCHUYLER
PAPILLION CREEK
WATERLOO
LITTLE
COUNCIL BLUFFS
OMAHA
RED OAK
SEWARD
LINCOLN
BEDFORD
HAMBURG
BARTLEY
INDIANOLA
FAIRBURY
CLYDE
FRANKFORT
ATCHISON
STONEHOUSE CREEK PROJECT
STRANGER CREEK PROJECT
CHARITON RIVER PROJECT
MANHATTAN
BARNARD
TOPEKA
LAWRENCE
KANSAS CITYS
ABILENE
SALINA
CLINTON DAM
OTTAWA
NEW HAVEN

L E G E N D

BASIN BOUNDARY	
SUBBASIN BOUNDARY	
STATE OR NATIONAL BOUNDARY	
DAM AND RESERVOIR OR LAKE	
LOCAL PROTECTION	•
WATERSHED PROJECT	
NAVIGATION AND STABILIZATION, AGRICULTURAL LEVEES	

SCALE 1/5,700,000

50 0 50 100 150 200

APPROXIMATE SCALE IN MILES

JUNE 1969

EXISTING IMPROVEMENTS FOR FLOOD CONTROL AND RELATED PURPOSES

EXISTING OR UNDER CONSTRUCTION IN JUNE 1965

COMPREHENSIVE FRAMEWORK STUDY

MISSOURI RIVER BASIN

MISSOURI BASIN INTER-AGENCY COMMITTEE

PLATE 8

Table 120 presents information on existing improvements with an indication of their effectiveness in reducing flood damages.

Flood Problems

The flood problems in the Missouri Basin vary widely because of the flood characteristics peculiar to each of the eight subbasins and the amount of protective works installed.

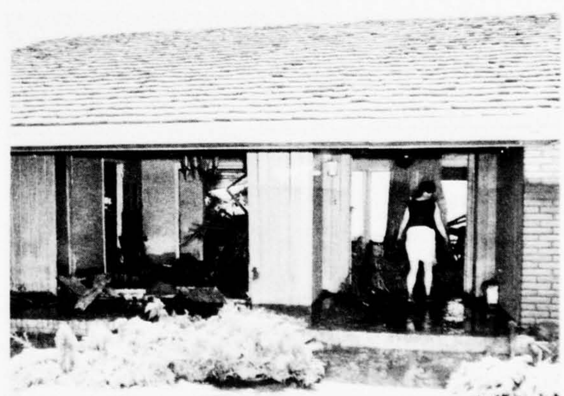
In the Upper Missouri, spring floods occur from snowmelt in the lower elevations often accompanied by ice jams. Later floods, usually in June and July, are caused by snowmelt from the higher elevations often augmented by rainfall. Rainfall floods are normally confined to small drainage areas. The intensity of damage is greatest along the Sun River; but, in general, average annual flood damages per acre are not great. Floods do occur at unprotected locations and in highly developed agricultural areas. Serious conditions exist at both Great Falls and Vaughn, Mont., located on the Sun River. Other communities adversely affected include Lewistown and Shelby, Mont.

In the Yellowstone, a large proportion of irrigated farmlands on the Yellowstone River below Columbus, Mont., is severely damaged whenever flooded. Boysen Reservoir and Bighorn Lake on the Bighorn River have reduced former damages to the Yellowstone River downstream about 40 percent. A relatively serious situation exists at Miles City, and additional flood plain development at Livingston and Billings is increasing the flood hazard from the Yellowstone River. Open-water floods below Boysen Reservoir and Bighorn Lake on the Bighorn River are no longer a serious hazard. Upstream of Boysen Dam flooding is frequent, but the flood plain is not developed extensively except in local areas such as the Riverton irrigation project. Rural damages are relatively low, the major hazard areas being at Hudson, Lander, and Dubois, Wyo.

In the Powder River drainage, rural flood damages are moderate even though floods occur on an average of once in 5 years. The valley lands are subject to erosion and the stream course often shifts radically during flood periods. The flood plains of Clear and Piney Creeks contain extensive irrigated croplands which can be severely damaged. Broadus, Mont., on the Powder River; Buffalo, Wyo., on Clear Creek; and Story, Wyo., on Piney Creek are subject to frequent and severe flooding. Because of sparse development flood damages along the Tongue River are relatively moderate. Major flood hazard areas exist at Miles City, Mont., Dayton, Wyo., and the unprotected area of Sheridan, Wyo.

At the present time, there are no widespread major flood problems in the Western Dakota Subbasin. The most significant are centered in the Black Hills area of the Cheyenne River drainage at Belle Fourche, Spearfish, and Sturgis, S. Dak. In the Grand River drainage, floods cause relatively minor damage because of the effectiveness of Bowman-Haley and Shadehill reservoirs. Damages in the other Western Dakota streams range from minor to moderate. Existing local protection projects at Marmarth and Mandan, N. Dak., are currently preventing nearly 50 percent of their total potential annual flood losses. The degree of protection in these urban areas should be increased if at all possible.

About 90 percent of estimated average annual flood damages in the Eastern Dakota Subbasin occurs in the Big Sioux River, Vermillion River, and James River drainages. The losses range from severe on the Big Sioux to moderate along the James to the north. The flood hazard along the Big Sioux River increases in intensity in a downstream direction and is most severe below the mouth of the Rock River. Although a major local protection project has been constructed at Sioux Falls, S. Dak., the residual flooding is of sufficient magnitude to warrant consideration of additional measures to increase the degree of protection. The flood plain of the Vermillion River in South Dakota and the James River in North Dakota is primarily agricultural, with few farmsteads located in the valley. However, because of the extreme duration of most floods, a significant portion of a year's agricultural production is lost whenever overflow occurs.



A Denver, Colorado, home after the 1965 flood on the South Platte River.

Conditions in the Platte-Niobrara Subbasin vary considerably, not only because of the diverse climatic and hydrologic characteristics, but also because of improvements located in the flood plains and the effects of reservoirs, diversion works, levees, channel improvements, and related structures. Floods on streams tributary to the South Platte River, particularly in the Denver area, have been frequent and damaging. A significant

Table 120 – EXISTING IMPROVEMENTS FOR FLOOD CONTROL AND RELATED PURPOSES

Subbasin and Project	Project Type[1]	Area Protected	Degree of Control In Years per Recurrence	Annual Damages Prevented
		(1,000 acres)		($1,000)
UPPER MISSOURI				
Box Elder Creek	WP	1.3	100	56
Canyon Ferry	R	20.0	varies	500[2]
East Bench (Clark Canyon)	R	30.0	varies	123[2]
Fort Peck	R	120.0	varies	4,600[2]
Glasgow	LP	- - -	100	10
Havre	LP	0.6	50	276
Jawbone Creek	WP	- - -	100	4
Lower Marias (Tiber)	R	7.4	varies	269[2]
Saco	LP	0.2	300	18
YELLOWSTONE				
Clyde Park	LP			7
Boysen	R	85.4	50-2	337[2]
Yellowtail	R	75.0	50-2	323[2]
Greybull	LP	0.4	1,000	141
Forsyth	LP	0.4	1,000	28
West Glendive	LP	0.3	250	20
Sheridan	LP	1.0	200	109
WESTERN DAKOTA				
Marmarth	LP	0.3	40	29
Dickinson	R	20.0	varies	1
Heart Butte	R	19.0	varies	5
Mandan-Lower Heart	LP	4.1	10-25	282
Bowman-Haley	R	16.5	varies	85
Scranton	LP	0.4	100	7
Shadehill	R	23.0	varies	55
Angostura	R			16
Belle Fourche	LP	- - -	20	11
Cold Brook	R		varies	100
Hot Springs	LP	0.1	250	135
Keyhole	R		varies	18
Pactola	R		varies	115
Red Dale Gulch	R	0.1	varies	8
EASTERN DAKOTA				
Garrison	R	135.0 (Garrison, Oahe, Big Bend, Fort Randall, Gavins Point combined)		10,200[2]
Oahe	R			9,100[2]
Big Bend	R			0[2]
Fort Randall	R			8,300[2]
Gavins Point	R			700[2]
Marne Creek	WP	0.2	50	16
Herreid	LP	4.7	100	5
Jamestown	R	3.1	varies	93
Turkey Ridge Creek	WP	6.3	50-25	62
Green Creek	WP	0.6	25-10	4
Richland Creek	WP	1.0	25	3
Silver Creek	WP	2.8	25-5	25
Scott Creek	WP	1.2	25	7
Pattee Creek	WP	1.2	25	20
Brule Creek	WP	7.6	25	92
Gant Creek	WP	0.4	10-5	26
Hawarden	LP	1.3	1,000	22
Sioux Falls	LP	0.6	125	335
Upper Deer Creek	WP	1.2	25	14
PLATTE-NIOBRARA				
Chatfield	R	16.0	1,000-1	3,467
West Cherry	WP	0.7	25-23	18
Franktown-Parker	WP	4.5	100-25	48
Cherry Creek	R	3.7	1,000	2,000

[1](R) reservoir, (LP) local protection – levee and/or channel, (WP) watershed project.
[2]Total damages prevented, including those allocated to the main stem system.

Table 120 (Cont.)

Subbasin and Project	Project Type[1]	Area Protected	Degree of Control in Years per Recurrence	Annual Damages Prevented
		(1,000 acres)		($1,000)
PLATTE-NIOBRARA (cont'd)				
Aurora	R	- - -	100	15
Coalbank Creek	WP	0.4	25	13
Kiowa Creek	WP	2.7	25	42
Brule	WP	0.1	100-2	9
Cure	WP	0.1	100-2	2
Seminoe	R		(Included in Alcova Dam Analysis)	
Pathfinder	R		(Included in Alcova Dam Analysis)	
Alcova	R	13.7	1,000-1	100
Glendo	R	44.2	1,000-1	280
Guernsey	R		(Included in Glendo Dam Analysis)	
Pine Ridge	WP	0.4	25-2	15
London Flats	WP	1.2	25-2	15
Angell Draw	WP	0.3	50-2	8
Arnold Drain	WP	0.1	25-2	14
Gering Valley	WP	34.0	50	889
Wild Horse	WP	0.7	100-2	20
Spring Creek	WP	15.1	100-2	198
Jones Creek	WP	1.5	25-2	9
Bellwood	WP	11.6	25-2	77
Schuyler	LP		1,000	8
Turtle Creek	WP	0.1	25-2	3
Sargent Unit	R			7
Farwell Unit (Sherman)	R			8
Madison	LP	0.7	14	20
Hooper	LP	0.1	100	17
Pierce	LP	1.3	100	21
Norfolk	LP	0.9	100	202
Pilger	WP	0.4	100-10	10
Waterloo	LP	0.8	250	20
West Point	LP	0.3	100	20
Clarkson	LP	0.3	100	14
Upper Salt Creek	WP	9.1	25-2	48
Oak-Middle Creeks	WP	3.0	25-2	23
Salt Creek	R	50.7	1,000-100	413
Cottonwood	WP	2.5	25-2	49
Antelope	WP	0.5	100-7	17
MIDDLE MISSOURI				
Bank Stabilization	LP	175.0		28,333
Agricultural Levees	LP	254.4	100	20,600
Ryan-Henschel	WP	3.4	25-1	21
Pony Creek	WP	3.1	25-2	49
Plattsmouth	WP	0.2	100-50	8
White Clay Creek	WP	0.6	100	152
Upper Plymouth	WP	4.1		9
South Hungerford	WP	0.5	25-1	9
Held	WP	1.6	25-2	22
Floyd River (Sioux City)	LP	3.5	150	1,030
Blackbird Creek	LP	2.7	50	7
Little Sioux Prev. Proj.	WP	13.6		373
Little Sioux River	LP	187.5	50	1,111
Davis-Battle Creek	WP	1.5		21
Big Park Creek	WP	1.1	25-2	28
Mill-Picayune	WP	2.3	100-1	148
Harmony Creek	WP			6
Omaha, Nebraska	LP	5.8	1,000	600
Council Bluffs, Iowa	LP	5.4	1,000	200
Little Papillion Creek	LP	1.1	33	234
Ziegler	WP	2.3	50	20
Wilson Creek	WP	11.0	25-5	139
Upper Big Nemaha	WP	16.8	25-2	227
Brownell Creek	WP	0.4	100-50	5

[1] (R) reservoir, (LP) local protection – levee and/or channel, (WP) watershed project.

Table 120 (Cont.)

Subbasin and Project	Project Type[1]	Area Protected	Degree of Control in Years per Recurrence	Annual Damages Prevented
		(1,000 acres)		($1,000)
MIDDLE MISSOURI (cont'd)				
Rock	WP	2.2	25-1	16
Bee-Jay	WP	1.2		31
Spring	WP	3.6	25-6	37
Mule Creek	WP	1.7	50-5	20
Davids Creek	WP	4.8	25-2	44
Crooked Creek	WP	2.2	50-2	33
Red Oak	LP	0.5	370	23
Simpson Creek	WP	1.1		6
Hound Dog Creek	WP	0.6	25-2	11
Hamburg Creek	WP	0.4	100-2	6
Hamburg	LP	0.9	50	34
Walnut Creek	WP	6.7	100-2	68
Hoover-Frankum Creek	WP	2.3	25-2	21
Platte River Tribs.	WP	2.1	25-2	4
102 River Tribs.	WP	1.6	25-5	6
Okabena & Ocheda Lakes	WP	2.0	25-10	9
Bedford	LP	0.4		17
Atchison	LP	0.2	1,000	232
Mosquito of Harrison	WP	7.3	25-1	84
Walters Creek	WP	5.3	50-2	39
West Douglas	WP	2.9		13
Pierce Creek #1	WP	0.6		9
Turkey Creek	WP	13.8	50-5	31
Stennett-Red Oak	WP	0.9	25-5	11
Blockton	WP	3.4	25	41
Dane Ridge	WP	4.8	25-2	49
Indian Creek	WP	1.1		24
North Pigeon	WP	1.5		28
KANSAS				
Bartley	LP	0.3		8
Bonny	R	[3]		707
Clyde	LP		100	34
Dry Creek	WP	1.4	25-2	10
South Dry Creek	WP	1.8	25-2	21
Enders	R	[3]		192
Harlan County	R	[3]		2,532
Indianola	LP	0.1		14
Lovewell	R	[3]		264
Medicine Creek	R	[3]		175
Milford	R	[3]		4,316
Norton	R	[3]		358
Red Willow	R	[3]		207
Stamford	WP	0.7	100-2	13
Trenton	R	[3]		911
Wray	WP	0.2	100-5	13
Abilene	LP	1.2	150	71
Barnard	LP	0.1	100	19
Cedar Bluff	R	[3]		479
Glen Elder	R	[3]		2,548
Kanopolis	R	[3]		1,866
Kirwin	R	[3]		1,204
Lost Watershed	WP	1.7	25-2	18
Salina	LP	13.9	100	420
Spillman Creek	WP	10.1	50-2	102
Turkey	WP	8.0	50-2	99
Webster	R	[3]		1,221
Wilson	R	[3]		1,483
Bear-Cedar Creeks	WP	6.5	25-2	82
Big Indian	WP	3.1	25-2	127

[1](R) reservoir, (LP) local protection – levee and/or channel, (WP) watershed project.
[3]A total of 756,700 acres are protected by all the major reservoirs in the Kansas Subbasin.

Table 120 (Cont.)

Subbasin and Project	Project Type[1]	Area Protected	Degree of Control in Years per Recurrence	Annual Damages Prevented
		(1,000 acres)		($1,000)
KANSAS (cont'd)				
Bowman Spring	WP	6.1	25-2	21
Buckley Creek	WP	3.1	25-2	15
Clatonia	WP	1.8	25-2	29
Cub Creek	WP	4.9	25-2	102
Dorchester	WP	0.8	25-2	21
Fairbury	LP	0.2	70	21
Frankfort	LP	0.2	100	100
Irish Creek	WP	1.5	100-2	74
Little Indian Creek	WP	3.9	25-2	14
Mission Creek	WP	3.0	25-2	46
Mud Creek	WP	1.5	25-2	47
North Black Vermillion	WP	6.7	50-25	227
Plum Creek	WP	4.7	25-2	59
Seward	LP	0.1	50	31
Snipe	WP	0.9	25-2	4
32 Mile Creek	WP	2.8	100-2	46
Tuttle Creek	R	[3]		10,141
Upper Black Vermillion	WP	5.5	50-25	269
Clinton	R	[3]		1,414
Lawrence	LP	8.0	200	229
Little Delaware Creek	WP	1.0	25-2	7
Little Delaware Tribs.	WP	11.6	25-2	59
Lower Wakarusa	WP	5.5	50-2	63
Manhattan	LP	1.3	625	336
Nebo Creek	WP	0.6	25	7
Perry	R	[3]		6,516
Stonehouse Creek	LP	3.0	10	17
Stranger Creek	LP			33
Thompsonville	WP	0.7	25	7
Topeka	LP	8.4	100	8,518
Upper Wakarusa	WP	8.4	25-2	93
LOWER MISSOURI				
Kansas Citys	LP	20.4	200+	27,198
Bank Stabilization	LP		(Included in Middle Missouri)	
Agricultural Levees	LP	21.0		
Wellington-Napoleon	WP			34
Tabo Creek	WP			146
Thomas Hill	R			
Callahan Creek	WP			25
New Haven	LP			9
Grindstone-Lost-Muddy	WP			161
East Fork of Big Creek	WP			5
Panther Creek	WP			22
Honey Creek	WP			21
Rathbun	R	90.0	varies	548
Moulton Creek	WP			20
Chariton River	LP	59.0	100-50	671
East Branch of Blackwater	WP			7
South Fork of Blackwater	WP			36
Melvern	R	[4]		568
Frog Creek	WP			19
Switzler Creek	WP			17
Pomona	R	[4]		539
Ottawa	LP	0.6	167	366
Fort Scott	R	[4]		256
Stockton	R	[4]		244
Pomme de Terre	R	[4]		114
Kaysinger Bluff	R	251.3	varies	539
Bagnell	R			

[1](R) reservoir, (LP) local protection — levee and/or channel, (WP — watershed project.
[3]A total of 756,700 acres are protected by all the major reservoirs in the Kansas Subbasin.
[4]Included with Kaysinger Bluff.

degree of protection will be provided to the Denver metropolitan area by the existing Cherry Creek Reservoir and by completion of the Chatfield Reservoir. Major flooding can still be generated from Bear Creek, Sand Creek, and other tributary streams. Downstream of Denver, Kiowa and Bijou Creeks have experienced very high flows. Extremely large discharges have been recorded in Bijou Creek, with widespread flooding on the South Platte River for a distance of almost 200 miles. Although large discharges are relatively rare, they indicate the high flood potential in the plains and foothills areas of the upper South Platte drainage. On the North Platte River, no highly destructive floods have occurred since the completion of six major reservoirs. Extreme flows have occurred on the tributaries to the North Platte, but generally damages have been quite low because few vulnerable structures exist on the flood plains.

Floods along the Platte River in western and mid-Nebraska have not caused significant damage. The valley is wide, and the braided channel occupies a large part of the flood plain. Major cities located along the Platte are generally not threatened, but an extreme flood could cause serious damage. Losses have been greatest in eastern Nebraska because of higher agricultural land use and the ability of the lower Loup and Elkhorn rivers to generate large flows. Floods in the Loup River drainage are typically moderate, but extreme discharges along the lower reaches have caused high damages in areas of urban flood plain encroachment. Floods in the Elkhorn River drainage occur almost annually, and their extent is often aggravated by ice jams.

The Niobrara River drainage has not produced big floods in the past, and there are few improvements or high value croplands in the flood plain subject to overflow. No major urban damages have been reported, the most significant losses having been suffered by transportation facilities. While flooding on the Niobrara is not a major problem, this river is a large contributor of sediment inflow to Lewis and Clark Lake which is located downstream from the confluence of the Niobrara with the Missouri River.

In the Middle Missouri Subbasin, just under 3 million acres of land are subject to flooding. In general, damages on the Missouri River flood plain are not now large, because of the control exercised by the main stem reservoirs and the degree of protection afforded by the agricultural levees. In contrast, the flood hazard in most tributary areas is severe. In the upper portion of the subbasin, the flood plain area of Perry Creek at Sioux City, Ia., is vulnerable to catastrophic flooding. The Floyd River channel through Sioux City has been improved, but rural damages are quite high in the upstream reaches. Other major streams in this upper portion which cause serious rural losses are Omaha Creek, Little Sioux River, Maple River, Boyer River, and Soldier River. Urban damages are relatively low with the exception of Missouri Valley, Ia., on the Boyer River; Cherokee, Ia., on the Little Sioux River; and Ida Grove, Ia., at the confluence of the Maple River and Odebolt Creek. The flood hazards on Papillion Creek at Omaha, Nebr., and Indian Creek at Council Bluffs, Ia., are predominantly urban in nature. The Omaha-Council Bluffs metropolitan area has expanded rapidly in recent years, and flood plains have been and are being developed for high-intensity urban use.

Severe urban and rural flood damages occur throughout the Nishnabotna River drainage to the east of Omaha. There is a serious urban flood situation at Atlantic, Ia., but damages on tributaries in the lower portion of the subbasin are predominantly rural. Portions of St. Joseph, Mo., and Atchison and Leavenworth, Kan., are subject to damage from small tributaries. Losses to rural areas in this locale are severe because of the high agricultural value of lands and the concentration of transportation facilities in the flood plain. Rural damages predominate in the Weeping Water Creek, Nemaha River, Nodaway River, and Platte River (Missouri) drainages. Smithville, Mo., and other smaller communities located near the expanding Kansas City's metropolitan area have been and will be experiencing major flood problems.

Conditions in the Kansas Subbasin vary considerably, with the flood hazard most severe in the humid eastern part which contains most of the concentrated development. There is little intensive development in the upper reaches of the Smoky Hill and Republican rivers drainages, and average annual flood damages are moderate, however, locally severe floods are fairly common, and occasional major floods cause widespread damage. Major reservoirs have reduced substantially the flood hazard along the lower Republican River and along the lower reaches of the Smoky Hill River and its major tributaries, the Saline and Solomon rivers. Damages in the Big Blue River drainage area are predominantly rural, but a few communities are vulnerable. Tuttle Creek Reservoir has essentially eliminated flooding along the lower reaches of the Big Blue. Floods along the Kansas River and its smaller tributaries account for most of the urban damage in the subbasin, even though the major cities of Manhattan, Topeka, and Lawrence enjoy a high degree of protection. A considerable part of the subbasin's economic development is concentrated in this area, and the damage potential is high in comparison with other localities.

In the Lower Missouri Subbasin, wider flood plains, longer duration of flood flows, and the existence of several sizeable urban developments result in relatively severe flood problems. Slightly over one-half of the area subject to flooding is located along the main stems of various streams. This area currently sustains almost 60 percent of the average annual flood damages in the

Topeka, Kansas, during the 1951 flood on the Kansas River.

subbasin. Existing flood control measures on the main stem of the Kansas River provide a fairly high degree of protection to most areas of the Kansas Citys; however, potential floods from tributary streams are significant. For example, along the Blue River (Missouri), frequent floods cause severe damage to important residential, commercial, and industrial developments. Flooding along the Fishing River and the Little Blue River (Missouri) also results in damage to urban environs of the general Kansas City area. Damages can be expected to increase as urbanization expands.

Backwater from Missouri River floods plus runoff from Wears Creek produce a severe situation at Jefferson City, Mo. Flood plain areas along the Grand, Blackwater-Lamine, Osage, Chariton, and Gasconade rivers, although less extensive than those along the Missouri River, experience moderate to severe flood damage. Under current conditions, an average of over $12 million annual damage is caused by the Missouri River at and below Kansas City, out of a total of about $34 million average annual loss in the entire subbasin.

Flood Damages

Damage evaluations are based on estimates of the primary tangible losses that could be expected from future flood occurrences under current economic development of the flood plain, and with existing protective works. Average annual damages resulting from floods throughout the full range of potential magnitude (frequency array) were estimated. Damages from historic flood occurrences provided a basis for estimating future damages. Estimates were adjusted to show the effects of

Kansas City during the 1951 flood on the Kansas River. Floodwater from the Kansas River is flowing from the landside of the floodwall into the Missouri River.

existing projects, and projects under construction, which would influence future levels of damage.

Three general classifications of damages are presented: (1) crop and pasture; (2) other rural; and (3) urban. For many areas detailed information was available, while for others little or no data existed. For areas where adequate data did not exist, damages were estimated by means of comparisons of generalized hydrologic, hydraulic, economic, land-use, and developmental characteristics with areas for which annual damages were available. The result of the evaluations presents a comprehensive picture of tangible flood losses and the areas subject to such damage throughout the Missouri River Basin.

In order to evaluate the relative severity of problems in upstream watershed areas, a grouping of watersheds was made.

Group	*Definitions*
A	Watersheds with high rates of damage. Flood plains usually exceed five percent of the total watershed area and are generally devoted to cultivated crops and with overflows occurring frequently to occasionally.
B	Watersheds similar to "A" above but with moderate rates of damage. Flood plains usually amount to three to five percent of the total watershed area.
C	Watersheds with low rates of damage. These watersheds usually have a low percent (under three percent) of flood plain lands.
D	Watersheds or tributaries that now have or will be provided with project measures to alleviate floodwater or erosion damages. (Residual damages, with project measures in place, are low.)

The groupings outlined are shown in plate 9. Table 121 summarizes the current level of flood damages and areas subject to floods through the basin.

For some urban areas within the basin, special problems were encountered with respect to flood damage evaluation. These areas are significant due to concentration of higher valued properties subject to inundation. Plate 10 illustrates the distribution of flood damages classified as urban. Urban places generally include any city, town, or community, regardless of size. Total urban damage under current conditions is estimated at $13.3 million (1960 price levels) annually, or about 14 percent of the average annual flood damage for the basin.

In addition to the tangible flood damages which are subject to direct evaluation, the potential for intangible and secondary damages exists wherever there is a flood hazard. These include, but are not limited to, loss of life, health hazards, and disruption of transportation. Such effects, obviously, cannot be expressed entirely in terms of dollar values, and within the scope of this study no attempt was made to evaluate them. It should be noted that, in some circumstances, these losses may be of commanding importance, and they should be given full consideration in project planning, formulation, and programming.

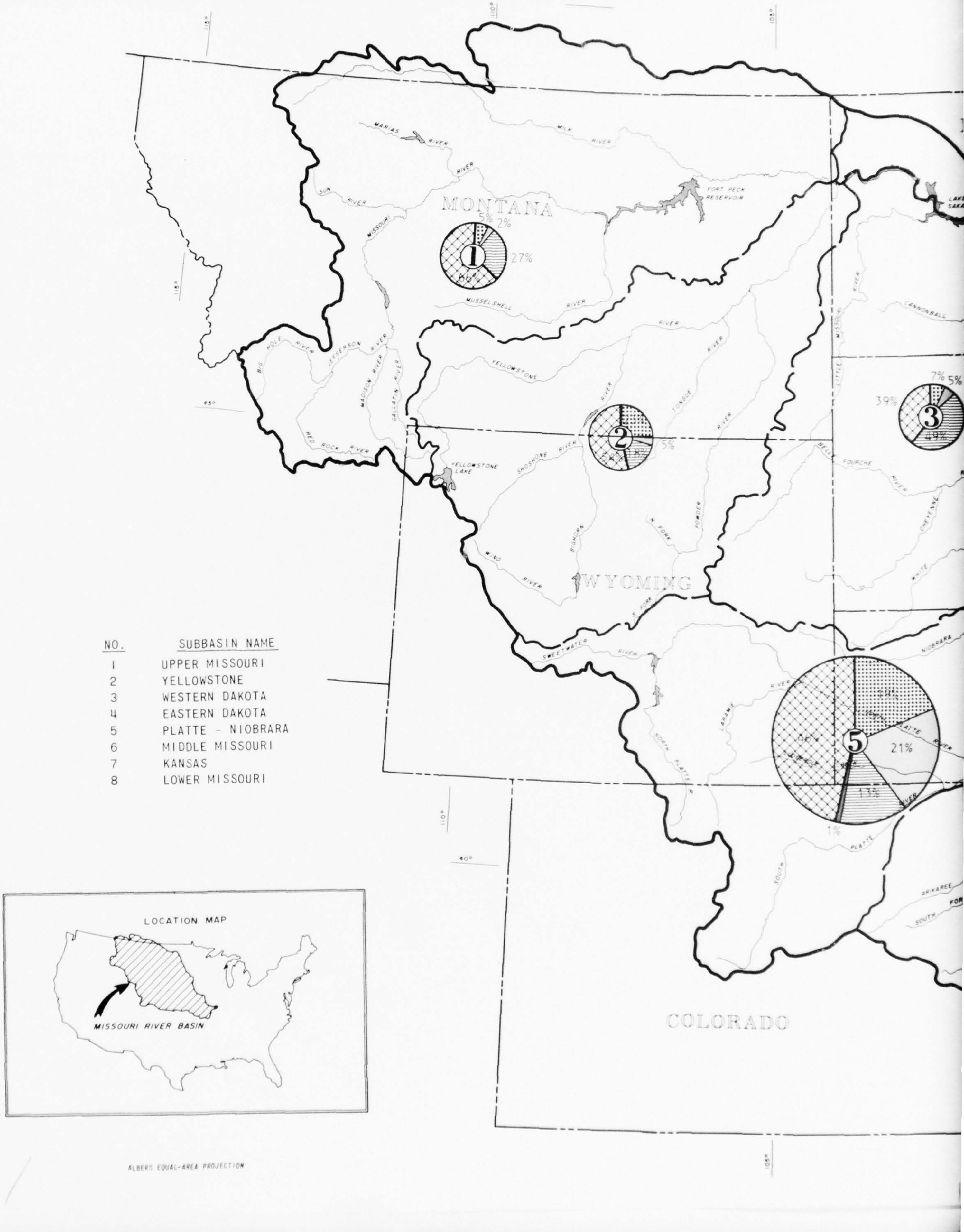
Streambank Erosion

Channel erosion losses along the larger streams were classified as *streambank erosion*, while related losses along channels in small drainage areas, due principally to local degradation of the channel profile, were classified as *gully erosion*. *Sheet erosion* of upland soils is discussed in the Land Resources Availability Appendix.

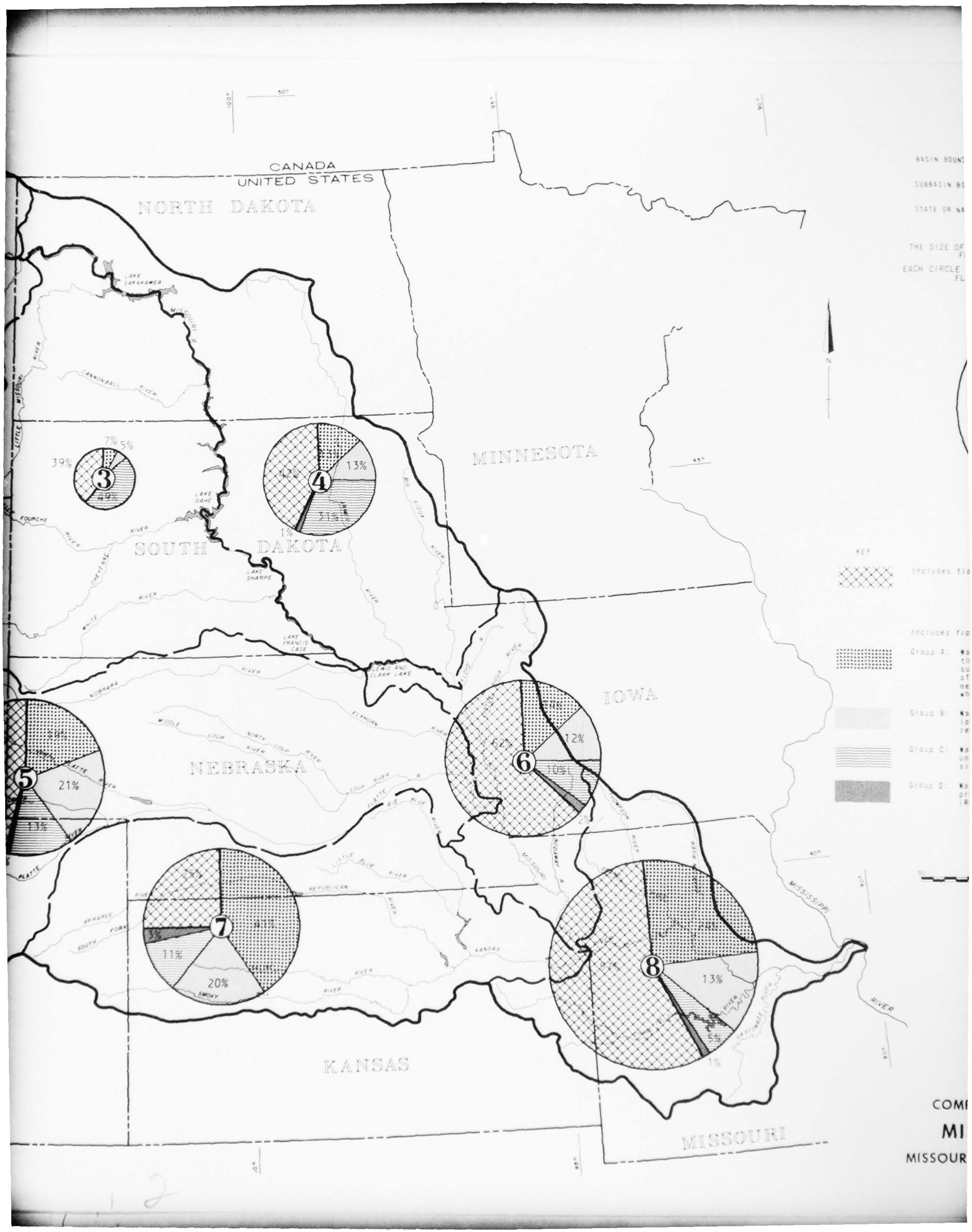
Streambank erosion damage occurs along most reaches of the major streams and along many tributaries in the basin. On natural streams, accretion tends to balance erosion so that the net channel area remains fairly constant. However, the value and productive ability of lands within the resulting meander belt are adversely affected. A more critical condition exists where streambank erosion threatens to destroy transportation facilities or other structures.

Streambank erosion along an interstate highway near Castle Rock, Colorado.

In the Upper Missouri Subbasin, relatively low erosion rates have been experienced along most streams. The more critical problems occur at bridge crossings where most of the trouble arises during large floods. The most serious erosion occurs along the main stem of the Missouri River and in the Marias and Milk river drainages.



ALBERS EQUAL-AREA PROJECTION



CANADA
UNITED STATES
NORTH DAKOTA
SOUTH DAKOTA
MINNESOTA
IOWA
NEBRASKA
KANSAS
MISSOURI
LAKE SAKAKAWEA
MISSOURI R
CANNONBALL RIVER
LITTLE MISSOURI RIVER
LAKE OAHE
FOURCHE
CHEYENNE RIVER
WHITE RIVER
LAKE SHARPE
LAKE FRANCIS CASE
LEWIS AND CLARK LAKE
BIG SIOUX RIVER
JAMES RIVER
NIOBRARA RIVER
ELKHORN RIVER
MIDDLE LOUP RIVER
NORTH LOUP RIVER
LOUP RIVER
PLATTE RIVER
NORTH PLATTE RIVER
BIG BLUE RIVER
LITTLE BLUE RIVER
REPUBLICAN RIVER
ARIKAREE
SOUTH FORK
SMOKY
KANSAS RIVER
NODAWAY
GRAND RIVER
OSAGE RIVER
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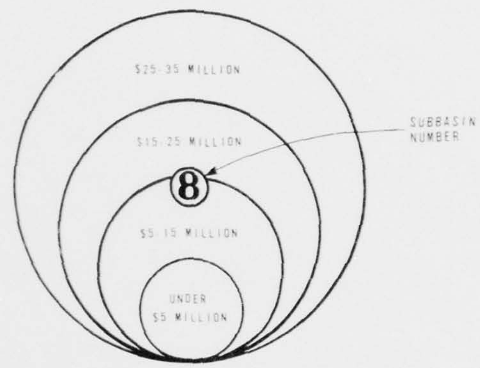
THE SIZE OF THE CIRCLE INDICATES THE AMOUNT OF AVERAGE-ANNUAL FLOOD-DAMAGE IN DOLLARS FOR EACH SUBBASIN.

EACH CIRCLE SEGMENT INDICATES THE PERCENTAGE DISTRIBUTION OF FLOOD-DAMAGE GROUPS WITHIN EACH SUBBASIN (1965 PRICE BASE)



KEY

MAIN STEMS

Includes flood plains with a drainage area of 400 square miles or

TRIBUTARIES

Includes flood plains with a drainage area of less than 400 squar

Group A: Watersheds with flood plains usually exceeding five per the total area, generally devoted to cultivated crops, subject to frequent or occasional overflows causing hig of damage. (The topography of the area is such that re measures can be installed at low or moderate cost at lo which will significantly reduce flood damages.)

Group B: Watersheds similar to "A" but with either lower rates o lower percentage of flood plains, or less desirable sit remedial measures having high cost.

Group C: Watersheds with a low percentage of flood plain lands (under three percent), or low rates of damage, or inadeq sites for remedial measures.

Group D: Watersheds or tributaries that now have or will be prov project measures to alleviate floodwater or erosion dam (Residual damages, with projects in place, are low.)

SCALE 1/5,100,000

50 0 50 100 150 200

APPROXIMATE SCALE IN MILES

JUNE 1969

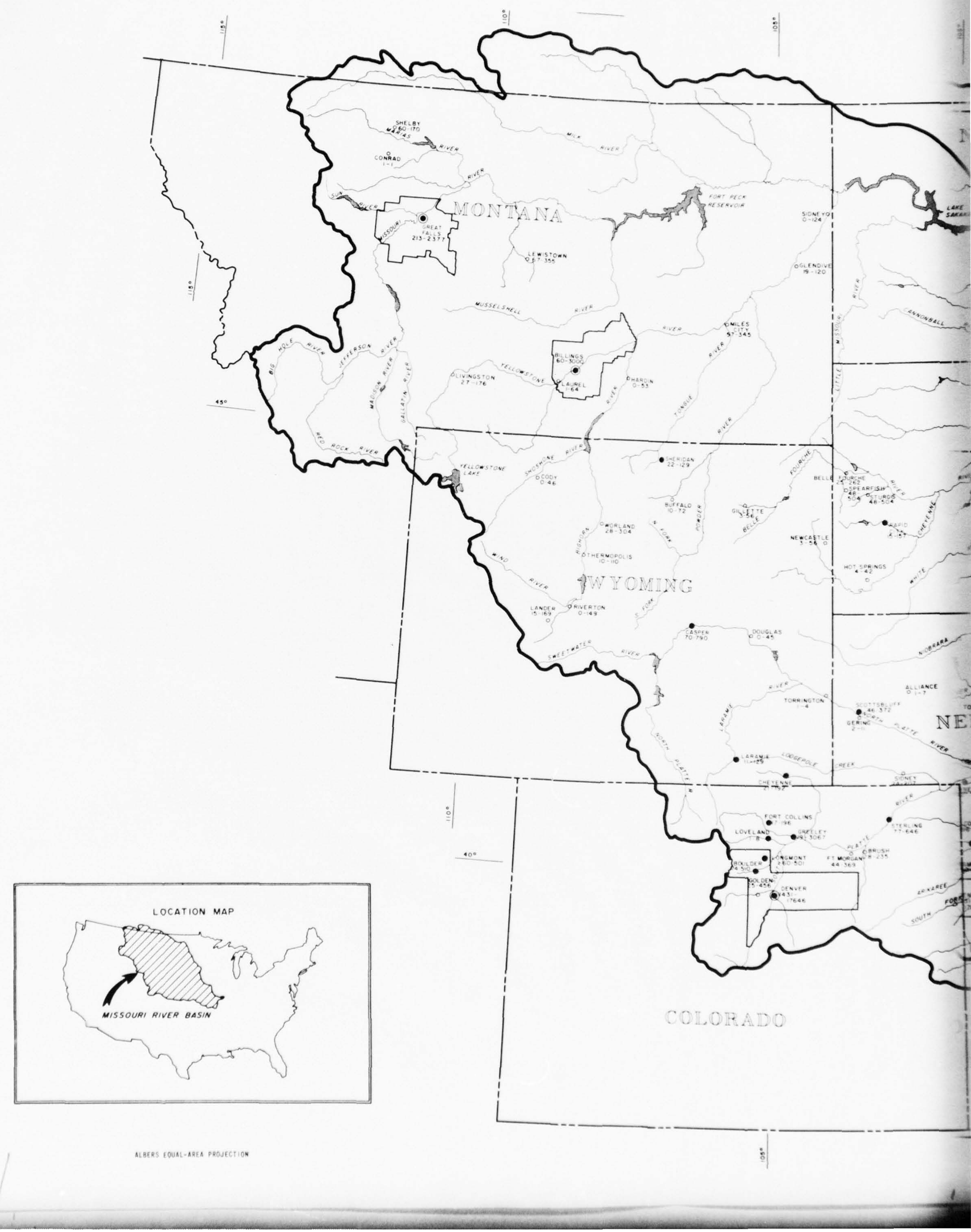
CURRENT FLOOD DAMAGE

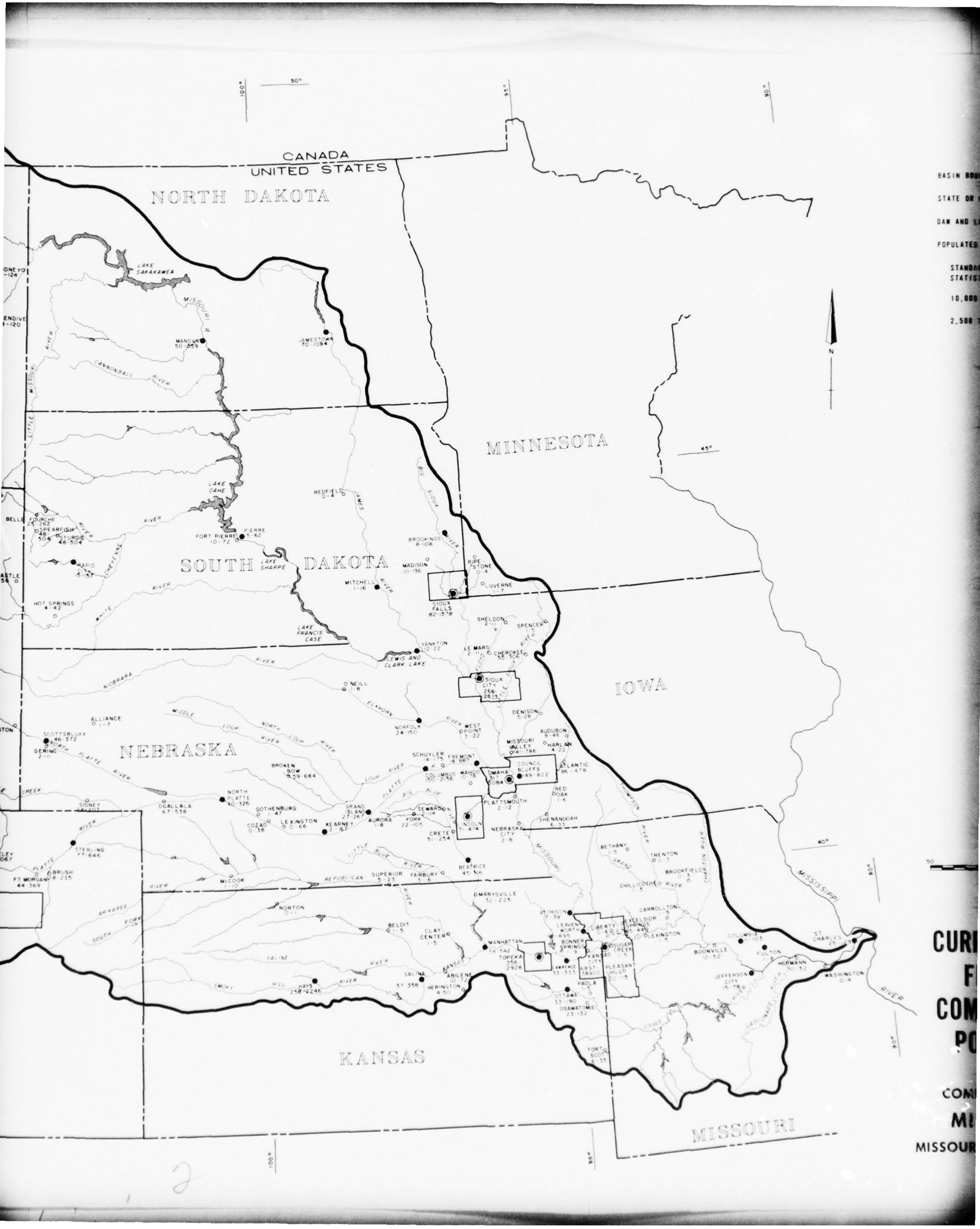
COMPREHENSIVE FRAMEWORK STUDY

MISSOURI RIVER BASIN

MISSOURI BASIN INTER-AGENCY COMMITTEE

PLATE 9


MONTANA
WYOMING
COLORADO
SHELBY
CONRAD
GREAT FALLS 213-2377
LEWISTOWN
FORT PECK RESERVOIR
SIDNEY 0-124
GLENDIVE 19-120
MILES CITY 57-345
BILLINGS 60-3000
LAUREL
LIVINGSTON 27-176
HARDIN 0-53
SHERIDAN 22-129
CODY 0-46
BUFFALO 10-72
GILLETTE
WORLAND 28-304
THERMOPOLIS 10-110
LANDER 15-169
RIVERTON 0-149
CASPER 70-790
DOUGLAS 0-45
TORRINGTON 1-4
LARAMIE
CHEYENNE 21-192
NEWCASTLE
BELLE FOURCHE
SPEARFISH
STURGIS 48-504
HOT SPRINGS 4-42
ALLIANCE
SCOTTSBLUFF 46-372
GERING
FORT COLLINS
LOVELAND
GREELEY
LONGMONT 260-501
BOULDER
GOLDEN 15-456
DENVER
FT. MORGAN 44-369
BRUSH
STERLING 77-646
YELLOWSTONE LAKE
MILK RIVER
MARIAS RIVER
SUN RIVER
MISSOURI
MUSSELSHELL RIVER
YELLOWSTONE RIVER
BIG HOLE RIVER
JEFFERSON RIVER
MADISON RIVER
GALLATIN RIVER
RED ROCK RIVER
SHOSHONE RIVER
WIND RIVER
SWEETWATER RIVER
NORTH PLATTE
LARAMIE RIVER
LODGEPOLE CREEK
POWDER
TONGUE
BELLE FOURCHE
CHEYENNE
WHITE
NIOBRARA
CANNONBALL
LITTLE MISSOURI
LAKE SAKAKAWEA
SOUTH PLATTE RIVER
LOCATION MAP
MISSOURI RIVER BASIN
ALBERS EQUAL-AREA PROJECTION
115°
110°
105°
45°
40°



CANADA
UNITED STATES
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
MINNESOTA
IOWA
MISSOURI
LAKE SAKAKAWEA
MISSOURI R.
MANDAN 50-359
JAMESTOWN 70-1094
CANNONBALL RIVER
LAKE OAHE
FORT PIERRE 10-72
PIERRE 5-62
REDFIELD 0-4
BROOKINGS 8-108
MADISON 10-136
PIPESTONE 0-4
LUVERNE 1-7
MITCHELL 1-16
SIOUX FALLS 62-1578
LAKE SHARPE
LAKE FRANCIS CASE
SPEARFISH
STURGIS 48-504
RAPID 15-157
HOT SPRINGS 4-42
YANKTON 12-22
LEWIS AND CLARK LAKE
SHELDON 2-11
SPENCER
LE MARS 2-11
CHEROKEE 55-306
SIOUX CITY 266 2835
O'NEILL 1-8
NIOBRARA
ELKHORN
NORFOLK 24-150
WEST POINT 3-22
DENISON 5-28
AUDUBON
HARLAN 4-22
MISSOURI VALLEY
ALLIANCE 1-7
SCOTTSBLUFF 46-372
GERING 2-11
NORTH PLATTE RIVER
MIDDLE LOUP RIVER
NORTH LOUP RIVER
SCHUYLER 4-175
FREMONT 14-887
COLUMBUS
WAHOO
OMAHA
COUNCIL BLUFFS
ATLANTIC 86-478
BROKEN BOW
LOUP RIVER
PLATTE
BIG BLUE
RED OAK 1-6
NORTH PLATTE 40-326
OGALLALA 67-538
GOTHENBURG 1-47
COZAD 0-38
LEXINGTON
KEARNEY
GRAND ISLAND 27-267
AURORA 1-8
SEWARD
YORK 22-105
LINCOLN
PLATTSMOUTH 2-12
SHENANDOAH 6-33
NEBRASKA CITY 2-8
CRETE 51-254
STERLING 77-646
BRUSH 28-235
FT MORGAN 44-369
McCOOK 1-10
REPUBLICAN
SUPERIOR 5-23
FAIRBURY
BEATRICE
LITTLE BLUE RIVER
BETHANY 1-5
TRENTON
GRAND
BROOKFIELD
CHILLICOTHE
CHARITON RIVER
MARYSVILLE 32-225
NORTON
BELOIT 1-5
CLAY CENTER 1-5
ATCHISON 7-39
LEAVENWORTH
LIBERTY
EXCELSIOR SPRINGS
CARROLLTON
LEXINGTON 1-5
BONNER SPRINGS
KANSAS CITY
SUGAR CREEK
MANHATTAN 54-542
TOPEKA 356 2928
LAWRENCE 33-333
PLEASANT HILL
SALINE RIVER
SMOKY HILL RIVER
SALINA 37-358
ABILENE
HAYS 258-2246
HERINGTON 4-50
PAOLA
OTTAWA 33-190
OSAWATOMIE 23-132
FORT SCOTT 6-35
BOONVILLE 10-52
COLUMBIA
FULTON
JEFFERSON CITY
HERMANN 70-52
WASHINGTON 0-4
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L E G E N D

BASIN BOUNDARY

STATE OR NATIONAL BOUNDARY

DAM AND LAKE OR RESERVOIR

POPULATED PLACES

STANDARD METROPOLITAN STATISTICAL AREA

10,000 TO 49,999 POP. (1960)

2,500 TO 10,000 POP. (1960)

AVERAGE ANNUAL
URBAN FLOOD DAMAGES
IN THOUSANDS OF DOLLARS
(1965 PRICE BASE)

OMAHA
317 - 3084
2020 DAMAGES: $3,084,000
CURRENT DAMAGES: $317,000

NOTE: THE COMPOSITE URBAN FLOOD DAMAGES FOR COMMUNITIES UNDER 2,500 POPULATION (NOT SHOWN) ARE ESTIMATED TO BE 2.03 MILLION DOLLARS CURRENTLY AND 17.42 MILLION DOLLARS IN 2020.

SCALE 1/5,700,000

50 0 50 100 150 200

APPROXIMATE SCALE IN MILES

JUNE 1969

CURRENT AND 2020 URBAN FLOOD DAMAGES FOR COMMUNITIES WITH 2,500 POPULATION AND OVER

COMPREHENSIVE FRAMEWORK STUDY

MISSOURI RIVER BASIN

MISSOURI BASIN INTER-AGENCY COMMITTEE

PLATE 10

3

Table 121 – FLOOD DAMAGES WITH CURRENT ECONOMIC DEVELOPMENT AND EXISTING PROJECTS

Subbasin	Flood Area	Average Annual Damages			
		Crop & Pasture	Other Rural	Urban	Total
	(1,000 Acres)	($ Thousand)			
Upper Missouri	850.4	351	757	409	1,517
Main Stems	340.6	83	655	261	999
Tributaries[1]	509.8	268	102	148	518
Yellowstone	695.7	759	1,012	311	2,082
Main Stems	401.6	386	703	168	1,257
Tributaries	294.1	373	309	143	825
Western Dakota	1,271.0	652	1,331	364	2,347
Main Stems	458.6	0	609	306	915
Tributaries	812.4	652	722	58	1,432
Eastern Dakota	1,046.4	3,634	1,746	341	5,721
Main Stems	515.0	1,773	373	255	2,401
Tributaries	531.4	1,861	1,373	86	3,320
Platte-Niobrara	2,348.2	7,849	4,525	3,287	15,661
Main Stems	1,331.4	2,278	2,516	2,465	7,259
Tributaries	1,016.8	5,571	2,009	822	8,402
Middle Missouri	2,857.6	9,113	4,402	1,454	14,969
Main Stems	1,975.2	4,558	3,144	1,348	9,050
Tributaries	882.4	4,555	1,258	106	5,919
Kansas	2,461.7	13,465	4,929	1,237	19,631
Main Stems	1,107.6	2,780	1,076	1,153	5,009
Tributaries	1,354.1	10,685	3,853	84	14,622
Lower Missouri	2,769.1	22,630	5,046	5,944	33,620
Main Stems	1,419.8	12,496	3,418	3,849	19,763
Tributaries	1,349.3	10,134	1,628	2,095	13,857
SUMMARY:					
Total Main Stems	7,549.8	24,354	12,494	9,805	46,653
(Mo. R. Flood Plain)[2]	(1,558.7)	(8,289)	(3,546)	(3,928)	(15,763)
Total Tributaries	6,750.3	34,099	11,254	3,542	48,895
Missouri Basin	14,300.1	58,453	23,748	13,347	95,548
Totals by States:					
Montana	1,350.3	911	1,340	631	2,882
Wyoming	432.7	371	871	244	1,486
North Dakota	615.8	524	470	253	1,247
Minnesota	86.4	626	204	1	831
South Dakota	1,513.8	2,789	2,249	338	5,376
Colorado	571.5	1,500	1,939	2,136	5,575
Nebraska	3,120.1	13,826	4,683	1,653	20,162
Iowa	1,670.1	4,376	1,380	863	6,619
Kansas	2,184.9	12,435	5,087	1,317	18,839
Missouri	2,754.5	21,095	5,525	5,911	32,531

[1]Includes drainage areas of less than 400 square miles.
[2]Included in main stems total.

In the Yellowstone Subbasin, bank erosion is most significant on the Yellowstone River below Livingston, Mont., and along the lower reaches of the Clarks Fork, Bighorn, Tongue, and Powder rivers. Along the lower reaches of such smaller streams as the Shields, Stillwater, and Boulder rivers, bank erosion varies widely in intensity and frequency with the aggregate damage being quite high. There is chronic erosion at most bridge crossings, irrigation structures, and at various communities.

In the Western Dakota Subbasin serious erosion occurs on the Knife, Heart, Bad, and White rivers and the resultant sediment contributions to the main stem reservoirs on the Missouri River are significant. Significant erosion damages also occur along the Missouri River between Garrison Dam and the headwaters of Oahe Reservoir.

In the Eastern Dakota Subbasin, bank erosion is generally minor because of the flat stream slopes. However, the Big Sioux River has soil and slope characteristics which contribute to streambank erosion, especially near the mouth of the stream where erosion of a critical nature currently exists. Erosion is also prevalent at the mouths of the James and Vermillion rivers.

Bank erosion characteristics in the Platte-Niobrara Subbasin vary widely due to its large size and the range in topographic features. In the South Platte River drainage, damages to high-cost facilities are significant during moderate flow periods and become quite severe during major floods. In the North Platte River system, erosion damages are relatively low, but some critical problems arise at a few communities during high-flow periods. In the Platte River system of Nebraska, bank erosion is a serious and continuing problem, with ice jams having a major effect. It is most active along the main stem and such tributaries as the Elkhorn River and the lower reaches of the Loup River, and is quite severe in the Logan Creek drainage. In the Niobrara River drainage erosion is relatively minor.

Streambank erosion in the Middle Missouri Subbasin is extensive, the erosion rate being relatively severe in some areas. Erosion is a serious problem in the western Iowa area of loess deposits, particularly in areas adjacent to the Missouri River flood plain. Extensive bank cutting has occurred also along the Nemaha and Little Nemaha rivers in southeastern Nebraska.

In the Kansas Subbasin, bank erosion is fairly extensive, but the rates range from low to moderate. Along the Kansas River, about 50 miles of streambank are currently subject to active erosion. Bank deterioration has substantially decreased along the Republican River during the period of major reservoir operation since about 1952. Active erosion occurs at scattered locations along the Smoky Hill, Saline, Solomon, and Blue rivers.

In the Lower Missouri Subbasin, streambank erosion is quite widespread but the intensity is relatively low. The most severe locations exist in three reaches of the Grand River and four reaches along the Chariton and Osage rivers.

On the main stem of the Missouri River, bank losses are limited primarily to the open-river reaches between the upstream reservoirs and in the unstabilized reach between Gavins Point and Sioux City, Ia.

In addition to these natural streambank erosion conditions, detrimental channel conditions have become significant below many dams. The construction of a dam frequently causes a change in the stream regimen below the structure. Detrimental effects include vegetative encroachments on the stream which deteriorate the channel and reduce the capacity to convey flows released from the reservoir; degradation of the streambed, which may lead to unstable conditions; as well as basic streambank erosion. An example is the reach of the Missouri River below Garrison Dam in North Dakota. As the State and local interests have pointed out, the deterioration of banks in this reach is of major concern. In this case, the State and the Corps of Engineers are cooperatively carrying out a bank stabilization program in the area affected.

From the comprehensive viewpoint, it would be desirable that anticipated channel and bank stabilization measures below dams be constructed as a part of a total program. However, in some stream reaches affected by reservoirs, erosion may have been even more severe before construction and operation of the dam and reservoir. This fact should not preclude undertaking the necessary measures to control the residual problem. Such is the case in the illustrative reach below Garrison Dam. Even though the extent of bank erosion is now less than before construction, the problem is of significant proportions, especially to the local residents of the area.

Reservoir aggradation is another phenomenon associated with the construction of dams. Aggradation occurs where a stream carrying sediment enters a relatively still reservoir of water. As the velocity of the stream is reduced, sediment is deposited in the headwaters area of the reservoir. This gradual process creates a delta which eventually raises the backwater levels upstream of the reservoir. The higher water surface elevation in turn raises the natural ground-water level and aggravates any local flood problems. The remedy for this condition, at existing reservoirs, is to trap the sediment behind tributary dams; however, that solution is often economically infeasible. The alternatives include levee protection, ground-water pumpage, or relocation of the affected improvements. Aggradation is a natural occurrence inherent with any reservoir project and should be given full consideration during the planning process.

Streambank Erosion Damages

A recent assessment of streambank erosion indicates that there are about 538,000 miles of streams, not including gullies, within the Missouri River Basin. The omission of those streams having a drainage area of less than one square mile was considered to exclude gullies. Currently, about five percent of those streambank miles is experiencing erosion and about one percent is classified as serious erosion. Some 20 percent of the streambank erosion is considered to be serious. Serious erosion along 11,200 miles of streambanks within the basin causes average annual damages estimated to be about $5.1 million. About 60 percent of the damage is attributed to land and productivity loss, 30 percent to sedimentation in reservoirs, and 10 percent to bridges, irrigation structures, and urban facilities. Potential average annual damages are projected to increase to $13.6 million by 2020 if no additional protection is provided. Table 122 summarizes streambank erosion damages throughout the basin.

Table 122 – POTENTIAL STREAMBANK EROSION DAMAGE WITH CURRENT AND PROJECTED ECONOMIC DEVELOPMENT AND EXISTING PROTECTION

Subbasin	Total Length of Channels	Current Length of Erosion	Length of Serious Erosion	Average Annual Damages			
				Current	1980	2000	2020
	(Stream-miles)	(Bank-miles)	(Bank-miles)	($ Thousand)			
Upper Missouri	110,700	2,600	460	510	660	930	1,190
Yellowstone	92,700	8,300	2,450	470	620	870	1,220
Western Dakota	107,200	11,700	1,970	454	620	830	1,110
Eastern Dakota	46,000	3,800	870	357	610	830	1,120
Platte-Niobrara	77,700	11,100	1,520	520	800	1,100	1,560
Middle Missouri	33,400	4,900	1,800	1,033	1,540	2,130	2,950
Kansas	26,000	5,200	530	1,287	1,800	2,410	3,220
Lower Missouri	44,300	5,100	1,600	469	650	900	1,230
Missouri Basin	538,000	52,700	11,200	5,100	7,300	10,000	13,600

Gully Erosion Problems

Gully erosion occurs at widespread locations and, in general, the scope and severity increase from the northwest to the southeast portions of the basin. Gully erosion and channel degrading account for a large share of the land damage in the basin. The process is accelerated by the lack of vegetative cover and is ordinarily most severe in cultivated areas of fine-grained soils in rolling or rough topography. Channel degradation is the process by which channels deepen and widen progressively headward in established stream systems. As the larger channels deepen, tributary drains likewise deepen.

Gully erosion in Gering Valley, Nebraska.

Gully erosion is presently a minor problem in the Upper Missouri. Although annual rates of loss are now low, as land values increase consideration will need to be given to reducing this erosion.

There are localized areas in the Yellowstone that have significant gully erosion, but most locations are not of the size and nature to require project action to treat. Under these conditions, treatment is being accomplished by individual landowners with assistance from government technical and cost-sharing programs. This procedure also applies to similar areas in the other subbasins.

In the Western Dakota Subbasin, streams fan out from the Black Hills dissecting the foothills and causing considerable areas of Badlands. These lands do not have a large enough production potential to readily justify the use of structural measures of improvement. The relatively low rainfall in the plains tends to commit much of this area to range, and proper care of rangeland is the most economical treatment to reduce erosion. This also applies to similar areas of other subbasins located in the less humid portions of the Missouri Basin.

The Eastern Dakota Subbasin has a slightly more significant gully problem, due primarily to the large glacial plain area which is overlain with loess.

Land damage by gully erosion and channel degradation is serious in the extreme eastern portion of the Platte-Niobrara Subbasin. On irrigated lands, losses from gullying often have been associated with and accentuated by irrigation water return flows, though current practice guards against this.

The Middle Missouri Subbasin has the greatest erosion problem in the entire basin. Its soils are formed largely from glacial till overlain by loess materials, generally lacking an effective rock underlay, and are subject to deep gullying.

The Kansas Subbasin has some gully erosion, although not as great as that of the Middle or Lower Missouri subbasins. Land values are frequently high enough to justify structural treatment.

In the Lower Missouri Subbasin, the most severe gully action is in the northern portion. Damages per acre run high in this area, as the land affected is generally valuable cropland. Soil and climatic conditions combine with past or present land use and erosion characteristics to produce moderate-to-high rates of gully growth and advance.

Gully Erosion Damages

In order to identify the different types and severity of project-type gully erosion problems, the following criteria were adopted:

Group	*Definition*
1	Areas with gully erosion critically affecting or destroying high value land. Rates of voiding and depreciation are high.
2	Areas similar to the above, but with moderate rates of damage, or areas of lower value land subject to damage.
3	Areas with low to moderate rates of damage affecting moderate to low-moderate value land. Rates of voiding and depreciation are usually low.
4	Areas which have remedial project measures completed or under construction.

The groupings outlined are shown in plate 11.

Within the basin, about 40,000 acres are damaged each year by gullies of the size and nature to require consideration of project-type action to treat. As these damages are cumulative, with little or no recovery, this rate of damage amounts to over 2 million acres in a 50-year period. The estimated equivalent loss from the agricultural productivity base during the next 50-year period is 942,000 acres, assuming no future development or improvements, either structural or nonstructural. Potential average annual damages are estimated to range from about $15 million currently to $50 million in the year 2020; however, much of this loss of productivity can be prevented by effective control measures. Table 123 summarizes gully erosion damages throughout the basin.

Capability of Existing Projects

Data presented in tables 120 and 121 provide a means for assessing the effectiveness of current flood control and related improvements, and for drawing general conclusions as to current needs. Table 124 and figure 60 show the flood damage reductions made possible by control works throughout the basin.

Existing flood-control projects give adequate protection, up to the limits for which they were designed. However, it should be recognized that the damage-prevention capability of a reservoir system decreases

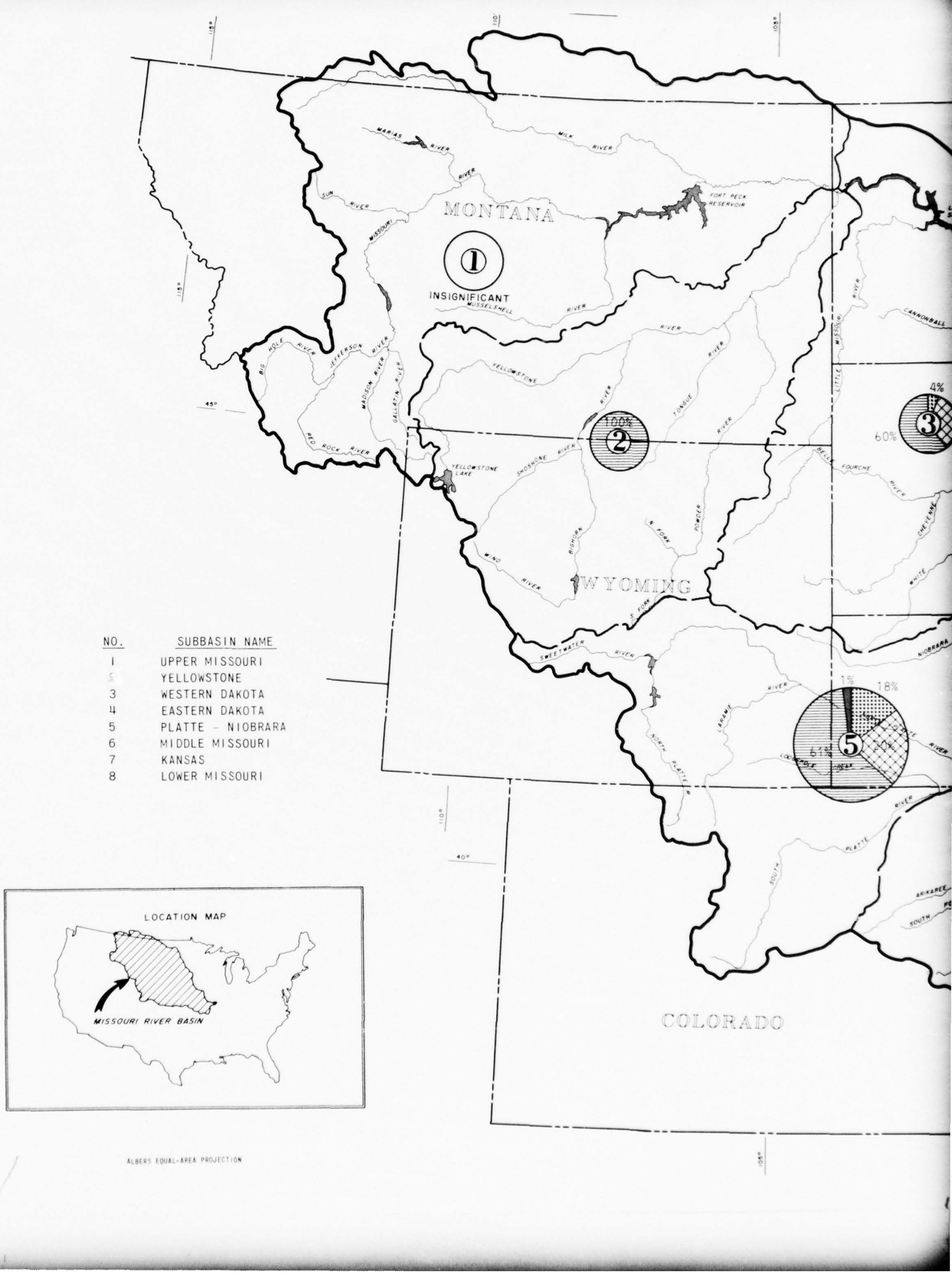
Table 123 – POTENTIAL GULLY EROSION DAMAGE WITH CURRENT AND PROJECTED ECONOMIC DEVELOPMENT AND EXISTING PROTECTION

Subbasin	Area Subject to Damage	Average Annual Damages			
		Current	1980	2000	2020
	(1,000 Acres)	($ Thousand)			
Upper Missouri	minor	---	---	---	---
Yellowstone	39	281	467	756	1,245
Western Dakota	17	39	53	72	96
Eastern Dakota	126	476	815	1,108	1,497
Platte-Niobrara	97	557	907	1,321	1,976
Middle Missouri	1,053	8,377	12,700	17,759	24,953
Kansas	169	1,075	1,600	2,362	3,570
Lower Missouri	540	4,649	6,869	10,471	17,029
Missouri Basin	2,041	15,454	23,411	33,849	50,366

Table 124 – POTENTIAL DAMAGE PREVENTION CAPABILITY OF EXISTING PROJECTS, MISSOURI BASIN

Subbasin	Average Annual Flood Damages							
	Without Current Projects				With Current Projects			
	Current	1980	2000	2020	Current	1980	2000	2020
	($ Million)							
Upper Missouri	2.3	4.4	7.9	15.2	1.5	2.9	5.2	10.0
Yellowstone	2.7	4.9	9.1	17.7	2.1	3.7	7.1	14.2
Western Dakota	3.2	6.0	10.2	18.8	2.3	4.1	6.2	12.3
Eastern Dakota	6.7	13.2	21.7	37.3	5.7	11.3	18.7	30.6
Platte-Niobrara	24.8	44.0	76.3	127.4	15.7	27.1	48.5	83.4
Middle Missouri	30.1	48.1	73.3	112.5	15.0	23.3	34.7	50.1
Kansas	30.3	49.5	82.9	142.2	19.6	30.1	44.5	67.9
Lower Missouri	100.9	158.3	268.6	500.3	33.6	50.0	76.4	123.8
Missouri Basin	201.0[1]	328.4	550.0	971.4	95.5	152.5	241.3	392.3

[1] Does not include about $45 million of downstream, main-stem benefits which have not been assigned to the individual subbasins.


MONTANA
WYOMING
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MILK RIVER
SUN RIVER
MISSOURI RIVER
FORT PECK RESERVOIR
MUSSELSHELL RIVER
BIG HOLE RIVER
JEFFERSON RIVER
MADISON RIVER
GALLATIN RIVER
RED ROCK RIVER
YELLOWSTONE RIVER
YELLOWSTONE LAKE
SHOSHONE RIVER
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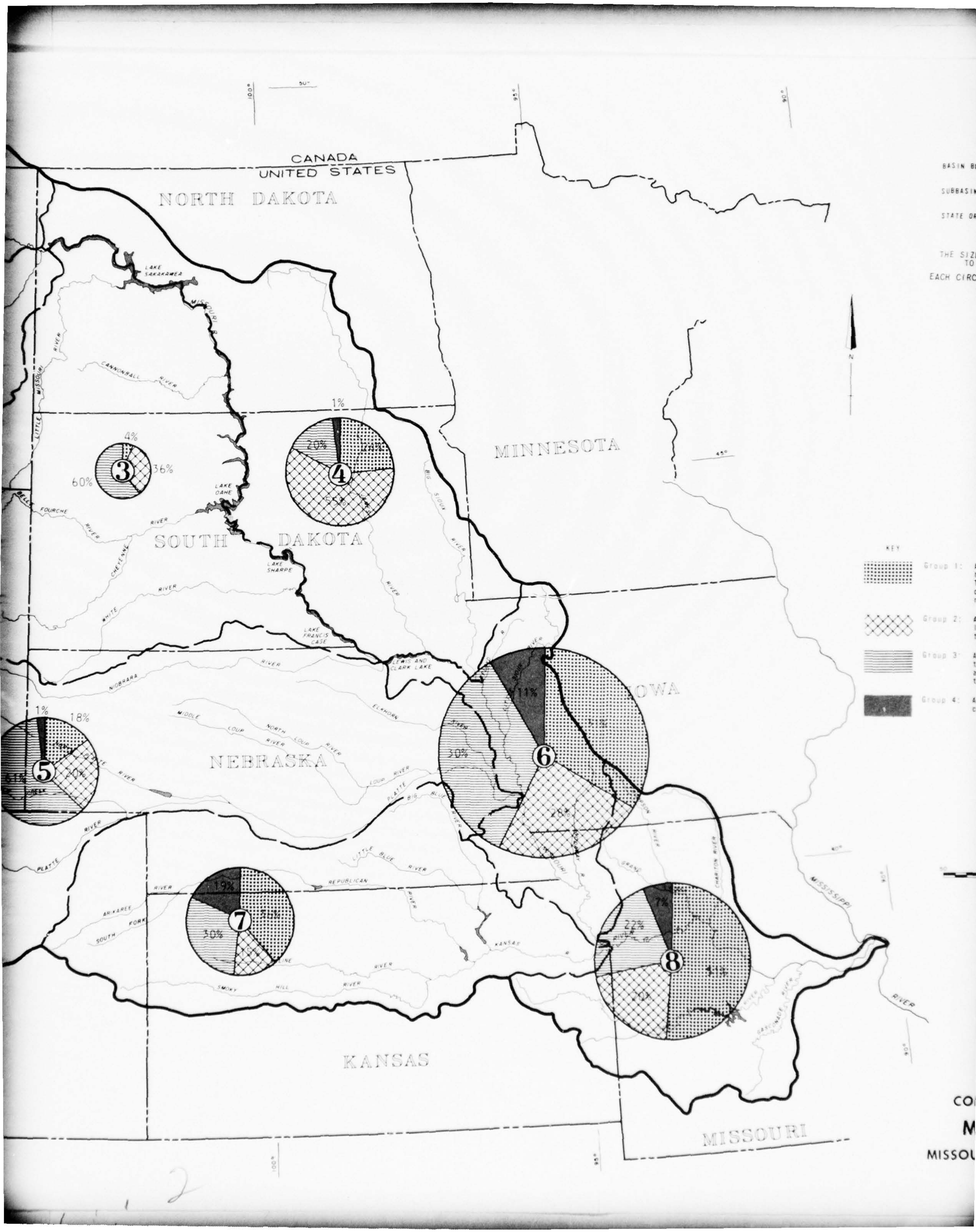
SWEETWATER RIVER
NORTH PLATTE R.
LARAMIE RIVER
SOUTH PLATTE RIVER
LITTLE MISSOURI RIVER
CANNONBALL
BELLE FOURCHE RIVER
CHEYENNE
WHITE
NIOBRARA
ARIKAREE
NO.
SUBBASIN NAME
1 UPPER MISSOURI
YELLOWSTONE
3 WESTERN DAKOTA
4 EASTERN DAKOTA
5 PLATTE - NIOBRARA
6 MIDDLE MISSOURI
7 KANSAS
8 LOWER MISSOURI
LOCATION MAP
MISSOURI RIVER BASIN
ALBERS EQUAL-AREA PROJECTION



CANADA
UNITED STATES
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
MINNESOTA
IOWA
MISSOURI
LAKE SAKAKAWEA
MISSOURI R
CANNONBALL RIVER
LITTLE MISSOURI RIVER
LAKE OAHE
BELLE FOURCHE RIVER
CHEYENNE RIVER
WHITE RIVER
LAKE SHARPE
LAKE FRANCIS CASE
LEWIS AND CLARK LAKE
BIG SIOUX RIVER
NIOBRARA RIVER
ELKHORN
MIDDLE LOUP RIVER
NORTH LOUP RIVER
LOUP RIVER
PLATTE RIVER
BIG BLUE RIVER
LITTLE BLUE RIVER
REPUBLICAN RIVER
ARIKAREE
SOUTH FORK
KANSAS R
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CHARITON RIVER
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22%
KEY
Group 1:
Group 2:
Group 3:
Group 4:

LEGEND

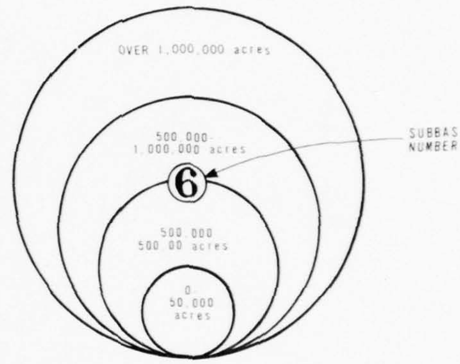
BASIN BOUNDARY

SUBBASIN BOUNDARY

STATE OR NATIONAL BOUNDARY

THE SIZE OF THE CIRCLE INDICATES THE AMOUNT OF AREA SUBJECT TO DAMAGE OVER A 50-YEAR PERIOD FOR EACH SUBBASIN.

EACH CIRCLE SEGMENT INDICATES THE PERCENTAGE DISTRIBUTION OF GULLY-EROSION GROUPS WITHIN EACH SUBBASIN.



KEY

Group 1: Areas with gully erosion critically affecting or destroying *high-value land*. Rates of voiding and depreciation are high. The topography and soils of the area will permit installatio of remedial measures, at low to moderate cost, to significan reduce voiding and depreciation damages.

Group 2: *Areas similar to the above, but with moderate rates of damag* lower-value land subject to damage, or with higher costs for the required remedial measures.

Group 3: Areas with low to moderate rates of damage affecting moderat to low-moderate value cropland. *Rates of voiding and deprec* ation are usually low. Costs of remedial measures are moder to high.

Group 4: Areas which have remedial project measures completed or unde construction.

SCALE 1:5,100,000

50 0 50 100 150 200

APPROXIMATE SCALE IN MILES

JUNE 1969

GULLY EROSION

COMPREHENSIVE FRAMEWORK STUDY

MISSOURI RIVER BASIN

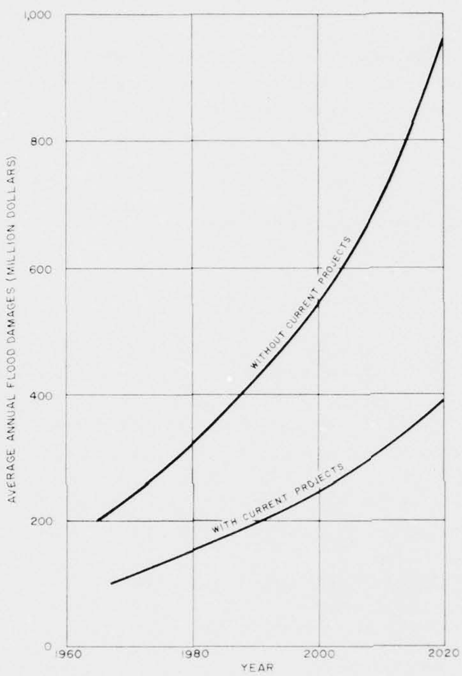
MISSOURI BASIN INTER-AGENCY COMMITTEE

PLATE 11

3

and secondary damages exists wherever there is a flood ages.

FIGURE 60
FLOOD DAMAGES AND CAPABILITY
OF EXISTING PROJECTS
MISSOURI RIVER BASIN



progressively downstream from the structures. Accordingly, the indicated residual damages with certain projects in place may appear to be high. At first glance, any additional control may seem to be justified solely on the basis of the extensive areal extent for which damage values were computed. However, a more detailed analysis is necessary to determine if additional protection is practicable and economical.

At major urban centers, flood damage reductions provided by existing improvements may be termed adequate even though residual damages appear to be quite large. For example, at the Kansas Citys urban area, average annual flood damages are reduced over 90 percent by existing improvements, but the computed residual damages of $6,897,000 are quite large. It is not practicable to increase the protection levels of the existing project at the Kansas Citys by local protection works; however, additional reservoir systems for solving other problems upstream could result in further damage reductions at the Kansas Citys. Again, it must be emphasized that such reservoir systems would not be specifically designed for the latter purpose.

Residual damage levels in areas protected by existing works have been projected into the future in a similar manner in areas which have no protective works. Residual flood damages in protected areas are projected to increase substantially, mainly because of the anticipated economic growth; nevertheless, the protection levels expressed in terms of recurrence of flooding would stay relatively constant. Again, the increasing magnitude

Temporary heightened floodwall at Omaha, Nebraska, during the 1952 snowmelt flood on the Missouri River. Subsequent construction of five main-stem dams now prevents the recurrence of a similar flood.

of these projected flood losses should not be construed to indicate that additional flood protection is presently justified.

Damage to cars and a duplex in Denver, Colorado, from the 1965 South Platte River flood.

A further scrutiny of existing projects seems warranted. Review of the current situation at certain urban areas indicates points where the degree of control should be increased, if at all practicable. As a general guide, a 200-year flood (0.5 percent chance of annual occurrence), or greater, is presently considered to represent a target for assessing a desirable degree of urban protection. It is recognized that physical and economic factors may preclude additional increments of flood protection for the various urban areas, but more study is warranted. The following table summarized the existing urban projects for which an additional level of development is desirable.

FUTURE CONDITIONS

Flood Damages

A realistic appraisal of flood and related damages must include an evaluation of future economic conditions. Estimates of future damage levels were based on economic projections. It was assumed that progressive economic development of the flood plain from 1965 through 2020 will take place at the same general rate as in flood-free areas. The damage estimates recognize the effects of existing projects but assume no future improvements, structural or nonstructural, to control or prevent damage. It was also assumed that flood and erosion risks will be accepted or ignored by individuals to the same extent as has been true in the past.

Table 125 – EXISTING URBAN PROJECTS FOR WHICH AN ADDITIONAL LEVEL OF DEVELOPMENT IS DESIRABLE

Subbasin	Stream	Location	Existing Degree of Control (years per recurrence)
Upper Missouri	Milk River	Havre, Mont.	50
Western Dakota	L. Missouri R.	Marmarth, N. Dak.	40
	Belle Fourche R.	Belle Fourche, S. Dak.	20
	Heart River	Mandan, N. Dak.	25
Eastern Dakota	Big Sioux River	Sioux Falls, S. Dak.	125
Platte-Niobrara	Union & Taylor Cr.	Madison, Nebr.	14
Middle Missouri	L. Papillion Cr.	Omaha, Nebr.	33
Kansas	Big Blue River	Seward, Nebr.	50

In estimating the probable future development in flood plain areas, agricultural production trends, projected population and employment, and projected growth in income and earnings were used to construct composite factors reflecting flood damage increases. These factors were applied to the damages under present conditions to obtain estimates of future damages.

Specifically, the index factors for estimating future levels of crop and pasture damage were based on projections of total realized gross farm income. In urban

Control and regulation of stream flows by Fort Randall and many other reservoirs provide flood protection in addition to other multiple benefits.

areas, projections of earnings per employee were used to develop an index applicable to estimates of future urban damage.

Projection of rural noncrop damages involved a more complex application of the economic projections. Agricultural noncrop losses are closely related to the production capability of farms and the capital required for farm operations. Projections of total-realized gross farm income were used as bases for estimates of future damage levels. On the other hand, rural nonagricultural damages were considered to be more related to the total economic activity of the area. Growth factors for such damages were obtained from projections of total earnings for the subarea and the subregion. A composite growth factor was thus developed to estimate future rural noncrop damages for specific local areas. In all cases, growth factors were modified as necessary to permit the best use of data from detailed studies and to reflect the character of local areas and reaches.

Projections for large urban areas were based on both economic projections and generalized estimates of the tendency and opportunity for future development of flood plain areas. The procedure provided a basis for assignment of future flood losses even though damage under current conditions may be insignificant or nonexistent. While the results for any given city or town must be considered as being approximate, they do provide a practical estimate of aggregate urban damages in the future.

The application of growth factors to current levels of damage resulted in projected levels for the benchmark years of 1980, 2000, and 2020. Current and projected levels of damage are shown in table 126.

The results of the flood-damage studies, as summarized, indicate that average annual damages within the Missouri Basin, in the absence of existing projects, would rise from about $201.0 million currently (1960 price levels) to $328.4 million by year 1980, $550.0 million by year 2000, and $971.4 million by year 2020. The capability of the existing projects reduces residual flood losses to $95.5 million, $152.5 million, $241.3 million, and $392.3 million, respectively. These existing projects reduce damages by 53 percent under current conditions. Since development of flood plain areas benefited by existing projects is projected to increase more rapidly than in other flood plain areas, the degree of damage reduction will tend to increase in the future and will rise to 54 percent in 1980, 56 percent in 2000, and 60 percent in 2020.

The information and data presented in this chapter outline the relative seriousness of the flood situation in terms of primary tangible losses for various levels of economic development in the future. These losses

The 1953 Floyd River flood at Sioux City, Iowa.

include physical damage as well as emergency and other costs incurred from flooding. Although these estimates are generally considered adequate for plan formulation purposes (screening of alternatives leading to more detailed planning studies), it should be recognized that intangible and secondary damages have not been included. However, intangibles, such as loss of life, health, security, and detrimental effects on national defense, must be carefully considered in the planning process.

Streambank and Gully Erosion

It is impracticable to project streambank and gully erosion patterns and damages resulting therefrom in the same manner as for floods. Detailed studies of relatively small individual areas would be required to fully assess the impacts and long range effects of erosion. In view of this situation, the current conditions of erosion, both bank and gully, were used as the benchmarks for determining needs in this functional category. The recent assessment of streambank erosion in the Missouri Basin indicates that only limited data exist to analyze the extent and severity of the problem. However, it did indicate that the problem is widespread, probably has widespread economic and social consequences, and that a wide-ranging program for control of streambank erosion could be in the regional and national interest. In view of the limitations encountered, a realistic approach for the future would be to undertake a more detailed inventory of streambank miles subject to erosion; undertake analytical studies to define the technical aspects of erosion as well as tracing the economic and social consequences; and start a testing program through prototype analyses to determine the various kinds of improvements which could prove effective and what costs would be required for implementation.

Table 126 – FLOOD DAMAGES WITH CURRENT AND PROJECTED ECONOMIC DEVELOPMENT AND EXISTING PROJECTS

Subbasin	Average Annual Damages			
	Current	Projected		
	1965	1980	2000	2020
	($ Thousand)			
Upper Missouri	1,517	2,887	5,200	10,007
Main Stems	999	2,018	3,833	7,622
Tributaries[1]	518	869	1,387	2,385
Yellowstone	2,082	3,671	7,059	14,160
Main Stems	1,257	2,268	4,619	9,464
Tributaries	825	1,403	2,440	4,696
Western Dakota	2,347	4,100	6,205	12,302
Main Stems	915	1,696	2,912	5,351
Tributaries	1,432	2,404	3,293	6,951
Eastern Dakota	5,721	11,335	18,668	30,598
Main Stems	2,401	4,941	8,477	13,493
Tributaries	3,320	6,394	10,191	17,105
Platte-Niobrara	15,661	27,125	48,452	83,353
Main Stems	7,259	13,635	27,856	49,797
Tributaries	8,402	13,490	20,596	33,556
Middle Missouri	14,969	23,258	34,702	50,100
Main Stems	9,050	14,275	22,101	32,408
Tributaries	5,919	8,983	12,601	17,692
Kansas	19,631	30,126	44,544	67,904
Main Stems	5,009	7,887	12,652	20,967
Tributaries	14,622	22,239	31,892	46,937
Lower Missouri	33,620	50,033	76,420	123,836
Main Stems	19,763	29,437	45,784	75,802
Tributaries	13,857	20,596	30,636	48,034
SUMMARY:				
Total Main Stems	46,653	76,157	128,234	214,904
(Mo. River Flood Plain)[2]	(15,763)	(23,322)	(36,804)	(62,284)
Total Tributaries	48,895	76,378	113,036	177,356
Missouri Basin	$95,548	$152,535	$241,270	$392,260
Totals by States:				
Montana	2,882	5,252	9,637	18,871
Wyoming	1,486	2,746	4,963	10,058
North Dakota	1,247	2,249	3,617	6,319
Minnesota	831	1,487	2,190	3,323
South Dakota	5,376	10,361	16,515	28,793
Colorado	5,575	10,346	22,212	40,536
Nebraska	20,162	31,765	48,252	73,451
Iowa	6,619	10,538	15,935	23,164
Kansas	18,839	29,685	44,604	69,266
Missouri	32,531	48,106	73,345	118,479

[1]Includes drainage areas of less than 400 square miles.
[2]Included in main stems total.

NATURE OF POTENTIAL SOLUTIONS

Flood Control

Solutions to flood problems and measures to minimize flood damages include both structural and non-structural programs. A review of historical flood data indicates that total damages continue to increase, even though a large number of flood control programs have been implemented. There are two reasons for this seeming paradox.

First, the continued economic expansion of the Nation results in higher values for property, materials, and labor so that the value of improvements subject to flooding also continues to increase and flood losses themselves are consequently higher. Secondly, the continuing economic expansion creates demands for land on which new improvements can be located. In many instances this has resulted in substantial encroachments on the flood plains and additional sets of improvements subject to flood.

It is apparent that a need exists for flood plain management. With proper management of the water and the land subject to inundation by flood waters, the trend of increasing flood damages can be reversed. This is not a simple task. Studies may be made to determine the best use of the flood plain lands, recognizing the flood risk, but implementation of flood plain regulations involves property rights. Thus legal authority must exist to initiate any planned regulation, and planned regulation of future flood plain development should be accomplished by all planning groups — Federal, State, and local. This means that planning should not stop at flood control structures but should incorporate to some degree land-use analysis, and local requirements for regulation and management for appropriate flood plain development.

In order that the program formulation studies would not be constrained or biased with respect to the applicability of structural or nonstructural measures, a basic and limiting assumption was made. The damage projections presented herein reflect continuing increases in damage levels as embodied in the historic record and as anticipated with continuing economic expansion in the future. Given such a pattern, planners can determine a framework for the solution of flood problems, encompassing both structural and nonstructural measures and considering the relative effectiveness of each.

Application of nonstructural measures would reduce future flood damage increases, while structural measures would provide positive control of floods resulting in not only a prevention of flood losses, but also possible higher economic use of previously flood-prone areas. These types of programs together should provide an optimum solution to the total flood problem.

Structural solutions to flood problems include levees, channel improvements, and reservoirs. Reservoir control of the larger streams may be desirable, in many instances, as the most comprehensive means of reducing flood losses along these streams and, in addition, provide a potential for reducing flood damage along the Missouri River. These same reservoirs may also perform multiple-purpose water resource functions. Portions of flood plains subject to flooding by both the Missouri River and one of its tributaries dictate special treatments. Existing Missouri River levees which tie back to the bluff line for protection against this common flood threat have been effective, and similar units may represent the best solution for those areas which need protection in the future.

Alleviation of flooding in upstream watershed areas will require the installation of land treatment measures, construction of floodwater-retarding structures, channel improvements, and levees where economically feasible. This integrated approach must consider flood, sediment, and other related matters in determining the need for structural measures and supporting watershed management and protection practices.

Streambank and Gully Erosion Control

With the exception of the bank stabilization project on the Missouri River, most of the efforts to alleviate bank erosion in the basin have been of an emergency or temporary nature. The measures utilized generally have fallen short of actual stabilization of stream channels. Instead, these measures have been aimed at protecting the most critical area of bank erosion by the use of riprap or substitutes, or by making local realignments of the channel itself. To the extent that more permanent measures may not be economically justified, it can be assumed that emergency measures will continue to be used for temporary protection. In fact it appears that the principal potential for alleviating bank damages on a single-purpose basis will be installations for critical areas as the need arises.

The installation of more permanent rock revetments is desirable whenever justified by local conditions. Increases in the economic losses due to future development, in combination with possible advances in the technology of bank stabilization, may provide a basis for justifying protection of relatively long reaches. Examples might include new urban areas or intensive irrigation areas with very high agricultural land values.

The corrections of gully erosion will require construction of grade stabilization structures and installation of complementary land treatment measures. In some areas, it will be more effective to construct multipurpose grade stabilization and floodwater-retarding structures to provide the desired protection. Streamflow regulation is also a possible means of reducing the effects of streambank and gully erosion.

OTHER CONSIDERATIONS

Several nonstructural measures are possible in the reduction of future flood damages. They include land management and treatment measures, flood forecasting, flood fighting, floodway regulation, flood plain planning and zoning, and flood-proofing of structures.

In general, land-treatment measures have a potential for reducing flood and associated problems within local areas. Widespread application of land-treatment measures may also have some effect on main stems and major tributary reaches. While these measures do not provide a substitute for structural installations, they do provide a means for alleviating local erosion and flood losses. They also complement structural measures, particularly with respect to sediment problems. In some instances there is the opportunity to utilize critical and gullied areas for nonagricultural uses for waterways and for wildlife.

Flood forecasting and flood fighting provide the opportunity for emergency measures to minimize damages by evacuation of persons and movable property from areas expected to be flooded, and by various emergency operations to reduce the anticipated damages. Floodway regulation is aimed at preventing development, whether subject to damage or not, that would adversely affect the passage of flood flows. Flood plain planning and zoning contemplate restrictions in the use of areas subject to flooding appropriate to the hazards of such use. Flood-proofing involves appropriate modification of buildings and other structures and their contents.

A program was established under the Housing and Urban Development Act of 1968 to make flood insurance available, eventually throughout the Nation, through a cooperative effort of the Federal Government and the private insurance industry. The Act requires that state and local governments also contribute by adopting and enforcing land use provisions so as to restrict future development of land in flood-prone areas. The Flood Insurance program is designed to meet an insurance need in flood zones. Through a Federal-business-local community effort and sharing of risks and losses, the new program is expected to provide the needed insurance. Essentially, the plan is to provide flood insurance, at subsidized rates, on existing structures and their contents and to advise prospective developers of the perils incident to building in the flood plain. In addition, insurance at full risk premium rates will be available for structures which do not qualify for lower premiums.

The foregoing measures have potential application to the extent that they can be reasonably achieved by individual and local action in combination with existing and future State and Federal programs. While these measures may tend to restrict the magnitude of future flood losses, they cannot by themselves eliminate the need for physically controlling floods.

Within the context of management concepts, present legal and institutional arrangements affect the implementation of improvements, whether of a structural or nonstructural nature. Careful review and analyses of existing arrangements should be made in order to establish the relative local, state, regional, and national interest in the various problem areas. Reviews should cover such items as cost-sharing, sponsorship, long-range maintenance responsibilities, and the competitive interrelationships that may exist between potential uses of a resource. In the nonstructural phases of flood control, legal and institutional arrangements will govern the applicability and implementation of these managerial programs.

AN OVERVIEW

The analyses of the flood and related problems are based primarily on estimates of expected flood and erosion losses for current conditions. Levels of losses in the long-term future are based on broad indicators of economic activity expected to prevail in the future. Accordingly, damage levels associated with flooding and erosion reflect, for the most part, historical trends. The values presented are considered adequate for initial framework planning studies. Further refinements and extension of the present studies will be required to properly evaluate conditions which include or exclude any given program considered during the formulation of a specific plan.

In many instances, positive programs of improvement will result in enhancement of the area affected, usually through a change in land use, or a higher level of use. Measurement of this effect can be made by determining the differences in net income brought about because flood and erosion protection is provided. This protection must be correlated with the meeting of other needs, such as increasing agricultural production through technological changes and irrigation practices, and providing additional areas for urban expansion.

Correlation with other problems or opportunities goes beyond that mentioned and is not directly obvious from data presented in this chapter. For example, the value of reducing sedimentation in a reservoir to permit not only a longer project life, but also better water quality for recreation and wildlife purposes, should be recognized. The factors discussed are equally applicable to single-purpose and multi-function programs that may be developed.

In addition to recognizing beneficial effects of flood and erosion programs in total, it is also considered important that costs associated with such programs be analyzed from a number of viewpoints. Based on flood losses presented herein and the recognition of other factors outlined above, the early development of flood and erosion control programs may be desirable in order to be ready for implementation at any time. To assure sound decisions, the social and economic costs of implementing or delaying such programs must be fully recognized. Significant factors include site preemption, escalating land costs, and the construction of high-priced developments in potential project areas. Vigilance within the next few years may save substantial funds and even prevent worthy projects from becoming economically infeasible.

CHAPTER 8

NAVIGATION

WATERWAY NAVIGABILITY

The Supreme Court has laid down a clear rule for determining the navigability of a waterway. Rivers are navigable in law, as in fact, if they are used, or susceptible to being used in their ordinary condition, as highways of commerce over which trade and travel can be conducted in the customary way by water; and they constitute "navigable waters of the United States," within the meaning of the Acts of Congress, when they form, in their ordinary condition, by themselves or by uniting with other waters, a continued highway over which commerce is or may be carried on with other states or with foreign countries.

Nearly all rivers that reach the sea form a continued highway under this rule and, if navigable in themselves, are navigable waters of the United States and under Federal jurisdiction. The main stem of the Missouri River from its mouth to Three Forks, Mont., and certain portions of many of the principal tributaries have been designated as navigable in law, although they are not necessarily navigable in fact over their total length.

This chapter covers a brief review of navigation in the Missouri Basin, the future of water transportation (1980, 2000, and 2020) on the Missouri River, the adequacy of the existing navigation project to meet present and future needs, and the resultant Missouri Basin navigation needs. This information is provided for background rather than a delineation of future needs. In consonance with the basic structure of the study, projects in operation and water uses in being were assumed as a depletion of surface flows and not included in planning needs. It is recognized that additional future depletions may affect navigability of the Missouri River and adjustments required.

HISTORY AND PRESENT STATUS OF NAVIGATION

The Missouri River has a length of 2,316 miles, a drainage area of approximately 529,000 square miles, and a total fall of about 3,630 feet. From its headwaters to the vicinity of Great Falls, Mont., the river valley is gorge-like in character and the surrounding area is mountainous. Sloping terrace lands and local "bad lands" are characteristic topographical features between Fort Benton, Mont., and the vicinity of Yankton, S. Dak., a distance of about 1,267 miles.

From Yankton to the mouth, the river flows through rolling plains, except for a short distance where it skirts the Ozarks highland region of Missouri. Shortly after Lewis and Clark blazed a trail up the Missouri in 1804, steamboats were utilizing the river from St. Louis to Fort Benton, Mont. The river served the pioneers as a natural route of communication and the principal artery of travel into the northwest until the faster, more flexible railroads with dependable schedules forced the decline of early day steamboat river traffic. In the following paragraphs the development and present status of navigation are discussed in subbasin order.

Yellowstone River

The Yellowstone River was at one time used as a navigation waterway throughout the reach between Billings, Mont., and the mouth, near the headwaters of the present Garrison Reservoir. As a result of such use by vessels engaged in interstate commerce, the river acquired the status of a waterway of the United States. Improvement of the Yellowstone River for navigation was started in 1879 and was continued until 1899. The work consisted of closing chutes, removal of snags, trees, boulders, and similar obstructions, and river regulation by use of wing dams and impermeable dikes. In 1910 the Bureau of Reclamation of the Department of the Interior constructed an irrigation diversion dam across the Yellowstone River at Intake, Mont., (mile 71.8), without the inclusion of a navigation lock structure. This dam is now the practicable head of navigation on the Yellowstone River and is so considered by the Congress.

Big Sioux River

The Big Sioux River is considered to be navigable for a distance of about 4 miles above its mouth. Historically, there has been no significant commercial navigation along this stream, nor has there been any expressed interest in its development, excepting for the authorized harbor project near the mouth at Sioux City, Ia. A report completed in 1967 concludes that a commercial navigation harbor improvement is no longer economically feasible under prevailing navigation practices, and recommends that the project be deauthorized.

Kansas River

Although considered a navigable stream by the Federal Government, the Kansas River was declared a non-navigable stream by the Kansas Legislature by an act approved February 25, 1864, (State of Kansas Session Laws, 1864, Chapter 97). The 1864 Act favored the coming of railroads "and authorized railroads and bridge companies chartered under state laws to bridge or dam any river without restriction." The law was repealed in 1913 (State of Kansas Session Laws, 1913, Chapter 259) because of litigation and the recognition that on any navigable river which is a property of the State, the State can collect royalties from sands, oil, gas, gravel, or other minerals taken from the lands lying in the bed of the river.

In September 1963 the Corps of Engineers was directed by the Congress to restudy the Kansas River in the interest of navigation from the mouth to Lawrence, Kan. There was considerable interest expressed in the study by potential shippers and receivers of freight, particularly prospective shippers of grain from as far upstream as Salina on the Smoky Hill River. Several organizations supported the study but reserved comment until its completion. The Kansas Water Resources Board questioned limitations as to an adequate water supply for maintaining a navigable channel and the adverse effect on lands in the valley if a slackwater channel is considered. The Kansas Railroads' Committee on Flood Control and Water Conservation opposed navigation. It submitted a detailed engineering study and reported on considerations for navigation on the Kansas River in support of their conclusions that navigation between Kansas City and Junction City would be infeasible and impracticable.

Blue River

The Blue River is a right bank tributary of the Missouri River at mile 356.9. The Blue is considered navigable from its mouth to Guinotte Dam, a distance of about 4 miles. The channel is not navigable in fact and there is little likelihood that it will ever become so, even as a port facility for Missouri River barge traffic. The Armco Steel Company has provided docking facilities on the right bank of the Missouri River near the mouth of the Blue River.

Grand River

The Grand River, which rises in Southwestern Iowa and joins the Missouri River at river mile 249.9, is considered to be navigable to Brunswick, located 3 miles above its mouth. Above this point the stream valley is interlaced with a network of railroads and highways. Local interests have indicated a desire to establish harbor facilities at Brunswick in connection with navigation on the Missouri River; however, no formal request to investigate this problem has been forthcoming.

Lamine River

The Lamine River, with its major tributary, the Blackwater, is a right bank tributary of the Missouri River at mile 205.5. Although considered to have the status of a navigable waterway from its mouth to mile 14, the Lamine is considered to be non-navigable except for small craft used in connection with commercial fishing and recreation. There has been no indicated local interest for the establishment of a boat harbor at or near the mouth of the river.

Osage River

The Marais des Cygnes-Osage River rises in east-central Kansas and flows easterly and southeasterly 190 miles to the Kansas-Missouri state line, thence east in Missouri 306 miles to its junction with the Missouri River, 129.9 miles above its mouth. The Osage River is considered a navigable stream from the mouth to mile 172 near Warsaw, Mo., although the construction of Bagnell Dam (mile 82) without locks divides the navigable portion into two reaches. A lock and dam at mile 12.1 was provided and was maintained until 1955; however, with the cessation of commercial navigation, the Federal property, including the lock and dam structure, was declared surplus and sold to non-Federal interests. Although the dam is still in existence, the lock is inoperable and permanently open to streamflow.

Gasconade River

The Gasconade River rises in Southern Missouri, flows northerly in a tortuous course 200 miles to a confluence with the Missouri River, 104 miles above the mouth. It is a navigable waterway of the United States from the mouth to Cooper Hill, mile 39.4. The first improvement work by the Government in the interest of navigation began in 1880 with the removal of snags up to Arlington. Later, this work was supplemented by open-channel improvement at the shoals, utilizing the natural flow to the best advantage by the construction of wing dams and other works. Prior to 1900 the traffic was as great as 50,000 tons per year. Since then it has been on a steady decline and, with the exception of the Gasconade boatyard harbor, commercial traffic has disappeared.

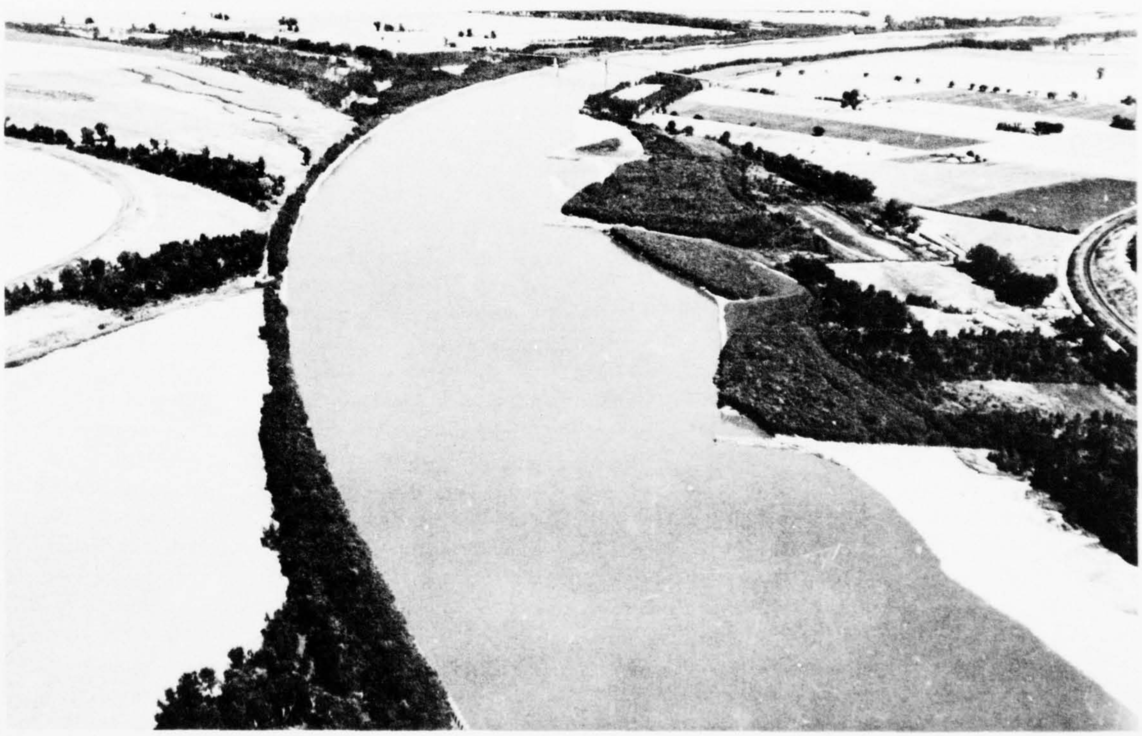
Missouri River Main Stem

A look into past events will assist in understanding today's conditions and projecting the possibilities of future development.

The first Federal expenditures for improvement to the Missouri River were made in 1824 when funds were provided for snag removal. During the latter part of the nineteenth century, experimental work on the stabilization of the banks and the provision of a more adequate navigable channel was undertaken at scattered locations.

In its natural state, the Missouri River meandered between rather low banks in numerous shallow channels separated by low, shifting sandbars and islands. The banks consisted of readily erodible, alluvial deposits which permitted the uncontrolled, meandering river to erode adjacent valley lands at one point and deposit these materials at other points. Over a long period of years, the areas of new deposits eventually filled to the original valley levels.

Improvement of the Missouri River, in the interest of bank stabilization and navigation from Sioux City, Ia., to the mouth, was initially authorized by the River and Harbor Act of 1912, which as amended provides for securing a navigable channel of 9-foot depth and 300-foot minimum width. The improvement was started in the early 1930's, and consists, in general, of integrating the numerous small, shallow channels of the natural river into one stabilized, comparatively deep channel.



Integrated bank stabilization works and reservoir operation overcome bank erosion and regulate flows permitting navigation.

This channelization has been accomplished by the initial construction of permeable dikes, which were later replaced by rock-fill dikes. These stabilization works, while not denying access of the river flows to the areas behind the dikes, lower the velocity of flow sufficiently to cause deposition of sediments in these areas and thus increase the extent and value of farm lands in the flood plain. In special cases, to eliminate either sharp bends or protracted horseshoe bends, cutoffs were developed by excavation of a pilot channel along the desired alinement. In other cases, it was found necessary to close off major secondary channels by the construction of rock and earth plugs, removal of snags, and dredging as required. When by the foregoing processes the river had been shaped into the proper alinement, the channel was finally stabilized by revetment of the newly established banks.

In addition, six multiple-purpose dams and reservoirs located on the main stem above Yankton, South Dakota, have been completed. The Fort Peck Reservoir, about 186 river miles upstream from the Montana-North Dakota state line, was authorized by the 1935 River and Harbor Act, primarily for navigation. The Garrison, Oahe, Big Bend, Fort Randall, and Gavins Point reservoirs were authorized by the 1944 Flood Control Act as part of the general comprehensive plan for the Missouri River Basin. This Act also modified the authorization for the Fort Peck Reservoir to provide for full multiple-purpose operation. While developed primarily for the four basic purposes of flood control, irrigation, hydroelectric power production, and navigation, these reservoirs also are of significant value from the standpoint of municipal and industrial water supply, improved stream sanitation, fish and wildlife conservation, and recreation.

Improvement of the Missouri River in the interest of flood control and bank stabilization for an 18-mile reach of river extending from Sioux City, Ia., to Miners Bend, Nebr., and S. Dak., was authorized by the 1941 Flood Control Act and modified by the 1948 Flood Control Act. This improvement, consisting of dikes, revetment, and channel improvement, was completed in 1961. It would require only minor modifications to be effective if navigation were to be extended upstream from Sioux City.

A report completed in 1965 was concerned primarily with navigation and bank stabilization for the reach of the Missouri River from Sioux City to Gavins Point Dam. Appropriate consideration also was given to other related problems, including the possibility of extending navigation via the James River. There are 78 miles of open river between Sioux City and Gavins Point Dam. Between Gavins Point and the Montana-North Dakota state line, a distance of 775 miles, the main stem reservoirs occupy about 660 linear miles of the valley. Studies of the area indicate that erosion problems upstream from Gavins Point are localized, that the more significant problems are being corrected, and that navigation into this area is not economically justified at this time. A plan of development which was physically and economically feasible was formulated to provide extension of navigation to Yankton, protection against erosion in the reach from Sioux City to Gavins Point Dam, and development of associated fish, wildlife, and recreational values. The report covering this investigation has not yet been submitted to the Congress.

A study to determine the factors involved in converting the presently authorized 9-foot open-river navigation and bank stabilization project to a slackwater system by use of locks and dams, including hydroelectric power-generating facilities in the system wherever practicable, was authorized by the Congress in September 1959. The specified study reach extended from the mouth of the river to Yankton, S. Dak. Following a series of public meetings at seven of the larger communities along the river from Jefferson City, Mo., to Bismarck, N. Dak., it was concluded that the study should not be continued at this time.

The navigation system is shown in color on figure 61.

PROJECTIONS OF MISSOURI RIVER COMMERCIAL BARGE TRAFFIC

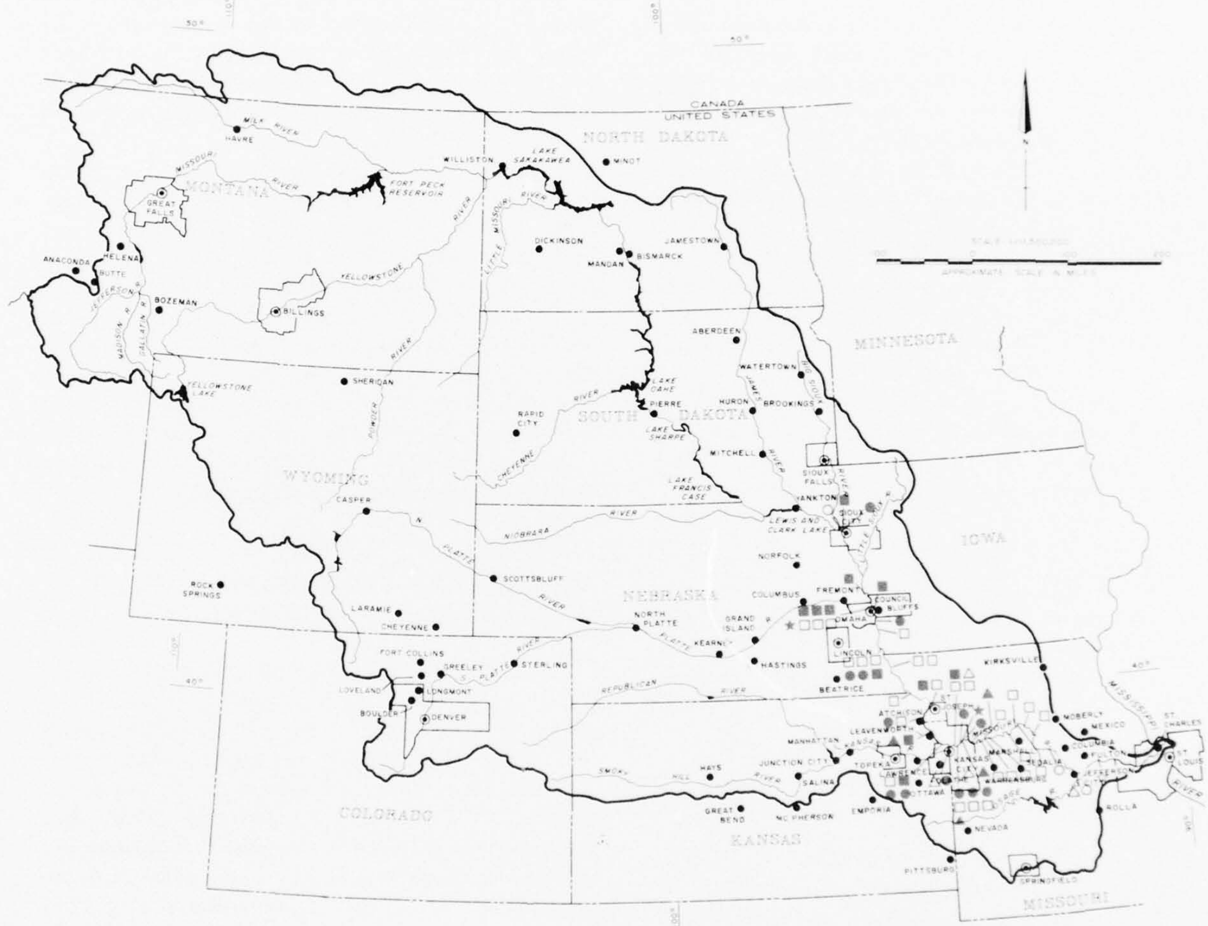
With the foregoing generalizations as basic considerations, the framework study of present and future needs for navigation in the Missouri Basin must translate the generalities into specific values in time and tonnage in order that the conclusions may have practicable significance. The present needs are reflected, and probably adequately expressed, in the available ton-mile statistics. The values, now available for a period of more than a decade, not only present factual data for recent years but also may be used as a basis of forecasting future needs and attainments. However, data such as the ton-mileage historical records do not represent a simple time-tonnage relationship. Many other influencing factors enter into the equation, with the result that the validity of a purely statistical treatment becomes the more questionable as the time component is extrapolated. Therefore, it is advisable to use several approaches to the problem.

Of the several alternative techniques used, the characteristics and limitations of available data become primary factors in determining the approaches selected. Some of the techniques yielded single-value estimates of future traffic, while others provided a range of high, medium, and low estimates. Major emphasis was devoted to developing projections to 1980, but estimates to the year 2020 are also included, since they are required for long-range planning purposes. Any projections extending that far into the future are subject to many unknowns, and must be considered highly tenuous. Thus, the projections for 2000 and 2020 essentially represent extrapolations of the 1980 estimates. These projections are intended to depict the likely direction and rate of change rather than the absolute level of future waterborne traffic. Periodic reevaluation and revision of the estimates, taking into account changing conditions, will be essential.

Missouri River barge traffic projections to 1980 were based on four methods including (1) parabolic extrapolation of the ratio of barge traffic to the gross product originating in the multi-state Missouri Basin, applied to the projected Missouri Basin gross product for 1980; (2) application of the projected rate of growth in total United States commercial waterway traffic to traffic on the Missouri River; (3) allocation of projected total

FIGURE 61

NAVIGATION SYSTEM ON THE MISSOURI RIVER



LEGEND

BASIN BOUNDARY

STATE OR NATIONAL BOUNDARY

10,000 TO 49,999 POPULATION

STANDARD METROPOLITAN STATISTICAL AREA

PERENNIAL STREAMS

LAKES AND RESERVOIRS

MISSOURI RIVER SERVICE AND CARGO FACILITIES

GRAIN	BULK, GENERAL
SAND, GRAVEL AND STONE	CEMENT
PETROLEUM PRODUCTS	YARD, REPAIR FACILITY, FUELING
TERMINAL, INCLUDING STEEL HANDLING	COAL AND LIGNITE

United States water traffic to the Missouri Basin on the basis of projected trends in the Missouri Basin-United States barge traffic relationships; and, (4) linear regression to 1980 of Missouri River historical trends, using alternative base methods.

Projection for 1980

The projection technique employing the relationship between ton-miles and gross product originating in Missouri Basin States has the greatest economic validity, since it reflects basic forces of demand and supply. The gross product originating in the basin must be transferred to its point of usage, either as a productive resource or end product. The supply side of the transportation market is, of course, provided by the various available or possible future transportation methods. With an increase in demand, if market requirements are to be met with little or no change in per-unit costs, supply must also increase. The shift in supply for barge traffic is assumed to increase at a decreasing rate. This is consistent both with historical trends as shown in table 127, and with the technoeconomic outlook for the transportation modes previously discussed. These considerations tend to support the gross product approach as the most valid.

Table 127 – COMMERCIAL BARGE TRAFFIC ON THE MISSOURI RIVER

Year	Length of Season (Months)	Tonnage (1,000 Tons)	Traffic (1,000 Ton-Miles)
1955	7	435	186,291
1956	7	319	132,614
1957	7	260	99,710
1958	7	596	242,986
1959	7	843	380,475
1960	8	1,441	658,818
1961	6-1/2	1,567	695,366
1962	8	2,210	659,843
1963	8	2,317	888,323
1964	8	2,552	1,077,543
1965	8	2,272	1,003,035
1966	8	2,557	1,167,947
1967	8	2,590	*

*Not available.

Projections for 2000 and 2020

Trends among economic factors influencing barge traffic flows on the Missouri River suggest that a declining rate of traffic growth can be expected for the future. The projections for 2000 and 2020, approximated by a logistic function, reflect this declining growth pattern. After finding the upper limit, the specific projection values for 2000 and 2020 were determined as regressed logarithmic percentages. It was found that, in each case, projections for the year 2020 were essentially 100 percent of the upper limit; therefore, the limit itself was used for the projection value. Curves were derived for high, medium, and low values based on the historical data and the adopted projection for 1980. The projections are summarized, together with historical data, in table 128. Traffic projections for the years 2000 and 2020 are essentially extrapolations of the historical and 1980 trends.

Data from the table have been consolidated into figure 62, in order to reflect the average projected traffic values. The resulting curve (averaging the high, medium, and low projections) is recommended for use in forecasting the future needs for navigation on the Missouri River below Sioux City.

The projections as derived should not be construed as firm forecasts of actual occurrences, but rather as likely ranges of probabilities provided that present and previous economic, political, and social trends and preferences continue to operate in the future as they have in the past. On the other hand, it may be found desirable to develop water resources in a manner differently from what has occurred previously. If so, these projections, which are simply tools or inputs for the planning process, may provide valuable guidance concerning reasonable expectations of water resource needs for commercial navigation purposes.

ADEQUACY OF THE EXISTING MISSOURI RIVER NAVIGATION PROJECT

The navigable channel of the Missouri River is a major artery of the Mississippi River system, which is connected with the Great Lakes and the St. Lawrence Seaway and with the Gulf Coast. Traffic surveys in 1950 indicated four million tons annually to be potentially available for commercial transportation on the river between Sioux City and the mouth. This estimate was increased to five million tons in consideration of future development. During the four-year period from 1954 through 1957, commercial tonnage averaged 330,000 tons annually. During the recent 4-year period, 1964 through 1967, commercial tonnage has averaged over 2.4 million tons, or an increase of about 700 percent. Tonnage figures for 1967 by commodity, upbound and downbound, are shown in table 129. An historical record of upbound, downbound, and total tonnage is shown in figure 63.

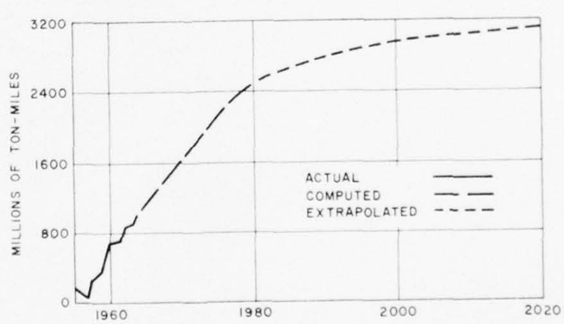
About two-thirds of the total present traffic is downbound farm grains, which account for 90 percent of the downbound traffic. Upbound traffic is comprised chiefly of chemicals, nonmetallic minerals, food products, stone products, petroleum products, and metal products. During the past four years, this upbound traffic has almost doubled in tonnage and in its relative importance to the overall traffic pattern.

Table 128 – COMMERCIAL BARGE TRAFFIC ON THE MISSOURI RIVER AND U. S. INLAND WATERWAYS FOR 1960 AND 1964, WITH PROJECTIONS (MILLION TON-MILES)

Geographical Unit	Historical		Projected			
	1960	1964	Value	1980	2000	2020
Missouri River[1]	659	1,078	Low	1,925	2,300	2,500
			Medium	2,605	3,200	3,300
			High	2,886	3,300	3,500
U. S. Inland Waterways[2]	220,000	250,000	Low	306,000	487,000	3
			Medium	447,000	900,000	3
			High	663,000	1,702,000	3

[1]Source: Developed by Midwest Research Institute. Historical data were adjusted from data reported in Waterborne Commerce of the United States, part 2, U. S. Army Corps of Engineers, various years.
[2]Includes the Great Lakes. Source of data: Historical from Statistical Abstract. Projected traffic from Hans H. Landsberg, Leonard L. Fishman, and Joseph L. Fisher, Resources in America's Future, Johns Hopkins Press, Baltimore, 1963, pp. 137-42, 651.
[3]Not available.

FIGURE 62
MISSOURI RIVER COMMERCIAL BARGE TRAFFIC



Typical Missouri River Tow

FIGURE 63
MISSOURI RIVER COMMERCIAL TONNAGE

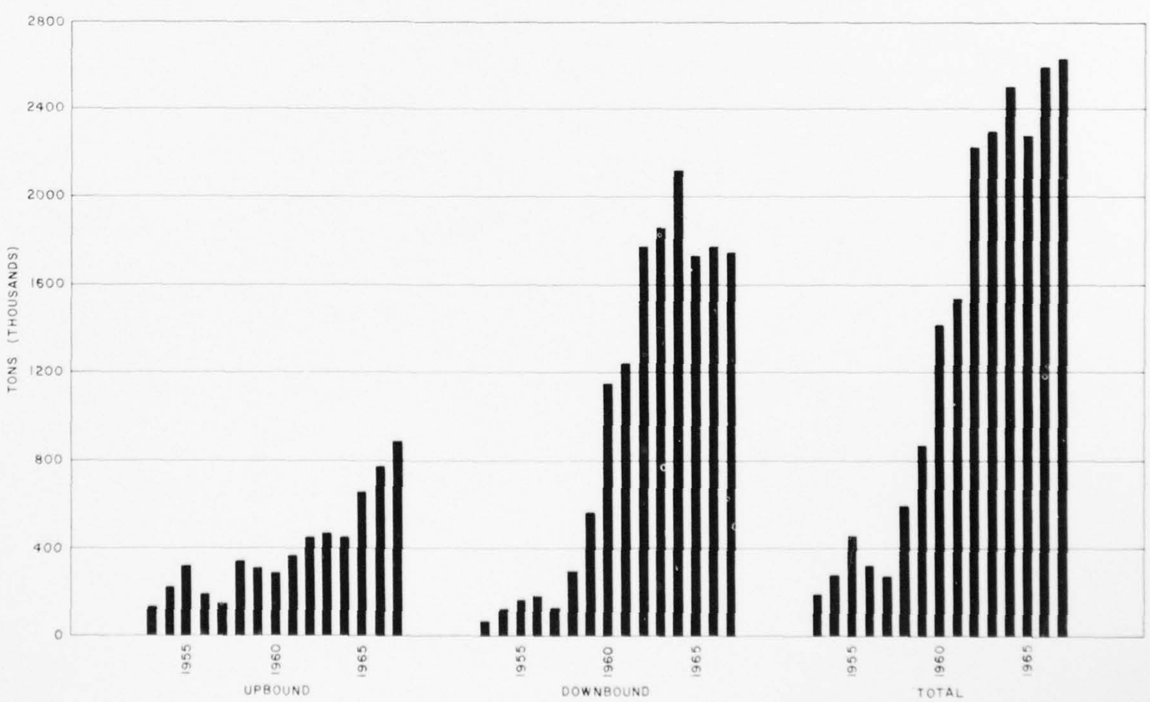


Table 129 – MISSOURI RIVER COMMERCIAL TONNAGE – 1967

Commodity	Sioux City to Kansas City			Sioux City to Mouth		
	Upbound	Downbound	Total	Upbound	Downbound	Total
Farm Products (Barley, Rye, Corn, Wheat, Sorghum Grains, and Soybeans)	0	552,139	552,139	0	1,557,512	1,557,512
Nonmetallic Minerals (Phosphate Rock and Salt)	103,025	0	103,025	157,780	0	157,780
Food and Kindred Products (Tallow, Wheat Flour, Animal Feed, Molasses, and Soybean Oil)	146,699	136,232	282,931	146,699	136,232	282,931
Textile Fibers (Twine)	800	0	800	1,600	0	1,600
Paper and Allied Products (Standard Newsprint)	6,211	0	6,211	6,211	0	6,211
Chemicals (Caustic Soda, Benzene, Paint, and Fertilizer)	231,936	3,284	235,220	277,627	3,284	280,911
Petroleum Products (Gasoline, Fuel Oil, and Naphtha)	0	0	0	88,418	13,060	101,478
Stone and Clay Products (Cement, Lime, and Materialite)	122,474	0	122,474	122,474	0	122,474
Metal Products (Iron and Steel Bars, Plate, Pipe, and Scrap)	27,001	0	27,001	77,076	1,770	78,846
Machinery	0	245	245	0	745	745
TOTAL	638,146	691,900	1,330,046	877,885	1,712,603	2,590,488[1]

[1]Grand Total, upbound and downbound, Missouri River.

Small grain production in the Missouri Basin was 40 million tons in 1964. This is expected to increase to 72 million, 91 million, and 118 million tons by the years of 1980, 2000, and 2020, respectively. The Missouri Basin will undoubtedly remain agriculturally oriented, and if so, downbound grain shipments will continue to dominate the barge traffic commodity shipment pattern. How much grain will reach the river ports in light of future transportation mode changes and innovation is conjectural. Based on the projections given previously, the capacity of the existing navigation project is considered to be adequate to accommodate both downbound and upbound barge shipments to the year 2020.

Harbor Facilities At The Kansas Citys

WATER REQUIREMENTS FOR MISSOURI RIVER NAVIGATION

There is no single flow rate that can be specified for navigation on the Missouri River below Sioux City because requirements vary with hydrologic changes and because deficiencies in flow can be offset to some extent by more extensive dredging in critical locations. On the basis of storage availability in the main stem reservoirs and from operating experience, indications are fairly firm that flow rates of 25,000 – 31,000 c.f.s. at Sioux City and 31,000 – 41,000 c.f.s. at Kansas City will permit satisfactory 9-foot navigation with nominal dredging.

Regulation of the upstream water supply can, for the most part, support navigation on the existing project below Sioux City. The upstream programs (assumed to be operative for regulation purposes) will have to be evaluated within the total framework plan before final conclusions can be reached as to meeting the future demands for water in support of downstream navigation.

MISSOURI BASIN NAVIGATION NEEDS

Recent studies indicate that extension of the upstream limit of navigation from Sioux City to Gavins Point is economically feasible. This can be accomplished by extending the existing project upstream, contracting the width somewhat, and requiring flows at Yankton, S. Dak., of about 5,000 c.f.s. less than those required at Sioux City. The average releases from Gavins Point during the navigation season would have to be increased only about 500 c.f.s. above the present releases. The net effect of such operation would be to reduce power generation in the winter, increasing it in the summer, with power revenue losses approximating $11,000 annually. The necessary increase in release rate and the relatively small losses of power revenues are not considered to be of major significance.

These same studies indicate that, although inland navigation could be extended upstream from Yankton, either by lockage of the main stem dams or use of the James River as a route into the upper part of the basin, there is no apparent need for movement of commodities by this mode of transportation. If future economic factors modify current projections of economic activity in the upper basin, consideration then could be given as to the need for extending navigation into the upper Missouri Basin. In addition, possible needs are indicated for providing navigable channels on the Kansas River below Turner, Kans., and on the lower 3 miles of the Grand River. Existing water supplies are adequate to support such improvements.

In summary, navigation in the basin is holding its own; the future seems to offer no great potential for a large growth. It is basically sound, and in its present level of maturity it serves to help stabilize other modes of transport. On this basis, and because of the integrated aspect of the channel and flood plain development, the future of navigation seems profitably and regionally beneficial.

CHAPTER 9

WATER QUALITY CONTROL NEEDS

Abundant supplies of clean water are necessary to support the American way of life. One key element to the effective management of water supplies for the beneficial use of man is the preservation and enhancement of the quality of waters in rivers, lakes, streams, and in ground-water aquifers. All water uses have a minimum quality requirement below which the water has limited value.

The many purposes that water serves are known as "beneficial uses." These include domestic water supply, industrial water supply (including cooling water), agricultural water supply (including irrigation), stock and wildlife watering (including refuges for waterfowl), propagation of fish and other aquatic life, swimming, bathing and water contact sports, boating and aesthetic enjoyment, water power, and navigation. Most waters have the potential for more than one use, although competing uses, institutional barriers, or pollution may limit such multi-purpose development.

Municipal drinking water supplies are judged in relation to the Public Health Service Drinking Water Standards based on bacterial, physical, and chemical characteristics. Industries are generally willing to accept, for most processes, water that meets drinking water standards. All recreational uses and especially swimming or similar whole-body contact sports require a water of high bacteriological quality.

GENERAL WATER QUALITY NEEDS AND PROBLEMS

This analysis of the needs and problems related to water quality management is based on the situation as of 1965 and economic projections. The data available vary from farily complete information regarding municipal waste loadings and treatment facilities to very limited waste loading data for industrial and other sources. The efficiency of existing waste treatment facilities was estimated on the degree of treatment provided, assuming continued good maintenance and operation.

Where data were not available, such as those for agricultural wastes and thermal discharges, estimates were made of existing situations and projections made for the future. The planning criteria adopted for the study established the water quality planning goals.

Determining water quality goals is a matter of public policy. Health is still a major consideration in water quality management, but safe water for drinking is no longer the sole consideration in water quality control. The overall costs of water pollution prevention and control must, therefore, be weighed against the overall benefits. In an increasingly crowded world, a high degree of effective treatment of all wastes represents a minimum approach to most water quality management problems. Already on the horizon is complete wastewater renovation in an ever-increasing number of situations.

Expanding population and the consequent pressures on national water resources have led inevitably to Congressional actions. Earlier efforts to confront water problems were further updated at the national level by the Water Quality Act of 1965 and the Clean Water Restoration Act of 1966. In this legislation, Congress established as a policy . . . "to recognize, preserve, and protect the primary responsibilities and rights of the States in preventing and controlling water pollution, to support and aid technical research relating to the prevention and control of water pollution, and to provide Federal technical services and financial aid to State and interstate agencies and to municipalities in connection with the prevention and control of water pollution . . ." The Act further states that "Nothing in this Act shall be construed as impairing or in any manner affecting any right or jurisdiction of the States with respect to the waters (including boundary waters) of such States."

To further implement these objectives, and in harmony with the national legislation, the States developed water quality standards which have been generally accepted by the Federal Government. These standards (objectives) have formed the basis for determining the water quality control needs, the end to which this chapter is directed.

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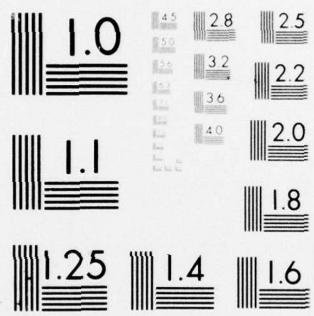


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Clean streams in a pleasant environment provide enjoyment for the entire family.

MAJOR TYPES OF WATER POLLUTION

Changes in natural water quality may be attributed directly to man's uses of water and indirectly to his activities on the land from which natural runoff is derived. The primary waste sources are domestic, agricultural, and industrial return flows. At present domestic and industrial wastes receive varying degrees of treatment before discharge. Most of the wastes from agricultural activities and surface runoff enter the waterways without treatment.

Industrial wastes vary, depending on the type of industry, and present a broad spectrum of pollution problems. Mining and chemical plant wastes often contain toxic substances, including radioactive material. Food processing plant wastes have high organic loadings. Some industrial plant wastes include oil and other detrimental insoluble materials. Other industries require large amounts of water for cooling purposes, such as the generation of thermal-electric power. The higher temperatures of return flows from these plants may significantly affect the biologic regime of streams.

Currently, the consumptive depletion of surface water in the basin is about 11.7 million acre-feet. At the present stage of development and rate of use accounting for such depletions, the average annual outflow from the basin at the mouth of the Missouri River is about 53.6 million acre-feet. This indicates a natural water supply of 65.3 million acre-feet. Disregarding the effects of rainfall and assuming a salt balance and no depositing of dissolved solids due to evaporation, it is estimated that the dissolved solids concentrations in the surface-water outflow have been increased about 20 percent, to a level of about 390 mg/1.

Streamflows contain dissolved solids contributed through natural overland runoff and ground-water accretion. Any consumptive depletion of water increases the dissolved solids concentration in the residual flows.

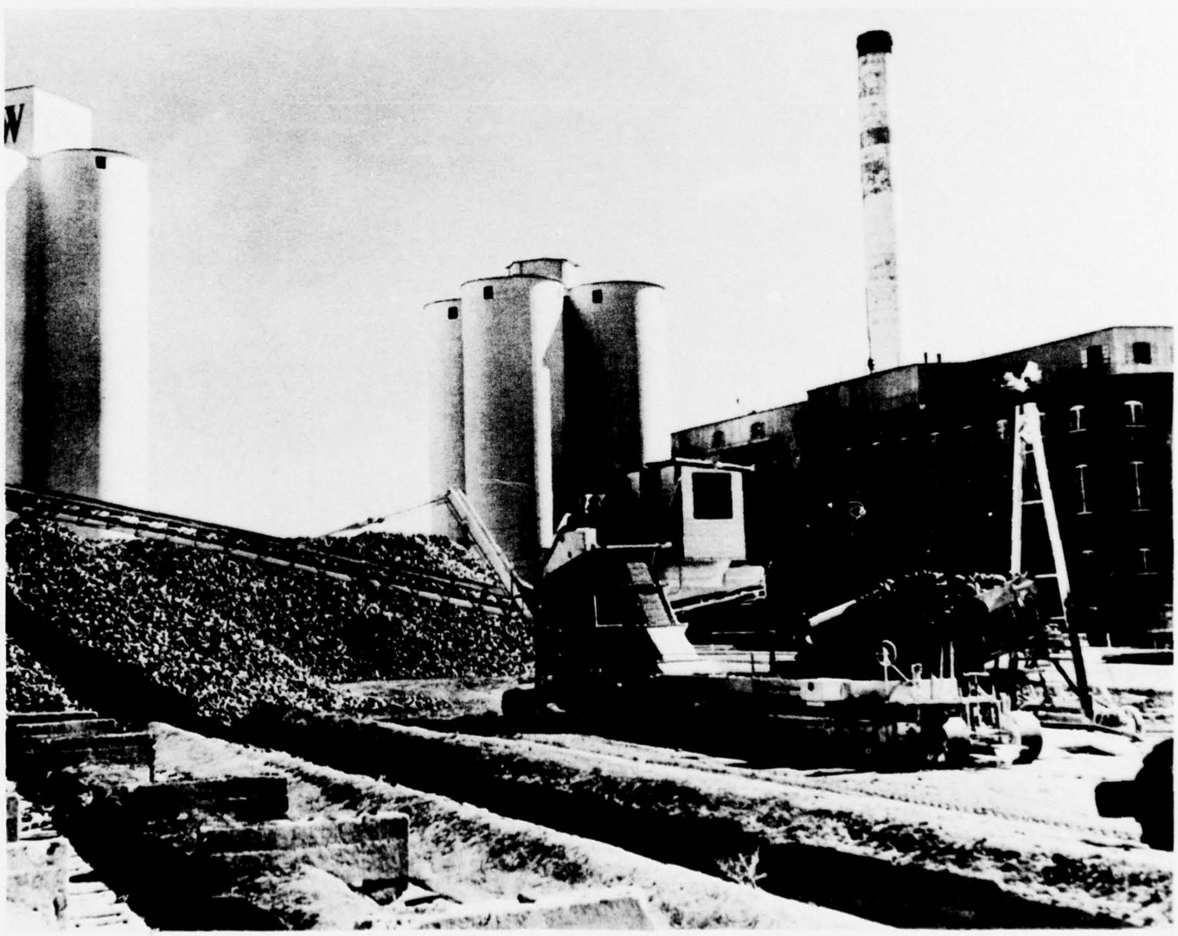
Return flows from 7.4 million acres of irrigation are also a contributing factor in the streamflow dissolved-solids concentrations. Irrigation return flows must convey the content of salts in the water applied back to the streams to prevent damaging salt accumulations in the soil profile. In addition, there may be some leaching of accumulated salts and fertilizers from the soil. Agricultural operations also are contributors of pesticides, fertilizer nutrients, and silt loadings. Farm animal wastes may seep into aquifers or enter streams or lakes in surface runoff. Over-fertilization of some lakes and reservoirs by inorganic nutrients, such as nitrogen and phosphorous compounds, has speeded up the aging process known as eutrophication.

Biologic and Organic Parameters

Biological agents may be primary pollutants or corollary pollutants. Primary pollutants comprise biota that are added directly to water as the result of man's activities; for example, enteric bacteria or viruses from sewage or animal wastes. Corollary pollutants represent indigenous living material that interferes with the beneficial uses of water, either by natural processes and growth, or, by stimulation from man's activities. A typical example is the algal blooms stimulated by nitrates and phosphates from waste discharges.

Organic waste matter and some of the complex mineral portions of these substances are utilized as sources of energy by a succession of living things. The decomposition or decay of such materials may be either by aerobic or anaerobic processes. Whenever waste loadings are added to a stream the dissolved oxygen in the water is reduced and this reduction may become critical to aquatic life. Bacterial and organic pollutants are largely contributed by decayed organic material, such as vegetation, and fecal material from man and warm-blooded animals.

There has not been a systematic program for obtaining area-wide biologic and dissolved oxygen data. There have been studies on the South Platte River, the Blue River, and other rivers, including the Missouri. Other



Food processing plants, such as this sugar beet plant, are potential sources of stream pollution.

data that are available have been obtained in association with limited problem areas.

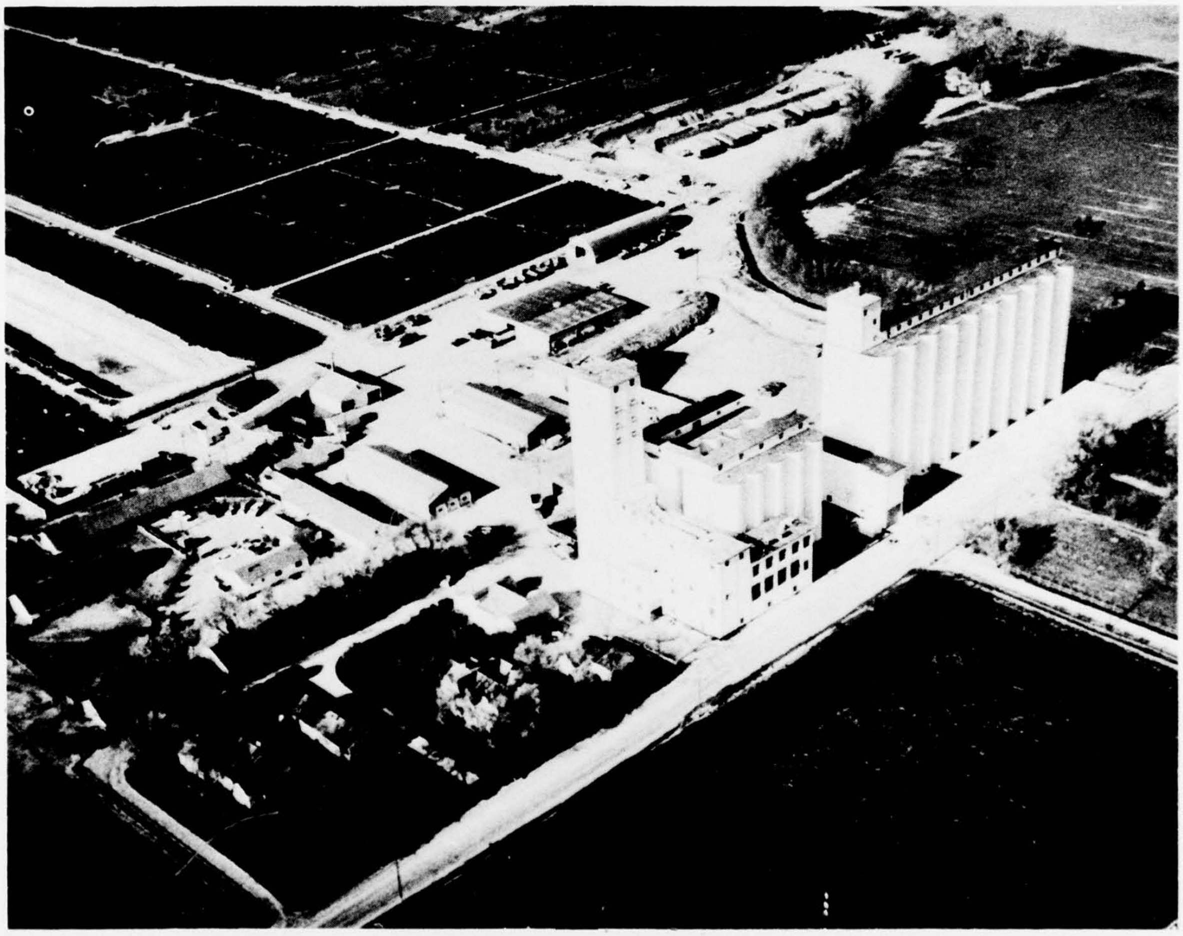
Inorganic Materials

All flowing or percolating water contains dissolved salts picked up from the soil and rocks of the earth's mantle. The soils of the high plains area in western portions of North Dakota, South Dakota, Nebraska, and Kansas make major contributions to the dissolved solids buildup of surface waters. Salt concentrations (TDS) are increased when there is a consumptive use of water without an accompanying use of the salt, as for irrigation.

A change in the chemical quality may result from seasonal effects or periods of heavy usage. During periods of ice cover or extreme low flows, the basic stream flow may be derived from ground water with different quality characteristics. This occurs in many of the smaller streams of the high plains.

Water quality data (chemical) have been obtained from many sampling stations in the Missouri Basin, on a continuous basis, since 1951. These basic data and projected depletions were used in estimating total dissolved solids concentrations in future water supplies.

An area of increasing concern is that of agricultural, domestic, and industrial chemicals as a source of water pollution. The pollution problems related to fertilizers, pesticides, and other commercial chemicals, have not been fully evaluated.



Large cattle feedlots add to the pollution problems of the basin, and measures have been initiated to accomplish effective control.

Sediment

The Missouri Basin is a diverse area, varying from flat and including non-drainage lands, to high mountains; from highly erodible soil to rock; and from subhumid to semiarid climate. Within these general physical diversities, there are areas with special localized characteristics. Thus, it is impossible to develop simple formulas for determination of sediment contributed to streamflow within the basin.

All streams transport some sediments resulting from the natural erosion process. The Missouri River and many of the tributaries were muddy streams at the time of settlement. However, the cultivation and intensive grazing of erodible lands undoubtedly have increased the sediment loads over natural conditions, in many streams. Poor irrigation practices also contribute sediment in return flows to some streams. While sediment load measurements in streamflows have been obtained in recent years, there is no accurate basis for comparison with the stream loads in their natural state. Modern soil and water conservation, improved grazing practices, and the trapping of sediment in reservoirs are reducing the sediment load in the Missouri River and in many of the tributary streams. However, there are still many streams in the basin with high sediment concentrations that make the water unsatisfactory for most uses. Recent studies have revealed that many agricultural chemicals, such as some pesticides and herbicides, become attached to sediment particles and as such are a form of stream pollution.

WATER QUALITY STANDARDS AND PLANNING CRITERIA

All of the basin States, in harmony with the Water Quality Act of 1965 as amended, have developed enforceable water quality standards. These standards contain three main elements: A listing of present and future beneficial water uses, water quality criteria, and a plan for implementation and enforcement. Administration of the water quality standards program is directed toward two simple objectives: To enhance the quality and value of the water resources, and to establish policy for the prevention, control, and abatement of water pollution.

Each Missouri Basin State has developed as a part of its Water Quality Standards a set of water quality criteria for beneficial water uses. The following is a summary of selected criteria:

Dissolved Oxygen Criteria

1. For cold-water fisheries, most States require a minimum of 6 or 7 mg/l.
2. For warm-water fisheries, requirements are generally 5 mg/l.
3. For domestic water supplies, minimum requirements in some States are 3 to 4 ng/l.

Total Dissolved Solids Criteria

1. For domestic water supplies, the requirements vary from 500 to 1000 mg/l.
2. For agricultural use, the limits are generally from 700 to 1500 mg/l.

Temperature Criteria

1. For domestic water supplies, usually not designated.
2. For cold-water fisheries, the maximum temperature criteria vary from 65° to 70°F. Other State limitations are: (a) No material increase in water temperature; (b) no more than 4°F temperature change; (c) no more than 5°F change; (d) no more than 2°F rise for water temperatures up to 67°F and a 0.5°F rise limitation on temperatures above 67°F.
3. For warm-water fisheries, the maximum temperature criteria vary from 73°F in the winter months to a maximum of 93°F in summer periods. Other State limitations are: (a) No material increase in water temperature; (b) a limit of 4°F rise in water temperature for waters with temperatures between 32°F and 85°F; (c) no greater than 0.5°F rise for waters with temperatures above 85°F; (d) maximum temperature rise of 5°F during summer months and 10°F during winter periods; (e) a maximum temperature rate of change no greater than 2°F per hour.

The State water quality standards were established after the comprehensive framework study was well underway. Prior to the existence of State standards, criteria were established for framework planning purposes which set the following requirements that are equal to or are compatible with the established State water quality standards:

1. A dissolved-oxygen concentration of 7 mg/l for cold-water fisheries and 5 mg/l for warm-water fisheries and other surface waters.
2. An average total dissolved-solids concentration of 500 mg/l as desirable (recommended maximum for drinking water) and up to 1500 mg/l as usable.
3. A limit of five degrees (F) for in-stream temperature increase resulting from thermal discharges.

These planning criteria were used in evaluating the present and future water quality management needs. The equivalent of "secondary" treatment by all wastes with a Biochemical Oxygen Demand (BOD) removal of 85 percent by 1980, 90 percent by 2000, and 95 percent by the year 2020 was established as the planning criterion. The loading resulting from discharge of treated waste was estimated for industrial discharges by considering their usual domestic waste equivalent.

Complexities of the various types of industrial waste treatment processes for the adequate handling of special wastes cannot be spelled out in this study. As used herein, the terms designating degree of treatment are meant to imply such treatment as is necessary to achieve the reduction of waste loading usually attributed to conventional primary, secondary, or tertiary treatment processes. The assumption was made that industry would not release toxic or other materials with their liquid wastes in such quantities as to contravene the water quality standards.

WATER QUALITY DATA

Water quality data obtained within the basin have been responsive to problems encountered in the use of water. Historically and aside from bacterial and biological aspects, the principal concern has been the dissolved solids and sediment concentrations as they affect domestic, industrial, irrigation, and other beneficial uses.

Temperature data have been obtained at several stream sampling stations within the river basin and, in general, the water temperature tends to approach the average daily air temperatures except as affected locally by ground water and thermal discharges. Estimates have been made of the effects on water quality of single-pass cooling systems for thermal-electric power plants.

There has not been a systematic program for obtaining area-wide biologic, bacteriological, and dissolved oxygen data. The data that are available have been obtained in association with problem areas. There are zones with high coliform densities immediately downstream from most principal waste outfalls, many animal feedlots, and some industrial sewers. There are also marked increases in coliform densities following heavy surface runoff of agricultural and urban areas. Table 130 summarizes the maximum values from a coliform study.

Table 130 – MISSOURI RIVER – WATER POLLUTION SURVEILLANCE DATA COLIFORM STUDY OCT. 1, 1964 TO SEPT. 30, 1965

Station[1]	Summary of Maximum Values			
	Oct.-Dec.	Jan.-Mar.	Apr.-June	July-Sept.
	(Coliform Bacteria per 100 Ml.)			
Williston, N. Dak.	12,000	2,500	2,500	5,000
Bismarck, N. Dak.	1,100	1,400	1,200	1,700
Yankton, S. Dak.	100	100	4,200	1,700
Omaha, Nebr.	23,000	50,000	85,000	150,000
St. Joseph, Mo.	280,000	100,000	200,000	150,000
Kansas City, Kans.	180,000	130,000	140,000	240,000
Kansas City, Mo.	700,000	1,000,000	600,000	1,000,000
St. Louis, Mo.	80,000	60,000	36,000	36,000

[1]Specific sampling locations not shown.

Data on dissolved solids have been obtained from many sampling stations in the basin on a continuing basis since 1951. Utilizing these data, the estimated present average annual total dissolved-solids concentrations for certain key locations are shown in table 131. Similar data derived for critical constituents such as sulfates, chlorides, and sodium absorption ratios are included in the appendix "Hydrologic Analyses and Projections."

Sediment data are available from many streamflow stations and from reservoir sedimentation surveys in the basin. Those data are presented in the appendix "Hydrologic Analyses and Projections." Specific information on special undissolved solid constituents such as oil refinery wastes, mine wastes, and debris are limited. Usually, unsatisfactory conditions are detected by observation, and appropriate corrective measures are taken.

Ground water is an important water supply source serving many uses within the basin. Ground-water quality is, therefore, of concern to residents of the basin. For the most part, this concern has been with the dissolved-solids concentrations and considerable data have been obtained in this field. These data are summarized and discussed in the appendix "Hydrologic Analyses and Projections." As illustrated there, dissolved-solids concentrations in the ground waters vary from less than 250 to more than 4000 milligrams per liter. Sufficient ground-water quality data have been obtained or analyzed throughout the basin to identify deteriorating quality trends, except in a few local areas, and there is a basic need for more dissolved-solids and bacteriological data, particularly in the areas experiencing large withdrawals for irrigation.

WASTE LOADINGS

The major types of water pollution and their general occurrence have been described. When available data were not adequate to estimate waste loadings, assumptions were made to determine associated water and treatment requirements.

Unsatisfactory conditions, for the most part, have been associated with intermittent events such as droughts, flood runoff, peak seasonal industrial activity, and accidental pollutant spills. However, there are serious continuing conditions developing in certain areas of the basin.

Table 131 – ESTIMATED TOTAL DISSOLVED SOLIDS CONCENTRATIONS AT KEY LOCATIONS – MISSOURI BASIN

Points of Analysis	1970 Flow Conditions: Average Annual Flow	Total Dissolved[1] Solids Concentration
	(1000 Ac. Ft)	(Mg/l)
Missouri River		
Williston, N. Dak.	16,100	430
Sioux City, Ia.	21,500	470
Omaha, Nebr.	22,600	470
Kansas City, Mo.	36,000	400
Hermann, Mo.	53,200	390
Cheyenne River		
Eagle Butte, S. Dak.	540	1,005
James River		
Scotland, S. Dak.	210	500
North Platte River		
Lisco, Nebr.	740	500
South Platte River		
Julesburg, Colo.	200	1,480
Platte River		
@ mouth (Nebr.)	2,700	390
Kansas River		
@ mouth (Kans.-Mo.)	4,200	390
Osage River		
@ mouth (Mo.)	6,600	245
Grand River		
@ mouth (Mo.)	2,600	210

[1] Estimated average annual TDS concentration in milligrams per liter. Seasonal monthly average variations in some areas range from one-half to twice the annual values. Below major storage reservoirs, stream-flow regulation tends to reduce the variation of concentration.

A census of the reported municipal and industrial waste outlets and treatment facilities was made and streamflow needs at the waste outlet were developed for purposes of framework planning. However, a point-by-point description of these needs is too voluminous to include in this appendix.

In 1965, there were 1,773 municipal water systems in the basin serving 6,280,000 people. Of the municipalities with water systems, 465 had no sewer systems, 1,009 provided secondary treatment facilities, 198 had primary treatment, and 101 provided no treatment. The estimated gross pollution load before treatment, including the industrial plants served by the municipal sewerage system, was 16.8 million population equivalent (P.E.). The estimated residual pollution of the wastes after the existing treatment was 9.1 million P.E. This existing situation, with an assumption of a requirement for 85 percent B.O.D. treatment removal, would require the enlargement of 1,009 secondary treatment facilities, the addition of secondary to an existing 198 primary treatment facilities, and the construction of 566 new secondary treatment facilities. Sewage collection systems are needed for 465 places. Table 132 shows a summary of this analysis by subbasins.

Industrial directories for 1965 list 3,409 water-using industries in the basin. Limited data were available for only 602 industries with separate waste systems. The number of industries connected to municipal systems is unknown. In all, the 602 industrial plants with separate outlets contributed over 10 million P.E. of wastes to streams within the basin. Of this total, 282 plants had adequate treatment facilities, 111 provided inadequate treatment, 195 provided no treatment, and 14 did not report the treatment provided. About 40 percent of the plants reporting was classed as processors of food and kindred products, 13 percent mining, and 11 percent petroleum and refining. The remaining 36 percent comprised general manufacturing classifications.

Table 132 – MUNICIPAL WATER AND SEWERAGE SYSTEMS AND REPORTED WASTE LOADINGS AS OF 1965

Subbasin	1969 Pop.	Water Systems: Number	Water Systems: Pop. Served	Sewerage Systems: None	Sewerage Systems: Treatment: None	Sewerage Systems: Treatment: Primary	Sewerage Systems: Treatment: Secondary	Waste Load: Before Treatment	Waste Load: As Discharged
	(Thousand)	(Actual)	(Thousand)	(Number)				(Thousand P.E.[1])	
Upper Missouri	298	95	215	15	0	14	66	430	230
Yellowstone	270	65	194	8	1	18	38	240	90
Western Dakota	299	110	186	18	3	14	76	380	90
Eastern Dakota	670	269	418	48	20	33	168	810	100
Platte-Niobrara	1964	340	1876	98	22	52	168	7570	4380
Middle Missouri	1293	255	941	73	42	22	118	3370	1930
Kansas	903	348	629	117	3	30	198	1160	630
Lower Missouri	2216	291	1821	88	10	15	178	2840	1650
Missouri Basin	7913	1773	6280	465	101	198	1009	16800	9000

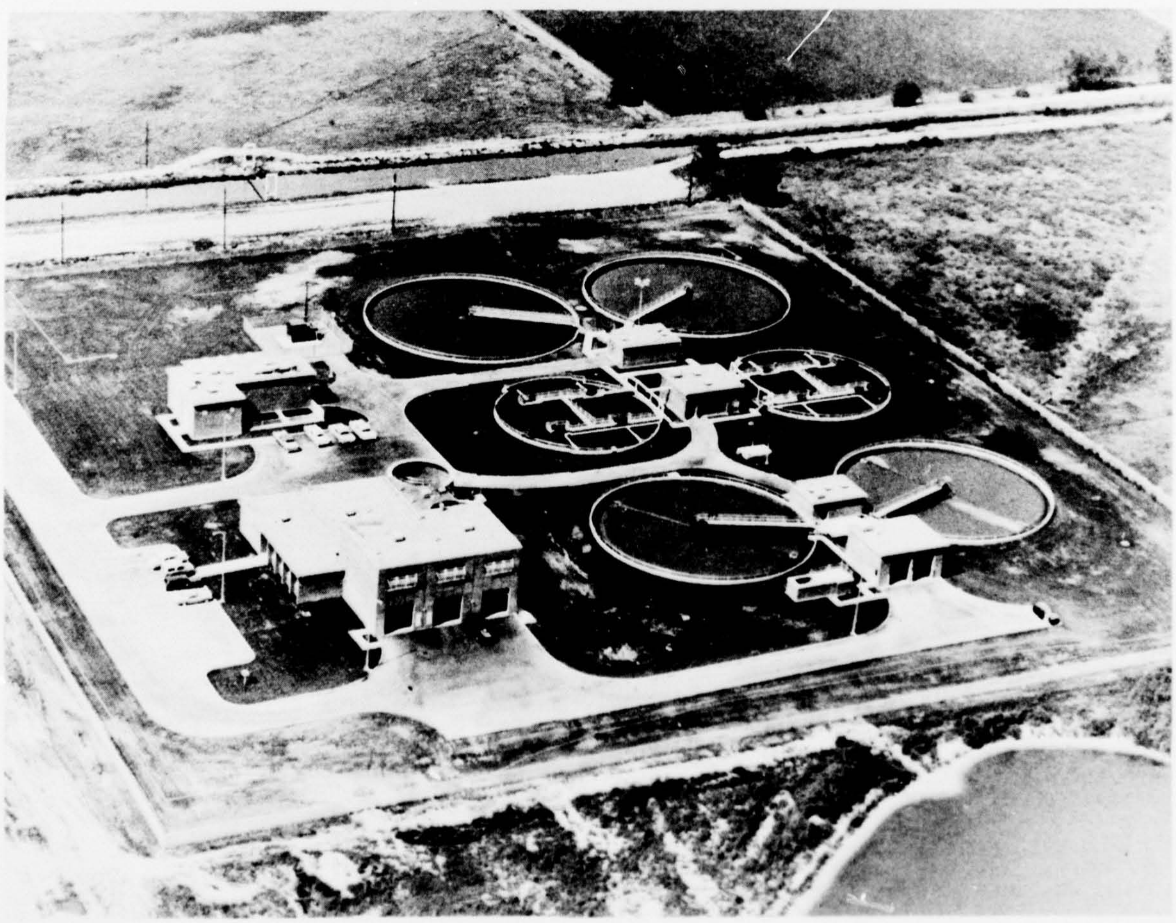
[1] The waste loading includes all industrial wastes reported discharging to municipal systems.

Prior to the advent of large cattle feedlots, there was little cause for public concern about pollution from livestock. Today, when 100 to 200 head of feeder cattle may be concentrated on one acre, it is of grave concern, since the organic waste from a single 1,000-pound cow approximates that from 16 humans. The pollution situation is similar in the case of confined feeding of poultry and hogs.

The magnitude of potential pollution from livestock waste depends on the size and location of the feedlot in relation to the receiving stream, the slope of the land, management of solid wastes, handling and treatment of liquid wastes, and general climatic conditions. Considering all of these factors, it is estimated that 30 percent of the basin's present feedlots can contribute to stream pollution, and that 5 to 10 percent of the total volume of wet and dry animal wastes from these lots reaches live streams. This estimate is based on the current status of feedlot management.

Assuming that one-third of the feedlots can contribute and that 10 percent of the generated waste reaches live streams, the total waste load now contributable by the livestock feeding industry may have a population equivalent of about 2 million.

In addition to feedlot waste problems, agricultural operations can result in pollution due to leaching and washing of pesticides, soil erosion, and the concentration of dissolved solids in irrigation return flows. The extent and impact of some of these problems are much more difficult to assess than with municipal and industrial wastes; hence, no overall evaluation has been made in these studies. It was assumed that the total amount of salts in irrigation streamflow diversions would be conveyed back to the streams. Because of the water depletions involved in irrigation and other consumptive uses, this has the effect of increasing the dissolved solids concentrations in both the irrigation return flows and the residual streamflow. On this basis, the potential impact of the consumptive uses of streamflow on future dissolved solids has been accommodated. However, it is recognized that current technology does not offer an economical method for reducing the dissolved solids content of these flows.



This waste-water treatment plant typifies the growing number of modern plants reducing stream pollution.

There may be instances where augmented flows will be required to reduce concentrations of TDS. However, only the streamflow requirements for dissolved oxygen and temperature were estimated — those for TDS were not. The TDS requirements are not additive to those for oxygen or temperature and only where the requirement for the control of the TDS concentration exceeds the water required for maintaining proper dissolved oxygen levels or temperature, would the requirements for TDS govern. Computations were made to determine the streamflow necessary at each waste effluent outfall where anticipated residual effluents would be received. These voluminous data were furnished in total to the planners, but are not included herein.

SUMMARY

Throughout the Missouri Basin there is a need to improve and upgrade municipal sewerage and treatment systems. Of the 1,773 communities with water systems, only 1,308 have sewerage systems. Of these 1,009 provide secondary treatment and 198 provide only primary. The estimated gross waste load, including connected industries, is about 16.8 million P.E., which is reduced to some 9 million P.E. by existing treatment and discharged into streams. The streams cannot always assimilate this residual; in fact, there are reaches which at times have less than a satisfactory dissolved oxygen level by accepted standards. In addition, the effluents contribute to unsatisfactory coliform levels in streamflows. For planning purposes, and in compliance with currently accepted standards, it was assumed that municipalities would be required to provide sewerage systems and treatment facilities to remove 85% of the BOD by 1980, 90% by 2000, and 95% by 2020. Many of the existing and potential industrial plants are expected to connect to municipal sewerage systems. Table 133 shows the estimated municipal waste loading, treatment objectives, and residual waste to be discharged to the basin's streams.

Table 133 – MUNICIPAL WASTE TREATMENT REQUIREMENTS

Year	Waste Load			B.O.D. Removal	Waste Loads in Effluent Discharged
	Domestic	Industrial	Total		
	(Thousand P.E.)[1]			(Percent)	(Thousand P.E.)[1]
1980	8.982	15.588	24.570	85	3.686
2000	13.363	23.152	36.515	90	3.652
2020	18.840	32.905	51.745	95	2.588

[1] P.E. – Population equivalent.

To accomplish the 85, 90, and 95% removal of BOD of the municipal waste loads will require upgrading of existing secondary plants, the addition of secondary treatment facilities to existing primary plants, and the construction of new secondary and tertiary plants throughout the basin. Table 134 summarizes the projected loading and treatment needs (by subbasin) for the years 1980, 2000, and 2020. It will be noted that, after treatment needs are met, there will still be a residual BOD to be assimilated by streamflow. This will require sufficient flow to maintain a satisfactory dissolved-oxygen level in accordance with accepted standards. The streamflow required at each effluent outfall was estimated and furnished to the planners as "a need to be met." The voluminous data covering location and streamflow estimates are included in unpublished technical reports, as they are beyond the scope of this appendix.

The 1965 Industrial Directories list 3,409 water-using industries in the basin. Limited data were made available for only 602 industries with separate waste systems. Some of the industries are connected to municipal systems but the exact number is unknown. There are many industrial effluent outfalls discharging untreated or partially treated waste to streams, thereby contributing to unsatisfactory stream quality. Since many of the existing and potential industrial plants are expected to connect with municipal sewerage systems, their waste load treatment needs have been included in the municipal treatment needs. Others are expected to maintain separate outfalls. To the extent possible, these were estimated and the streamflow requirements to maintain satisfactory dissolved-oxygen levels after the 85, 90, and 95 percent-treatment were furnished the planners as "needs to be met." Major industrial plants such as sugar beet factories, paper mills, oil refineries, fertilizer plants, meat packing plants, etc., were projected as to location and their streamflow requirements were estimated. Undoubtedly many potential smaller plants were not included. These needs will require more detailed study to assure a satisfactory streamflow water quality control. While streamflow requirements to assimulate the residual load after treatment were estimated for the industrial plants not connected to municipal sewerage systems, the treatment facilities were not included as needs to be met. It was assumed these would be private production costs in compliance with State water quality standards.

Table 134 – MUNICIPAL WASTE TREATMENT FACILITY NEEDS BY TARGET DATES

Subbasin	Total Population (1000)	WASTE TREATMENT SYSTEMS		WASTE TREATMENT NEEDS (1000 PE)[1]				TREATMENT FACILITY NEEDS REQUIRED BY TARGET DATES		
		Number	Population Served (1000)	Gross Load	Removed by[2] Existing Facilities	Estimated Additional Load to Be Removed	Residual Load[3] After Treatment	Enlarge Secondary Facilities	Add Facilities	Construct New Facilities
1965-1980										
Upper Missouri	368	100	301	600	228	282	90	66[4]	14	20
Yellowstone	352	65	308	385	89	238	58	38	18	9
Western Dakota	357	110	269	540	91	368	81	75	14	21
Eastern Dakota	778	275	602	1,200	101	919	180	168	33	74
Platte-Niobrara	3,060	350	2,900	10,400	4,380	4,460	1,560	168	52 Secondary	130 Secondary
Middle Missouri	1,467	300	1,330	6,000	1,932	3,168	900	118	22	160
Kansas	1,060	350	850	1,570	625	709	236	198	30	122
Lower Missouri	2,991	388	2,422	3,875	1,650	1,644	581	178	15	195
Missouri Basin	10,433	1,938	8,982	24,570	9,096	11,788	3,686	1,009	198	731
1980-2000										
Upper Missouri	472	105	416	830	510	237	83	90[4]		5
Yellowstone	493	70	465	580	327	195	58	60		5
Western Dakota	463	120	390	780	459	243	78	100		10
Eastern Dakota	997	300	920	1,760	1,020	564	176	240		25
Platte-Niobrara	4,612	400	4,500	16,600	8,840	6,100	1,660	270		50 Secondary
Middle Missouri	1,855	310	1,750	7,890	5,100	2,001	789	200		10
Kansas	1,355	375	1,250	2,200	1,334	646	220	250		25
Lower Missouri	4,098	543	3,672	5,875	3,294	1,993	588	290		155
Missouri Basin	14,345	2,223	13,363	36,515	20,884	11,979	3,652	1,500		285
2000-2020										
Upper Missouri	605	170	530	1,060	747	260	53		105	65
Yellowstone	690	100	620	775	522	214	39		70	30
Western Dakota	612	200	540	1,080	702	324	54		120	80
Eastern Dakota	1,305	400	1,160	2,320	1,584	620	116		300	100
Platte-Niobrara	6,940	500	6,660	26,640	14,940	10,368	1,332		400 Tertiary	100 Tertiary
Middle Missouri	2,430	400	2,280	8,200	7,101	689	410		310	90
Kansas	1,746	700	1,580	2,920	1,980	794	146		375	325
Lower Missouri	5,732	1,400	5,470	8,750	5,287	3,025	438		543	857
Missouri Basin	20,060	3,870	18,840	51,745	32,863	16,294	2,588		2,223	1,647

[1] Industrial waste sources, reported connected to municipal sewerage systems, are included.
[2] Estimates for 1980 include upgrading of 1965 waste treatment facilities to provide for 85% BOD removal of estimated 1980 waste loadings. Estimates for 2000 and 2020 are for upgrading and enlarging waste treatment facilities to provide more effective treatment of the projected waste loadings. (90% by 2000 and 95% BOD removal by the year 2020).
[3] Population Equivalent of treated wastes discharged to streams.
[4] Plants built late in preceeding time frame would be designed for loading of the following target date.

Cattle feeding in commercial lots is a major industry in the basin and is projected to expand. Instances of unsatisfactory streamflow quality conditions have been identified with feedlot operations. The amount of the present waste load contributed to streams is not known, but the potential as a contributing source of pollution is recognized.

Current trends and State and Federal statutes indicate that any feedlot operation which is an identified source of streamflow pollution will have installed waste-control facilities by 1980, or sooner. Such control will consist primarily of preventing foreign water from entering the feedlots, composting the solid waste, and providing holding basins for any solid or liquid waste leaving the lot. As these basins fill, the liquid material will be pumped onto adjacent land in controlled quantities. Solid waste, if not composting within the feedlot, will be spread on agricultural land.

It is the objective that nearly 100 percent control of animal waste will be achieved by 1980. Registration or certification of large feedlots is now mandatory in most basin States and by 1980 will be required in all States. Before existing large lots are approved, a satisfactory system of controlling wastes is required. State statutes provide for mandatory control of waste from the small lots if it is demonstrated that they are a pollution source. In estimating the water quality control needs it was assumed that by 1980 compliance with State standards would achieve the nearly 100 percent control of animal wastes. Control and treatment requirements were assumed as private production costs and were not included as needs to be met. No specific streamflow requirements were estimated, although future studies may show that there are residuals which will have to be assimulated.

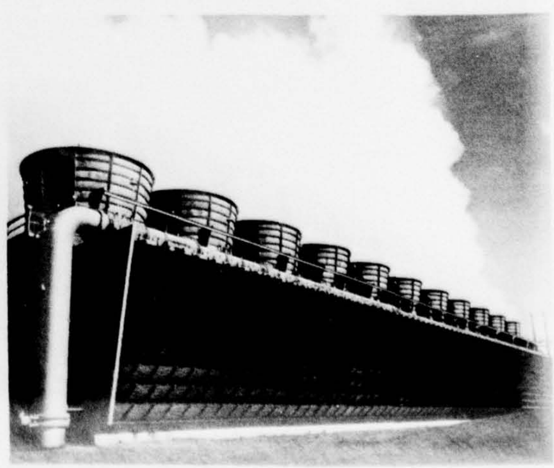
Another problem in the basin is the unsatisfactory levels of undissolved solids in streamflow. These include pesticides, other chemicals, and sediments contributed to streams largely by human activity. Varying levels of unsatisfactory conditions have been identified at times for several locations; however, the seriousness of this problem has not been fully appraised nor has the specific source of the pollutants been identified. State quality-of-water standards provide a criteria for better identification, control, and prevention of this type of pollution.

An estimate as to what the basin needs in order to maintain satisfactory levels of biologic water-quality control was based on the available data. It is expected the surveillance and control embodied in the State water-quality standards will improve and will prevent degradation from current conditions of the biologic quality of the basin's streams. As provided in the Water Quality Act and the State water quality standards, systematic stream sampling and analysis is a basic need if all the problems are to be identified.

Currently, there are about 24.6 billion kwh of power generated within the Missouri Basin of which 12.9 billion is generated by thermal-electric plants utilizing flow-through cooling water. It is projected that thermal-electric generation, utilizing flow-through cooling, will increase to 27.2 billion kwh by 1980, 44.3 billion kwh by 2000, and 53.7 billion kwh by 2020. Such plants, utilizing flow-through cooling, are located in every subbasin and in total divert 1.7 million acre-feet of water annually. It is estimated the flow-through cooling diversion demand will increase in every subbasin except the Platte-Niobrara and the Kansas. The diversion demand is projected to be 3.0 million acre-feet by 1980; 4.0 million acre-feet by 2000; and 4.3 million by 2020. As an indication of the size of the problem, the average cooling effluent is about 18°F warmer than when diverted. The general location and diversion demands for thermal plants were estimated and these data furnished the planners as "water quality control needs to comply with streamflow temperature standards."

While the people of the Nation and the basin are concerned about the historical and potential water-quality degradation of surface and ground waters, the causes and degrees of the degradation are not well known. There are data available which have yet to be analyzed and there is also a need for additional data. This need for additional data and analysis has been generally known by the basin States and is further recognized in this study. A solid technical base is a prerequisite to implementation of the actions necessary for improving water quality. To achieve this:

1. There must be a continued effort to identify and quantify waste sources.
2. Simultaneous measurements of quality and rate of flow of the basin's streams and quality and quantity of ground waters should be obtained.
3. The economic effects of water quality must be determined.



Cooling towers, ponds, and other forms of off-stream cooling at thermal-electric power plants.

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