Minnesota Works Progress Administration: Writers Project Research Notes.

Copyright Notice:

Version 3
August 20, 2018

in stream flow and increased water needs resulted in general impairment of the quality of water for urban use. Cities improved their methods of water treatment and some undertook to treat sewage and other wastes, but stream flow throughout several months of the year was so inadequate for the dilution of wastes that the water was unsatisfactory for city use and the streams themselves became odorous and highly objectionable.1/ During the severe drouth conditions in the middle 1930's, low-water stream

---

1/ Report on regional planning, part V - Red River of the North, National Resources Committee, p. 21, August 1937.

---

flow reached a most critical point. In the Red River, available water failed to meet the aggregate of demands and was subjected to re-use from city to city down the valley. Thick ice of cold winters, especially if the stream was low, greatly aggravated the problem of pollution by reducing the volume of water flow, diminishing re-aeration, and checking the biochemical action which purifies water.

The unanimous opinion that a permanent solution of the water supply and sanitary problems of the Red River Valley must be found, together with the current program of the Federal Government with regard to public works, resulted in the organization of the Interstate Committee on the Red River of the North Drainage Basin.2/ Since

---

2/ Idem, p. 21.

---

the year 1935 sewage treatment plants have been built or are under construction at a number of Minnesota communities in the Red River valley, including Barnesville, Calloway, Dilworth, Fergus Falls, Henning, Lake Park, McIntosh, New York Mills, Pelican Rapids, Perham, Roseau, Red Lake Falls, and Thief River Falls.

Peak water requirements of St. Paul and Minneapolis equal about 50 percent of the minimum stream flow of the Mississippi River. Since the peak demand for water

usually comes at the time of minimum flow, this is a dangerously narrow margin and suggests the need for flow correction by greater storage development on the Mississippi above the Twin Cities. Future needs may actually exceed the present minimum flow.

Pollution occurs in the Mississippi and certain of its tributaries below St. Paul as a consequence of the discharge of untreated or partially treated wastes from rather closely spaced urban centers and industrial plants. Treatment facilities recently completed at South St. Paul, with those now about to begin operation at Newport, will greatly alleviate this condition. Completion in 1938 of the Twin Cities sewage disposal project by the Minneapolis-St. Paul Sanitary District made a tremendous difference in the degree of pollution below the cities. In the course of a year, approximately 38 billion gallons of sewage is treated (more than enough to fill a trainload of tank cars reaching around the world) to remove approximately 93 million pounds of sewage solids formerly discharged into the river.

Abatement of pollution along the Mississippi River is not merely a wise public health measure. It also makes possible a fuller public enjoyment of the natural advantages of the region as a recreation area. Already the river in the St. Paul-Minneapolis area is returning to a beauty almost forgotten, and game fish again frequent its depths.

Further improvement of sanitation is also needed in the St. Croix Valley recreation area. The river clean-up program, started in 1935, has drawn attention to the importance of sanitation as a public health measure and as a factor in the maintainence of fish life. Since 1935 sewage treatment plants have been constructed or are being constructed at Pine City, Mora, and Moose Lake, on the Minnesota side of the basin.

The erratic flow habits of the Minnesota River and its tributaries, coupled with increasing urbanization and industrialization in that basin, creates serious pollution problems which will grow more acute unless further remedial measures are undertaken. Many existing treatment plants are inadequate and additional disposal facilities are needed. Sixteen waste treatment plants have been constructed since 1935 or are in the process of construction.

Installation of Duluth's new sewage system and treatment plant brought about a great reduction in the pollution of water supplies in the Duluth-Superior area. Other Minnesota and Wisconsin municipalities are in need of sewage treatment.

Rainy River waters above International Falls are polluted by domestic wastes and below the city by domestic sewage and industrial refuse from pulp and paper mills. These mills discharge chemical wastes and undigested bark and other refuse which collect in masses of floating sludge that are highly injurious to fish life and complicating to water treatment. The problem is now being studied by representatives of Minnesota and the Province of Ontario.

Under the impetus given by various Federal relief agencies in recent years, tremendous strides have been taken in meeting the pollution problem in all sections of the State by providing sewage treatment and water purification plants, and by regulating stream flow. There is evidence that a public program of considerable magnitude remains. In January 1940, a total of 132 communities of 500 or more population, not including those with plants then under construction were still discharging sewage without treatment into waters of the State. The aggregate population of these communities was about a quarter of a million (220,903 according to the census of 1930). Communities, industrial plant owners, farmers and rural home owners, are all chargeable with the responsibility of keeping streams

and other sources of natural water supply safe from contamination. Figure - shows what has been done in stream pollution survey work by the State Department of Health. With the information obtained from such surveys, it is possible to plan the necessary remedial measures.

EROSION AND SILTATION

When the first pioneers came to Minnesota, they found dense forests, lush prairies, and a land of outstanding soil resources. A deep layer of topsoil, high in organic matter and plant nutrients, blanketed the greater part of the area. It had taken centuries to accumulate, at the rate of about 400 years to the inch, under the protective cover of trees and tall grass.

Pioneers responded naturally to the bread-and-butter requirements of their time. They cut down vast forests for building material or to clear the land, and left piles of slash and fire-blackened stumps behind them. They plowed long straight furrows, pulverized the soil, and sowed acres of wheat or corn year after year. They burned crop residues which if plowed in would have helped to make the soil more absorptive, and they set fire to pasture and meadowland. Growing America called for ever greater quantities of Minnesota's food and timber.

Most of the farmers who settled in Minnesota came from northwestern Europe, where rains are slow and light. They were not accustomed to the slashing thunder-storm type of mid-continent rains and did not prepare their fields to receive them. Before long, dashing summer rains and heavy winds began to steal away the soil no longer protected by Nature's cover of vegetation. Seldom did the pioneer farmer realize the extent to which erosion was robbing him of his fertile topsoil. But so much surface soil was lost, even during the lifetime of many of the settlers, that crop yields no longer repaid the cost of farming. Truly, soil is slow to form

but quick to go. Theodore Roosevelt once said, "When soil is gone, men must go, and the process does not take long."1/

1/ Eighth Annual Message, Dec. 8, 1908.

Agents Of Erosion

Wind and water are the principal agents of erosion. For ages, together with other geological agencies, they have been gnawing away at the earth without disturbing the natural balance between soil manufacture and soil removal. Geological erosion is an orderly and almost unnoticeable process. It is only when man fails, through recklessness or ignorance, to adjust his activities to natural forces that erosion becomes accelerated and destructive, even to the point of devastation.

In Minnesota, water is the great leveler, working quietly most of the time. The sediment visible in a stream on a clear day is evidence of the way fertile upland farms are being carried away, particle by particle. On gentle slopes water moves slowly in a thin smooth film and while it can push or roll grains of dirt it cannot carry them in suspension. On steeper slopes water runs faster, and if it flows at a depth of no more than a quarter of an inch and at the rate of one foot a second, it nearly always carries suspended matter. Doubling the speed of flowing water multiplies its cutting power by 4 and the weight of soil particles it can carry by 64. In other words, the more swiftly water moves, the more soil it can carry, and the more soil it carries, the faster it can cut into the ground.

Many of the influences that govern run-off also affect erosion. Chief Hugh H. Bennett of the United States Soil Conservation Service, contends that the nature of the vegetative cover is the primary factor, and after that the character and condition of the soil. If water flowing off steep slopes can be made to move slowly and kept from concentrating into rivulets, its destructiveness can be dissipated

and erosion controlled. If run-off can be kept clear of suspended matter, the earth pores will be kept open to allow water to get into the topsoil.

The effect of crop systems and other land uses on the extent of erosion and run-off varies with slope and soil conditions. Table - which reproduces data from the Upper Mississippi Valley Soil and Water Conservation Experiment Station at La Crosse, Wisconsin, discloses that the greatest average annual soil and water losses are from fallow soils, and the next greatest from soils continuously cultivated to one open-grown crop (in this instance corn). Losses from soils rotated under open and close grown crops and hay are much smaller, while from soils with sod-forming crops like blue grass, the loss is almost negligible.

Experiments conducted on three small watersheds at La Crosse showed that from May to November 1935 soil was washed away at a rate of 600 pounds per acre from a cleared and grazed watershed, 1,600 pounds per acre from a grazed wooded watershed, and only 17 pounds per acre from an ungrazed timbered watershed. Of the total rainfall occurring during the period, the cleared pasture watershed yielded 3 percent in run-off, the grazed woodlot watershed about 9 percent, and the ungrazed timbered watershed only 0.15 percent.1/

1/ Influences of vegetation and watershed treatments on run-off, silting, and stream flow, A progress report on research, U. S. Dept. of Agri. Misc. Pub. no. 397, pp. 47-48, 1940.

Average Annual Soil and Water Losses, 1933-37 Inclusive
Experiment Station, La Crosse, Wisconsin

Item	Soil Losses Tons Per Acre[1]	Percent Water Loss[2]
Corn, annually	102.4	25
Rotation (3 year system of corn, barley, clover)		
Corn	49.6	17
Barley	30.8	19
Clover	.8	11
Continuous Blue grass sod	.08	5
Fallow Fallow soil	166.4	25

1/ On Clinton silt loam, 16 percent slope.
2/ Percentage of the total rainfall on the plot.
The precipitation for the 5 year period totaled 158 inches.
Note: 140 tons equals approximately an acre-inch of soil. Average depth of topsoil on farms in Minnesota is from 6 to 8 inches.
Source: Soil Conservation Service.

Erosion and run-off data reveal that hard rains do most of the damage. Of the annual soil loss, 70 to 80 percent occurs during three or four driving storms. During one rainstorm, corn plots at the La Crosse station lost 70 tons of soil per acre, a loss equivalent to a half-inch of soil. In round numbers, six storms a year during the period 1934 to 1939 caused 96 percent of the soil losses from corn plots, 90 percent from grain, and 50 percent from hay. As for run-off, these storms caused 64 percent of the total from corn, 58 percent from grain, and 38 percent from hay land.1/ April and May are the most critical months for spring sown crops as the soil is then unprotected and finely worked and storms are frequent and intense.

1/ Hays, O. E., and Atkinson, H. B., Run-off and soil losses from critical storms occuring in the Upper Mississippi Valley, U. S. Dept. of Agri., Soil Conservation Service, mimeographed 1941.

Kinds Of Erosion

There are three more or less distinct types of erosion - sheet, gully, and wind erosion.

Sheet Erosion - Sheet erosion gradually strips off the life-giving topsoil grain by grain, layer by layer. This is the most widespread type of soil wastage in Minnesota, though not the most dramatic. Most sloping land that is planted to cultivated crops such as corn, potatoes, beans, and sugar beets loses some topsoil by sheet erosion during heavy rains. Per acre productivity of the farmers land gradually declines as its store of plant food is thus carried away.

Gully Erosion - As run-off water trickles over the unprotected topsoil toward a depression in the land, it cuts little furrows like the fingers of a hand. If neglected, the fingers grow with every rainfall and some become main channels. These are cut deeper and deeper until they become great gullies. Almost any depression or break in the surface of easily erodible soil may be the beginning of gully erosion. A plow furrow running up and down the slope, or even a wagon track, may start the ripping out of a nasty looking gully. Fields riddled with gullies are shocking evidence of careless use of land.

Wind Erosion - The rate of removal and accumulation of soil depends upon wind severity and upon the vulnerability of the land. Only dry soils are blown about by the wind; moist or wet earth is not subject to removal. In recent years a number of small dune areas ranging from less than 1 to more than 200 acres have been started on sandy soils in the Red River Valley, especially in Clay and Norman Counties, where fields have been plowed in dry windy seasons or allowed to become bare of vegetation.1/

1/ Nikiforoff, C. C., and others, Reconnaissance soil survey Red River Valley area, U. S. Dept. Agri., Series 1933, no. 25, pp. 62-63, 1939.

Where unprotected, loose sandy soils drift easily. Dry windy periods in which dense clouds of dust and fine sand are moved from the fields, occur almost regularly twice a year, in spring and fall.1/ In northeastern Norman County and adjacent

---

1/ Idem, p. 37.

---

parts of Polk County, and to a lesser extent in Kittson County, shifting sand has formed some dunes which reach from 20 to 40 feet in height. In dry periods the fine sandy loams of the Anoka Sand Plain (Figure -) are blown into drifts if they lack protective vegetation.

Losses From Erosion

Acreages and percentages of non-urban land in Minnesota which is affected by different kinds of erosion are given in table -. More than 10 million acres, or about one-fifth of the total area of Minnesota, has lost from one-fourth to three-fourths of its surface soil as a result of sheet erosion. Gullying combined with sheet erosion has severely depleted 511,348 acres. Wind has damaged almost one-fourth of the land acreage, while 3,436,745 acres have been damaged severely. Figure - shows the extent of erosion in Minnesota. These losses cause, in addition, heavy damage from the clogging of reservoirs and shoaling of stream channels, damage to water-power sites, depreciation of agricultural lands, and diminished crop yields. Figure - illustrates the decrease in productivity of eroded lands.

Results Of Wind And Water Erosion In Minnesota

(more than one-quarter of the land affected as represented below)

Erosion Condition	Acres Affected	Percentage of Area of Minnesota
Areas with little or no erosion	27,951,147	54.3
Total area affected by sheet erosion One-fourth to three-fourths topsoil gone	10,083,066	19.6
Total area affected by wind erosion	12,692,812	24.6
Moderate wind erosion (some gullying)	9,256,067	18.0
Severe wind erosion (some gullying)	3,421,202	6.6
Destroyed by wind erosion (some gullying)	15,543	1/
Total area affected by gullying	7,804,518	15.2
Occasional gullies (with sheet erosion)	7,293,170	14.2
Severe gullying (with sheet erosion)	511,348	1.0
Total area exclusive of large cities and water	51,452,394	100.0

1/ Less than 1/10 of 1 percent

Source: Reconnaissance Erosion Survey, 1934, U. S. Dept. Agri., Soil Conservation Service, (revised 1935).

Figure - shows the general areas affected by the most harmful and extensive erosion. In the rugged Driftless Area extending along the Mississippi from Winona southward to the State's border and on the hilly upland to the north and west, erosion is recognized as serious. The fine textured soils of this section are highly erodable, especially when loosened by spring thaws following deep freezing, and erosion progresses rapidly from sheet to gully stage on the steep slopes. The productivity of this highly developed agricultural area led to a more extensive tilling of hilly ground than is usually found in such dissected country. Moreover, as the oldest farming area in Minnesota, this region has been longest subjected to man made erosion.

Soil erosion has reached its most serious stage on the privately owned farms of southeastern Minnesota. Seventy-five percent of the farms in the area are

seriously impaired.1/ On many cultivated fields, from one-half to three-fourths

---

1/ Report of the Mississippi Valley Committee of the Public Works Administration, p. 63.

---

of the original surface soil of from 8 to 14 inches has been lost and it is not uncommon to find gullies ranging from 6 to 20 feet in depth.

Erosion is a public problem, for soil losses are not the sole concern of the individual land owner; they affect the entire community. The problem is mainly to find a way to bring about the adoption of affective methods of erosion control on a great number of individually-owned farms. Figure - indicates the extent of Soil Conservation Service activities in Minnesota. Farmers in the project and camp areas shown on the map, cooperating with Soil Conservation Service technicians, develop agricultural programs providing for proper land use and soil and moisture conservation practices. In Minnesota there are 169,975 acres and 1,162 operators under a 5-year cooperative agreement. About 82,672 acres have been contour-tilled, 48,819 acres strip-cropped and 6,536 acres terraced in Minnesota. Approximately 486,120 acres are in Soil Conservation Districts authorized by the Minnesota Legislature of 1937.

Sedimentation

Silting Of Reservoirs - Sand, silt and other eroded materials collect in Minnesota reservoirs to cause heavy damage. Losses include the waste of valuable soil, decrease in water storage space for flow regulation, gradual forfeiture of the original cost of the reservoirs, damage to recreation and wild life conservation sites, and in some cases destruction of water power developments. A well-made reservoir ought to last several hundred years. By contrast, it is estimated that of all the existing reservoirs in the country, 38 percent will in fact have a useful

life of only 1 to 50 years; 24 percent, 50 to 100 years; 21 percent, 100 to 200 years; and only 17 percent will last more than 200 years.1/

1/ Brown, C. B., Rates of silting in representative reservoirs throughout the United States, Natl. Research Council, Amer. Geophys. Union Trans., Ann. Mtg. 18: 554-557, 1937.

One of the most striking instances of reservoir silting in Minnesota is the case of Lake Como, near Hokah. A new dam was built across the Root River there in 1922 to replace one torn out by flood waters some years before. The impounded waters formed a natural beauty spot and a popular resort for swimming and boating. By 1936, however, Lake Como was completely filled with sediment, washed down from steep deforested and cultivated slopes in the watershed above. In the short space of 14 years, erosion and sedimentation had turned the lake into an almost worthless mud flat, overgrown with weeds. Farmers lost their soil; the village lost its lake.

In Coon Rapids Reservoir, built in 1899 on the Mississippi north of Minneapolis, the average percentage of the original water capacity stolen each year by silt is 1.08.2/ At the present rate, the reservoir will be completely filled with

---

2/ Eakin, Henry M., U. S. Dept. Agr. Technical Bull. 524, p. 22, 1936.

---

silt in 51 years. The cost of silt removal from reservoirs by hydraulic dredging or mechanical removal generally runs 5 to 50 times the cost of the original storage.3/

3/ Eakin, Henry M., U. S. Dept. Agr. Technical Bull. 524, p. 3, 1936.

Shoaling Of Channels - Harmful sedimentation also occurs where silt accumulates along the banks or on the bottoms of streams. Mud flats or shoals form, clogging the channel, so that floods are more frequent. The raising of ground water levels

causes swamps to develop on adjacent valley lands. Excessive erosion in southeastern Minnesota resulting in heavy silt deposits in the Mississippi by tributary streams may eventually injure the canalization program, thus threatening navigation.

Flood Plain Damage - Deposition of sediment on soils along the flood plains of streams is another serious problem. Thousands of acres of productive valley lands are annually covered with deposits of infertile or sterile material. In and adjacent to the Driftless Area, deposits on valley lands often take the form of alluvial fans at the mouths of gullies and V-shaped tributary valleys where these debouch upon larger valleys of lesser gradient. On the basis of reconnaissance examinations made in 1937, it is estimated that over 1,000 acres of bottom land in the watershed of the Zumbro River, southeastern Minnesota, have been covered with alluvial-fan deposits to such depths as to cause a permanent average reduction of 80 percent in the productive capacity of the land, while an additional 200 acres was suffering similar damage, of which about one-quarter will be permanent damage.1/

1/ Influences of vegetation and watershed treatments on run-off, silting, and stream flow, A progress report of research, U. S. Dept. of Agr. Misc. Pub. 397, p. 58, 1940.

Damage resulting from deposits of sediment is not confined to the land. In Winona County alone, the county engineer has estimated the average cost of removing sediment from county and township highways at approximately $30,000 a year.2/

2/ Op. cit., Misc. Pub. 397, p. 59.

NAVIGATION

In navigation facilities, Minnesota ranks high among the states. Its rivers and lakes provide a cheap form of transportation, and explorers, fur traders, soldiers, colonizers, farmer-settlers, all in their turn, found the waterways in-

dispensable. They still have a prominent place in the transportation scheme, along with railroads, trucks, pipelines, and airlines, but navigation is now of secondary importance, as compared with their usefulness for water supply, recreation, power and other purposes.

Mississippi River

Before the railroads came, the Upper Mississippi was the most economical route to and from the northwest region. Its use for steam navigation extended above the Falls of St. Anthony in the 1850's and 1860's. Navigable water above the falls as a rule only reached to Sauk Rapids above St. Cloud, but at high water, boats sometimes operated as far as Pokegama Falls near Grand Rapids.1/ The highest number

---

1/ Robinson, E. V., Early economic conditions and development of agriculture in Minnesota, p. 31, 1915.

---

of boat arrivals at St. Paul was in 1857 and 1858.2/ Decline in river traffic after

---

2/ Sixth report of the Minnesota Commissioner of Statistics, 1874.

---

the Civil War is mainly attributable to railroad competition, railroad control of shipping terminals, and consistent refusal of railways to pro-rate freight with the water cariers.3/ Navigation interests were particularly vulnerable to railroad

---

3/ Op. cit., Robinson, p. 31.

---

competition because the rivers, ran at right angles to the direction of heaviest traffic.

Congress in 1878 approved a 4.5-foot channel project on the Upper Mississippi from the mouth of the Ohio River to St. Paul. This River and Harbor Act was amended in 1907 to provide for a 6-foot channel. The River and Harbor Act of July 3, 1930

provided for a 9-foot channel on the main stem between the mouth of the Illinois and Minneapolis. On August 30, 1935 Congress once again modified the Upper Mississippi project, making the Missouri River its southern limit and authorizing further improvement of the harbor at St. Paul. By the River and Harbor Act of August 25, 1937, Congress sanctioned extension of the 9-foot channel above St. Anthony Falls.

The Upper Mississippi system involved the construction of 23 new locks and dams between the mouth of the Missouri River and Minneapolis. Appropriation of funds to prosecute the work legalized above St. Anthony Falls would add another lock and dam. This series of locks and dams, together with three dams previously completed at the Twin Cities, Hastings, and Keokuk, provides a water stairway rising 326 feet over its length of 673 miles and assures a 9-foot channel between St. Louis and Minneapolis. All 23 structures were ready for operation at the opening of navigation in 1940. Barges can now travel more than 4,000 miles on a 9-foot waterway from the Gulf of Mexico to the Twin Cities and from the Twin Cities to Chicago and Pittsburgh.

Total costs of the 9-foot canalization project on the Mississippi above the Missouri, from its creation in July 1930 to June 30, 1940, and exclusive of $40,000 contributed for new work, totaled $156,596,378. This includes a total of $16,285,739 for operation and maintenance. About $213,000,000 in Federal expenditures have gone into the various canalization projects on the Upper Mississippi since the 4.5-foot channel was authorized in 1878. Excluding extension of the project above St. Anthony Falls, the project was about 87 percent completed on June 30, 1940.

Estimated project costs, actual costs, and the percentages of completion as of June 30, 1940 of the various locks and dams in connection with the 9-foot channel in the St. Paul Engineering District are given in table -. Since lock and dam number 10 at Guttenburg, Iowa was recently transferred to this district

UPPER MISSISSIPPI RIVER NINE-FOOT CHANNEL
Construction of Locks and Dams in the St. Paul District

(Compiled from Annual Report - Cheif of Engineers, 1940)

PROJECT	STATUS, INCLUDING ALL WORK IN POOL AREAS: REVISED ESTIMATED COST	COST TO JUNE 30TH 1940	PER CENT COMPLETE	YEAR OPENED TO NAVIGATION
St. Anthony Falls - Upper Lock	$ 4,628,000	-		
St. Anthony Falls - Lower Lock	3,631,000	-		
Lock and Dam No. 1 - At St. Paul, Minn.	1,000,540	2/ 1,000,539.26	100.00	1917
Lock and Dam No. 2 - Above Hastings, Minn.	3/ 5,111,000	2/ 2,244,453.63	43.91	1930
Lock and Dam No. 3 - Above Red Wing, Minn.	5,843,000	5,499,921.21	94.13	1938
Lock and Dam No. 4 - At Alma, Wis.	5,050,000	4,829,324.74	95.63	1935
Lock and Dam No. 5 - At Minneiska, Minn.	5,386,000	5,021,027.10	93.22	1935
Lock and Dam No. 5A - Above Winona, Minn.	4,825,000	4,502,230.53	03.31	1936
Lock and Dam No. 6 - At Trempealeau, Wis.	4,830,000	4,437,226.65	91.87	1936
Lock and Dam No. 7 - At Dresbach, Minn.	5,802,000	5,566,959.14	95.95	1937
Lock and Dam No. 8 - At Genoa, Wis.	6,382,000	6,055,627.52	94.89	1937
Lock and Dam No. 9 - Below Lynxville, Wis.	6,804,000	6,296,032.71	92.53	1938
Miscellaneous	-	152,843.39		
Lock and Dam No. 10 - At Guttenberg, Iowa	4/ 4,893,000	4/ 4,629,090.96		
Total Existing Project prior to 1940	5/ $59,292,540	5/ $45,606,185.88		
Total Existing Project after 1940	6/ $64,185,540	6/ $50,235,276.84		
Previous Projects:				
(2)	3,297,350.80	3,297,350.83		
(4)	1,965,316.20	1,965,316.22		
Grand Total	$69,448,207.00	$55,497,943.89		

1/ Exclusive of $40,000 contributed funds.
2/ Costs incurred under previous projects, properly charged to construction of locks and dams indicated.
3/ Includes estimate for construction of new lock.
4/ Lock and Dam No. 10 at Guttenburg, Iowa until 1940 was included in the Rock Island District.
5/ Funds do not include adjustments necessitated by change in boundary between St. Paul and Rock Island District during fiscal year 1940.
6/ Funds include adjustments necessitated by change in boundary between St. Paul and Rock Island District during fiscal year 1940.

it is given separately in the cost statistics of the project in the district. All sites except locks and dams 9 and 10 are within or touching on Minnesota.

Total traffic on the stretch of the Mississippi between St. Paul and the mouth of the Missouri was 3,495,028 tons in 1939. Total up-bound traffic was almost twice the down-bound traffic. Figure - illustrates the rising importance of river freight traffic at St. Paul and Minneapolis. It shows barge receipts and shipments since 1934 and reveals that industry gives a significant amount of its heavy and non-perishable freight to barge lines. In 1940 the combined total for the two cities was 974,774 tons of which 598,481 tons was St. Paul traffic and 376,293 Minneapolis. In-bound commerce far out-weighed the out-bound - 913,046 tons as against 61,728.

The Upper Mississippi 9-foot channel project has long been a subject of controversy among engineers and economists. The Mississippi Valley Committee of the Public Works Administration (investigated the conditions and problems of the use and control of water in the Mississippi Drainage Basin and issued a report in 1934) contended that it is impossible to economically justify the vast expenditures on the improvement of these waterways, especially from the viewpoint of self-liquidation. It did not recommend discontinuance of the project, however, because: (1) It had already been authorized by Congress, (2) There are advantages in having the main stem of the Mississippi as one navigation unit from its mouth to the headwater cities, and (3) Changes may evolve in commercial relations within the Valley as a result of the 9-foot channel, decentralization of industry, and adjustments in land utilization.

The Federal Barge Line began service on the Upper Mississippi in 1926. Its operation under government auspices is an experimental, pioneering venture; it is still regarded as a temporary arrangement, with the government expected to withdraw when barge service becomes sufficiently profitable to attract private investment.

Of obvious advantage to Minnesota is the substantial saving in shipping costs through barge service. The 9-foot channel may enable new industries to operate with profit in the Upper Mississippi Valley. New riverside elevators, bulk plants, packing plants, and wholesale houses, will be needed if traffic increases. Municipal barge terminals for the handling of bulk and package freight have been constructed in Minneapolis, St. Paul, Stillwater, and Red Wing. Hastings, Wabasha, and Lake City have levees for the transfer of cargo. Harbor and terminal facilities are under construction at Winona. Incidental benefits to the Northwest are the employment of thousands of workers during construction, and the creation of a series of artificial lakes behind the dams, affording new recreational facilities along the State's southeast border.

Plans of the Corps of Engineers, United States Army, include development of an upper harbor at the St. Anthony pool. This will require a dredged channel about 7,000 feet in length along the west bank of the river from the present harbor to the Hennepin Avenue bridge, and the construction of lock and dam facilities at St. Anthony Falls. Extension of navigation facilities beyond this point has doubtful value at the present time. Regional water consultants of the National Resources Committee in 1936 took the position that no economic justification could be forseen for the canalization from Minneapolis to Brainerd which would cost about $40,000,000.

Minnesota River

Steamboating on the Minnesota, beyond the lower stretch near Fort Snelling, began in 1850.1/ Navigation was at its peak from 1857 to 1862. This traffic de-

---

1/ Op. cit., Robinson, p. 31.

---

veloped to serve a rapidly expanding agriculture, but the very same influence was responsible in large part for its eventual collapse. Extensive tillage exposed

large areas of loose soil to rapid erosion, until the river channel was choked with shoals and sand bars. An added factor of importance was the advance of the railway up the valley from St. Paul, to reach Mankato in 1869 and New Ulm in 1871.1/ The

---

1/ Op. cit., Robinson, p. 31.

Minnesota can still be restored to navigable condition whenever enough traffic is available to justify the cost of flow correction and dredging.

St. Croix River

The St. Croix River is navigable to Stillwater, but is little used for commercial navigation. Many pleasure craft frequent the river throughout the summer season.

DRAINAGE

In its natural state Minnesota had more than 10,000,000 acres of swamp land, most of it in the northern counties.2/ St. Louis County had 1,392,160 acres,

---

2/ Palmer, Ben, Swamp land drainage with special reference to Minnesota: University of Minnesota Bulletin No. 5, p. 88, 1915.

Beltrami 1,451,520 acres, Koochiching 1,000,000 acres, Lake 798,600 acres, Itasca 590,600 acres, Roseau 533,680 acres, Aitkin 529,880 acres, Cass 316,240 acres, Pine 293,000 acres, Marshall 258,240 acres, Clay 230,000 acres, and there were over 100,000 acres each in Kittson, Ottertail, Polk, Crow Wing and Cook counties (Table -).3/

3/ Drainage Commission Report, pp. 66-67, 1910.

In addition, large aggregates of swamp land, unrecorded in surveys, existed in some southern counties. Today Minnesota has a greater acreage in drainage enterprises than any other state.

Location of Original Wet Lands in Minnesota

Original Area of Swamp, Wet, and Overflow Lands

County	Acres	County	Acres
Aitkin	529,880	Mahnomen	50,000
Anoka	50,000	Marshall	258,240
Becker	50,000	Martin	45,180
Beltrami	1,451,520	Meeker	27,120
Brown	77,280	Mille Lacs	34,000
Carlton	70,000	Morrison	20,000
Cass	316,240	Mower	20,000
Chippewa	20,900	Murray	55,296
Chisago	15,000	Nobles	12,000
Clearwater	72,000	Norman	50,000
Clay	230,000	Ottertail	162,000
Cook	102,159	Pine	293,000
Cottonwood	19,000	Polk	174,000
Crow Wing	127,000	Red Lake	202,175
Dakota	12,300	Redwood	120,000
Faribault	28,000	Renville	120,000
Fillmore	23,000	Roseau	533,680
Freeborn	154,000	St. Louis	1,392,160
Grant	33,000	Sibley	36,300
Hubbard	77,000	Stearns	40,000
Isanti	20,000	Steele	16,000
Itasca	590,600	Stevens	44,960
Kanabec	42,000	Swift	57,000
Kandiyohi	80,120	Todd	45,000
Kittson	184,000	Traverse	42,000
Koochiching	1,000,000	Wadena	80,000
Lac qui Parle	51,000	Waseca	27,016
Lake	798,600	Washington	15,360
Le Sueur	12,000	Wilkin	50,000
Lincoln	12,000	Yellow Medicine	51,000
Lyon	18,000		

These estimates are contained in the 1913 report of the State Drainage Commission, and were prepared from personal surveys and examinations, official records, estimates of county officials and other sources. Counties were omitted that included only small amounts of swamp land or did not contain any.

1/ Includes area organized as Lake of the Woods County - 1922

Source: Palmer, Ben, Swamp land drainage with special reference to Minnesota: University of Minnesota Bulletin no. 5, p. 122.

Small-scale reclamation of wet and overflow land began at an early date in southern Minnesota. An era of excessive drainage, mostly in northern counties, extended from 1905 to 1919 (Table -). Of the total acreage of land in drainage projects in 1930, approximately 81 percent was added during that 15-year period. Rising land values and inflated farm prices had induced farmers and land speculators alike to join in an orgy of drainage. Many of the ditches authorized were promoted solely by land sharks. Table - shows that of the 11,474,683 acres drained in Minnesota to 1930, 4,891,573 acres, or 42 percent of the total, was land not previously in farms.

Public drainage in Minnesota could be instituted through any one of four agencies - town supervisors, county commissioners, district courts, or the State Drainage Commission. Since county drains serviced nearly 95 percent of the total land in drainage enterprises in 1930, and because the procedure was much the same in all cases, only the steps that were necessary in establishing county projects need be examined here (Table -). The essential steps were petition by one or more land-owners to a county commissioner, appointment of engineers and viewers by the commissioner, report of engineers and viewers, hearing, approval (after 1917) of Director of Division of Drainage and Waters, order to construct, assessments of benefits and damages to lands in drainage areas, letting of contracts, issuance of bonds, approval of work done, and collection of assessments to meet bond maturities.1/ In 1930 almost 100 percent of all drainage enterprise land was situated

---

1/ For more detailed description of drainage procedure in Minnesota the reader is referred to Palmer, Ben, "Swamp Land Drainage with Special Reference to Minnesota": University of Minnesota Bulletin no. 5, Chap. VI.

Land and Capital in Drainage Enterprises
By Date of Organization

Date of Organization	Land		Capital Invested to Jan. 1, 1930	
	Acres	Percent	Dollars	Percent
All Enterprises	11,474,683	100.0	64,139,641	100.0
1880 - 1889	38,699	0.3	32,425	1/
1890 - 1899	468,662	4.1	386,052	0.6
1900 - 1904	823,483	7.2	1,470,836	2.3
1905 - 1909	2,420,005	21.1	6,501,049	10.1
1910 - 1914	3,624,266	31.6	12,989,989	20.3
1915 - 1919	3,290,051	28.7	27,044,315	42.2
1920 - 1924	721,220	6.3	14,678,162	22.9
1925 - 1929	88,297	0.7	1,036,813	1.6

1/ Less than 1/10 of 1 percent
Source: Drainage of Agricultural Lands, U. S. Census of 1930

Land and Capital, by Purpose of Drainage, 1930

Purpose of Drainage	Land		Capital Invested to Jan. 1, 1930	
	Acres	Percent	Dollars	Percent
All Enterprises	11,474,683	100.0	64,139,641	100.0
Reclamation of swamp land not previously in farms	4,891,573	42.6	18,645,079	29.1
Improvement of land already in farms	6,207,228	54.1	44,103,629	68.8
Protection against overflow	375,882	3.3	1,390,933	2.1

Source: Drainage of Agricultural Lands, U. S. Census of 1930

either in organized drainage districts having their own officers or in township, county, or state enterprises under control of public officials (Table -).

In the sense of making productive land available, drainage has been generally effective. It made cultivated land more productive, and by 1930 it had brought 3,923,527 acres of otherwise untillable land - some of it rich soil - into a condition fit for farming. It has long been obvious, however, that much of the drainage was very ill-advised. In 1930, about 2,037,481 acres of the drained area classed as unfit for crops because it still lacked of proper drainage and 3,747,812 acres were idle in 1929 (Table -).1/ Unwise drainage brought millions of acres of marginal

1/ Idle land includes all land not in productive use, such as idle crop land, land in unoccupied farms, woodland, and other unimproved land not intensively used for pasture, or farm wood lots. Practically all timber and cut-over lands are classed as idle.

and even submarginal land into use. Four counties - Roseau, Lake of the Woods, Koochiching, and Beltrami - contained two-thirds of all the land in drainage enterprises in Minnesota which was reported in 1930 as unfit to raise any crop because improperly drained (Table -). Table - presents drainage statistics and analyzes the condition and use of land in drainage enterprises in 1930.

Drainage Of Infertile Lands

The most successful agriculture, in northern Minnesota east of the Red River Valley is found along the Rainy River, which affords natural drainage, and on the large moraines of young gray drift extending to the eastward south of Lower Red Lake. Soils in those areas are of fair to good quality, and in the main well suited to farming, though some areas require special treatment or should be retired from agricultural use.

Between these naturally drained and farmable areas lies an extensive region where the losses from drainage far out-weight the gains. Here are peat deposits extending over approximately 1,660,000 acres,2/ with irregularly scattered beach

2/ Jesness, O. B. and Nowell, R. I., Program for land use in northern Minnesota, p. 52, 1935.

ridges and islands of loamy sand of low inherent productivity.

Land and Capital, by Character of Enterprise - 1930

Character of Enterprise	Land		Capital Invested to Jan 1, 1930	
	Acres	Percent	Dollars	Percent
All Enterprises	11,474,683	100.0	64,139,641	100.0
Drainage district	14,000	0.1	125,296	0.2
County drains	10,849,450	94.6	62,666,365	97.7
Township drains	3,260	1/	4,000	1/
State projects	606,173	5.3	1,339,180	2.1
Individually owned projects	1,800	1/	4,800	1/

1/ Less than 1/10 of 1 percent
Source: Drainage of Agricultural Lands, U. S. Census of 1930

Area, Drains and Investment in Drainage Enterprises for Minnesota - 1930

	1930
Approximate land area of State (Acres)	51,749,120
Land in drainage enterprises (Acres)	11,474,683
Improved land	7,396,575
Unimproved land	4,078,108
Land unfit to raise any crop for lack of drainage	2,037,481
Land drained, fit to raise normal crop	7,322,252
Land partly drained, fit for partial crop	2,114,950
Land in occupied farms	8,782,323
Land in planted crops	5,916,067
Land idle	3,747,812
Ditches completed (Miles)	14,477.6
Tile drains, completed (Miles)	9,451.3
Capital invested in enterprises	$64,139,641

Source: Drainage of Agricultural Lands, U. S. Census, 1930

LAND IN DRAINAGE ENTERPRISES, CAPITAL INVESTED, COST PER ACRE, CONDITION AND USE OF LAND, AND DRAINAGE WORKS IN 1930, BY COUNTIES.

County	Approximate Land Area	Land in Drainage Enterprises	Capital Invested	Cost Per Acre When Completed	Land Fit to Raise A Normal Crop			Land Unfit to Raise Any Crop		Land Drainage 1930		
					1930	Prior to Drainage	Increase Since Drainage	1930	Prior Drainage	Ditches Only	Tile Only	Tile and Ditches
	Acres	Acres	Dollars	Dollars	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Aitkin	1,171,200	435,231	1,223,274	2.81	61,444	3,567	57,877	137,547	412,185	435,231	-	-
Anoka	293,760	123,483	320,398	2.59	96,078	40,542	55,536	12,340	63,676	115,643	1,040	6,800
Becker	863,360	18,901	209,696	11.09	12,061	1,905	10,156	1,965	9,225	18,901	-	-
Beltrami 1/	1,584,640	645,416	1,896,123	2.94	146,465	-	146,465	385,470	645,406	645,416	-	-
Benton	259,200	8,471	66,507	7.85	8,246	4,855	3,391	125	1,003	8,471	-	-
Big Stone	314,240	31,999	210,688	6.58	26,290	11,946	14,344	2,197	15,834	20,858	4,041	7,100
Blue Earth	487,680	79,318	1,576,553	19.88	79,318	1,868	77,450	-	75,663	11,826	39,582	27,910
Brown	391,680	91,203	900,609	9.87	91,203	57,633	33,570	-	33,570	37,449	35,059	18,695
Carlton	554,880	78,282	401,289	5.13	26,882	19,282	7,600	51,400	59,000	78,282	-	-
Carver	240,640	6,285	122,055	19.42	5,535	3,085	2,450	195	1,845	4,695	-	1,590
Cass	1,346,560	81,530	300,238	3.68	24,162	9,943	14,219	13,154	46,439	81,530	-	-
Chippewa	378,240	66,749	956,748	14.33	54,842	29,291	25,551	1,428	7,672	24,794	9,705	32,250
Chisago	273,280	45,168	143,408	3.17	30,924	14,505	16,419	5,801	19,945	45,168	-	-
Clay	667,520	309,396	1,055,379	3.41	304,351	290,837	13,514	2,100	18,559	309,396	-	-
Clearwater	652,160	78,720	156,571	1,99	56,900	40,800	16,100	5,300	19,420	78,720	-	-
Cottonwood	409,600	45,554	1,304,740	28,64	42,727	30,074	12,653	429	13,080	2,048	18,126	25,380
Crow Wing	676,480	41,615	93,113	2.24	29,644	11,967	17,677	3,550	18,700	41,615	-	-
Dodge	281,600	14,421	84,220	5.84	13,501	12,811	690	600	1,410	1,310	-	13,111
Douglas	414,720	24,605	354,103	14.39	22,179	95	22,084	520	18,980	20,216	814	3,575
Faribault	460,160	252,519	2,580,791	10.22	251,244	208,790	42,454	875	24,174	15,189	67,230	170,100
Freeborn	470,400	123,815	1,733,104	14.00	111,517	63,360	48,157	12,080	60,455	39,071	2,534	81,200
Grant	353,920	62,415	383,152	6.14	60,726	26,441	34,285	400	28,111	50,775	4,760	6,880
Hennepin	361,600	20,614	480,086	23,29	14,494	6,453	8,041	1,645	10,247	17,202	646	1,680
Houston	364,800	11,046	234,144	21,20	6,000	4,261	1,739	1,261	3,000	11,046	-	-
Hubbard	613,120	21,956	53,235	2.42	18,399	3,828	14,571	2,658	17,628	21,956	-	-
Isanti	282,880	29,127	365,462	12.55	15,617	10,826	4,791	4,869	10,620	27,851	-	1,276
Itasca	1,747,200	110,000	314,200	2.86	30,200	60	30,140	61,400	107,900	110,000	-	-
Jackson	449,280	251,866	2,258,563	8.97	250,773	214,126	36,647	50	35,293	-	93,133	158,733
Kanabec	341,760	14,717	125,782	8.55	9,738	5,730	4,008	1,685	5,717	13,817	-	900
Kandiyohi	512,640	66,608	960,673	14.42	52,775	78	52,697	2,467	36,724	49,961	3,067	13,580
Kittson	711,040	382,038	1,087,388	2.85	214,462	43,286	171,176	39,879	220,989	382,038	-	-
Koochiching	2,010,240	693,371	1,520,886	2.19	92,194	19,800	72,394	501,828	634,875	693,371	-	-
Lac Qui Parle	505,600	81,397	883,583	10.86	81,397	53,833	27,564	-	27,564	33,311	7,886	40,200
Lake of the Woods 2/	861,440	676,335	1,378,327	2.04	305,000	-	305,000	224,335	676,335	676,335	-	-
Le Sueur	298,240	16,220	265,735	16.38	3,063	-	3,063	3,347	11,626	16,220	-	-
Lincoln	342,400	56,303	553,480	19.83	56,303	40,917	15,386	-	15,386	13,020	6,983	36,300
Lyon	453,120	94,148	1,017,198	10.80	79,932	28,502	51,430	4,819	37,797	14,480	15,440	64,228
McLeod	317,440	57,229	463,308	8.10	57,229	57,229	-	-	-	45,938	11,291	-
Mahnomen	366,080	50,331	282,816	5.62	29,601	2,100	27,501	1,650	12,150	50,331	-	-
Marshall	1,144,320	819,305	2,526,724	3.08	439,594	179,377	260,217	74,286	341,137	819,305	-	-
Martin	460,160	297,350	2,936,410	9.88	297,350	217,168	80,182	-	80,182	14,189	114,736	168,425
Meeker	397,440	65,723	265,990	4.05	40,154	12,487	27,667	17,562	42,429	56,133	3,340	6,250
Mille Lacs	373,120	19,774	47,860	2.42	8,030	4,568	3,462	7,222	9,806	19,444	-	330
Morrison	731,520	61,676	101,521	1.65	30,399	19,578	10,821	10,290	21,680	61,676	-	-
Mower	455,040	17,100	236,287	13.82	12,221	11,049	1,172	2,110	3,320	-	3,000	14,100
Murray	450,560	202,020	2,284,010	11.31	181,860	128,274	53,586	7,778	50,462	30,066	90,404	81,550

Continued

LAND IN DRAINAGE ENTERPRISES, CAPITAL INVESTED, COST PER ACRE, CONDITION AND USE OF LAND, AND DRAINAGE WORKS IN 1930, BY COUNTIES. - Continued

County	Approximate Land Area	Land in Drainage Enterprises	Capital Invested	Cost Per Acre When Completed	Land Fit to Raise A Normal Crop			Land Unfit to Raise Any Crop		Land Drainage 1930		
					1930	Prior to Drainage	Increase Since Drainage	1930	Prior Drainage	Ditches Only	Tile Only	Tile and Ditches
	Acres	Acres	Dollars	Dollars	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Nicollet	283,520	89,065	410,538	4.61	72,080	35,583	36,497	3,353	27,367	70,321	11,249	7,495
Nobles	462,080	104,098	1,585,461	15.23	90,608	48,372	42,236	5,115	42,016	7,640	32,577	63,881
Norman	550,400	346,680	885,417	2.55	233,326	146,337	86,989	38,639	120,915	346,680	-	-
Otter Tail	1,304,960	53,157	392,427	7.38	33,938	1,479	32,459	5,030	39,849	50,635	945	1,577
Pennington	388,480	322,483	852,411	2.64	160,274	71,665	88,609	13,928	109,135	111,783	-	-
Pine	904,320	37,428	125,236	3.35	11,230	4,165	7,065	6,460	21,825	37,428	-	-
Pipestone	300,160	21,801	251,000	11.51	21,801	-	21,801	-	-	-	-	21,801
Polk	1,266,560	761,913	2,295,076	3.01	643,025	329,961	313,064	10,791	115,339	747,813	-	14,100
Pope	443,520	40,795	178,979	4.39	40,595	31,442	9,153	200	9,353	40,795	-	-
Ramsey	103,040	4,178	134,990	32.31	2,955	885	2,070	899	2,644	3,051	-	1,127
Red Lake	276,480	159,062	257,344	1.62	138,916	63,119	75,797	3,790	64,922	159,062	-	-
Redwood	563,840	212,506	2,893,835	13.62	164,416	15,690	148,726	9,200	113,973	7,544	52,862	152,100
Renville	625,920	296.493	5,238,177	17.67	257,143	98,790	158,353	20,950	160,260	96,100	42,393	158,000
Rice	316,800	15,338	131,368	8.56	9,301	8,101	1,200	1,190	2,390	15,338	-	-
Roseau	1,068,800	899,518	1,698,728	1.89	359,341	177,147	182,194	257,479	534,293	899,518	-	-
St. Louis	4,161,920	252,657	1,353,781	5.36	250,072	23,943	226,129	2,527	228,656	252,657	-	-
Scott	234,240	11,614	75,970	6.54	11,614	2,635	8,979	-	8,979	11,614	-	-
Sherburne	286,720	76,378	327,149	4.28	59,992	13,551	46,441	6,518	26,580	53,678	-	22,700
Sibley	374,400	18,371	686,118	37.35	18,371	-	18,371	-	18,371	6,124	1,655	10,592
Stearns	871,680	68,535	376,725	5.50	68,535	51,925	16,610	-	16,490	67,795	-	740
Steele	275,840	23,954	353,449	14,76	21,382	11,602	9,780	1,050	4,242	13,630	6,539	3,785
Stevens	360,960	36,859	447,625	12.14	29,177	6,625	22,552	3,526	23,594	17,444	4,215	15,200
Swift	474,240	83,359	1,570,046	18,83	83,359	8,700	74,659	-	26,146	22,210	6,499	54,650
Todd	612,480	97,050	349,670	3.60	61,063	25,115	35,948	14,930	54,650	97,050	-	-
Traverse	363,520	152,602	328,032	2.15	152,602	4,376	148,226	-	120	152,322	280	-
Wadena	344,320	90,279	175,296	1.94	66,036	22,099	43,937	8,707	52,474	88,599	-	1,680
Waseca	275,840	32,959	331,184	10.05	25,242	11,051	14,191	4,481	16,077	26,928	991	5,040
Washington	254,080	10,284	107,559	10.46	5,547	1,675	3,872	1,464	2,167	8,190	1,680	414
Watonwan	277,760	60,452	730,270	12.25	53,977	24,389	29,588	1,040	30,355	120	29,598	22,972
Wilkin	476,800	253,295	726,639	2.87	235,318	196,030	39,288	7,397	49,188	253,295	-	-
Wright	442,240	13,017	264,347	20.31	11,164	1,234	9,930	-	10,363	9,923	158	2,936
Yellow Medicine	479,300	38,962	1,740,446	44.67	38,837	12,786	26,051	-	5,525	8,577	6,222	23,516
Other Counties 3/	1,044,480	8,191	147,921	18.06	7,991	1,126	6,865	200	4,797	4,849	3,342	-
Minnesota	51,749,120	11,474,683	64,139,641	5.59	7,322,252	3,398,725	3,923,527	2,037,481	5,950,274	8,953,007	734,022	1,566,449

1/ Part taken to form Lake of the Woods in 1922
2/ Organized from part of Beltrami in 1922.
3/ Includes only Dakota, Rock and Wabasha counties in 1930: and Dakota, Houston, Rock, Scott and Wabasha counties for 1920.
Source: Drainage of Agricultural Lands, U. S. Census, 1930.

In general, the benefits expected from drainage of this area did not materialize. Effective drainage proved difficult and much of the land was never settled. Reclaimed peat and mineral soils, deficient usually in potassium and phosphorus and sometimes in lime, generally could not be farmed with sufficient profit to meet heavy drainage assessments, and this led to extensive farm abandonment. Moreover, in many drainage enterprises some lands remained too wet for cultivation while others became too dry. The peat beds which formerly were moist and relatively safe from fires, became so dry and highly inflammable as the water table fell, that the fire-fighting costs of the State Division of Forestry rose far higher in the region than elsewhere in Minnesota. It is now recognized that the value of the region for agricultural use is not equal to its natural worth as a wildlife refuge and breeding ground, and a recreation and forest reserve area.

It was anticipated that drainage improvements would be self-liquidating through the collection of special assessments on benefited properties. Table - shows the total capital investment in various types of drainage in 1930. Failure of landowners to pay their assessments made it necessary for the counties (most enterprises were county projects) to meet bond obligations through taxation. As assessment defaults accumulated this burden became unbearable and the State finally had to assume some responsibility. By the Legislative Act of 1929 (Chapter 258, Laws of 1929), creating the Red Lake Game Preserve of 1,700,000 acres in parts of Lake of the Woods, Beltrami and Koochiching counties, the State took over certain of these drainage lands and assumed the outstanding indebtedness. The act authorized the State Auditor to issue $2,500,000 in certificates of indebtedness. In 1935 (Chapter 242, Laws of 1935) an additional $1,451,207 was approved for expenditure in these three counties for the same purpose.

A county ditch bond relief act passed in 1931 (Chapter 407, Laws of 1931) rescued three other counties from threatened bankruptcy - Mahnomen, Aitkin, and Roseau. Under this act the State Auditor was authorized to issue $1,500,000 in certificates of indebtedness. An additional $750,000 was appropriated in 1937 (Chapter 312, Laws of 1937) to meet further bond maturities of the same three counties. In 1933 Marshall County received a reforestation grant of $750,000 (Chapter 402, Laws of 1933) for retirement of drainage bonds. Altogether, the State has appropriated $6,951,207 to relieve counties in financial distress as a result of drainage expenditures.

Drainage Of Fertile Lands

Organized drainage of vast marshy areas has been notably beneficial in the Red River Valley. Thousands of acres of otherwise almost worthless land have thus been made productive. By 1930, drainage projects had added more than 1,300,000 acres to the total of farm lands in the Valley fit for normal cropping. In all, approximately 4,500,000 acres of land were drained by about 4,000 miles of ditches, according to the 1930 census on drainage of agricultural land. Almost $12,000,000 had then been invested, at an average cost of nearly $3.00 per acre of land in drainage areas in the Valley. The flatness of these fertile lands and their stickiness when wet accounts for the paradox of artificial drainage in a region of limited rainfall. Need of both drainage and water conservation presents a nice problem of planning land use to attain a proper water balance.

In southern Minnesota, with its fertile and comparatively expensive lands, drainage generally called for a greater capital investment per acre. In Yellow Medicine County, for example, investment amounted to $44.67 an acre, in Sibley County $37.35 an acre, and in Ramsey County $32.31 an acre (Table -). When farm prices were high, such costs were easily justified, but with the price slump on

farm products subsequent to 1920, many landowners found themselves in serious financial difficulties. Heavy drainage assessments then had to be met out of sharply reduced incomes.

The extended drouth and prolonged depression of the 1930's led to widespread neglect of drains. Many systems are obstructed as a result of tile breakage and root growth, while trees and brush and washed-in sediment have reduced the carrying capacity of some open ditches almost to nothing.

Summary

Sufficient data do not exist for measuring the influence of drainage on some of the basic hydrologic balances. It does seem reasonable to believe that the extensive drainage of natural water reservoirs that occurred in Minnesota was an important contributing factor in the lowering of the water table along a north-south zone in western Minnesota. Contrasting figure - with figure -, the zone is found to contain a great deal of drained land, particularly in the northern portion. Non-selective drainage lowered the levels of many lakes and streams and in some cases destroyed them altogether.

The wet lands of Minnesota constitute a great reserve of potential farm land. There is a wide variance in potential value, with soils ranging from high to low in productivity. Future pressures of population upon productive lands may make it desirable to draw upon this reserve. In the meantime, as the Mississippi Valley Committee suggests, a good deal of swamp land might well be restored to its proper present use as forest, or refuge and feeding grounds for wild game. The Division of Drainage and Waters of the Minnesota Department of Conservation, as indicated in its various published reports, shares this opinion.

Recreation And Conservation Of Wild Life

Attraction of Minnesota lakes and streams to tourists and sportsmen from all parts of the country is proving a major source of wealth. People attracted to the Ten Thousand Lakes Country by its scenery and its resources for outdoor sport require certain services while they are here. Promotion of the recreation industry through the well-planned use and control of water is a matter of general public interest and productive of economic benefit to the entire State.

Resort owners and recreationists desire uniform and generally high lake and stream levels. By storage of waters during periods of excess run-off, with proper provision for the possibility of drought, adequate levels may be sustained in most of Minnesota's lakes. Such water conservation will also aid in maintaining the dry-weather flow of rivers, so that their recreation usefulness will not be impaired nor fish life destroyed in seasons of scanty rainfall. Moreover, storage at reasonably uniform levels is a means of providing wildfowl with the feeding and resting places they need.

A number of water conditions are harmful to the fish supply in lakes and streams of Minnesota. Silt in roily water is often directly injurious to fish life, and it may cause even greater indirect harm by destroying plankton, the basic fish food, and lake flora, and through deposition over spawning grounds. Streams with gentle current and relatively uniform flow generally contain fish food organisms in richer abundance than do erratic streams, subject to violent floods. Wide fluctuations in the water level of streams and lakes cause great losses of fish as thousands are left stranded when flood waters recede. Cold water fish are especially susceptible to marked changes in water temperature. In some localities, deforestation has raised water temperatures by admitting greater sunlight, until streams formerly ideal for trout (temperatures between 50° and 60° F.) will no longer sustain them. Obstructions

in streams during the annual spawning migration hinder natural propagation. Pollution destroys fish in a number of ways. It may suffocate them by reducing the oxygen supply, or poison them with chemical wastes; it may destroy their food, or form sludge deposits which interfere with spawning.

Drainage of lakes, marshes, muskeg bogs, and shallow, river-bottom swamps, destroyed many of the feeding, breeding, and resting grounds of water birds and mammals. Reduction of natural cover enabled predators to make greater inroads upon wildlife. With drainage and logging, fires destroyed more animals than previously. An accurate estimate of the damage is impossible, but a census taken in 1929 placed Minnesota's water-fowl population at about one-third that of 1919. A large portion of this decrease may rightly be attributed to the drainage of swamplands.1/ Since 1929 wild fowl have been further reduced by eight years of

---

1/ Rysgaard, G. N., "A short history of water-fowl", The Conservation Volunteer, vol. 2, no. 9, pp. 75-77, June 1941.

---

drought. Damming of drainage ditches and increased rainfall in recent years have restored some swamplands, contributing no doubt to the Bureau of Biological Survey's recently reported increase of 5 to 10 percent in water-fowl population.

In planning for wider and better use of lakes and streams for recreation, there is need for more data on the location, extent, depth, physiographic character, source of supply, natural fluctuations, and plant and animal life of Minnesota's water bodies. At present only about half of the lakes are meandered (6,005 lakes), and even as to those, much of the information was derived from secondary sources.

Although a vast amount of work remains to be done, a considerable start has been made. In recent years, 343 dams have been constructed in lake outlets to

maintain more nearly uniform levels in lakes and outlet streams (Figures-, -, -, -, -, -, -, and -). Some lakes may be made to function as retarding basins for flood waters.

Conflicts of interest often arise in the conduct of a program of water control. Proper management of a storage basin may necessitate the raising or lowering of water levels at times when such action is harmful to recreation interests. Moreover, the manipulation of controls in such a way as not to damage farm lands during the growing season on the one hand and at the same time maintain lakes at levels suitable for resort purposes on the other is one of constant controversy. Such diverse water interests as those of recreation, farming, lumbering, water power and navigation calls for careful coordination, and frequent compromise. Some of the problems are so difficult as to tax the wisdom of a Solomon. The mediator of water-level disputes needs breadth of vision to comprehend all the interests involved, wisdom to appraise them in relation to one another, and force of character to serve them in the order of their true importance.1/

1/ The problems of Minnesota's water resources, Minnesota Resources Commission, p. 8, January 1940.

POWER

To build a dam for flow correction alone may not be economically feasible in a given case, but if the dam will also provide power, add new recreation facilities, improve navigation, control floods, and store a public water supply, it may become a profitable and attractive public investment. Power development at strategic sites in Minnesota may occasionally be the coordinating factor needed to justify expenditures for water control.

Water power depends directly upon stream-flow, which in turn is dependent upon precipitation and physiography. Any effective analysis of water power resources, therefore, must be based primarily upon thorough study of

the hydrology and physiography of Minnesota. The distance to which current can be economically transmitted is also a cogent factor. Under ordinary conditions today, the limit is 200 to 300 miles. The available near-by market for power is therefore fully as important as the physical suitability of the site. The cost of developing a hydroelectric project generally exceeds that of a steam generating plant, but sites which would be unprofitable for hydroelectric power if developed now might be successful if developed at some future time.

Water power generates 29 percent of the electric energy produced in Minnesota, steam 68 percent, and internal combustion engines 3 percent. These percentages are substantially the same as for United States as a whole. Figure - shows installed capacity and potential hydro installation by drainage basins. It shows Minnesota with 279,543 developed horsepower and 217,130 undeveloped. Developed power is that which is available from the best power sites, situated within easiest reach of the most thickly populated and industrialized areas.

Potential water power, it should be recognized, comprises all undeveloped power which is theoretically available. Development is subject to many physical and economic limitations. The figures on possible water power development, as used in the chart and in table -, are from 308 Reports of the Corps of Engineers, United States Army. These surveys show that some of the potential power may be developed at reasonable cost, providing markets can be found, while the remainder is not likely to be harnessed because cheaper power sources are already available. Note in figure - that the bulk of the potential power which is feasible of development lies in northern Minnesota, in the Rainy River and Lake Superior Basins. Tributary areas are sparsely populated and contain little or no industry, and are being developed for forest and recreation areas.

The Corps of Engineers has reported on twelve sites on the Mississippi River above Minneapolis. If developed, they could produce an annual total of about 89,600,000 kilowatt hours of primary power and 319,300,000 kilowatt hours of secondary power. The estimated cost of production at the sites ranges from

HYDRO-ELECTRIC RESOURCES OF MINNESOTA

River	Developed Water Power		Potential	Undeveloped Water Power	
	KWH	H. P.	Primary KWH	Secondary KWH	H. P.
St. Louis	233,000,000	109,820	173,000,000	75,000,000	24,800
Vermillion			25,650,000	6,680,000	9,420
Gooseberry				3,940,000	1,800
Beaver Bay			15,000,000		3,600
Baptism and Manitou			54,000,000	6,000,600	16,000
Temperance and Popular			58,000,000	6,000,000	16,000
Cascade			21,500,000	5,300,000	8,000
Devil Track			19,700,000	5,000,000	7,500
Brule			103,000,000	6,400,000	28,700
Pigeon			100,000,000	7,000,000	35,200
Little Fork				29,000,000	9,200
Big Fork				29,000,000	9,840
Kawishiwi	20,000,000	5,400			
Secondary can be replaced by			29,000,000	7,500,000	2,800
Mississippi above Coon Rapids	118,100,000	57,115	89,600,000	319,300,000	28,170
Mississippi above Coon Rapids Tributaries		8,413			
Mississippi below Coon Rapids		48,800			
Mississippi below Coon Rapids Minor Tributaries		8,360			
Minnesota		1,850			
Minnesota Tributaries		2,785			
St. Croix	85,000,000	35,400	56,400,000	198,900,000	16,100
St. Croix Tributaries	900,000	1,600			
Total	457,000,000	279,543	744,850,000	705,020,600	217,130

Source: War Department - Corps of Engineers, U. S. Army

5.27 mills to 10.8 mills per kilowatt hour of primary power.1/ Any increase of minimum flow will increase the firm capacity of the power sites and de-

---

1/ Drainage basin reports, National Resources Committee, 1936.

---

crease unit costs of power production. The interim report of the Federal Power Commission (1935) indicated a deficiency of power for the probable future demand in this section. Low seasonal flows preclude any large expansion of existing water power development on tributaries of the Mississippi below St. Paul, unless such development can be coordinated with flow correction. Estimated potential power resources on the St. Croix are 56,400,000 kilowatt hours of primary power and 198,900,000 kilowatt hours of secondary power. Two of the sites on the St. Croix are reported as favorable for early development, pending further economic study.

Illustrations And Tabulations

Forests*

Forests are intimately bound up with the whole economy of Minnesota. They occupy nearly two-fifths of the land area of the State. Between fifty and seventy thousand persons engage in enterprises connected more or less directly with forests. Forests supply wood and all the products thereof that contribute to people's comfort, convenience, health and pleasure. Forest lands provide essential refuges for wild life, both plant and animal, and spacious natural playgrounds for healthful recreation. They conserve water and help regulate it for power and navigation, for domestic, industrial, recreational and other uses. Trees, with their canopy of foliage and filter pad of leaves and twigs on the forest floor, break the force of raindrops while countless roots help to hold the soil in place. Woodlands afford windbreaks and favorably affect local climate and basic hydrologic balances.

Forests are reproducible and may therefore be considered as "crops", but the original resource cannot be profitably replaced once it is destroyed. Problems of forest conservation in Minnesota derive mainly from wasteful logging and from the devastating fires that accompanied pioneer exploitation of the original forest resource. Conservationists have agreed that remaining timber supplies should be conserved and used wisely, inferior woodlands improved, and idle and non-productive lands restored to forest growth. Their main concern is whether the second-growth forest will be properly managed or destructively logged and burned over just as the original stands.

Original Forests

Climate, physiography and soils governed development of the varied plant cover in Minnesota. Figure - depicts the general composition and distribution of the natural vegetation of the State. It is seen that the northeastern third of the State was in the main covered by coniferous forests, the western and southwestern areas by prairie grasses and associated herbaceous flowering plants, and the area between by a transition cover of aspen and hardwoods varying from a

* Much of the substance of this chapter is found in "Forests of Minnesota", by R. N. Cunningham and H. C. Moser, Lakes States Forest Experiment Station, 1938, to which the writer acknowledges his indebtedness.

few miles to over one hundred miles in width. Boundaries of these vegetative zones were not sharply defined because of the modifying affect of varied elevation and diverse soils on the principal determining factor, climate. About 31,500,000 acres, or three-fifths of the State's land area originally sustained forests. Acreages of cover types of the forest primeval were about as given in table -.

Coniferous Forests

Pines of northeastern Minnesota occupied the lighter well drained soils (Figure -). On stony moraines and till plain areas of more finely grained soils with good but not excessive internal drainage, northern white pine or mixed stands of white and Norway pine grew in immense forests. On less productive soils and drier sites, Norway pine predominated. Jack pine was the principal species on sandy and gravelly soils of glacial outwash plains and on recently burnt-over tracts. Remnants of magnificent "pineries" may be seen at Itasca State Park, Cass Lake, Little Falls city park, Scenic State Park, and along the Gunflint Trail in Superior National Forest.

Spruce-balsam forests subsisted on inadequately drained northern areas where soil was heavy and predominantly acid. In general, they occupied uniform expanses of the Superior Upland north and east of Duluth, extensive low areas among the large moraines extending southward and eastward from Lower Red Lake, and better drained tracts along Rainy River and its tributaries (Figure -). Balsam fir was the dominant tree. Other characteristic species in the association were white spruce, black spruce, tamarack, paper birch, aspen and northern white cedar.

Coniferous swamp forests grew mainly on nearly level wet areas created by glacial Lake Agassiz and glacial Lakes Upham and Aitkin (Figure -). Cold and poorly-drained deep peat sustained stunted and scattered black spruce, cedar, or tamarack, while better drained and shallower peat lands supported a more thrifty forest growth of these species together with scattering of poplar,

ORIGINAL FORESTS IN MINNESOTA

Early General Land Office surveys in Minnesota indicated that about 31,500,000 acres, or three-fifths, of the State's land area was originally forested. Forest cover types of this portion were about as follows:

Type	Acres
Pine	5,800,000
Spruce-fir	6,300,000
Coniferous swamp	6,100,000
Maple-basswood	8,400,000
Bottom-land hardwoods	2,000,000
Aspen and scrub oak	2,900,000
Total	31,500,000

The distribution of type acreages is shown in the accompanying map.

Coniferous forests occupied the northeastern third of the State, extending west roughly as far as Roseau, Bagley, and Wadena, and south as far as Little Falls, Milaca, and Pine City. Aspen and scrub Oak occupied a transitional belt between the conifers and the open prairie, extending all the way from the Canadian line south to the border of Iowa. Bottom-land hardwoods were found in narrow strips throughout the State.

Source: Cunningham, R. N., and Moser, H. C., Forests of Minnesota, U. S. Dept. Agri., Forest Service, 1938.

birch, and balsam fir that formed a mixture in some places. Except around the borders, and on the margins of streams, very little material in the swamps reached saw-timber size.1/

1/ Cunningham, R. N. and Moser, H. C., Forests of Minnesota, p. 20, Lake States Forest Experiment Station, U. S. Dept. of Agr., Forest Service, 1938.

Hardwood Forests

In transition areas hardwoods attained large thick stands on fertile and adequately drained calcareous clays where rainfall was sufficient. Best and most extended example of this type of forest was the "Big Woods" which grew over an area nearly 100 miles long and about 40 miles wide west and south of the Twin Cities (Figure -). Trees were tall, straight, close set and principally sugar maple, basswood, red oak, and white elm. Intermixtures of trees such as green ash, butternut, and bur oak obtained in some places but they lacked hemlock and beech and contained little yellow birch. Conservationists urge that Nerstrand woods in Rice County be made a state park since the remnant well typifies the historic forest.

East and south of "Big Woods" the forest was smaller and much thinner and consisted largely of oaks of various species. Along the Mississippi watershed below Hastings, forests in many respects resembled the oak-hickory woods characteristic of western Ohio, Indiana, Illinois, Iowa, and Missouri. Red and white oaks, elms, and basswood predominated with a light interspersion of more typical southern hardwood species such as black walnut, butternut, hickory, honey locust, coffee tree and hackberry.

White oak thrived on morainic soils of red drift in east central Minnesota (Figure -). The droughty Anoka Sand Plain and other especially sandy areas had thin and stunted forests of Hill's oak, either in pure stands or intermingled with equally short and branchy bur oaks. Bur oak grew abundantly on gravelly outwash, often leaving what earlier settlers called "oak openings". Toward the northwest

prairie the hardwoods became progressively poorer both in variety of species and in the quality of timber. Characteristic tree was the scrubby bur oak which grew in scattered stands or groves. On the "brush prairie" of northwestern Minnesota, scrub growth of oaks mingled with aspen, balsam poplar, spruce, tamarack and willows and a few other trees of inferior quality.

River Bottom Forests

Narrow bottom lands of the Mississippi and St. Croix Rivers were originally well wooded. Generally, a bank of gigantic cottonwood trees lined the water's edge and back of these grew a growth of black ash, white elm, soft maple, and balsam poplar intermixed with many other species. In the coniferous forest region there were no cottonwoods, but red maple, yellow birch, alder, and balsam fir grew in association with balsam poplar, black ash, and elm. Back of the edging cottonwoods of the Minnesota and Red Rivers, marshy vegetation was the principal cover.

Forest Depletion

Of all the changes of natural landscape that accompanied occupation of this continent by white men, there was none more striking or of more far-reaching effect than the alteration of the primeval forest cover in Minnesota. Approximately one-third of the original woodland of 31,500,000 acres, during the past century, was taken over permanently for other uses, principally crop and pasture land (table -). Forest survey work of Lake States Forest Experiment Station, 1934-1938, showed that greatest reductions in forest area occurred where hardwood and scrub types grew. Lease areal change occurred in coniferous swamp forests because there the land was unsuitable for most non-forest uses.

Of the 19,615,400 acres now classed as forest land, great sections have been burnt off or cut over until they hardly merit that description. Growth ranges from 1,566,500 acres of forest fit for lumber and 9,233,100 9,366,900 acres growing up again after the first cutting, to 4,123,100 acres of grass and brush and fire

PRESENT STATUS OF ORIGINAL FOREST AREAS IN MINNESOTA

Original Forest Cover Type	Total Area Originally Forested	Status of Original Areas in 1934			
		Devoted to Nonforest Uses	Temporarily Deforested 1/	Aspen and Scrub Oak	Type Similar to Original
	Acres	Acres	Acres	Acres	Acres
Pine	5,800,000	1,444,100	550,900	2,134,800	2/ 1,670,200
Spruce-fir	6,300,000	1,978,300	617,500	2,615,900	1,088,300
Coniferous Swamp	6,100,000	900,400	1,608,300	260,900	3,330,400
Maple-basswood	8,400,000	4,783,100	848,400	1,398,900	1,369,600
Bottom-land hardwoods. .	2,000,000	560,000	449,600	374,300	616,100
Aspen and scrub oak. . .	2,900,000	2,218,700	48,400	632,900	- - -
Total	31,500,000	11,884,600	4,123,100	7,417,700	8,074,600

1/ Deforested acreage includes only lands intermingled with other forest lands and capable of supporting forest growth; it does not include once-forested lands now permanently converted to nonforest uses.

2/ Mostly jack pine

Source: Cunningham, R. N., and Moser, H. C., Forests of Minnesota, U. S. Dept. of Agri., Forest Service, 1938

scarred stumps on cut-over, burnt-over and idle land (Table -). Table - reveals that of the original woodland types, coniferous swamp forests have the greatest proportion of the land in temporarily deforested category. Figure - contrasts the virgin forest area in Minnesota with areas now in merchantable timber. In this connection, it should be noted that probably not more than a third of the original forest was old-growth saw-timber when logging first started in the State.1/

1/ Op. cit., Forest of Minnesota, p. 21.

The forest survey conducted by Lake State Forest Experiment Station inventoried forest areas in Minnesota by type group and timber size class (Table -). It revealed that the white and Norway pine forests which once endowed a booming timber industry are largely gone. Only 133,600 acres remain, chiefly white pine in small tracts, widely scattered and commercially inaccessible. Old-growth timber stands of the great coniferous swamp forests contain a bare 2,600 acres and spruce-fir forests only 23,000 acres. Remnant acreages of old-growth upland hardwoods amount to 134,900 acres, bottom-land hardwoods to 27,300 acres and aspen and miscellaneous forest stands to 18,300 acres. In just a century all but 2 percent of the vast natural heritage of timber has been used up or destroyed.

That so little is left of the old-growth timber is not the only harmful result of destructive and neglectful use of the forest resource. Perhaps even more significant are the indirect and less obvious affects that have upset the physical and biological conditions of the forest - for example, the distribution of tree species, the fertility of soils and the prevalence of diseases and pests.

Before large scale timber drives in Minnesota, it was still the white and Norway pine and better hardwoods that normally took possession of abandoned clearings, burns, and cut-over tracts by the process of natural reseeding. But as lumbering went on and more and more land was denuded and seared with forest

FOREST AREAS, BY FOREST COVER TYPE, SIZE CLASS
AND FOREST SURVEY UNIT, IN MINNESOTA, 1934

Forest Cover Type and Size Class	State Total	Forest Survey Unit					
		Cloquet	Central Pine	Rainy River	Superior	Hardwood	Prairie
	Acres	Acres	Acres	Acres	Acres	Acres	Acres
White Pine							
Old growth	106,000	2,400	30,300	38,900	33,600	800	-
Second growth	13,200	-	12,300	-	-	800	100
Cordwood	91,300	7,800	11,700	9,600	61,000	800	400
Restocking	23,200	5,500	7,800	800	3,200	4,800	1,100
All white pine	233,700	15,700	62,100	49,300	97,800	7,200	1,600
Red Pine							
Old growth	27,600	800	13,900	12,100	-	800	-
Second growth	34,200	-	20,100	9,700	2,600	1,600	200
Cordwood	78,700	11,700	37,800	12,100	13,500	2,400	1,200
Restocking	30,000	3,900	18,300	3,200	1,700	2,400	500
All red pine	170,500	16,400	90,100	37,100	17,800	7,200	1,900
Jack Pine							
Old growth	2,400	-	2,400	-	-	-	-
Second growth	280,100	19,700	59,400	14,600	184,500	1,600	300
Cordwood	522,800	61,100	200,400	61,600	196,100	2,400	1,200
Restocking	460,700	40,700	218,600	24,200	174,200	2,400	600
All jack pine	1,266,000	121,500	480,800	100,400	554,800	6,400	2,100
Maple-basswood							
Old growth	106,100	10,200	6,100	1,600	-	70,500	17,700
Second growth	177,300	14,200	64,900	3,200	1,900	74,500	18,600
Cordwood	248,600	13,300	56,400	3,200	200	140,300	35,200
Restocking	361,600	44,800	174,900	6,400	100	108,200	27,200
All maple-basswood	893,600	82,500	302,300	14,400	2,200	393,500	98,700
Oak							
Old growth	28,800	-	2,300	-	-	16,800	9,700
Second growth	82,300	800	3,100	-	-	49,700	28,700
Cordwood	258,300	-	11,600	-	-	156,300	90,400
Restocking	106,600	4,800	20,400	-	-	51,200	30,200
All oak	476,000	5,600	37,400	-	-	274,000	159,000
Ash-elm							
Old growth	27,300	800	800	5,600	-	13,600	6,500
Second growth	80,300	10,200	29,400	8,900	-	21,600	10,200
Cordwood	200,700	27,500	71,800	26,700	-	50,500	24,200
Restocking	307,800	78,400	97,300	32,500	-	67,300	32,300
All ash-elm	616,100	116,900	199,300	73,700	-	153,000	73,200
Spruce-balsam							
Old growth	24,000	6,300	6,900	10,500	-	-	300
Second growth	131,700	33,800	44,000	44,500	7,100	800	1,500
Cordwood	495,300	149,800	116,600	141,100	81,400	1,600	4,800
Restocking	437,300	236,200	76,400	99,500	20,200	1,600	3,400
All spruce-balsam	1,088,300	426,100	243,900	295,600	108,700	4,000	10,000
Spruce Swamp							
Old growth	-	-	-	-	-	-	-
Second growth	18,900	1,600	-	9,700	6,800	-	800
Cordwood	619,100	44,000	67,200	260,000	222,400	3,200	22,300
Restocking	891,800	307,700	154,300	198,500	210,200	4,000	17,100
All spruce swamp	1,529,800	353,300	221,500	468,200	439,400	7,200	40,200
Tamarack Swamp							
Old growth	-	-	-	-	-	-	-
Second growth	9,300	-	3,100	5,700	-	-	500
Cordwood	144,500	14,200	37,000	66,500	-	21,600	5,200
Restocking	503,100	93,400	125,900	234,100	-	31,200	18,500
All tamarack swamp	656,900	107,600	166,000	306,300	-	52,800	24,200
Cedar Swamp							
Old growth	2,600	-	-	2,400	-	-	200
Second growth	18,300	800	4,600	8,900	3,200	-	800
Cordwood	186,100	38,400	27,000	89,900	22,800	-	8,000
Restocking	173,600	42,300	44,800	76,200	3,500	-	6,800
All cedar swamp	380,600	81,500	76,400	177,400	29,500	-	15,800
Nonproductive Swamp							
Cordwood	6,400	-	1,500	3,200	-	-	1,700
Restocking	756,700	192,300	74,900	315,100	14,700	800	158,900
All nonproductive swamp	763,100	192,300	76,400	318,300	14,700	800	160,600
Aspen-birch							
Old growth	18,300	3,100	3,900	9,700	-	1,600	-
Second growth	377,800	54,100	132,100	84,200	97,800	9,600	-
Cordwood	1,315,500	208,000	491,200	176,800	341,300	62,400	35,800
Restocking	4,598,200	1,395,900	1,687,100	797,000	247,500	309,900	160,800
All aspen birch	6,309,800	1,661,100	2,314,300	1,067,700	686,600	383,500	196,600
Scrub Oak							
Cordwood	288,500	-	2,300	800	-	238,000	47,400
Restocking	253,900	8,500	121,300	4,000	-	100,100	20,000
All scrub oak	542,400	8,500	123,600	4,800	-	338,100	67,400
Scrub Aspen							
Cordwood	103,100	-	-	-	-	-	103,100
Restocking	462,400	-	-	-	-	-	462,400
All scrub aspen	565,500	-	-	-	-	-	565,500
All Cover Types							
Old growth	343,100	23,600	66,600	80,800	33,600	104,100	34,400
Second growth	1,223,400	135,200	373,000	189,400	303,900	160,200	61,700
Cordwood	4,558,900	575,800	1,132,500	851,500	938,700	679,500	380,900
Restocking	9,366,900	2,454,400	2,822,000	1,791,500	675,300	683,900	939,800
Deforested	4,123,100	1,140,900	890,800	895,200	79,200	690,600	426,400
Total All Cover Types	19,615,400	4,329,900	5,284,900	3,808,400	2,030,700	2,318,300	1,843,200

Source: Cunningham, R. N., and Moser, H. C., Forests of Minnesota, U. S. Dept. of Agri., Forest Service, 1938

fires, the light-seeded, fast growing species such as poplar, birch, pin cherry, alder, red maple, to say nothing of many kinds of shrubs, soon overtook and passed the pine and more heavily-seeded hardwoods in their capacity of reseed on vacant land. Forest Service survey data of 1934 indicate aspen (aspen-birch and scrub-aspen) and scrub oak occupied 57 percent of the restocking forest land, 37 percent of cordwood-sized forest land, and 31 percent of the second-growth saw-timber area.

Forest fires which oftentimes followed logging contributed immeasurably to the decimation and deterioration of the forests. On much land that would have naturally reforested itself with better species, fires, sometimes repeatedly burning over the same area, helped less desirable species to obtain predominance. Forest-growing soils in many places suffered material changes as a result of deep-burning fires which destroyed humus and organic matter. Where this has occured, it will be necessary to wait upon the slow re-establishment of normal soil conditions under transitional forests of lesser economic quality, for trees are sensitive to differences in soil. Even in recent years fires have destroyed an average of 279,861 acres annually (Table -).

Gradual deterioration in some hardwood stands has resulted from repeated culling and pasturing, in pine forests from excessive thinning by intermittent logging and failure to leave seed trees, and in swamp forests from Christmas tree cutting and premature pulpwood operations. White pine blister rust, forest tent caterpillars and jack pine budworms have quitely worked their damage. Trees weakened by injury, fire, or drought are especially susceptible to diseases and pests.

Forests of Minnesota, the report of the forest survey findings, directs attention to the understocked condition of most second-growth forest areas of all types due to imperfect reseeding, recent forest fires and partial logging operations. Only 29.3 percent of the cut-over swamps contain seedlings suf-

FOREST FIRES IN MINNESOTA - 1920 to 1939

Year	No. Fires	Area Acres	Damage	Federal and State Fire Control Costs
1920	991	97,624	$ 152,401.00	$ 90,137.85
1921	949	119,984	274,284.00	111,029.85
1922	1,292	511,214	1,132,948.00	151,290.02
1923	1,675	514,636	2,151,478.00	269,561.95
1924	1,142	170,234	378,264.00	204,211.94
1925	1,391	332,347	1,022,334.00	227,372.97
1926	1,560	554,699	669,626.00	240,445.03
1927	507	29,688	20,332.00	187,349.08
1928	1,295	125,736	76,710.00	248,412.74
1929	2,445	408,448	719,938.00	341,168.80
1930	2,315	278,696	422,353.00	393,286.90
1931	2,852	1,008,452	3,523,423.00	393,716.60
1932	2,165	102,041	103,713.00	403,455.39
1933	3,602	357,332	552,110.00	390,021.35
1934	3,242	364,954	449,772.00	358,741.44
1935	837	28,822	35,607.00	375,099.69
1936	2,369	302,407	879,714.00	739,290.83
1937	918	29,004	34,184.00	500,427.09
1938	1,594	192,048	579,129.00	480,970.55
1939	1,505	68,853	151,002.00	599,897.37
Total	34,646	5,597,219	$13,329,322.00	$6,705,887.44

Source: Forest Resources of Minnesota, Minnesota Resources Commission, p. 11, 1940.

ficient to provide well-stocked stands (700 trees or more per acre). Only 20.5 percent of the total area of young pine and still smaller proportions of the total area of young spruce-fir and hardwood timber are fully stocked.1/

1/ Op. cit., Forests of Minnesota, p. 5.

Present Forest Resources

Forests cover approximately 38 percent of the land surface of Minnesota. In Wisconsin 48 percent and in Michigan 52 percent of the land classifies as forest land (Table -). Economic value of forests, however, obviously cannot be measured by area alone. Character and condition of forests, quantity and quality of timber, location of forests with reference to transportation and markets, potentialities for future production, character of ownership, utility of forests for purposes other than production of raw materials, and various other factors must be considered in measuring their value to the community and to the state.

Character and Condition

Forests of Minnesota include a wide variety of useful trees. At least forty native species are of recognized commercial value and nearly sixty receive consideration in forest management. Table - lists and briefly describes the principal forest trees in Minnesota.

Existing forest areas in the State and various forest-survey units are shown by forest cover type and timber size class in table -. Figure - locates the various forest survey units. Of the total present forest land, 1,566,500 acres, or 8 percent, can be classified as saw-timber area (land bearing at least 2,000 board feet per acre in trees of 9 inches or more in diameter). Only 343,100 acres of this, or one-fourth of the total saw-timber area, is rated as old-growth (50 percent or more of volume occurs in trees 15 inches or more in diameter at breast height). In summarizing the data given in table - the Lake State Forest Experiment Station report called attention to the following facts:

AREA OF FOREST LAND IN THE LAKE STATES REGION BY STATE AND FOREST SURVEY UNIT

State and Unit		Gross Land Acreage 1/	Area in Forest		Area not Forested	
			Acres	Percent	Acres	Percent
Minnesota:	1	5,369,400	4,329,900	80.64	1,039,500	19.36
	2	7,206,000	5,284,900	73.34	1,921,100	26.66
	3	4,141,100	3,808,400	91.97	332,700	8.03
	4	2,101,300	2,030,700	96.64	70,600	3.36
	5	11,356,300	2,318,300	20.41	9,038,000	79.59
	6	20,851,900	1,843,200	8.84	19,088,700	91.16
Total.		51,026,000	19,615,400	38.44	31,410,600	61.56
Wisconsin:	1	5,750,000	4,567,000	79.43	1,183,000	20.57
	2	6,933,000	5,683,000	81.97	1,250,000	18.03
	3	16,475,000	4,869,000	29.55	11,606,000	70.45
	4	5,969,000	1,827,000	30.61	4,142,000	69.39
Total.		35,127,000	16,946,000	48.24	18,181,000	51.76
Michigan:	1	5,000,000	4,350,000	87.00	650,000	13.00
	2	5,571,000	4,986,000	89.50	585,000	10.50
	3	10,774,000	7,441,000	69.06	3,333,000	30.94
	4	15,055,000	2,296,000	15.25	12,759,000	84.75
Total.		36,400,000	19,073,000	52.40	17,327,000	47.60
Regional Total.		122,553,000	55,634,400	45.40	66,918,600	54.60

1/ Data obtained from surveys of the United States General Land Office.

Source: Cunningham, R. N., and Moser, H. C., Forest Areas and Timber Volumes in the Lake State, U. S. Dept. of Agri., Forest Service, 1938.

PRINCIPAL FOREST TREES IN MINNESOTA

Common and Scientific Name	Description
Cedar, Northern White (Arborvitae) Thuja Occidentalis	Leaves scale like, crowded, resinous and aromatic. Cone resembles an open scaly bud.
Fir, Balsam Abies Balsamea	Leaves not sharp pointed; flexible and flattened. Cone 1" long with scales falling when ripe.
Pine, jack Pinus Banksiana	Leaves two in cluster up to 1½" long. Cones 1" to 2" long, incurved, irregular shaped.
Pine, Norway (Red Pine) Pinus Resinosa	Leaves two in cluster 5" to 6" long. Cone 2" long without prickles.
Pine, White Pinus Strobus	Leaves five in cluster 3" to 5" long. Cone cylindrical 4" to 8" long.
Spruce, Black Picea Mariana	Leaves blue green, somewhat blunt pointed. Cone on incurved stalk, persistent for years. Cone scales with rough edges. Twigs finely hairy.
Tamarack (American Larch) Larix Laricina	Leaves 1" long in clusters falling in winter. Cone three-fourts inch long.
Ash, Black Fraxinus Nigra	Leaves opposite, of 7 to 11 leaflets without any stems (sessile). Branchlets round, flowers without calyx, polygamous.
Ash, Green Fraxinus Pennsylvanica Lanceolata	Leaves opposite, of 7 to 9 tapering long stemmed smoothed leaflets and branchlets. Wing extends part way up the fruit body. Flowers of two kinds on separate trees.
Ash, White Fraxinus Americana	Leaves opposite, of 5 to 9 leaflets each, broadly oval, usually smooth and whitish below. Flowers of two kinds on separate trees.
Aspen, Large Tooth Populus Grandidentata	Leaves coarsely toothed, broad, with flattened leafstalks.
Aspen, (Popple) Populus Tremuloides	Leaves broad, finely toothed, leaf stalks flat and long.
Balsam, Poplar (Balm of Gilead) Populus Balsamifera	Leaves dull-toothed, leaf stalks rounded. Stinted buds one-half inch long, shiny and resinous.
Basswood Tilia Glabra	Leaves coarsely toothed, smooth except tufts of hairs on upper surface. Flower stalks smooth.
Birch, Paper Betula Papyrifera	Bark pure white to light grey, separating in thin sheets. Leaves thick, rounded at base.
Butternut Juglans Cinerea	Leaves 15" to 30" long, of 11 to 17 leaflets. Nut longer than thick. Velvety cushion above leaf scar.
Cherry, Choke Prunus Virginiana	Leaves broadly oval, sharp pointed, shiny. The flowers in long clusters (racemes), cherries dark-red.
Cherry, Pin Prunus Pennsylvanica	Leaves long, pointed, finely toothed. Flowers in flat culsters, (umbels). Cherry red, each on long stem. Spreads rapidly on burned over forest land.
Cottonwood, Eastern Populus Deltoides	Leaves triangular, finely toothed, fragrant, with flattened stems. Buds resinous.
Elm, American Ulmus Americana	Leaves doubly and sharply toothed, smooth above. Wings of seed with tiny hairs. Large tree with drooping branches.
Elm, Slippery Ulmus Fulva	Leaves rough, hairy above, soft and downy below. Winged seeds not hairy on edges. Inner bark mucilaginous.
Hickory Bitternut Hicoria Cordiformis	Leaves of 7 to 9 long pointed leaflets. Nut broad, thin husked, with bitter kernel.
Hop Hornbeam (Ironwood) Ostrya Virginiana	Thin brown scally bark. Fruit resembling hops, each seed in bag. Leaves doubly toothed.
Locust, Honey Gleditsia Triacanthos	Leaves doubly compound of small elliptical leaflets. Pods 10" to 18" long. Twisted sweet pulp. Tree usually spiny.
Maple, Silver (Soft Maple) Acer Saccharinum	Leaves opposite, deeply lobed, toothed, silvery below. Flowers before leaves. Keys fall early.
Maple, Sugar (Hard Maple) Acer Saccharum	Leaves opposite, paled and smooth below, 5 lobed round sinuses. Keys ripen late. Tree yields sweet sap.
Oak, Bur Quercus Macrocarpa	Leaves deeply lobed and notched, broadest toward apex. Acorn enclosed in mossy or scaly cup.
Oak, Red (Northern) Quercus Borealis	Acorn large in flat shallow cup. Leaves mostly with 7 to 11 uniform lobes 6" to 9" long, dull above, green below. High grade timber tree.
Oak, White Quercus Alba	Leaves deeply and wavily lobed. Acorn in low flat cup. Important timber tree.
Walnut, Black Juglans Nigra	Leaves 12" to 24" long of 15 to 23 leaflets, nut round. Bark rich brown. High grade cabinet wood.
Willow, Black Salix Nigra	Leaves slender, long, pointed, finely toothed. Branchlets reddish. Largest of the willows.

Note: Descriptions of the principal forest trees are taken from "Forest Trees and Forest Regions of the United States", a publication of the U. S. Dept. of Agriculture. No introduced or exotic trees are included, although there are many, and some have found a congenial home in the State and have become naturalized.

1. The 1,566,500 acres of saw-timber is divided almost equally among (a) pine, (b) aspen, (c) better hardwood, and (d) other types.

2. Most extensive stands in 4,558,900 acre cordwood forests (areas bearing 3 cords or more per acre) are of aspen and scrub oak types while the most valuable constitute spruce swamp and jack pine types.

3. In 9,366,900 acre restocking area a notable shortage of white and red pine and a strong preponderance of aspen prevails.

4. Aspen type, including aspen-birch and scrub aspen, represents by far the most widespread forest type - 6,875,300 acres (Figure -).

5. Only 396,100 acres of the aspen type, or but 6 percent, bears timber of saw-log size and 74 percent has timber below cordwood size.

6. Second most widespread cover type is mainly grass and brush occupying 4,123,100 acres of deforested land (Figure -).

Economically the forest cover is poorly balanced. Too small a proportion of the existing forest stand is approaching merchantable size and too large a proportion is very young.1/ To remedy these defects the forest survey report suggests

---

1/ Op. cit., Forests of Minnesota, p. 8.

---

that growth in young understocked stands be allowed to accumulate for a number of years, that cutting be confined to mature or overmature trees, and that harvesting of present old-growth and second-growth timber be spread over a period sufficient for ripening of younger trees.

Geographic Distribution

Size Classes - Distribution of Minnesota's forest land acreage among the different forest-survey units by size class is shown in figure - and table -. Principal conditions revealed are:

1. Two-fifths of remaining old-growth and second-growth timber acreage lies in relatively remote Superior and Rainy River units. Approximately half of existing saw-timber and high-grade pulpwood is in the Rainy River and Superior units.1/

2. Cloquet and Central Pine units, although they embrace approximately half of the forest land and lie tributary to the main manufacturing centers, contain slightly less than two-fifths of the remaining old-growth and second-growth timber acreage. Much of that, moreover,

---

1/ Op. cit., Forests of Minnesota, p. 6.

---

exists within parks and other reservations and so is not available for commercial utilization. The economic units support only 32 percent of the saw timber and 33 percent of the high-grade pulp wood.1/

3. Cloquet, Central Pine, Rainy River and Prairie units contain more forest land acreage that supports restocking growth than any other size class.2/ In Cloquet and Central Pine units more than 50 percent of the land classes as restocking land and in the Rainy River slightly more than 47 percent.

4. Large aggregates of deforested acreage exist in each forest survey unit except in the Superior district where it constitutes only 3 percent of the area. In Cloquet unit it amounts to 26 percent of the land and in the Rainy River unit 24 percent.

1/ Op. cit., Forests of Minnesota, p. 7.
2/ Forest areas were classified as restocking if there were less than 3 cords of wood in cordwood trees and less than 2,000 board feet of saw-timber per acre and if at least 10 percent of available growing space was occupied by small trees of commercial species.

Cover Types - Distribution of Minnesota's forest land acreage among different forest survey units by cover types is shown in figure - and table -. Principal conditions revealed are:

1. Superior unit which contains only about 10 percent of the forest land in the State and no industries of any consequence embraces 42 percent of Minnesota's acreage of white pine and 44 percent of the jack pine. It includes 26 percent of the white and red pine saw-timber, 39 percent of the total spruce volume, and 59 percent of the total jack pine volume.1/

2. Central Pine unit which includes approximately 27 percent of Minnesota's forest land encloses 53 percent of the State acreage of red pine and 38 percent of the jack pine.

3. Superior and Rainy River units contain 68 percent of the State's old-growth white pine, 70 percent of the jack pine saw-timber, and 45 percent of the old and second-growth spruce-balsam and spruce swamp.

4. Rainy River unit which embraces 19 percent of the State's forest land encloses 33 percent of the total area in spruce-balsam, spruce swamp and tamarack swamp. Spruce swamp and tamarack swamp together in this unit contain 43 percent of the State's cordwood of that type.

5. Aspen-birch covers 44 percent of the forest area in Central Pine unit, 38 percent in Cloquet unit, 34 percent in Superior unit, and 28 percent in Rainy River unit.

1/ Op. cit., Forests of Minnesota, p. 6.

Volume of Timber

Forest survey findings revealed that 19,615,400 acres of forest land in Minnesota (1934) sustain 8,461,240,000 cubic feet of live timber, or about one-third of the quantity standing in Minnesota 100 years ago.1/ Of this, 6,903,410,000 cubic

---

1/ Total cubic-foot volume in this survey included all wood, exclusive of bark, that lay between the stump and a top diameter of 4 inches inside bark. In hardwood, it included not only the main stem but limbwood 4 inches or larger in diameter. Cubic volume of cull trees was excluded from the volume estimates.

---

feet represents sound wood. On an average each acre supports 352 cubic feet of sound wood, or less than five cords. Average total cubic volume per acre in Minnesota is 431 cubic feet, in Wisconsin 488 cubic feet, in Michigan 659 cubic feet, and for comparison, 850 cubic feet in Finland and Sweden. Volume of timber in Minnesota is shown by product and cover type in table -.

Saw-Timber - On the forest lands stand 12,454,740,000 board feet of saw-timber of many different kinds but divided about equally between softwood and hardwood species.2/ Aspen and jack pine are about equal in importance from the standpoint

---

2/ Board-foot volume was estimated by the International $\frac{1}{4}$" - kerf log rule, which closely approximates green lumber tally. Board foot volume was computed for all trees 9 to 17 inches in diameter at breast height containing at least a 10-foot log of good quality or a 16-foot log of poor quality, and all trees larger than 17 inches containing at least a 16-foot log of good quality or two 16-foot logs of poor quality.

---

of volume (Table -). White pine, probably the most valuable saw-timber species, ranks third with spruce and red pine following in order. Note from table - that 22 percent of the saw-timber volume occurs in old-growth stands and 36 percent in small or scattered trees on cordwood and restocking areas. Table - indicates the volume of saw-timber in the various forest survey units by species.

Approximately 22 percent of the saw-timber of Northern Lake States stands in Minnesota, 29 percent in Wisconsin, and 49 percent in Michigan (Table -). These

VOLUME OF TIMBER BY FOREST COVER TYPE AND KIND OF PRODUCTS. MINNESOTA, 1934.

Forest Cover Type	Saw Timber	Cordwood			Cedar Products	Total Merchantable Volume	Additional in Cull Trees
		Small Trees	Tops and Limbs	Cull Sawlog			
	M ft. b.m.	Cords	Cords	Cords	M cu. ft.	M cu. ft.	Cords
Pine:							
Jack Pine	2,240,380	7,241,000	2,525,000	111,000	190	1,078,420	2,213,000
Red Pine	760,640	888,000	245,000	80,000	760	198,750	194,000
White Pine	1,452,810	1,499,000	660,000	389,000	8,060	405,000	690,000
All Pine	4,453,830	9,628,000	3,430,000	580,000	9,010	1,682,170	3,097,000
Upland Hardwoods:							
Maple-basswood	1,338,980	3,026,000	2,501,000	347,000	1,000	602,100	3,056,000
Oak	526,820	2,615,000	1,098,000	161,000	-	351,310	727,000
All Upland Hardwoods	1,865,800	5,641,000	3,599,000	508,000	1,000	953,410	3,783,000
Bottom-land Hardwoods:							
Ash-elm	620,260	1,758,000	1,231,000	166,000	4,000	321,310	2,229,000
All Bottom-land Hardwoods	620,260	1,758,000	1,231,000	166,000	4,000	321,310	2,229,000
Spruce-fir	1,421,840	4,050,000	1,655,000	321,000	42,710	705,530	2,339,000
Coniferous Swamp:							
Spruce	601,050	5,889,000	818,000	39,000	16,830	617,910	1,166,000
Tamarack	76,100	895,000	86,000	9,000	3,000	91,670	128,000
Cedar	134,730	806,000	192,000	21,000	130,030	295,070	1,200,000
Nonproductive	710	87,000	1,000	-	-	7,030	26,000
All Coniferous Swamp	812,590	7,677,000	1,097,000	69,000	149,860	1,011,680	2,520,000
Miscellaneous:							
Aspen	2,868,960	15,571,000	3,391,000	621,000	12,170	1,859,550	6,280,000
Scrub Oak	97,040	2,036,000	209,000	25,000	-	176,060	556,000
Deforested	314,420	1,406,000	597,000	82,000	80	193,700	2,448,000
All Miscellaneous	3,280,420	19,013,000	4,197,000	728,000	12,250	2,229,310	9,284,000
Cedar Tops and Unmerchantable Trees on All Cover Types	-	-	-	-	117,920	-	-
All Cover Types	12,454,740	47,767,000	15,209,000	2,372,000	336,750	6,903,410	23,252,000
Equivalent Cubic Feet (M)	2,036,990	3,439,200	912,490	177,980	336,750	6,903,410	1,557,830

Source: Cunningham, R. N., and Moser, H. C., Forests of Minnesota, U. S. Dept. of Agri., Forest Service, 1938.

VOLUME OF SAW TIMBER IN MINNESOTA IN 1934 BY SPECIES AND TIMBER SIZE CLASS

Species	Total Volume	Volume by Size Class			
		Old Growth Saw Timber	Second Growth Saw Timber	Cordwood	Restocking or Deforested
	M ft. b.m.	M ft. b.m.	M ft. b.m.	M ft. b.m.	M ft. b.m.
Softwoods					
White Pine	1,598,200	1,014,520	218,070	288,650	76,960
Red Pine	998,380	435,140	301,200	174,000	88,040
Jack Pine	2,262,790	35,390	1,660,100	452,460	114,840
Spruce	1,240,730	160,750	386,810	619,840	73,330
Balsam Fir	350,310	49,340	139,700	134,740	26,530
Tamarack	137,340	20	36,140	79,300	21,880
All Softwoods	6,587,750	1,695,160	2,742,020	1,748,990	401,580
Hardwoods					
Aspen	2,366,700	171,690	1,311,560	647,540	235,910
Paper Birch	783,340	83,220	233,680	382,100	84,340
Oaks	761,790	141,130	320,080	231,390	69,190
Elm	701,690	209,610	242,440	89,610	160,030
Basswood	451,200	151,520	181,160	66,180	52,340
Sugar Maple	306,120	176,670	84,530	21,370	23,550
Yellow Birch	93,230	37,990	35,210	12,630	7,500
Soft Maple	110,640	14,630	28,200	62,430	5,380
Miscellaneous Hardwoods	292,280	37,100	134,480	71,910	48,790
All Hardwoods	5,866,990	1,023,460	2,571,340	1,585,160	687,030
All species	12,454,740	2,718,620	5,313,360	3,334,150	1,088,610
Percent of Total	100	21.8	42.7	26.8	8.7

Source: Cunningham, R. N., and Moser, H. C., Forests of Minnesota, U. S. Dept. of Agri., Forest Service, 1938.

VOLUME OF SAW TIMBER BY SPECIES AND FOREST SURVEY UNITS, MINNESOTA, 1934

Species	Total Volume	Volume by Forest Survey Unit					
		Cloquet	Central Pine	Rainy River	Superior	Hardwood	Prairie
	M ft. b.m.	M ft. b.m.	M ft. b.m.	M ft. b.m.	M ft. b.m.	M ft. b.m.	M ft. b.m.
Softwoods							
White Pine	1,598,200	69,870	468,090	568,370	463,690	13,450	14,730
Red Pine	998,380	34,660	450,160	293,010	208,970	7,520	4,060
Jack Pine	2,262,790	144,380	412,510	106,720	1,590,920	5,460	2,800
Spruce	1,240,730	100,800	199,780	416,280	503,450	720	19,700
Balsam Fir	350,310	41,330	116,780	121,130	61,640	5,150	4,280
Tamarack	137,340	2,930	33,140	77,460	760	16,280	6,770
All Softwoods	6,587,750	393,970	1,680,460	1,582,970	2,829,430	48,580	52,340
Hardwoods							
Aspen	2,366,700	263,070	681,180	534,100	773,070	77,330	37,950
Paper Birch	783,340	168,670	125,990	113,820	353,140	13,960	7,760
Oak	761,790	7,440	75,570	2,270	-	495,440	181,070
Elm	701,690	23,150	127,070	72,230	-	321,960	157,280
Basswood	451,200	20,080	116,230	10,540	-	242,640	61,710
Sugar Maple	306,120	30,440	56,060	70	-	172,900	46,650
Yellow Birch	93,230	85,580	6,240	340	-	900	170
Miscellaneous	402,920	59,810	72,760	30,790	52,390	152,210	34,960
All Hardwoods	5,866,990	658,240	1,261,100	764,160	1,178,600	1,477,340	527,550
All Species	12,454,740	1,052,210	2,941,560	2,347,130	4,008,030	1,525,920	579,890
Percent	100.0	8.4	23.6	18.9	32.2	12.2	4.7

Source: Cunningham, R. N., and Moser, H. C., Forests of Minnesota, U. S. Dept. of Agri., Forest Service, 1938.

TOTAL VOLUME OF PRINCIPAL PULPING SPECIES IN MINNESOTA IN 1934

Species	Total Volume	Volume Classed As Saw Timber	Small High-Grade Pulpwood	Substandard Material
	M Cords	M Cords	M Cords	M Cords
Spruce	10,288	2,360	5,429	2,499
Balsam Fir	5,135	752	2,551	1,832
Jack Pine	13,573	5,514	5,400	2,659
Aspen	22,081	4,892	4,216	12,973
Tamarack	1,639	295	644	700
All Species	52,716	13,813	18,240	20,663
Percent	100.0	26.2	34.6	39.2

Source: Cunningham, R. N., and Moser, H. C., Forests of Minnesota, U. S. Dept. of Agri., Forest Service, 1938.

PULP SPECIES VOLUME IN MINNESOTA IN 1934 BY FOREST SURVEY UNITS

Species	Total Volume						
	Total	Cloquet	Central Pine	Rainy River	Superior	Hardwood	Prairie
	M Cords	M Cords	M Cords	M Cords	M Cords	M Cords	M Cords
Spruce	10,288	1,094	1,164	3,709	4,019	36	266
Balsam Fir	5,135	1,194	1,557	1,647	629	47	61
Jack Pine	13,573	1,257	3,277	926	8,063	23	27
Aspen	22,081	2,929	7,407	3,997	4,880	1,028	1,840
Tamarack	1,639	134	423	781	13	218	70
Total	52,716	6,608	13,828	11,060	17,604	1,352	2,264
Volume Included in Saw-timber Estimate							
Spruce	2,360	192	380	792	958	1	37
Balsam Fir	752	89	251	260	132	11	9
Jack Pine	5,514	352	1,005	260	3,877	13	7
Aspen	4,892	544	1,408	1,104	1,598	160	78
Tamarack	295	6	71	166	2	35	15
Total	13,813	1,183	3,115	2,582	6,567	220	146
Small High-grade Pulpwood							
Spruce	5,429	305	398	1,911	2,653	17	145
Balsam Fir	2,551	751	572	695	484	22	27
Jack Pine	5,400	547	1,142	440	3,259	2	10
Aspen	4,216	592	1,565	649	738	197	475
Tamarack	644	4	96	436	9	62	37
Total	18,240	2,199	3,773	4,131	7,143	300	694
Substandard Material							
Spruce	2,499	597	386	1,006	408	18	84
Balsam Fir	1,832	354	734	692	13	14	25
Jack Pine	2,659	358	1,130	226	927	8	4
Aspen	12,973	1,793	4,434	2,244	2,544	671	1,287
Tamarack	700	124	256	179	2	121	18
Total	20,663	3,226	6,940	4,347	3,894	832	1,418

Source: Cunningham, R. N., and Moser, H. C., Forests of Minnesota, U. S. Dept. of Agri., Forest Service, 1938.

SUMMARY OF TIMBER BY PRODUCT AND VOLUME IN MINNESOTA, WISCONSIN AND MICHIGAN

Product	Regional Total	Minnesota	Percent of Regional Total	Wisconsin	Percent of Regional Total	Michigan	Percent of Regional Total
Saw timber 1/. . . . . M ft. b.m.	57,615,740	12,454,740	21.6	16,612,000	28.8	28,549,000	49.6
Cordwood 2/							
Small trees . . . . . .Cords	122,286,000	47,767,000	39.1	32,195,000	26.3	42,324,000	34.6
Tops and limbs. . . . . .Cords	70,394,000	15,209,000	21.6	22,834,000	32.4	32,351,000	46.0
Cull in sawlog trees. . .Cords	30,289,000	2,372,000	7.8	11,428,000	37.7	16,489,000	54.5
All Cordwood . . . . .Cords	222,969,000	65,348,000	29.3	66,457,000	29.8	91,164.000	40.9
Cedar products							
Poles . . . . . Pieces	41,518,000	11,059,000	26.6	7,589,000	18.3	22,870,000	55.1
Round posts . . . . . Pieces	224,774,000	61,953,000	27.5	49,174,000	21.9	113,647,000	50.6
Split posts . . . . . Pieces	99,715,000	15,318,000	15.4	25,959,000	26.0	58,438,000	58.6
Others 3/ . . . . . .Cords	5,256,000	1,787,000	34.0	788,000	15.0	2,681,000	51.0
Cull trees . . . . . .Cords	52,166,000	23,252,000	44.6	9,719,000	18.6	19,195,000	36.8
EQUIVALENT CUBIC VOLUME							
Saw timber . . . . . M cu. ft.	9,520,990	2,036,990	21.4	2,953,000	31.0	4,531,000	47.6
Small trees. . . . . M cu. ft.	8,804,200	3,439,200	39.1	2,318,000	26.3	3,047,000	34.6
Tops and limbs . . . . M cu. ft.	4,223,490	912,490	21.6	1,370,000	32.4	1,941,000	46.0
Cull in sawlog trees . M cu. ft.	1,992,980	177,980	8.9	743,000	37.3	1,072,000	53.8
Cedar. . . . . M cu. ft.	1,267,750	336,750	26.6	240,000	18.9	691,000	54.5
Cull trees . . . . . M cu. ft.	3,494,830	1,557,830	44.6	651,000	18.6	1,286,000	36.8
All products . . . . . M cu. ft.	29,304,240	8,461,240	28.9	8,275,000	28.2	12,568,000	42.9
Average cubic volume per acre	527	431		488		659	

Note: Dead trees are not included.

1/ International 1/4" kerf rule.

2/ Exclusive of cedar, and of cordwood cut from saw timber. Small trees include scrub trees of large diameter unsuitable for sawlogs.

3/ Includes small cedar trees containing no piece products, and tops above piece products.

proportions differ significantly from the areal percentages in forest land in those states - Minnesota 35 percent, Wisconsin 30 percent, and Michigan 35 percent.

Pulpwood - Tables- and - present some of the forest survey data on pulpwood, the raw material for the paper industry. Minnesota forests contain 52,716,000 cords of wood of the five principal pulping species, about 26.2 percent of which grades suitable in size and material for saw-timber, 34.6 percent as small high-grade pulpwood, and 39.2 percent as substandard material, much of which cannot be marketed as pulpwood at this time (Table -). Aspen and jack pine are leading pulp species. Table - indicates the northerly concentration of Minnesota's pulpwood volume. Superior unit alone has 61 percent of the better quality jack pine and 46 percent of better quality spruce.

Approximately 41 percent of the total volume of principal pulp species in the Northern Lake States grows in Minnesota, 20 percent in Wisconsin, and 39 percent in Michigan. Minnesota possesses nearly two-thirds of the spruce pulpwood of the region and three-fourths of the jack pine pulpwood.

Cedar Products - According to forest survey data Minnesota forests contain approximately 11,059,000 cedar poles varying in length from 16 to 45 feet and from 4½ to 9 inches in top diameter, depending on the length of the pole. There is enough smaller cedar material in the forests to make 77,271,000 cedar posts 7 feet long with a minimum top diameter of 4 inches. Distribution of cedar timber volume by products is given in table -.

Table - reveals that Minnesota has over 26 percent of the cedar poles in Northern Lake States, over 27 percent of the round posts, and over 15 percent of the split posts.

Forest Ownership

Forest resources of Minnesota are held in many ownerships, and the policies of these owners vary widely. Table - presents the status of ownership of all

forest land and the land supporting various timber size classes. Note that about one-third of the forest acreage in Minnesota is publicly owned (1934), a unique condition in eastern forest lands. Federal agencies possess slightly over 10 percent of the total forest area and the State 23 percent. Of 13,154,400 acres of privately owned forest land, large owners, those owning 1,800 acres or more, hold 28 percent, miscellaneous small owners 35 percent, and farm woodlot owners 37 percent. Area classified as privately owned included over 5,000,000 acres at time of the survey that were tax-delinquent with reversion to public ownership likely.

Public forests contain about the same proportion of old-growth and second-growth timber land as of total forest -- one-third. The Federal government holds 20 percent of the saw-timber area and the State 16 percent, proportions in inverse ratio to the amount each holds of all forest land. Farm woodlots contain the largest share of the saw-timber on lands privately held, although at the same time, they, like the other timber holdings, tend to fall short of their full timber producing possibilities. Approximately half the cordwood is held by farm woodlot owners and miscellaneous small private woodland owners. Smaller proportions of the area held by Federal agencies classify as restocking or deforested land than is the case with other types of ownership. State, farm woodlot owners and miscellaneous small private owners each hold about one-fourth of the 4,123,100 deforested acres. Table - shows forest land ownership by forest cover type.

Public Forests and Conservation Areas - Locations of national and state forests and other public reservation are shown in figure -. Table - gives the areal status of two national (including purchase units) and thirty-one state forests in Minnesota as of 1940.[1] National forests contain a gross of 5,051,617 acres of which the Federal government owns 2,464,311 acres. State forests embrace a gross area of 5,342,312 acres, but only 1,335,170 acres are under definite state control.

[1] At the time of this writing 2 forests are being made to turns a 978 acre tract of sand dune land in Sherburne County into a state forest

FOREST LAND OWNERSHIP IN MINNESOTA IN 1934 BY TIMBER SIZE CLASS

Ownership group	All classes	Old-growth saw timber	Second-growth saw timber	Cordwood	Restocking	Deforested
	Acres	Acres	Acres	Acres	Acres	Acres
Federal	2,014,300	40,500	264,800	737,800	760,800	210,400
State	4,546,700	53,400	197,500	828,500	2,451,400	1,015,900
Large private	3,614,800	92,300	214,700	751,100	1,884,600	672,100
Farm woods.	4,826,900	123,800	289,000	1,288,900	2,031,500	1,153,700
Miscellaneous small private. . . .	4,612,700	33,100	257,400	1,012,600	2,238,600	1,071,000
All groups.	19,615,400	343,100	1,223,400	4,692,700	9,233,100	4,123,100

Note: Acreages shown for the various groups are not all comparable as to time. For the most part, ownership status is shown as of July 1, 1937. Data tabulated omit 86,300 acres of planted shelterbelts in Prairie district, nearly all included in privately owned farms.

Source: Cunningham, R. N., and Moser, H. C., Forests of Minnesota, U. S. Dept. of Agri., Forest Service, 1938.

FOREST LAND OWNERSHIP IN MINNESOTA IN 1934 BY FOREST COVER TYPE

Ownership group	All types	Pine	Spruce-fir	Productive swamp	Non-productive swamp	Hardwood	Aspen, scrub oak, deforested
	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Federal	2,014,300	446,800	84,900	346,500	41,800	72,700	1,021,600
State	4,546,700	202,000	241,500	1,144,400	490,700	188,300	2,279,800
Large private	3,614,800	412,400	360,200	445,400	84,900	212,600	2,099,300
Farm woods.	4,826,900	205,800	124,200	236,100	95,600	1,119,700	3,045,500
Miscellaneous small private. . . .	4,612,700	403,200	277,500	394,900	50,100	392,400	3,094,600
All groups.	19,615,400	1,670,200	1,088,300	2,567,300	763,100	1,985,700	11,540,800

Note: Acreages shown for the various groups are not all comparable as to time. For the most part, ownership status is shown as of July 1, 1937. Data tabulated omit 86,300 acres of planted shelterbelts in Prairie district, nearly all included in privately owned farms.

Source: Cunningham, R. N., and Moser, H. C., Forests of Minnesota, U. S. Dept. of Agri., Forest Service, 1938.

STATE FORESTS IN MINNESOTA

	Name	County Location	Year Established	Gross Area	State Trust Fund Lands 1/	State Land Acquired	State Land	Private and Federal Land	Approximate Water Area
				Acres	Acres	Acres	Percent	Acres	Acres
1.	Bay Lake	Crow Wing	1935	75,437	681	-	1.0	65,014	9,742
2.	Beltrami	Lake of Woods, Roseau	1933-1935	445,440	-	34	-	445,406	-
3.	Blackduck	Beltrami	1935	75,732	4,120	-	6.0	66,367	5,245
4.	Buena Vista	Beltrami	1935	79,641	4,275	-	6.1	65,574	9,792
5.	Burntside 2/	St. Louis	1905	20,000	-	20,000	100.	-	-
6.	Chippewa 3/	Beltrami, Cass, Itasca	1927	80,629	80,629	-	100.	-	-
7.	Cloquet Valley	St. Louis	1933	230,400	13,815	3,959	7.8	208,258	4,368
8.	Crow Wing	Crow Wing	1935	182,425	2,071	-	1.5	129,501	50,853
9.	Finland	Lake	1933	149,760	11,055	540	11.7	137,749	416
10.	Fond du Lac	St. Louis, Carlton	1933	96,710	6,067	-	6.5	86,324	4,319
11.	Foot Hills	Cass, Crow Wing	1933-1935	177,650	7,450	-	4.3	164,812	5,388
12.	George Washington	Itasca, St. Louis	1933	341,440	76,492	14,592	28.2	231,728	18,628
13.	Grand Portage 4/	Cook	1933	151,760	27,722	3,005	21.1	114,671	6,364
14.	Kabetogama 4/	St. Louis	1917-1933	918,560	134,361	23,116	21.2	584,008	177,075
15.	Koochiching 3/	Koochiching	1931	260,061	260,061	-	100.	-	-
16.	Land O' Lakes	Cass	1933-1935	138,241	6,191	-	4.8	122,036	10,014
17.	Mille Lacs	Mille Lacs, Morrison, Aitkin, Crow Wing	1935	128,110	3,664	-	3.2	108,292	16,154
18.	Minnesota 3/	Lake, Cook, St. Louis	1917	217,180	217,180	-	100.	-	-
19.	Mississippi Hdwtrs.	Clearwater, Hubbard, Beltrami	1935	91,377	5,374	-	6.0	83,866	2,137
20.	Nemadji	Carlton, Pine	1935	163,741	6,500	-	3.8	156,981	260
21.	Northwest Angle	Lake of Woods	1935	79,276	-	-	-	79,276	-
22.	Paul Bunyan	Hubbard	1935	125,709	8,048	32,095	33.2	83,159	2,407
23.	Pillsbury	Cass	1897-1935	51,773	890	956	4.4	39,247	10,680
24.	Pine Island	Koochiching	1933	384,142	264,032	160	68.9	119,110	840
25.	Rum River	Mille Lacs, Kanabec	1935	69,003	1,140	-	1.7	64,543	3,320
26.	Savanna	Aitkin	1933	211,580	16,062	-	8.0	182,858	12,660
27.	Smokey Hills	Becker	1935	109,874	4,557	-	4.7	91,447	13,870
28.	St. Croix 3/	Pine	1931	3,212	3,212	-	100.	-	-
29.	Third River	Itasca	1933	46,080	16,304	1,718	37.7	27,038	1,020
30.	Waskish	Beltrami, Koochiching	1935	76,729	34,931	-	46.0	40,878	920
31.	White Earth	Mahnomen, Clearwater, Becker, Hubbard	1933-1935	160,640	10,911	7,202	7.9	124,117	18,410
	Total			5,342,312	1,227,795	107,375	26.7	3,622,260	384,882

Note: Effective being made to Turn ~ 97 acres tract of sand dune land in Beltrami County into a state forest

1/ Includes unsold, forfeited and reverted trust fund lands.
2/ Federal grant for forestry purposes.
3/ State land made state forest by legislative act.
4/ Recommended by the Conservation Commission for federal acquisition as additions to the Superior National Forest and approved for this purpose by the National Reservation Commission.
Source: Minnesota Department of Conservation, Forestry Division.

NATIONAL FORESTS IN MINNESOTA

Name	County Location	Year Established	By Whom Established	Year of Addition	By Whom Added	Gross Areas	Federal Land	State Land	Private Land	Approximate Water Area
						Acres	Acres	Acres	Acres	Acres
Superior National Forest	Lake, Cook and St. Louis	1909	Pres. T. Roosevelt	1912 1927	Pres. W. H. Taft Pres. C. Coolidge	2,872,363.83	1,727,526.75	400,216.60	744,620.48	
Kabetogama Purchase Unit	Koochiching					750,544.82	98,917,64	185,314.41	466,312.77	
Pigeon River Purchase Unit	Cook					102,940.99	4,532.67	27,223.51	71,184.81	
Superior National Forest And Purchase Units						3,725,849.64	1,830,977.06	612,754.52	1,282,118.06	1,000,000.00
Chippewa National Forest	Itasca	1908	Act of Congress			1,325,767.00	1/ 633,334.00	235,000.00	124,433.00	283,000.00

1/ Federal land includes 70,008 acres of Indian allotments within Chippewa National Forest.
Source: Forest Service, U. S. Department of Agriculture, May 1940.

The original plan in establishing the public forests was to maintain a "prudent reserve." This idea was broadened until, at the present time, the national and state forests are used as demonstration areas for forest management and as means of conserving scenic and recreational values, protecting watersheds, and reforesting desolated areas. Little has been done with county or community forests in Minnesota even though they long ago proved their worth in New England.

Besides the forest land enclosed in national forests in Minnesota, the Federal government owns considerable public forest acreage within Indian reservations, biological survey lands, conservation areas leased to the State, recreational areas, and unappropriated public domain (Table -). Over three million acres of state owned forest land is distributed in state parks, game refuges and public hunting grounds, trust fund lands, reforestation and flood control areas, and miscellaneous state lands. Figure - depicts the geographic distribution of forest land by ownership.

Private ownership of forests is waning in Minnesota. Most enterprisers find investment in timber production too hazardous. Not only must they wait a long time for trees to mature, but they are obliged to assume risks from fire, insects, storms and disease, and the uncertainties of a future market. Also, as present taxes are often applied, possible profits from raising trees are absorbed before the timber is fully grown. The public, on the other hand, finds it can ill afford not to make investments in forestry. Wood is a necessary crop and provision must be made against future needs on public lands, if not on private lands. Forest services such as scenery, recreation, wild game cover and watershed protection for which it is diffucult to make compensation to private owners must be guaranteed.

Forest land ownership in Minnesota is not static. Between four or five million acres of land now in the process of reversion to the State and counties through tax forfeiture, probably will round out the public forest pattern. By this procedure, however, much of the land will come into public ownership in a thoroughly depleted condition. A workable system for clearing titles and con-

solidating holdings by exchange of land between the state and federal government is urgently needed. Ownership is the key to forest conservation because the owner determines the forest management policy.

Growth and Consumption

Minnesota, having depleted its finest and most accessible forests now uses more than three times as much lumber as it produces (Figure - and tables - and -). This means wood must be imported from other sections, chiefly western and southern states. Because transportation costs are heavy, it would be more economical in the long run for Minnesota to grow new trees to meet its lumber requirements. Self-sufficiency, however, is not the desired goal, as certain wood products can be imported more economically than they can be grown locally and Minnesota should be able to export considerable forest products to adjoining prairie states.

Current annual growth of timber in Minnesota, 1935-1944, is estimated at 373 million cubic feet (Table -). Estimated annual drain averages 257 million cubic feet as follows:

Lumber	51,328,000 cubic feet
Pulp wood	37,576,000 cubic feet
Fuel wood	40,894,000 cubic feet
Miscellaneous	31,501,000 cubic feet
Logging	161,299,000 cubic feet*
Destroyed (fire and other causes)	95,423,000 cubic feet
Total	256,722,000 cubic feet

Annual production exceeds annual drain by some 116,388,000 cubic feet, but a far larger proportion of the total growth is in submerchantable stands (36% in restocking) than in saw-timber (11% in saw-timber). About half of the growth consists of aspen, paper birch, soft maple, scrub oak and other so-called inferior species for which commercial uses are now being developed.

---

* This is approximately 57 cubic feet per person, or over three times the wood consumption per inhabitant in England and nearly two and one-half times that of France. Almost 70 cubic feet for each inhabitant in Minnesota is actually used, however.

LUMBER CONSUMPTION IN MINNESOTA AND SOURCE OF SUPPLY IN ALTERNATE YEARS 1922-38

Year	Apparent Consumption 1/		Source of Supply			
	Total	Per Capita	Minnesota		Other Sources	
	M ft. b.m.	Ft. b.m.	M. ft. b.m.	Percent	M ft. b.m.	Percent
1922	985,545	405	217,019	22	768,526	78
1924	889,705	361	215,543	24	674,162	76
1926	831,973	333	179,098	22	652,875	78
1928	736,492	291	178,516	24	557,976	76
1930	517,161	201	87,491	17	429,670	83
1932	218,446	85	54,355	25	164,091	75
1934	293,885	113	84,145	29	209,740	71
1936	549,600	209	107,747	24	419,213	76
1938	454,783	170	85,109	22	354,451	78

1/ The term "apparent consumption" is used because these figures are compiled from estimates showing the quantities of domestic lumber retained within the State for consumption, plus the domestic lumber received by distribution from other states, plus the foreign lumber which apparently enters the state. The figures are subject to considerable discrepancies on account of secondary distribution which cannot readily be traced.

Source: Compiled from Reynolds, R. V., and Pierson, A. H., Lumber distribution and consumption, 1934, U. S. Dept. of Agri., Misc. Pub. in cooperation with U. S. Dept. of Commerce, Bureau of the Census, and Dominion of Canada Bureau of Statistics, and similar publications for 1936 and 1938.

ESTIMATED NORMAL ANNUAL LUMBER CONSUMPTION IN MINNESOTA IN DECADE 1935-44

Use	Annual requirements
	M ft. b.m.
Construction	
Urban	
Residential	87,000
Nonresidential	17,400
Repairs, alterations, and additions	32,500
Rural	
Farm	180,000
Nonfarm	37,100
Public projects	
Wharves and docks	4,450
Highways	14,200
Other	8,000
Total construction	380,650
Manufacturing	175,720
Grand total	556,370

Source: Cunningham, R. N., and Moser, H. C., Forests of Minnesota, U. S. Dept. of Agri., Forest Service, 1938.

Table – shows the relation of consumption to growth of timber of sawlog dimensions in Minnesota. Current annual forest growth is 551,240,000 feet board measure, or approximately 5,000,000 less than estimated lumber utilization (Table –). For the State as a whole, growth exceeds present forest depletion by 18 percent, but in all survey units, except the Rainy River and Superior, the most inaccessible districts, drain exceeds the productive capacity of the forests. Certain kinds of valuable timber such as white pine, balsam fir and basswood are being exhausted rapidly. Growth of jack pine, aspen and birch saw-timber considerably exceeds consumption.

The situation with respect to pulpwood is similarly maladjusted. Spruce and balsam fir are being depleted by cutting and fire losses faster than new growth comes in on accessible acres while surpluses accumulate in remote districts. Surpluses of jack pine and aspen occur mainly in inaccessible districts.

Allowable Cut

Current annual growth cannot all be cut without impairing the future productivity of the forest. Forest survey data have shown that forests of Minnesota are generally understocked with trees and poorly balanced in size classes. Too little of the forest stands approaches merchantable size and too much is very young. To remedy these defects, increase forest growth from the present comparatively low average of 19 cubic feet per acre, and make a start toward balancing the timber budget, the Forest Service recommends: (1) Allow growth in young and understocked stands to accumulate for a number of years, (2) Restrict logging to mature and overmature stands and to mature and defective trees on previously cut-over land, and (3) Spread cutting of ripe timber over a period sufficient for maturing of younger stands.

On the basis of physical conditions of the forest and certain other considerations 1/ the Forest Service estimated that allowable current annual cut from

---

1/ Main assumptions in computing allowable annual cut were that cutting of mature timber of slow growing types will be spread over about 40 years, mature timber of faster growing types will be cut in about 20 years, thrifty young growth will not be molested, and the cut will be properly distributed geographically.

CURRENT ANNUAL GROWTH, DEPLETION AND ESTIMATED ALLOWABLE CUT OF SAW TIMBER IN MINNESOTA FROM 1935-1944 BY SPECIES

Species	Present Stand	Current Annual Growth	Present Annual Depletion	Allowable Annual Cut
	M bd. ft.	M bd. ft.	M bd. ft.	M bd. ft.
Softwood				
White pine	1,598,200	19,070	60,006	27,700
Red pine	998,380	24,320	29,277	19,100
Jack pine	2,262,790	131,410	58,195	120,800
Spruce	1,240,730	76,370	53,080	31,300
Balsam fir	350,310	11,950	20,921	14,500
Tamarack	137,340	8,840	10,505	3,100
All softwoods	6,587,750	271,960	231,984	216,500
Hardwood				
Aspen	2,366,700	145,610	107,752	127,000
Birch	876,570	54,330	32,289	34,500
Oak	761,790	25,880	33,648	11,500
Sugar maple	306,120	6,420	4,955	6,500
Elm	701,690	25,390	26,282	11,300
Basswood	451,200	9,910	24,358	8,300
Miscellaneous	402,920	11,740	5,044	21,400
All hardwood	5,866,990	279,280	234,328	220,500
All species	12,454,740	551,240	466,312	437,000

Source: Cunningham, R. N., and Moser, H. C., Forests of Minnesota, U. S. Dept. of Agri., Forest Service, 1938

ANNUAL CUBIC GROWTH AND DEPLETION OF MERCHANTABLE TREES AND ESTIMATED ALLOWABLE CUT IN MINNESOTA FROM 1935-1944 BY SPECIES

Forest Cover Type	Present Stand	Current Annual Growth	Present Annual Depletion	Allowable Annual Cut
	M cu. ft.	M cu. ft.	M cu. ft.	M cu. ft.
Softwood				
White pine	352,170	7,370	13,015	4,900
Red pine	231,320	8,250	6,328	3,450
Jack pine	1,034,430	47,170	26,650	28,090
Spruce	792,040	30,570	39,196	18,650
Balsam fir	383,490	1/	16,435	12,890
Tamarack	121,230	5,820	6,219	2,420
Cedar	336,750	8,260	8,793	7,510
All softwoods	3,251,430	1/	116,636	77,910
Hardwood				
Aspen	1,588,230	165,290	68,256	75,050
Birch	582,650	1/	20,154	18,730
Oak	439,790	18,590	24,344	4,440
Elm	282,630	1/	10,594	3,860
Basswood	203,640	1/	8,756	3,140
Sugar maple	121,390	1/	2,493	2,310
Miscellaneous	433,650	1/	5,489	5,440
All hardwood	3,651,980	1/	140,086	112,970
All species	6,903,410	373,110	256,722	190,880

1/ Not available separately
Source: Cunningham, R. N., and Moser, H. C., Forests of Minnesota, U. S. Dept. of Agri., Forest Service, 1938

Minnesota forests is about 437,000,000 board feet, or about four-fifths of current average growth (Table -). Contrast of recommended cuts by species with current saw-timber depletion by species reveals the maladjustments in timber utilization in Minnesota (Table -).

Estimated annual growth that can ultimately be attained merely by placing moderate restrictions on logging and by improving fire protection and cutting practices is 751,069,000 feet board measure, a figure well over present State requirements. Attainment of this annual growth will be slow, however, mainly because of the poor condition in which cut-over forest lands are being left, general understocked state of the forests, heavy grazing of woodlands in hardwood districts, slow growth of some species, and because about one-fifth of the forest land is deforested. The rise will not be rapid enough to prevent local shortages of lumber and industrial migrations.

Potential annual growth under intensive forest management which in addition to improved protection and utilization practices might involve planting, thinning, weeding, release and sanitation cutting and pest control could reach an estimated 1,701,412,000 feet board measure. There is little likelihood of producing more wood than can be marketed locally or in adjacent prairie states but intensive forestry measures seem economically feasible only on most accessible and productive lands.

Sustained Yield

If forest resources are to be kept accordant with requirements, sustained yield forestry is needed. Under this system, forest land is so regulated that timber is protected, reproduced and harvested at a sufficiently moderate annual rate to permit new growth to replace that cut and thus give continuous and permanent output of forest products. Sustained-yield management constitutes an ideal at present far from attainment in Minnesota. Yet it is not an idle dream, for the principle has already been applied to management of national and state forests within the State.

Sustained-yield management requires the following basic principles of operation: (1) Reproduction of forests after cutting operations, (2) Protection of forests before, during and after logging, (3) Adjustment of average annual cut to sustained-yield capacity of forests, and (4) Stabilization of forest ownership. It should be borne in mind that with better harvesting practices, more effective protection, and more intense forest management, greater sustained yields will result.

Transition in Minnesota from a prevailing policy of forest liquidation to sustained-yield management will be difficult for a number of major reasons: (1) Poor distribution of age classes in forest stands, (2) Large proportions of relatively inferior cover types in forests, (3) Thinly stocked and scattered condition of stands in new forests, (4) Inaccessibility of large proportions of the timber, (5) Uncertain and unstable ownership of forest lands, (6) Great number of individuals and companies holding forest lands, (7) High costs of marketing and distributing from small-scale operations, and (8) Excessive taxation on timber holdings.

Sustained yield in practical procedure must be applied to the tributary timberland circle of such major wood-using centers as Cloquet, Grand Rapids, or International Falls, and the mill capacities in the long run accordingly adjusted. A major difficulty in attaining this is that in nearly all sections present sawmill capacity greatly exceeds the sustained-yield output of remaining forest land. Pulpwood resources of northern Minnesota, largely on public or semi-public land, however, are sufficiently large and of a character to permit sustained-yield management.

Most obvious advantages of sustained-yield forests are that they (1) result in stabilization of communities dependent upon forests with a higher standard of living, (2) assure continuous supplies of forest products to the consuming public of the state without waste and minus the extra cost involved in a migratory forest industry, (3) secure with intensive management continuous quantities of export products which can be sold in adjacent wood deficient states, (4) furnish permanently the beneficial influences of forest cover in regulating and conserving stream flow and preventing soil erosion, and (5) afford constant protection and suitable habitat for many game animals and other forms of wild life.

Forest Industry

Forty years ago Minnesota ranked as third highest producer of lumber in the Nation, now it stands only twenty-sixth on the list (Figure -). Wasteful logging and disastrous fires without adequate provision for renewal quickly depleted a great forest resource. Many other states also experienced the same mistake and deeply regret it.

Three stages in the history of the lumber industry in Minnesota are illustrated in figure - and table -. It indicates Minnesota was only a temporary encampment in the one-hundred year migration of the lumber industry from New England to the Pacific Northwest. When Minnesota's best forests had fallen or burned, the industry turned its back on the State and moved westward, leaving behind millions of acres of stumps and slash, scores of ghost towns, several huge personal fortunes, and an economic aftermath of bankrupt local governments, tax delinquency, land abandonment, unemployment, and maladjusted agriculture.

Lumber cut by species at intervals from 1869 to 1938 is revealed in table -. Note the preponderance of white pine lumber in the cut of 1899. Spruce cutting reached its height in 1909. Up to 1938 there were removed from forests of Minnesota an estimated 72,841,000,000 board feet of lumber, 6,500,000 cords of pulp-

LUMBER PRODUCTION IN MINNESOTA
1869 - 1938

Year	Quantity in Feet M. B. M.	Percent of U. S. Total	Rank Among States
1869	242,000	1.90	14
1879	564,000	3.12	8
Period of Highest Development			
1889	1,310,000	4.84	4
1899	2,342,338	6.68	3
1904	1,942,248	5.69	5
1905	1,925,804	6.31	4
1906	1,794,144	4.78	7
1907	1,660,716	4.14	9
1908	1,286,122	3.87	9
1909	1,561,508	3.51	11
1910	1,457,734	3.64	12
1911	1,485,015	4.01	10
1912	1,436,726	3.67	11
1913	1,149,704	3.00	14
1914	1,312,230	3.51	11
1915	1/ 1,021,568	3.27	14
1916	1/ 1,063,046	3.06	12
1917	1/ 999,476	3.01	12
1918	1/ 911,453	3.07	11
Period of Decline			
1919	699,639	2.02	19
1920	1/ 556,265	1.86	19
1921	412,145	1.53	20
1922	511,744	1.62	18
1923	551,592	1.48	19
1924	527,962	1.47	19
1925	578,703	1.51	19
1926	471,090	1.28	19
1927	396,891	1.15	19
1928	412,343	1.21	19
1929	357,180	.97	20
1930	222,389	.85	20
1931	94,968	.57	20
1932	58,082	.57	25
1933	48,655	.35	25
1934	95,360	.62	26
1935	108,160	.62	26
1936	123,002	.50	26
1937	122,000	.41	25
1938	96,000	.56	27

1/ U. S. Dept. of Agri. Bulletin, Lumber production 1869-1934, shows an alternate larger total, including the estimated cut of nonreporting mills.

Source: Compiled from Pierson, A. H., and Reynolds, R. V., Lumber production 1869-1934, Misc. Pub. U. S. Dept. of Agri., Forest Service, 1936 and subsequent Forest Service releases.

chart

chart

LUMBER PRODUCTION IN MINNESOTA BY SPECIES
1869-1938

Species	Thousand Feet Board Measure											
	1938	1936	1934	1932	1930	1929	1919	1909	1899	1889	1879	1869
Softwood												
Balsam	1,567	1,194	803	381	368	26,343	10,584	11,140	-	-	-	-
Cedar	1,079	963	422	120	155	1,414	1,105	1,945	11,875	-	-	-
Hemlock	17	120	145	-	-	-	-	15,552	1,576	-	-	-
Larch (Tamarack)	1,384	1,194	767	110	1,794	1,781	35,765	63,555	230	-	-	-
Spruce	1,810	2,575	1,482	2,405	6,371	10,855	29,298	78,500	1,205	1,000	-	-
White Pine	57,638	77,316	64,289	38,067	144,391	266,395	560,544	1,308,861	2,264,777	1,209,000	524,000	230,000
All other	-	-	-	-	-	-	-	-	-	25,000	15,000	5,000
Total	63,495	83,362	67,908	41,083	153,079	305,788	637,296	1,479,553	2,279,663	1,235,000	539,000	235,000
Hardwood												
Ash	688	512	55	48	253	155	889	3,326	3,690	-	-	-
Basswood	2,280	2,516	720	364	903	1,362	5,113	20,131	7,941	-	-	-
Beech	-	25	-	-	-	-	-	-	-	-	-	-
Birch	2,535	2,191	2,479	680	2,722	2,060	9,986	9,785	1,196	-	-	-
Cottonwood	22,170	28,280	22,381	13,908	61,655	44,247	30,135	16,668	1,145	-	-	-
Elm	1,795	1,220	342	637	408	829	5,831	14,645	8,354	-	-	-
Hickory	-	-	-	-	-	-	1	28	-	-	-	-
Maple	431	1,294	79	242	189	341	1,868	1,519	2,139	-	-	-
Oak	2,568	3,602	1,396	1,105	2,875	2,316	8,518	15,801	38,140	50,000	15,000	5,000
Walnut	4	-	-	-	-	-	1	28	5	-	-	-
All other	7	-	-	15	305	82	1	24	65	25,000	10,000	2,000
Total	32,478	39,640	27,452	16,999	69,310	51,392	62,343	81,955	62,675	75,000	25,000	7,000
All Woods	95,973	123,002	95,360	58,082	222,389	357,180	699,639	1,561,508	2,342,338	1,310,000	564,000	242,000
Number of Mills	228	186	174	67	199	212	365	745	404	-	-	-

Source: U. S. Dept. of Agriculture, Forest Service. Compiled as follows:
1869-1936, Forest products statistics of the Lake States, Statistical Bull. no. 68.
1938, Forest products 1938, Bureau of the Census in cooperation with U. S. Dept of Agriculture, Forest Service, November 1939.

wood and an indeterminable amount of poles, posts, ties, and other forest products. This represents a value, as reported by the United States Census, of about one and three-quarters billions which indicates the contribution Minnesota forests have made thus far to the wealth of this State. During the period of maximum activity the lumber industry employed directly in the logging camps and mills about 24 percent of all the wage earners in the State and 35 percent of the total capital invested.1/ There were 745 mills sawing lumber, laths, and shingles in 1909, as against 228 in 1938.

1/ Land utilization in Minnesota, Committee report on land use, p. 118, 1934.

Present Forest Industry

Forest resources still constitute a substantial part of Minnesota's industrial base. The $56,944,000 value of forest industry products of the state in 1937 represented about 6.1 percent of the value of all manufactured products.2/

2/ For industries not reported seperately by state, the figures were pro-rated on the basis of the number of establishments. See table 17, Economic Note No. 11, Lake States Forest Experiment Station, August 1939.

The three most important forest industry products are pulp and paper valued at $27,315,159 in 1937, planing mill products at $7,825,057, and lumber and timber products at $4,780,810. In 1935 the value of raw forest products was $10,478,214.3/

3/ The Minnesota state finance and tax survey (Fiterman Report), vol. 2. part 3.

Farm forest materials, valued at $487,191 for the State as a whole in 1939, constitutes an important crop to a great many farmers in northern Minnesota.

Canvass made in 1934 and 1935 in connection with the forest survey disclosed the following forest industry data for Minnesota:

1. Primary forest-products manufacturing plants numbering 1,241 establishments - sawmills, lath mills, shingle mills, pulp mills, etc., - along with associated logging camps normally employ about 15,000 men..

2. Production of ties, mine timbers, poles, Christmas trees, and other wood products which do not pass through any manufacturing plant employs about 33,000 men for an average period of 100 days per year.

3. Secondary wood-using industries numbering 1,304 establishments - planing mills, furniture factories, box factories, cooperage plants, etc., - employed approximately 13,000 workers in 1929.

4. Regular public forestry work requires services of about 600 men

5. Employment in CCC has averaged about 9,000 men during the past few years.

In 1938 firms engaged in manufacture of basic lumber and timber products - logging establishments, sawmills, and planing mills - employed 2,176 men and paid out $2,637,844 in wages. The finished lumber products group, which includes firms engaged in manufacture of furniture and fixtures, containers, window screens, shades, and similar articles, employed 4,195 men and paid out $5,458,612 in wages. Together the basic lumber industries and the finished lumber products industries in 1938 accounted for 6% of the total employment in manufacturing in Minnesota and 6% of the total wages paid in manufacturing.1/

1/ Based on employment and wage data reported to the Division of Employment and Security. Data from:-Hatfield, R. F., Distribution of payrolls in covered industries in Minnesota, 1938, by counties, Minnesota Resources Commission, 1939; and Hatfield, R. F., Manufacturing payrolls by county and type in Minnesota, 1938, Minnesota Resources Commission, 1940.

All this suggests that while forests and forest industries do not dominate the economic life of Minnesota, they are of great significance. Many communities depend for their existence on a thriving wood products business. In such towns, merchants and professional people as well as factory workers depend substantially on the forest-products mill payroll and so do nearby farmers. Importance of forest

industry employment has been emphasized by the drastic shrinkage in iron ore mining labor requirements. Potentially, industries based on forest resources are in a good position to take up slack employment.

New techniques in processing and new uses for wood have greatly expanded the volume and varieties of certain types of products that derive from Minnesota forests. The history of Cloquet illustrates the shift to diversified use of forest resources. Originally Cloquet was a saw-mill town; today lumber is only a memory. New industries have come in - one factory manufactures "nu-wood" and balsam-wood, another supplies matches and clothespins, and the paper company has expanded. Present industries with a payroll of more than two million dollars a year, mainly use wood fibres which come from pulpwood, a product that can be grown and harvested in a few decades in contrast to the century required for most valuable saw logs.

New Forest Industries

Experiments sponsored by the Northwest Research Foundation in the use of aspen (or popple) for production of alpha cellulose appear to be leading to new forest industries in Minnesota. An alpha cellulose "pilot plant" recently erected at International Falls will give chemists and engineers a chance to perfect certain processes preparatory to commercial production. Alpha cellulose represents a basic raw material for munitions, rayon, cellophane, plastics and a host of similar products. Its primary uses, however, are for rayon and plastics. Aspen trees grow on an estimated seven million acres of Minnesota cut-over land and contain about 4,250,000 cords of merchantable size timber.

In laboratories scientists continuously seek to develop new uses for timber products and their by-products and find acceptable substitutes for exhausted wood materials.

The Cut-Over Lands - Problem Area

Minnesota

The wedge of cut-over lands in northeastern Minnesota, embracing fourteen counties with a total population of 435,576, is an area of chronic economic and social distress caused mainly by misuse of natural resources. Many of the people suffer from lack of economic opportunity and are unemployed. Too many people must be aided by relief of one kind or another. Numerous local units of government are financially disabled because of a shrunken tax base and heavy debts incurred in earlier years. The people and the area, faced with excessive costs of local government, high taxes, and relatively low income, constitute one of Minnesota's gravest problems. Until the cut-over section is put back on its feet it will be a burden to the entire State.

The cut-over lands, although a serious problem area, at the same time offer one of the greatest opportunities for rehabilitation through orderly, well-planned development of forests. Nature is ready to cooperate. It already has done a better job than most poeple realize in restoring a forest cover to the land. Restocking lands, some of which already bear timber of cordwood and saw log size, could within a few years be made the basis for prosperous wood-products industries, if properly managed and protected.

Northern Lake States

Forest land experiences and forest land difficulties do not divide on state lines. Minnesota, Wisconsin and Michigan all witnessed almost identical development of similar problems in their northern forests. Figure - outlines the Northern Lake States problem area. The region embraces 55,634,000 acres which is half again as large as New England and contains a population of one and one-half million people.

Approaches to recovery lie in replenishing natural resources, improving forest utilization methods, preventing deterioration of forests on tax delinquent lands, broadening the control of forest fires, insects and disease, revising the existing system of taxation on forest lands, promoting better small timber-sale markets, and applying the principles of cooperative sustained-yield.

In a recent National Resources Committee Report, Regional Planning, Part VIII - Northern Lake States (May 1939), the region is pictured as one which has certain attributes which justify optimism. In order to make that optimism a reality certain objectives were set up by the Committee toward which it seemed imperative to work if the region is again to become self-sustaining.

OBJECTIVES

1. To meet the immediate social problem through the development of opportunities for work within the region, both continuous and seasonal.

2. To encourage agriculture where feasible, both as a full-time occupation and on a subsistence basis supplemented by other employment.

3. To renew and operate intelligently the forests; to adjust the use of land and waters to the best advantage of the region; to expand public acquisition of lands; and to develop the recreation possibilities of the region.

4. To explore, to develop, and utilize properly its mineral resources.

5. To encourage the development of industry through research into the possibilities of the region's resources for manufacturing.

6. To attain uniformity of commercial fishing regulations so as to stimulate the use of practices which will renew and maintain that resource.

7. To bring about practices which will promote economical local government.

8. To coordinate Federal, State, and Local efforts so that regional problems may be attacked unitedly.

9. To encourage local leadership and initiative to undertake the development of objectives and plans of action.

"If measurable progress is made toward attaining these objectives, it is fair to assume that the future way of life for the people in this region will be an attractive one. It will not be easy or simple, but it will be a better way."

Illustrations And Tabulations

RECREATION AND WILDLIFE

As automobiles and good roads have stimulated pleasure travel, shorter hours of labor have increased leisure time, and educators and parents have recognized the importance of play, the recreational use of natural resources has assumed growing prominence. The affect on the forested north country of Minnesota has been phenomenal. Where trappers, prospectors, lumberjacks and sawmill workers once held the scene, tourist camps, resorts, wilderness lodges and service stations now flourish. The number of intra-state and inter-state vacationists has steadily increased until "tourist business" now leads all other in the forested region. The movement is so vigorous as to give rise in some quarters to the illusory belief that recreational use of land will solve most of the State's idle-land problems.

Most natural resources contribute in some way to more and better recreation, and adequate recreation helps to make better workmen. When climate is sunny, moderate and variable; forests large, dense and quiet; prairies and meadows green and thickly grassed; water sufficient, clean and sparkling; game, fish and other wildlife plentiful; soils rich and anchored against wind and water, then people of Minnesota can live happier as well as more abundant lives. Outdoor recreation in the State is mainly dependent upon the following natural resources.

Forests

Forests provide the background for outdoor recreation in Minnesota, particularly the timbered fringe of lakes and streams. If they served no other purpose and yielded not a single board nor cord of pulpwood, the use of a great deal of land for forests would thus be economically justified. However, as already seen, usefulness of forest lands is manifold. At the same time that they are growing and producing timber, they serve also as breeding places and shelters for fish and animals and recreation grounds for men, women and children. The forest is a natural

habitat of wild life because, for most species, it furnishes three prime essentials; food, breeding grounds, and protection from enemies and weather.

Forest area of Minnesota, not including deforested lands, is 15,492,300 acres, or 30 percent of its total area. Over one-third of this is publicly owned. The proportion in northern parts of the State, the recreational center, reaches much higher. Figure - shows areas of public forests in Minnesota in which visitors can wander at will. Sound technical management within those areas will maintain and enhance recreational values of the forest.

Lakes and Streams

Minnesota has a pattern of fresh-water lakes and streams unexcelled in United States. The Superior lakeshore, and the lakes, ponds, rivers, streams, and waterfalls set in forested areas throughout the northern two-thirds of the State, are among the more important features which attract people to come to Minnesota. In a survey conducted by the Minneapolis Civic and Commerce Association in 1939, lakes and scenery were oftenest mentioned by tourists (33 percent of those questioned) as Minnesota's leading attractions.

"Land of Ten Thousand Lakes" is no exaggeration, for there are in fact more than eleven thousand lakes within the borders of the State ranging in size from a few acres to the vast expanse of Red Lake (274,994 acres), the largest in Minnesota. Second in size is Mille Lacs with 126,326 acres. Other lakes lying wholly within Minnesota that have an area of more than 10,000 acres are Leech, Winnibigoshish, Vermilion, Kabetogama, Cass, Gull, and two of the Pelican lakes. More than 300 of them exceed a thousand acres in area. Minnesota ranks second among the States in inland water area. Exclusive of Lake Superior, water comprises approximately five percent of the gross area of the State. In some counties from 10 to 20 percent of the area is water.

Lakes occur in all parts of the State except in older glacial drift areas of southeastern and southwestern Minnesota, in the Driftless Area, and in the Red River Valley (Figures- and -). Figure - reveals four principal areas of lake concentration in all of which considerable summer home and commercial recreation development has taken place. The southeastern lake region and two central lake regions provide recreation of a type preferred by those who desire seclusion and pleasures of water and woods and yet wish for planned and regulated recreational communities which make available simpler (if they choose the most complete) collective conveniences and services. Here care must be exercised to prevent exclusive possession by few owners, overcrowding, and annoying commercialized activities which do not fit the general setting.

The northeastern lake and river region lying almost entirely in the Superior National Forest differs markedly from the others. Lakes are rock-bottomed, formed by invading glaciers which gouged out long and oftentimes narrow depressions in the scraped-off bedrock, and then melted into them. The border country, especially embraces a labyrinth of lakes and inter-connecting streams in which occasional short portages are welcome variations in the paddler's day. Topography is rugged, the surface studded with outcropping ledges, and the forests wild. Virgin timber stands exist in some localities.

The wild beauty and romantic past of Minnesota's border lake land make it the Nation's most attractive canoe and camping region. Famous fishing and many game and fur animals add to the appeal to sportsmen and nature lovers. In 1925 the primitive plan was established whereby 1,200 square miles of government land were set aside within which automobile roads, resorts, summer homes, etc., were never supposed to be constructed. In this reservation area, with its nearly 4,500 lakes, was to be developed and preserved those characteristics of wild nature which lure those who revel in life of log camps and transportation by pack and canoe.

The Superior lake and river region featured by approximately 176 miles of Lake Superior shoreline is crisscrossed with hundreds of miles of excellent trout streams. The North Shore Highway traverses what is some the most beautiful scenery in Minnesota. It winds through wooded glades, past deep ravines and about the high rocky points that line the northern shore of Lake Superior. Add to scenic beauty the low summer temperatures which prevail as a result of the cooling influence of the large lake and one can easily understand why this region is so attractive in summer time.

Extended areas of great scenic beauty obtain along streams and rivers of Minnesota. Most notable perhaps are the bluff lands along the St. Croix, Mississippi, and Minnesota rivers. Choice river frontage makes excellent sites for summer homes.

Climate

Minnesota's climate is almost as favorable to summer recreational enjoyment as are its forests and lakes. In the 1939 poll of visitors, cool summer days, with a 23 percent vote, ranked second to lakes and scenery as tourist attractions.

Prevailingly warm days and cool nights and a stimulating variance in the weather cycle, make Minnesota an ideal vacation land. As seen in figure -, summer temperatures in northern Minnesota average about ten degrees cooler than in the Corn Belt. Note the more than 20-degree summer temperature gradation from southern states to northern Minnesota. The Arrowhead is one of the few places in United States, outside mountainous areas, where an average summer temperature of sixty degrees or less prevails (Figure -). Lakes, with their moderating effect on summer "heat waves", give comfort to the thousands of tenants and transients on their shores.

Summer rains that occur about every three and one-half days, nearly always come as thunder showers which last but an hour or two and are promptly followed by clearing weather with northwest breezes and cooler dry air that is noticeably bracing. Northern latitude and low humidity provide long clear days of healthful sunlight.

Wildlife

Minnesota has always been famous for its wildlife. Its flora and topography are exceptionally conducive to great abundance and variety. Three major types of natural habitat converge in Minnesota - coniferous forest, western prairie, hardwood forest - and the marginal areas are particularly favorable to animal life, A myriad of lakes, streams, wooded swamps, and open marshes, ranges, hills, and diverse climate afford a vast range of temperature and moisture conditions, varieties of food, and other environmental factors necessary for a multiformity of dependent animal life. All major groups of the animal kingdom are present except the starfish group which exists only in sea water. Eighty-eight distinct kinds of mammals, 326 species and 30 subspecies of birds (includes many rarities), 35 to 40 commonly found species of lizards, snakes and turtles (45 have been listed), and approximately 148 kinds of fish, to name but a few of the major groups, add life, movement, and zest to the outdoors to a degree met with in few other states.

Wildlife of Minnesota may be divided by place of natural habitat into four general classes - forest, prairie, farm, and water or marsh. Forest wildlife includes deer, elk, moose, caribou, bear, some species of grouse and partridges and some fur bearers and predators. Prairie animals include jack rabbits, coyotes, gophers, badgers, weasels, prairie chickens, and some species of grouse. Farm wildlife includes small fur-bearers, rabbits, squirrels, raccoons and upland game birds such as pheasants, Hungarian partridges, prairie chickens and quail

which profit by easily obtained food and prefer areas where brush cover and open spaces occur. Water and marsh wildlife includes aquatic fowl which seek secluded lakes, marsh areas, and wild shores for resting places, food, and breeding grounds, all forms of fishlife, and some fur bearing animals such as muskrats, beavers and otters.

Figure - indicates the geographical distribution of some of Minnesota's principal game species. Commonest big game animal is the Virginia white-tailed deer. They are most abundant north and east of the deer line shown in figure -, although originally their Minnesota habitat was restricted to hardwood forests and prairie lands. Hunting, the development of agriculture, the cutting of hardwood forests, and the cover of mixed hardwoods and evergreens that succeeded on the cut over coniferous forest land of northern Minnesota, induced the shift in deer population. Table - presents a summary of deer counts taken in Minnesota since 1935.

MINNESOTA DEER CENSUS SUMMARY

Year	Number of Census Areas	Total area censused (sq. miles)	Number deer counted	Sex ratio F.:M.	Deer per section
1935	45	75	1256	63.0:37.0	16.6
1936	51	69	1175	61.8:38.2	17.0
1937	50	61	832	62.5:37.5	13.6
1938	48	61	774	61.2:38.8	12.7
1939	45	51	700	65.0:35.0	13.7

Black bear is the only other big game variety which is sufficiently numerous to justify an open hunting season. While this animal undoubtedly ranged over the entire forested portion of the State at one time, it is now common only in somewhat restricted areas in counties bordering upon Canada. Occasionally, it may wander from northern forests into settled districts in search of a new feeding ground. Evidence indicates that Minnesota bears are commonly larger than those found in other States.

American elk, or wapiti, once numerous in Minnesota but completely gone by 1900, appears now to be re-establishing itself. In 1935, 27 animals formerly kept in corrals in Itasca State Park were released in the northwestern portion of Beltrami County. Only few losses have been discovered and a steady increase is apparent each year. Most recent estimates place the number at about 100 animals. They have greatly extended their range, some elk being found as far as 100 miles from the point of release.

Minnesota is the only state in which woodland caribou has survived at all in the wild. In recent years the combination of drainage, weather, predators, fire, and other factors made conditions so unfavorable for them that the herds diminished to a point where introduction of additional stock seemed imperative. Most reliable information available reveals that by 1937 all but three cows had disappeared. In the winter of 1937-1938 nine healthy caribou were obtained from the Province of Saskatchewan, through cooperation of the Canadian Government and the Hudson Bay Company, to restock the Minnesota caribou range. Efforts to replenish the native supply show promise of success, with approximately 15 animals now ranging in northern muskegs.

Inroads of civilization caused moose to retreat until at present they are found only in isolated areas in northernmost Minnesota. In some areas, particularly the Red Lake Game Refuge, moose seem to be slowly increasing in number, but over northern Minnesota as a whole their decline has been steady and will continue to be largely as a result of fires, lumbering operations, drainage, poaching and recreational development. Diseases and parasites of moose have been studied during the past ten years by the University of Minnesota.

Four species of grouse breed in Minnesota, ruffed grouse, sharp-tailed grouse, pinnated grouse and Canada spruce grouse. A fifth species, the willow ptarmigan, at intervals migrates from Canada into northern sections of the State. Ruffed grouse (partridge), while it breeds in practically all wooded sections, is most

abundant in that part of the State east of the line shown in figure -. Sharp-tailed grouse (white breasted grouse, pintail grouse, spike-tailed grouse), though now confined largely to brushland and open forest areas in the northern half of Minnesota, once bred over most of the State. According to recent reports, the species is most abundant in northwestern Minnesota and fairly numerous from Lake County west to Red Lake and southeast to Pine County. Pinnated grouse (prairie chicken) spread into Minnesota from Wisconsin and northwestern Iowa with grain farming, and now occupies much the same farm-forest range as the sharp-tail (Figure -). Canada spruce grouse (spruce hen) in primeval time inhabited most of the evergreen forest; the present population lives largely in wilderness areas along the International Boundary from Lake Superior to Lake of the Woods. Except for Canada spruce grouse, for which information on cycles is too meager, all are definitely cyclic and fluctuate markedly in population number at intervals of about ten years.1/

1/ For more detailed data concerning ranges and life histories of grouse the reader is referred to Krefting, L. W., The grouse of Minnesota, The Conservation Volunteer, vol. 2, no. 9, pp. 25-29, June 1941.

Hungarian partridges began to migrate into Minnesota from Iowa between 1913 and 1914. Minnesota sportsmen became interested in the birds and began to raise money to obtain more of them. Through their efforts, almost 7,000 were released in all parts of the State between 1926 and 1928.2/ The Division of Game and Fish then

---

2/ Carlson, C. E., The Hungarian Partridge in Minnesota, The Conservation Volunteer, vol. 2, no. 7, pp. 41-44, April 1941.

---

assumed the task of increasing the number and liberated about 3,000 birds annually until 1933. In all, more than $100,000 was spent by the State and sportsmen up to 1934 in establishing the Hungarian partridges in Minnesota. From 1931 to 1937, while adapting themselves to their new environment in the corn and small grain

producing western counties, their number remained about stationary. Subsequent increase made it possible to open the first hunting season in northwestern border counties in 1939.

Chukar partridges have demonstrated that they will thrive in Minnesota. Chukars seem to thrive best in northeastern section of the State where none of the other artificially reared birds flourish. Bobwhite quail has shown an appreciable increase in the last few years, probably as a result of better cover, construction of large shelters in southeastern counties, an ample food supply, good winter weather and heavy restocking. Figure - shows the approximate limits of range where quail are abundant.

Introduction of ring-necked pheasants (Chinese pheasants) has been an outstanding success in Minnesota. They predominate south and west of the line drawn in figure -, an area which coincides with the corn and small grain producing region of the State. North and east of the line the number drops off rapidly until, beyond a line drawn from northern Polk to southern Pine County, the pheasant is very rare. A recently completed technical study of the food habits of pheasants largely exonerated the birds of the charge of serious harm to farm crops.1/ Reports of damage to newly planted and growing corn by digging

---

1/ Fried, L. A., Food habits of the pheasant, The Conservation Volunteer, vol. 2, no. 8, pp. 7-12, May 1941.

---

or pulling, it was found, have been greatly exaggerated; only 5.8 percent of the corn eaten in June is sprouted.

Northern and western Minnesota is one the chief resting and feeding grounds of migratory water-fowl on the best flyway leading out of the Canadian breeding grounds. It is also one of the principal breeding grounds of ducks and shore birds in United States. Of all the states, Minnesota ranks first in sale of duck hunting stamps. As a result of a working agreement between the Canadian and

American governments, with the cooperation of sportsmen in both countries, ducks and geese have been on the increase from the extreme low of the drought years. It has been estimated that the largest flights of the past ten years made the southern journey (in 1939 and 1940). Because of these increases, the open season was extended to 60 days. It should be noted, however, that it will require about five years at the present rate of increase to restore water-fowl population to 100,000,000 birds (about the same as the 1930 population, which was considered critically low). Duck sickness is regarded as the greatest natural mortality factor effecting western water-fowl.

A great many of Minnesota's 11,000 lakes and 25,000 miles of streams have been progressively fished out both as to quantity and quality. Even so, Minnesota waters provide some of the best fishing in United States. Available appraisals of the fish resource place the average for the State at about 75 pounds per acre of water. It is estimated that 148 species of fish inhabit the waters of Minnesota. These may be classified broadly as game fish, pan and food fish, commercial fish and rough fish. Only the most common of the fish species are named below.

Game Fish

Wall-eyed pike, great northern pike, pickerel, brook trout, brown trout, rainbow trout, lake trout, muskellunge, large mouthed black bass, small mouthed black bass.

Pan and Food Fish

Crappies, sunfish, rock bass, silver bass, perch, bluegills, bullheads, catfish, sturgeon.

Commercial Fish

Lake trout, herring, ciscoes, ciscoets, whitefish, pike, pickerel, perch, red fins, tullibees, goldeyes.

Common Rough Fish

Carp, buffalo, sheepshead, garfish, dogfish, chubs, eelpout.

Chemical and physical conditions affect the number and species of fishlife in lakes and streams. For example, nitrogen and forms of lime and phosphates greatly influence the growth of water plants which in turn determine the amount and kind of fish food. Of equal significance are the temperature conditions and types of bottoms of the lakes. Thus, there are trout lakes, pike lakes, bass - crappie - sunfish lakes and other types of lakes. Fish may be not only directly propagated in hatcheries but also indirectly through improvement of their natural habitat.

Extensive Outdoor Recreation Areas

Extensive outdoor recreation areas are lands suitable especially for such activities as hunting and fishing, nature study, hiking, canoeing, camping, horseback riding, enjoyment of natural scenery and the like, which normally require large areas not highly developed.

The land area of Minnesota is 51,205,760 acres. Of this 9,370,094 acres, or 18.3 percent of the total, as shown by table -, is publicly owned and controlled. Approximately 7.6 percent is federally owned and 10.7 percent state owned. Of the publicly owned lands, 2,501,677 acres, or 26.7 percent, lies in national and state forests[1]; 2,789,706 acres, or 29.8 percent, in trust fund lands and unappropriated and unreserved public domain; 774,260 acres, or 8.3 percent, in water and flood control, reforestation, and conservation development areas; 967,621 acres, or 10.3 percent, in roads and highways; 830,900 acres, or 8.9 percent, in Indian reservations and Indian lands; 615,264 acres, or 6.6 percent, in wildlife reserves; and 73,098 acres, or .8 percent, in parks and similar recreation areas. These lands, except that belonging to the Indians, are by statute available to the public within the regulations incidental to the use of any public land. In practice, however, many factors limit the extent of actual public use. Lacking public easement, the shores of many lakes and streams are inaccessible and existing large tracts of public lands are far from centers of population.

[1] At the time of this writing, efforts are being made to turn a 978 acre tract of sand dune land in Sherburne County into a state forest.

Land in Minnesota is made available for public recreation by either two of well-defined means; public ownership by national, state, county, or municipal governments, or statutory control. A third method which might be employed is public inducement or subsidy. For example, the forest crop law (inoperative to date) might be modified to open private forests to specified public privileges, as in Wisconsin.

Table - presents a list of the extensive outdoor recreational areas in Minnesota. In pages which follow, discussion of recreational lands and their utilization is arranged according to ownership and the use to which they are put. Figure - shows the location of existing state and federal recreational areas as determined by the Minnesota Park, Parkway, and Recreational Area Study.

Federal Recreational Areas

National Forests - United States Forest Service performs an important role in Minnesota recreation as administrator of the Superior and Chippewa National Forests (Figure -). Superior National Forest is the larger of the two and embraces a more primitive area. In fact, it is the largest national forest in United States. With the purchase units it has a gross area of 3,725,850 acres (1,830,977 acres federal land) within which are found more than 5,000 lakes ranging in size from a few acres to 70 square miles. Twenty-one roadside campgrounds for motorists and 37 campsites for canoests have been constructed. A roadless area of 1,046,000 acres just south of the International Boundary has been set aside as a "wilderness reserve."

Chippewa National Forest, located in the heart of the northern central lake region, has a gross area of 1,325,767 acres of which 633,334 acres is federally owned. Ten sections (6,400 acres) of virgin Norway pine around Cass Lake and Pike Bay have been preserved in their native state. Numerous well stocked lakes, scenic drives and trails through vast woodlands, and camp and picnic facilities make this a mecca for vacationists.

EXTENSIVE RECREATIONAL AREAS

STATE RECREATIONAL SYSTEM

	Present Acreage	Recommended Addition	Recommended Total
STATE PARKS			
Alexander Ramsey	185.38	1.10	186.48
Beaver Creek Valley	325.17	675.00	1,000.17
Buffalo River	280.00	404.00	684.00
Camden	469.96	-	469.96
Cottonwood River	836.48	-	836.48
Gooseberry Falls	637.83	430.00	1,067.83
Interstate	154.00	.14	154.14
Itasca	31,816.00	160.00	31,976.00
Jay Cooke	3,375.00	3,288.00	6,663.00
John A. Latsch	350.20	600.00	950.20
Kaplan Woods	180.00	-	180.00
Lac Qui Parle	267.00	-	267.00
Lake Bemidji	205.48	460.00	665.48
Lake Carlos	403.56	596.44	1,000.00
Lake Shetek	184.62	200.00	384.62
Middle River	285.00	-	285.00
Minneopa	110.24	40.00	150.24
Scenic	2,121.30	3,230.00	5,351.30
Sibley	378.83	565.76	944.59
Two Rivers	711.76	1,354.00	2,065.76
Whitewater	688.28	315.00	1,003.28
Totals	43,966.09	12,319.44	56,285.53
STATE MEMORIAL PARKS			
Birch Coulee	82.00	80.00	162.00
Charles A. Lindbergh	110.42	-	110.42
Fort Ridgely	214.00	120.00	334.00
Monson Lake	198.95	8.00	206.45
Totals	605.37	208.00	813.37
STATE RECREATIONAL RESERVES			
Mound Springs	195.70	310.00	505.70
Pomme de Terre	363.51	70.00	433.51
Split Rock Creek	227.64	-	227.64
Totals	786.85	380.00	1,166.85

	Present Acreage	Recommended Addition	Recommended Total
STATE WAYSIDE			
Camp Release (Memorial)	17.30	-	17.30
Father Hennepin (Historic)	129.75	-	129.75
Garvin Heights (Scenic)	17.00	-	17.00
Horace Austin (Scenic)	50.00	-	50.00
Inspiration Peak (Scenic)	82.00	-	82.00
Joseph R. Brown (Memorial)	3.00	10.50	13.50
Old Crossing Treaty (Historic)	6.00	20.00	26.00
Oronoco (Scenic)	105.00	50.00	155.00
Sleepy Eye (Scenic)	40.00	-	40.00
Toqua Lakes (Scenic)	40.00	-	40.00
Traverse des Sioux (Historic)	2.27	-	2.27
Watson (Scenic)	12.00	-	12.00
Totals	504.32	80.50	584.82
STATE MONUMENTS			
Action	0.10	5.00	5.10
Brook Park	0.25	-	0.25
Hinckley	0.10	-	0.10
Milford	1.00	-	1.00
Moose Lake	0.10	-	0.10
Sam Brown Memorial	1.00	-	1.00
Schwandt	0.10	.90	1.00
Wood Lake	1.00	-	1.00
Totals	3.65	5.90	9.55
GRAND TOTALS	45,866.28	12,993.84	58,860.12

STATE HIGHWAY WAYSIDES

Appleton	Fountain	Hinckley	Long Prairie	Pine Lake
Buffalo	Garrison	Indus	Milaca	Pomme De Terre
Cambridge	Gooseberry	Isabella	Montevideo	Preston
Cascade	Grand Marais	Kenyon	North Stillwater	Princeton
Christmas Lake	Granite Falls	Lake Brophy	Ottertail	Red Wing Quarry
Climax	Hastings	Lanesboro	Palisades Head	Redwood River
Cold Springs	Hawley	Lion's Springs	Palmers	Spring South Grand Rapids
Flute Reed	Hewitt	Little Fork	Pine Island	Temperance
				Thief River Falls

STATE FORESTS

	Gross Area Acres	State Land Acres		Gross Area Acres	State Land Acres
Bay Lake	75,437	681	Mille Lacs	128,100	3,664
Beltrami	445,440	34	Minnesota	217,180	217,180
Blackduck	75,732	4,120	Mississippi Headwaters	91,377	5,374
Buena Vista	79,641	4,275	Nemadji	163,741	6,500
Burntside	20,000	20,000	Northwest Angle	79,276	-
Chippewa	80,629	80,629	Paul Bunyan	125,709	40,143
Cloquet Valley	230,400	17,774	Pillsbury	51,773	1,846
Crow Wing	182,425	2,071	Pine Island	384,142	264,192
Finland	149,760	11,595	Rum River	69,003	1,140
Fond Du Lac	96,710	6,067	Savanna	211,580	16,062
Foot Hills	177,650	7,450	Smokey Hills	109,874	4,557
George Washington	341,440	91,084	St. Croix	3,212	3,212
Grand Portage	151,760	30,725	Third River	46,080	18,022
Kabetogama	918,560	157,477	Washkish	76,729	34,931
Koochiching	260,061	260,061	White Earth	160,640	18,113
Land O'Lakes	138,241	6,191	Total	5,342,312	1,335,170

Note: Efforts are being made to turn a 978 acre tract of sand dune land in Sherburne County into a state forest

NATIONAL FORESTS

	Gross Area Acres	Federal Land Acres	State Land Acres	Private Lands Acres	Approximate Water Area (Acres)
Superior National Forest	2,872,363.83	1,727,526.75	400,216.60	744,620.48	
Kabetogama Purchase Unit	750,544.82	98,917.64	185,314.41	466,312.77	
Pigeon River Purchase Unit	102,940.99	4,532.67	27,223.51	71,184.81	
Total	3,725,849.64	1,830,977.06	612,754.52	1,282,118.06	1,000,000.00
Chippewa National Forest	1,325,767.00	633,334.00	285,000.00	124,433.00	283,000.00

OTHER RECREATION AREAS

St. Croix Federal Recreational Area
Pipestone National Monument
Beltrami Development Project
Pine Island Development Project

St. Croix Federal Recreation Area - Located east of the Town of Hinckley in Pine County, this playground lies midway between the Twin Cities and Duluth. The 27,116 acre tract of cut-over land borders the St. Croix for approximately twenty miles and is under jurisdiction of the National Park Service. The recreational area was established as part of the Federal Government's program of retiring submarginal land from agricultural use and putting it into multiple land use. Among its recreation facilities are two organized camps and a public use area for campers, picnickers and fishermen.

Pipestone National Monument - This natural feature near the City of Pipestone consists of 116 acres of rocky depression along the Pipestone River. An area of considerable historic and romantic appeal, it was transferred in 1937 from the Office of Indian Affairs to the National Park Service (Figure -). Pipestone, or catlinite, found interstratified in the Sioux quartzite is of great interest. It supplied the Indians with a soft material from which they made their peace pipes. Indian tribes have held the spot sacred for many centuries and they still work the quarries.

Beltrami and Pine Island Projects - The two land utilization projects (including retirement of submarginal lands), formerly administered by the Soil Conservation Service and earlier emergency agencies, were leased to the State of Minnesota in August 1940 for 50 years by the United States for combined uses and management practices, including forestry, recreation and wildlife (Figure -). Under terms of the lease, "the State shall operate, maintain, and administer the existing and subsequently developed recreational facilities for the use and benefit of the general public, ***. Any recreational facilities that may be subsequently developed shall be consistent with the other uses of the land." Lands originally acquired by the United States in connection with the projects total 81,365 acres in the Beltrami Island Project and 19,571 acres in the Pine Island Project. They comprise a gross area of 1,550,000 acres of which 1,200,000 acres are tax delinquent lands, now reverted to the State.

Federal Wildlife Refuges - Federal lands providing refuge for wildlife under the administration of the Bureau of Biological Survey have an important recreational value. Both animal and plant life is being restored and preserved in these areas for their conservation, education and pleasure values. Federal refuges located in Minnesota are:

Name	Gross Acreage 1/	Place
Mud Lake Migratory Waterfowl Refuge	66,553	Marshall County
Rice Lake Migratory Waterfowl Refuge	15,335	Aitkin County
Tamarac Migratory Waterfowl Refuge	40,624	Becker County
Talcot Lake Refuge	965	Cottonwood County
Upper Mississippi Wildlife and Fish Refuge	27,982	Wabasha, Winona and Houston Counties

1/ Gross acreage includes acquired acreage, acreage in process of being acquired, area indirectly controlled, flowage easements, and water area within present or contemplated exterior boundaries as of December 1940.

State Recreational Areas

State Forests - Thirty-one state forests in Minnesota cover a gross area of approximately 4,957,430 acres (roughly 10% of the State), but only 1,335,170 acres is actually state-owned land.2/ This figure does not include abandoned and tax-delinquent land, millions of acres of which may eventually revert to the State. Figure - gives the location of each of the state forests listed in table -. The CCC and other relief programs have greatly advanced recreational developments in state forests in recent years. Land not needed for public recreation is often leased as private summer homesites. The following tabulation presents a brief summary of recreation facilities developed in state forests as reported in 1939:1/

833 summer homesites surveyed and platted

195 summer homesites leased (located on 30 lakes)

44 acres developed for public camp grounds

47 acres developed for public picnic grounds

20 acres developed for bathing

1/ The Minnesota state park and recreational area plan, Division of State Parks, Dept. of Conservation, p. 90, 1939.

2/ At the time of this writing, efforts are being made to turn ~978 acres of scrub dune land in Sherburne County into a state forest

State Parks and Recreational Reserves - Minnesota has 21 state parks which embrace large areas of outstanding natural landscape, four sizeable areas with historical significance, and three tracts that afford some opportunity for recreation but lack outstanding scenic values (Figure -). Their combined area, 45,358 acres, sounds like a great deal, but for a population of 2,792,300, it actually is relatively meagre. All developed areas provide tables, fireplaces and water for picnicking and some have fine refectories and rustic shelters and restrooms. Bathing beaches and facilities exist in Buffalo River, Camden, Cottonwood River, Itasca, Lake Bemidji, Lake Shetek, Middle River, Scenic, Sibley, Two Rivers, Whitewater and Pomme de Terre. Excellent camp grounds and accommodations for overnight stays are provided in Gooseberry Falls, Interstate, Scenic, Sibley, and Whitewater State Parks. Itasca, Interstate, Scenic and Whitewater afford overnight cabin accomodations. Boat excursions may be enjoyed in Itasca, Lake Shetek, Interstate and Horace Austin State Parks. Attendance in state parks in 1940 exceeded one and one-quarter million people.

State Waysides and State Monuments - Table - lists twelve state waysides of Minnesota and indicates which are of scenic, historic and memorial significance. They provide the highway traveler a place to stop and rest and at the same time an opportunity to enjoy a superlative landscape or some historic or scientific feature (Figure -).

The eight state monuments are small tracts or structures established to commemorate persons, events or sites of state-wide historical importance. Their limited area precludes any but passive recreational pursuits (Figure -).

State Highway Waysides - Table - lists forty-one state highway waysides and figure - indicates their geographic location. These afford the motoring public overlooks and turn-outs and convenient stopping places for rest and picnic lunch.

County Recreational Areas

County Parks - It was not until 1937 that the State Legislature passed an act (Chapter 23) that enabled establishment of county parks and recreation areas.

To date only three counties, Lyon, Ramsey and Winona have availed themselves of the authority. Ramsey County's facilities consist of a bathing beach, golf course, and one picnic area. Lyon County has one park and Winona two. They serve the county population and at the same time supplement facilities provided by municipalities and the State.

Intensive Outdoor Recreation Areas

Intensive outdoor recreation areas include lands provided for sports, games, picnicking, boating, and the activities which require relatively small tracts, highly developed and well equipped. In general, grounds are provided by communities and local public and semi-public agencies.

School and Municipal

School Facilities - All schools provide recreation for students and they generally serve also as community amusement centers for adults. No definite inventory has been made of the number of athletic fields, baseball diamonds, softball diamonds, stadiums, playgrounds, tennis courts, field houses, swimming pools, and other school recreational facilities constructed in Minnesota. The State Department of Education estimates that there are 688 school gymnasiums.

Municipal Parks - During recent years the number and recreational use of municipal parks have increased rapidly. Response to a questionnaire sent to all municipalities by the Division of State Parks revealed that there are more than 325 "in town or neighborhood parks" and more than 140 "large parks" (Figure -). Winona, St. Paul and St. Cloud have established municipal forests as authorized by the legislative act of 1927 (Section 133 - Mason's Minnesota Statutes).

Municipal Playgrounds - Many municipalities have athletic fields, municipal stadiums and facilities providing for volley ball, tennis, and similar sports. As reported to the Division of State Parks there are 160 public athletic fields, 385 children's playgrounds, 408 ball diamonds, 111 bathing beaches, and 371 skating rinks in Minnesota.

Municipal Tourist Camps - Open shelters, cabins, and tent and trailer sites have been established by many municipalities. A total of 181 camps were reported to the Division of State Parks in its survey. They vary in capacity, accommodations ranging from only five touring units to several hundred. Figure - shows the approximate location of municipal tourist camps and their relation to the principal highways of the State.

Semi-Public and Private

Golf Courses - Minnesota is bountifully supplied, as seen in figure -, with golf courses well distributed throughout the State. Thirty-six of 130 courses reported to Division of State Parks are publicly owned and many more are open to the general public. Tournaments and special matches, both amateur and professional, held during the golfing season on representative courses, attract thousands of spectators. From the standpoint of man-days of use, golf courses have a pronounced recreational value.

Resorts and Tourist Camps - Accommodations for tourists and vacationists exist throughout Minnesota, especially in the lake regions. Included are simple over-night cabins, elaborate resorts, seasonal and year-around hotels, clubs and health centers. Figure - reveals the distribution of cabin camps. The 1940 Census reports 765 tourist cabin camps, with 5,056 cabins, for Minnesota, or more than in any other state. The State Tourist Bureau reports that more than 20,000 hotels, lodges, resorts, camps and cafes in Minnesota depend heavily upon tourists.

Country Clubs - Golfing is the principal outdoor recreation afforded by country clubs in Minnesota. Of 130 courses in the State, 69 are owned by country clubs. Some clubs also have tennis courts, swimming pools, and archery ranges, and most of them provide indoor recreation

Group Camps - Outdoor recreation is fostered by 64 organized group camps in Minnesota, sponsored by churches, Boy Scouts, Girl Scouts, Camp Fire Girls, 4-H Clubs and similar groups (Figure -). Business, professional, and civic clubs in

many instances assisted in the construction of these clubs and have enabled children who would otherwise be unable to do so to attend camp. Figure - also locates 17 privately organized group camps operated for profit.

Summer Cottages - They constitute one of the most stable forms of recreation in Minnesota. They represent a large aggregate investment and on some cut-over lands provide the most important source of property taxes. Summer cottages bring hosts of people to outdoor recreation regions for vacations and visits.

Outdoor Recreation Areas Of Scientific Interest

Statewide and local effort has long been exerted with some success in restoring, preserving and acqiring sites of outstanding historic interest, archaeologic importance, botanic and zoologic value, and geologic significance. Interest in sites worthy of preservation and maintenance is occasionally stimulated by public spirited groups.

Historic Areas - While Minnesota does not possess the quality of ancient cultural ruins or the number of interesting sites and buildings recorded and preserved in some parts of the country, it does have a rich historical heritage of recreational appeal. Sites of Indian villages, battles, and ceremonials, and the many mound groups memorialize the Indian's occupancy of Minnesota. Trading posts, forts, trails, camp sites, and canoe portages help portray the romantic era of exploration and fur trading. Military roads and garrisons, Indian missions, ox-cart trails, ferrys, battlefields, and famous houses hark back to the early days of settlement. Historic buildings, mills, bridges, stores, taverns, churches, schools, and other cultural features mark a century of growth to the present time. Figure - locates many of the most significant historical sites and the general area through which notable explorers, settlers, and military roads and trails traversed. Over one-hundred State Historical Society markers along the highways draw attention to Minnesota's history. Other historic sites should be restored and preserved before they become lost or destroyed beyond replacement.

Archaeologic Areas - Approximately 10,000 Indian mounds have been found in the State and more are being discovered each year. Mounds exist mainly in the cross-section of Minnesota bounded on the south by the Minnesota River and on the north by a line drawn north of Mille Lacs Lake. The northeast triangular area, according to present findings, is practically void of archaeological sites (Figure -). The mounds almost invariably contain such artifacts as arrowheads, knives, scrapers, awls, mallets, harpoons, and earthen jars. A law passed in 1939 prohibits opening of any Indian mound without permission of the Department of Conservation.

Geologic Areas - Numerous sites of particular geologic interest exist in Minnesota. Rock formations at Taylors Falls in the Inter-State Park are of interest to geologists and laymen alike. The same is true of those in Jay Cooke Park. Iron ore bodies and mining operations attract sight-seeing tourists, scientists, and students. The seven-mile spit forming Minnesota Point at Duluth, the Duluth-Superior harbor, the broad aggraded valleys of the entrenched Minnesota and St. Croix Rivers, Mississippi gorge and St. Anthony Falls, the abandoned channel and ancient falls of the Mississippi at Minnehaha Creek, Lake Pepin, the northern border lakes, the beached and faulted north shore of Lake Superior, the lacustrine plains, the bare rock areas of the Rainy River basin, and the multitudes of glacial features such as moraines, eskers, kames, kettle holes, and huge boulders, excite interest of naturalists and casual observers. It has been suggested that more attention be given to marking most notable features and simply explaining them.

Botanic and Zoologic Areas - Preservation of sites of especial botanic value has received some attention. The Minnesota Academy of Sciences has acquired property along the Anoka-Isanti County line to preserve a cedar swamp which is of particular interest as an island of northern plants. ~~Several~~ Other areas of notable interest but not yet acquired for preservation are the Minnesota River bottomlands just west of Savage, ~~Nerstrand Woods in Rice County~~, and a Winona bluff which is an unusual area containing outposts of vegetation, from the west and

The last remnant of the big rectangular woods (473 acres) between Northfield & Faribault in Rice County recently became the property of the federal government. Eventually it will be turned to minnesota for a state park. (2)

south. These and many other sites are a subject of great concern to naturalists, who know that secrets of the plant and animal kingdoms inevitably pass away from the living record when farms and villages replace primeval conditions. Figure - shows areas set aside to preserve animal life in Minnesota.

Economic Importance Of Tourist Industry

Tourism has become a big industry in Minnesota. As an income producer, it ranks fourth to agriculture, manufacturing and mining. Estimates of the Travel Bureau of the Department of Interior for the 1940 travel season show that Minnesota ranks tenth among the states in volume of recreational travelers' retail expenditures with a total of $151,872,600. The very important part that vacationists have played in Minnesota's economic life during the period from 1936 to 1940 is seen in table -. According to the State Tourist Bureau, the average tourist visits Minnesota for 13 days and spends $132.

RECREATIONAL TRAVELERS' RETAIL EXPENDITURES
1936-1940

(Thousands)

	1936	1937	1938	1939	1940
Minnesota	$118,308	$128,008	$131,612	$138,066	$151,873
Percent of U.S.	2.43	2.38	2.46	2.40	2.53
United States	$4,869,752	$5,378,574	$5,359,689	$5,751,218	1/$6,000,000

1/ Preliminary estimate
Source: Travel Bureau, United States Department of Interior

The cut-over country of Minnesota receives the lion's share of the tourist business which amounted to $54.39 for every person in Minnesota in 1940. Economists believe that the average vacationists' dollar turns over about twenty times when spent and benefits nearly all types of business and employment. Farmers are enabled to market more milk, eggs, vegetables, and fuel during the summer, and to realize incidental income in the form of cottage and boat rentals. Almost nine hundred farmers representing nearly every county in the State were queried at the Minnesota State Fair in 1939 on what employment benefits they derive from the tourist industry with the following results:

Question		Number Interviewed	Percent
Do any members of your family find employment during the summer at resorts, hotels, restaurants, filling stations or any other type of business that profits directly from tourist trade?	Yes	164	19.20
	No	690	80.80
		854	100.00
	No reply	6	
	Interviews	860	

Authorities differ widely on just how the travel dollar is divided. Application of the percentages of total tourist expenditures in various enterprise groupings, as revealed by a recent Babson survey of the national travel market, to the approximately $152,000,000 of estimated tourist expenditures in Minnesota in 1940, gives the estimated distribution shown in table -. This rough and simple analysis reveals that the tourist dollar covers a wide field of industrial and trade activity in Minnesota.

ESTIMATED DISTRIBUTION OF TRAVELERS' RETAIL EXPENDITURES - 1940

Group	Percent	Amount
Retail stores - at home and away		
Sports clothes and equipment, food, luggage, etc.	25	$38,000,000
Restaurants and cafes	22	33,440,000
Hotels, lodges, tourist camps, resorts	17	25,840,000
Gasoline stations	12	18,240,000
Theaters and amusements	9	13,680,000
Transportation - rail, air, bus, taxi	7	10,640,000
Confectionery stores and roadside stands	5	7,600,000
Incidentals - newspapers, magazines, post cards, etc.	3	4,560,000
Total	100	$152,000,000

Source: Percentages obtained from Babson's Reports, April 1, 1940.

Sale of non-resident fishing and hunting licenses is an important source of State revenue (Table -). The proportion of gasoline tax receipts attributable to tourist travel has never been accurately determined. An average of over two million dollars increase in gasoline tax revenue is realized in the months of June, July and August over January, February and March, of which the State Tourist Bureau estimates at least half is paid by tourist visitors.

INCOME FROM ISSUANCE OF NON-RESIDENT FISHING AND HUNTING LICENSES

Type of License	1936-1937	1937-1938	1938-1939	1939-1940
Non-resident fishing license	$206,338	$255,855	$255,298	$259,251
Non-resident hunting license (small game)	3,563	3,910	4,625	7,493
Non-resident hunting license (big game)	3,525	1,915	2,865	1/
Total	$213,426	$261,680	$262,788	$267,744

1/ No open season
Source: Minnesota Department of Conservation.

Outdoor Recreation Problems

While Minnesota's natural endowment as a recreation area is far above the average, the tourist industry which is based upon these blessings is an extremely sensitive one. It will diminish rapidly under the influence of mismanagement and shortsightedness. A high degree of courage, foresight, and breadth of vision is necessary to deal effectively with such general problems as these:

1. Preservation and improvement of natural playgrounds. Lakes need a forest background, which requires reforestation, forest management on private as well as public lands, and efficient fire control. Water levels must be stabilized within certain levels by means of dams and other devices and by regulation of water use. If wildlife resources are to be preserved, land and water habitats must be improved through proper forestry practices, land utilization programs, restoration of drained lands, pollution abatement and water control.
2. Provision of easily available and satisfactory public facilities. Not all of them are large enough, nor, as seen in figure -, sufficiently accessible to the people who need them most - residents of large cities. The Minnesota State Park and Recreational Area Plan prescribes a park or recreational reserve within a 30-mile

radius, wherever practical, of every resident living in Minnesota. At present only about one-eighth of the total population is so situated.1/ Table - shows the acreages now in state parks and

---

1/ The Minnesota State Park and Recreational Area Plan. Division of State Parks, Dept. of Conservation, p. 119, 1939.

---

recreational areas and the recommended additions. Fourteen additional parks or recreational reserves are required to meet present needs. The nearest state park is more than fifty miles from the Twin Cities area with its population of almost a million.

3. Regulation of commercial facilities in the light of community interest. Poor taste and a desire for quick profits are detracting from natural advantages in some places. Pleasant landscapes are marred by billboards, roadside signs and tawdry commercial development. Over-commercialization of primitive areas can quickly stop the stream of visitors. Through cooperative action, recreation purveyors can set reasonable standards of safety, sanitation, housing facilities and charges which will operate in the long run to the advantage of all.

4. Determination of public and private prerogatives in recreation development. Definite state policies must be formulated if historic and scientific features are to be preserved, and suitable, adequate facilities and accommodations provided for visitors.

5. Appropriation of adequate state advertising funds. For Minnesota to get its rightful share of the six-billion dollar national tourist trade it must vigorously market its attributes as a vacation land through advertising. In general, state appropriations for recreational advertising have increased steadily in recent years, but

Minnesota's has not. Table - lists in order of amount the sums appropriated by state legislatures for advertising in 1939. Note in the table that Minnesota spent $50,000 (the amount also appropriated for 1940), that many states spent from two to sixteen times as much as Minnesota, and that the State was in 20th position in the amount of money appropriated. These comparisons suggest Minnesota is short of necessary funds to carry on an adequate campaign for tourist business.

STATE TOURIST ADVERTISING APPROPRIATIONS - 1939

Florida	$825,000
New York	500,000
Pennsylvania	394,000
Maine	300,000
Washington	166,250
Wisconsin	137,230
New Mexico	135,000
Michigan	125,000
Illinois	125,000
Louisiana	125,000
Oregon	100,000
North Carolina	100,000
New Jersey	100,000
New Hampshire	98,414
Massachusetts	83,900
Arizona	75,000
Virginia	68,500
Idaho	65,000
Connecticut	60,000
Alabama	60,000
Kansas	60,000
Arkansas	57,050
Minnesota	50,000
Mississippi	50,000
Maryland	46,000

Source: Report of the Commissioner of the Department of Conservation: Statistical report for biennium ending June 30, 1940, p. 265, December 1940. Primary source is Council of State Governments.

Wild Life Propagation

Until recent years, there was a progressive decrease in most forms of wildlife in Minnesota, in some cases to the point of extinction. The reduction resulted mainly from great changes in the face of the land. Some of the losses were inevitable, others unnecessary since farsighted sportsmen and naturalists long ago advocated wildlife conservation. The State Game and Fish Division is now mainly concerned with recouping the unnecessary losses.

The Division enjoyed several advantages which presaged success for its efforts. It was dealing with a wonderfully varied region almost ideally located geographically for protection and development of game life. Some forests remained and there were wild areas available as game propagating centers. By prohibiting wholesale destruction of game and fish, establishing state game refuges, fish hatcheries, and game farms, distributing fish fry and releasing game birds, and through research and education, the State had succeeded by the late 1920's in effecting changes so beneficial that wildlife began a significant comeback.

Game Refuges

Today, Minnesota possesses the largest area of game refuges of any state in the Nation. One hundred and forty-five statutory game refuges cover 2,825,127 acres, 7 state-owned refuges and public hunting grounds contain 497,129 acres, and 21 state parks, 4 state memorial parks, and 3 state recreational reserves comprise 45,358 acres - a total of 180 state refuges covering 3,367,614 acres (tables - and - and figure -). As already noted, the Bureau of Biological Survey owns or controls five areas in Minnesota aggregating 151,460 gross acres, which it administers as wildlife sanctuaries (Figure -).

STATE-OWNED GAME REFUGES AND PUBLIC HUNTING GROUNDS

Refuge or Hunting Ground	County	Acreage
Lower Rice Lake[1/]	Clearwater	4,400
Carlos Avery	Anoka and Chisago	10,265
Red Lake[1/]	Beltrami and Lake of the Woods	462,020
Talcot Lake	Cottonwood	1,600
Green-Calhoun	Kandiyohi	678
Thief Lake	Marshall	15,772
Whitewater[1/]	Winona	2,394
		497,129

1/ Not opened for hunting during last three seasons. Red Lake was opened for deer only in 1940.

Source: Minnesota Department of Conservation.

STATUTORY GAME REFUGES

County	Statutory Acres	Number Refuges	County	Statutory Acres	Number Refuges
Aitkin	220,280	2	Martin	10,139	2
Anoka	18,730	3	Mille Lacs	2,000	1
Becker	3,468	2	Morrison	14,637	4
Beltrami	119,040	3	Mower	2,400	1
Blue Earth	7,760	3	Nicollet	1,415	2
Carlton	14,760	2	Nobles	7,360	1
Cass	15,539	6	Olmsted	30,080	1
Chippewa	840	1	Pennington	49,280	2
Chisago	700	1	Pine	119,860	2
Clay	25,476	3	Pipestone	1,120	1
Clearwater	18,730	3	Polk	92,285	5
Cottonwood	1,249	2	Pope	1,206	1
Crow Wing	8,670	2	Ramsey	67,518	1
Dodge	10,714	2	Renville	5,200	3
Faribault	2,040	2	Rice	4,683	4
Freeborn	15,200	1	Roseau	2,880	1
Goodhue	5,760	1	Sibley	700	1
Hennepin	57,870	2	Stearns	10,632	7
Houston	680	1	Stevens	2,880	2
Hubbard	33,103	4	St. Louis	1,339,006	7
Isanti	702	2	Todd	140	2
Itasca	178,354	10	Traverse	7,520	1
Kanabec	710	1	Wabasha	881	1
Kandiyohi	9,682	2	Wadena	69	1
Kittson	25,600	2	Waseca	23,360	1
Koochiching	109,760	3	Washington	16,600	3
Lake	5,000	1	Watonwan	738	1
Lake of the Woods	8,320	3	Wilkin	3,454	2
Le Sueur	4,900	1	Winona	13,565	3
Lyon	2,240	2	Wright	2,502	2
McLeod	10,560	2	Yellow Medicine	1,200	1
Marshall	53,380	3	Total	2,825,127	145

Source: Minnesota Department of Conservation.

Even with all this publicly owned land, private lands continue to produce the larger part of the game supply. To promote propagation on private lands, some game management specialists think it wise to restrict the shooting privileges of owners and public. Provision is gradually being made for public areas that will be available to the rank-and-file hunting public. During the last three seasons all but three game refuges and public hunting grounds have been opened to public hunting, that is, all but the center third of the areas which are inviolate refuges for game propagation and preservation (Table -). A network of refuges surrounded by public shooting grounds has long been advanced by conservationists as a wise solution of the public hunting problems. That these hunting grounds should be accessible to the more populated centers is now recognized.

From the State's two game farms 40,971 pheasants, 21,044 quail, and 18,024 Chukar partridges were released in 1940. The farm at Madelia produces only ringnecked pheasants; Carlos Avery Game Farm, intended at first only for quail, is now also rearing a considerable number of Chukar partridges. Examination of table - reveals amount and variety of wild game taken each year in Minnesota is large.

Fur Animals

The wild fur animal resource is still of considerable importance in the State. The estimated 222,584 pelts taken in 1939 had an adjudged value of $350,945; in 1934, the 613,559 pelts believed taken that year were worth $685,374. It is important that study and research on the problem of maintaining and encouraging wild fur animals be continued and expanded.

LICENSES ISSUED AND ESTIMATED GAME TAKEN

	1937	1938	1939
Licenses Sold			
Small Game	150,788	210,447	241,483
Licenses reported on	32,419	28,735	35,901
Percentage basis for estimate	21.5	13.7	14.8
Big Game	63,322	61,498	Closed
Licenses reported on	22,845	22,254	Closed
Percentage basis for estimate	36.0	36.2	Closed
Ducks			
Mallard	513,952	492,446	1,118,066
Bluebill	345,480	391,431	618,196
Green-winged Teal	146,217	147,313	289,779
Blue-winged Teal	125,002	113,641	255,971
Canvas Back	Closed	1,726	35,498
Redhead	Closed	1,347	64,475
Pintail	74,925	31,567	109,875
Shoveler (Spoonbill)	42,392	37,880	68,823
Bufflehead (Butterball)	Closed	484	10,625
Ringneck (Ringbill)	8,322	12,627	11,591
Widgeon (Baldpate)	18,255	10,522	46,123
Black Mallard	9,255	6,313	27,288
Ruddyduck	Closed	253	7,244
Gadwall (Gray Duck)	12,537	10,522	42,742
Golden Eye (Whistler)	5,745	6,313	11,833
Unclassified	18,450	2,104	3,622
Merganser	6,015	6,313	1/
	1,326,547	1,272,802	2,721,751
Shorebirds			
Coot (Mudhen)	66,800	48,403	70,030
Jacksnipe	5,535	14,731	13,765
Rail	1/	484	186
Gallinule	37	231	186
Yellow Legs	1/	231	1/
	72,372	64,080	84,167
Geese			
Canada Goose	960	1,894	8,452
Whitefronted Goose	1/	1/	1,111
Snow Goose	15	126	411
Blue Goose	1/	1/	138
	975	2,020	10,112
Upland Birds			
Ringnecked Pheasant	586,124	648,177	970,762
Partridge (Ruffed Grouse)	Closed	Closed	66,166
Hungarian Partridge	Closed	Closed	9,901
Prairie Chicken	Closed	Closed	411
Quail	982	2,104	9,176
Dove	450	4,209	28,253
	587,556	654,490	1,084,669
Small Game			
Squirrels	322,395	393,536	419,573
Rabbits	221,767	389,327	301,970
Raccoon	2/	2/	1,932
	544,162	782,863	723,475
Grand Total	2,531,612	2,776,255	4,624,174
Big Game			
Deer	34,080	33,260	Closed
Bear	219	123	Closed

1/ None reported
2/ Not available from reports on game taken

Source: Minnesota Department of Conservation

Open season for taking bear, mink, muskrat, skunk, and raccoon are provided by law. Beaver (with the exception mentioned below), otter, fisher, and marten are protected at all times. All other fur animals may be taken at any time.

Beaver had become so abundant in many areas in northern Minnesota that an open season was declared for eight days in May of 1939. Total reported catch was 11,048. Otter, fisher, and marten demand continued protection, with fisher very scarce and marten extremely rare.

Table - gives the estimated number of fur pelts taken by licensed trappers based on reports received by the Game and Fish Division. Since the law provides that individuals may trap fur animals on their own land, or land leased and occupied as a permanent abode, without procuring a license, it is obvious that this table includes only a part of the total fur harvest.

LICENSES ISSUED AND ESTIMATED FUR ANIMALS TAKEN

	1938		1939	
Licenses Sold	19,938		12,816	
Licenses reported on	3,772		3,703	
Percentage basis for estimate	18.9%		28.9%	
Kind of Pelt	Estimated Number	Estimated Value	Estimated Number	Estimated Value
Badger	1,857	$4,439.47	100	.....
Bobcat	1,576	2,670.39	782	$1,448.95
Fox, cross	575	2,542.64	121	884.29
Fox, red	8,226	29,315.86	6,697	22,965.71
Fox, silver	53	1,223.31	21	189.14
Fox, gray	2,121	3,804.57	2,786	4,764.59
Lynx	296	683.47	263	234.48
Weasel	116,629	37,690.09	68,566	21,405.80
Wolf, gray timber	550	2,529.68	225	1,157.70
Wolf, brush or coyote	2,190	18,096.14	1,073	3,170.73
Mink	40,262	255,100.94	30,512	178,483.98
Muskrat	269,547	172,142.31	2,558	966.83
Raccoon	7,274	17,222.81	5,410	17,486.74
Skunk	112,010	135,255.67	79,932	95,708.21
Fox Squirrels	3,021	362.10	2,084	96.32
Gray squirrels	7,020	458.38	3,724	159.03
Civet cat	4,015	1,022.82	3,644	1,433.34
Snowshoe rabbit	9,305	149.18	4,385	40.87
Jack rabbit	10,003	390.24	4,565	226.49
Cottontail rabbit	17,029	273.97	5,136	122.28
Totals	613,559	$685,374.04	222,584	$350,945.48

Source: Minnesota Department of Conservation.

Metallic Minerals

The more common metals used for industrial or structural purposes, in the order of their importance are iron, copper, lead, aluminum, and zinc. Of these, Minnesota has only iron in commercial quantities, but it has that in a quantity and quality unsurpassed anywhere in North America. No precious metal - gold, silver, or platinum - is mined in Minnesota.

Iron Ore

Through the years 1911-1940, iron ore produced in Minnesota averaged 61.8 percent of the total United States output, and for the years 1911-1937 1/, it was almost 23.4 percent of the world total. In 1940, a near record year, the State produced approximately 64.8 percent of the Nation's total.2/ Table - shows the relation of Minnesota's production to that of United States from 1884 to 1940 and to that of the world from 1905 to 1937. Figure - reveals the relation of Minnesota's ore production to that of United States from 1885 to 1940. Figure - depicts the trend in output of Minnesota and the United States in relation to world production.

The immense iron ore deposits of Minnesota are of comparatively recent development (Table -). Their exploitation brought about remarkable changes in the industrial map of United States, and is largely accountable for American supremacy in the production of iron and steel. The importance of these deposits lies in the high quality of the ore, the ease with which it can be mined, the cheap transportation available, and expanding demands for the metal.

Iron Ranges

The iron ores of Minnesota are located in four ranges in the northeastern part of the State. From southwest to northeast the ranges are the Cuyuna, Mesabi, Vermilion, and Gunflint ranges (Figure -).

1/ Data for years after 1937 are not available because of war conditions.
2/ In the year 1940, production nearly equalled that of 1937, the year of highest output.

PRODUCTION OF IRON ORE IN MINNESOTA, UNITED STATES AND THE WORLD - 1880 TO 1940.

Year	Thousands of Tons Produced			Proportion Minnesota's Production Is of Nations	Proportion Minnesota's Production Is of World	Average Price Per Ton of Ore at Mine	
	Minnesota	United States	World			Minnesota	United States
	Gross tons	Gross tons	Metric tons	Percent	Percent	Dollars	Dollars
1940	47,737	73,696	1/	64.79	1/	2.48	2.48
1939	31,548	51,731	1/	62.92	1/	2.89	3.00
1938	14,449	28,447	1/	50.79	1/	2.89	3.05
1937	48,416	72,093	213,700	66.10	23.02	2.87	2.95
1936	31,634	48,789	173,300	64.84	18.55	2.56	2.54
1935	19,365	30,540	141,000	63.44	13.96	2.48	2.51
1934	15,390	24,588	120,100	62.59	13.02	2.58	2.65
1933	11,980	17,553	91,200	68.25	13.35	2.59	2.59
1932	5,154	9,847	76,200	52.34	6.37	2.42	2.79
1931	17,445	31,132	118,780	56.04	14.92	2.60	2.70
1930	34,518	58,409	179,000	59.10	19.59	2.64	2.66
1929	45,761	73,028	201,187	62.66	23.11	2.61	2.62
1928	37,564	62,197	174,076	60.40	21.93	2.46	2.47
1927	35,461	61,741	171,300	57.44	21.03	2.47	2.47
1926	40,702	67,623	154,904	60.19	26.70	2.51	2.53
1925	36,856	61,908	151,255	59.53	24.76	2.52	2.53
1924	31,902	54,267	129,139	58.79	25.10	2.91	3.00
1923	44,348	69,351	135,732	63.95	33.20	3.45	3.55
1922	28,789	47,129	104,388	61.04	28.00	3.12	3.27
1921	17,811	29,491	73,449	60.39	24.64	3.37	3.56
1920	39,453	67,604	124,086	58.36	32.31	4.11	4.11
1919	36,001	60,965	109,104	59.05	33.53	3.50	3.51
1918	41,954	69,658	126,850	60.23	33.60	3.39	3.34
1917	44,595	75,289	141,956	59.23	31.92	3.15	3.18
1916	44,585	75,168	177,569	59.31	25.51	2.34	2.32
1915	33,465	55,526	115,739	60.27	29.38	1.83	1.77
1914	21,947	41,440	117,812	52.96	18.93	1.81	1.74
1913	38,659	61,980	177,385	62.37	22.14	2.19	2.21
1912	34,432	55,150	148,663	62.43	23.53	1.88	1.80
1911	24,645	43,877	130,002	56.17	19.17	2.11	2.07
1910	31,967	57,015	139,385	56.07	23.30	2.47	2.46
1909	28,975	51,294	108,102	56.49	27.23	2.15	2.08
1908	18,652	35,983	108,787	51.84	17.42	2.27	-
1907	28,970	51,721	134,190	56.01	21.94	2.55	-
1906	25,364	47,750	120,467	53.12	21.39	2.11	-
1905	21,735	42,526	114,636	51.11	19.26	1.77	-
1904	12,729	27,644	-	46.05	-	1.56	-
1903	15,371	35,019	-	43.89	-	1.89	-
1902	15,138	35,554	-	42.58	-	1.84	-
1901	11,110	28,887	-	38.46	-	1.71	-
1900	9,834	27,553	-	35,69	-	2.42	-
1899	8,161	24,683	-	33.06	-	1.42	1.22
1898	5,964	19,434	-	30.69	-	1.14	.78
1897	5,601	17,518	-	31.97	-	1.08	-
1896	4,284	16,005	-	26.77	-	1.42	1.23
1895	3,866	15,958	-	24.23	-	1.14	.73
1894	2,968	11,880	-	24.98	-	1.14	-
1893	1,500	11,588	-	12.94	-	1.66	-
1892	1,255	16,297	-	7.70	-	2.04	2.46
1891	945	14,591	-	6.48	-	-	-
1890	892	16,036	-	5.56	-	-	-
1889	865	14,518	-	5.96	-	2.30	2.87
1888	512	12,063	-	4.24	-	-	-
1887	395	11,300	-	3.50	-	-	-
1886	308	10,000	-	3.08	-	-	-
1885	227	7,600	-	2.99	-	-	-
1884	62	7,718	-	0.80	-	-	-
1883	-	8,800	-	-	-	-	-
1882	-	8,700	-	-	-	-	-
1881	-	7,120	-	-	-	-	-
1880	-	7,120	-	-	-	-	-

1/ Not available.

Source: Statistics from tabulation in Report of the Committee on Mineral Resources of Minnesota State Planning Board, (manuscript report in files of Minnesota Resources Commission) for years 1880-1936. Compiled from Minerals yearbooks 1937-1940 (mineral resources), Bureau of Mines, U. S. Dept. of Interior.

TOTAL RANGE SHIPMENTS OF LAKE SUPERIOR IRON ORE IN GROSS TONS

Years	(Minnesota) Mesabi Range	(Minnesota) Vermilion Range	(Minnesota) Cuyuna Range	Gogebic Range	Marquette Range	Menominee Range	Mayville Baraboo Range	Total Lake Superior District (U.S.)
1940	45,667,677	1,547,469	1,734,176	5,975,727	5,920,463	3,103,334	-	63,948,846
1939	30,314,857	1,417,360	1,290,673	5,345,558	4,907,623	2,160,596	-	45,436,667
1938	13,304,036	929,952	581,823	2,277,706	1,476,257	980,135	-	19,549,909
1937	45,932,539	1,453,080	1,775,445	5,661,270	5,747,812	2,649,062	-	63,219,208
1936	31,459,429	1,064,473	1,305,439	4,630,341	4,627,889	2,163,679	-	45,251,250
1935	18,876,642	857,099	798,481	3,070,825	3,265,537	1,634,022	-	28,502,606
1934	14,650,099	785,149	532,571	2,287,131	2,473,847	1,335,027	-	22,063,824
1933	13,471,625	740,404	741,139	2,400,932	2,807,325	1,510,985	-	21,672,410
1932	1,934,719	216,744	98,737	673,425	357,262	307,721	-	3,588,608
1931	15,270,411	1,140,710	898,090	2,908,282	1,809,445	1,469,290	-	23,496,228
1930	31,067,292	1,884,529	1,929,189	5,063,631	3,633,968	3,609,052	-	47,187,661
1929	43,008,239	1,873,742	2,596,186	7,624,085	5,409,712	5,645,395	-	66,157,359
1928	35,398,660	1,671,466	2,097,716	6,540,019	4,298,717	4,841,637	7,426	54,855,641
1927	32,975,506	1,547,847	1,981,501	6,385,558	4,147,777	5,213,256	92,654	52,344,099
1926	38,250,856	1,586,030	2,082,689	7,537,078	4,435,029	5,946,377	131,950	59,970,009
1925	35,890,174	1,437,741	1,514,053	7,068,478	4,197,846	5,269,633	156,887	55,534,812
1924	29,142,247	978,163	1,469,054	5,159,990	3,174,835	3,836,826	135,203	43,896,318
1923	41,806,230	1,278,684	2,220,733	6,579,730	3,891,801	4,855,370	138,800	60,771,348
1922	28,064,247	1,211,559	1,496,356	6,220,985	2,818,374	4,079,444	110,101	44,001,066
1921	16,349,935	869,354	489,500	2,336,500	1,116,560	1,584,466	52,413	22,798,728
1911-1920	332,927,885	13,859,858	13,849,779	60,587,322	39,843,199	51,600,841	1,227,478	513,896,362
1901-1910	193,495,975	15,138,295	-	34,021,279	36,743,671	41,418,406	843,476	321,661,102
1891-1900	31,389,888	11,968,274	-	22,731,022	26,825,234	21,196,080	126,510	114,237,008
1881-1890	-	3,223,005	-	8,470,250	18,749,258	11,935,877	-	42,378,390
1871-1880	-	-	-	-	10,344,731	901,314	-	11,246,045
1861-1870	-	-	-	-	3,597,014	-	-	3,597,014
1854-1860	-	-	-	-	242,994	-	-	242,994
Unknown	-	-	-	-	73,553	-	1/ 200,000	273,553
Total	1,120,649,168	68,680,987	41,483,330	221,557,124	206,937,733	189,247,825	3,222,898	1,851,779,065

1/ Estimated shipments to local furnaces, 1849-1892.
Source: Minnesota Mining Directory, p.202 Compiled by Lake Superior Iron Ore Association.

Mesabi Range - This is by far the largest of the four, extending over 100 miles from west of Grand Rapids to Birch Lake, nearly on the St. Louis-Lake County boundary. The district varies in width from 2 to 10 miles and contains approximately 400 square miles.1/ About seventy miles of the range are productive and mines occupy scattered sites over its entire length (Figure -).

1/ Leith, C. K., The Mesabi iron-bearing district of Minnesota: U. S. Geol. Survey Mon., vol. XLV, 1903.

The iron ore formation lies on the south slope of the granitoid Giants range which forms the main topographic feature of the district. Slate and gray-wacke formations delineate the ore bodies on the south and they have never been found extending any distance underneath them. The outcrop of iron-bearing rocks of the Animikie group of formations ranges in width from one-half to three miles (Figure -).2/

2/ Report of the Committee on Mineral Resources (manuscript report in file of the Minnesota Resources Commission), p. 20, August 1937.

About 88 percent 3/ of the Mesabi ore is taken from huge open pits.

3/ Average for the years 1931-1940. Computed from statistics in Mining Directory of Minnesota, 1941, Table 8.

The over-burden, seldom exceeding 100 feet in depth , is stripped off, exposing the soft ore body for cheap power-shovel mining. On the Mesabi are found the largest mines in the country. Of the 43 iron mines in the United States which produced more than 500,000 gross tons each in 1940, Minnesota had 24, and 23 of these were on the Mesabi range. Fifteen of the 43 mines produced more than

1,000,000 tons each, and of these 15, 11 were on the Mesabi. The largest open pit mine in the world is the Hull-Rust, located at Hibbing, from which more cubic yards of material have been dug than were excavated in building the Panama Canal.

The Mesabi range contains 95 percent of all the known ore deposits in Minnesota, and is the source of about 89.5 percent 1/ of the ore shipped from

---

1/ Average for the years 1931-1940. Computed from statistics in Mining Directory of Minnesota, 1941, Table 8.

Minnesota each year. From 1892 through 1940 it has supplied 1,120,649,168 gross tons, or 91 percent of the total iron ore output from Minnesota to date (Table -). In 1940 its output accounted for 93.3 percent of the State's shipments, in 1939 about 91.8 percent, and in 1938 approximately 89.8 percent. In 1940 it accounted for 71.4 percent of the total shipments from the Lake Superior District (United States). 2/ Figure - contrasts the annual shipments of the Mesabi with other ranges

---

2/ Computed from statistics in Mining Directory of Minnesota, 1941, Table 6.

---

in the Lake Superior District since 1892. Production in 1940 was the second highest since 1890, when ore was discovered on this range at Mountain Iron (Table -).

Gunflint Range - The ores of the Gunflint range lie mainly in northwestern Cook County, west of Gunflint Lake (Figure -). The belt extends about eight miles, and then is cut off by Duluth gabbro, but it reappears in small patches in Lake County and in the Mesabi range in St. Louis County. 3/ Geologically

---

3/ Report of the Committee on Mineral Resources (manuscript report in file of the Minnesota Resources Commission), p. 38, August 1937.

the Gunflint range is an extension of the Mesabi, the ore bodies of both belonging to the Animikie group of formations. The apparent continuity of the original Gunflint formation with the Mesabi makes the area an attractive one for prospectors and promoters.3/

3/ Idem., p. 29.

Presence of iron ore on the Gunflint range was mentioned as early as 1850, but no development was attempted until 1892. Due to the structure and grade of the ore, no shipments were made and work was discontinued in 1893. Corresponding in minerals and hardness to eastern Mesabi deposits, the Gunflint ores might be concentrated by methods already in use. Unfortunately, the dip of the beds (generally 10 degrees to the south, except close to the gabbro where the dip is 45 to 60 degrees) carries the ore underground in a short distance and no such extensive open pit operations are possible as on the Mesabi range. The ore bodies are reported to be deficient in quantity and quality for underground mining.

Vermilion Range - The Vermilion range characterized by deep-lying ore bodies, extends northeasterly from eastern Lake Vermilion to the vicinity of Gunflint Lake on the international boundary, a distance of about 100 miles. It is generally from 5 to 10 miles wide, though in places as much as 15 miles. Productive mines of the Vermilion range occur in the Soudan formation which is a member of the Keewatin series of the Archean system (Figure -). The larger ore bodies were formed as lenses during the Ely greenstone lava flows and possibly for a time thereafter.1/ They lie in a folded formation of jaspers

---

1/ Op. cit., p. 38.

---

and slaty material and occur in deep, narrow, pitching troughs and lenses that

must be mined by vertical shafting. The ore is a hard specular hematite, a shiny, somewhat metallic, blue mineral used primarily in the steel making process. Figure - gives the location and classification of iron ore properties.

Average production of the Vermilion range is a little more than 4 percent2/

2/ Average for the years 1931 to 1940. Computed from statistics in Mining Directory of Minnesota, 1941, Table 8.

---

of the State total. From 1884 to 1940 it contributed 68,680,987 gross tons, or 5.6 percent of the total iron ore shipped from Minnesota to that date (Table -). In 1940 it supplied 3.2 percent of the State's shipments, in 1939 4.3 percent, and in 1938 6.3 percent. Vermilion range shipments may be compared with those from other ranges in the Lake Superior District in figure -. Maximum production for the Vermilion was in 1902 when 2,084,000 tons were shipped.

Cuyuna Range - The Cuyuna range lies about 75 miles west and a little south of Duluth. It extends approximately 65 miles in a southwesterly direction from near the center of Aitkin County through Crow Wing, Morrison and Todd Counties (Figure -). The most productive portion is in Crow Wing County. As may be noted in figure -, the Cuyuna lies far out in the slate and gray-wacke series by which it is surrounded on all sides. The iron ore bearing strata (Animikie formation) varies from 1 to 12 miles in width. Detailed geological investigation indicates that most, if not all, of the bands of the iron formation lie in a single horizon, interrupted at intervals through erosion of the folded intervening heights of iron bearing slate.

Besides its iron this range carries the bulk of the manganiferous ores found in the Lake Superior District. Ores for the most part are unconsolidated, soft, ochery, yellow to brown material. Open pit practices prevail in the fold ore bodies, while deeper ore deposits lying along the steeply dipping monoclines are generally worked by underground methods. All the folding and

mountain-building movements took place before concentration of the ore, with the result that nearly all the ores are soft, and underground mining is best done by caving methods. Figure - gives the location and classification of iron ore properties.

The Cuyuna range now produces about 3.9 percent1/ of the annual ore shipments from Minnesota. Since the first shipment in 1911, it has supplied 41,483,000 gross tons, or 3.4 percent of the total mined in Minnesota to date (Table -). In 1940 it supplied 3.5 percent of the State's ore output, in 1939 3.9 percent, and in 1938 3.9 percent. Figure - shows the ratio of Cuyuna shipments to those of other ranges in the Lake Superior District. Highest yearly output, 2,596,186 tons, was in 1929 (Table -).

1/ Average for the years 1931 to 1940. Computed from statistics in Mining Directory of Minnesota, 1941, Table 8.

Quality of Ore

Iron Minerals - Iron is a more or less important constituent of many different minerals, but only a few of these rate as iron ores. Unless the iron-bearing minerals contain the requisite percentage of iron, they cannot be profitably mined and smelted. Important ores mined in Minnesota are hematite, from which the bulk of the Nation's iron is produced, and limonite. Both are oxide minerals in which iron has combined with oxygen. A small tonnage of magnetite, also an oxide ore, has been mined, but is not being extracted at present except as it occurs in small amounts in combination with other ores. Some siderite, an iron carbonate, is found intermingled with the ores.

*Hematite. Fe_2O_3 - In pure form contains 70 percent iron. Sometimes contains titanium and magnesium. Rhombohedral; but crystals are rare. Commonly in compact granular masses; also earthy; sometimes scaly or micaceous, called specular ore. Color varies from black in crystalline forms to red in earthy forms. Streak, cherry-red. Luster, metallic to dull-earthy. Hardness 5.5 to 6.5. Specific gravity 4.9 to 5.3.

*Limonite (Brown Hematite). $2FeO.3H_2O$. Contains 59.8 percent iron. Often contains manganese replacing part of the iron. Not crystallized. Usually in stalactitic and botryoidal or mamillary forms containing fibrous structures; also concretionary, massive and earthy. Grades into loose bog-ores, and as such may contain organic acids, phosphates, and manganese. Color, brown to ocher-yellow. Luster, sub-metallic to silky to dull-earthy. Streak, yellowish-brown. Hardness, 5 to 5.5. Specific gravity, 3.6 to 4.0.

(Hematite and limomite differ mainly in combined water content).

*Magnetite (Magnetic Iron Ore). $FeO.Fe_2O_3$, commonly stated Fe_3O_4. The iron in FeO is often replaced in part by magnesium, yielding $(FeMg)O.Fe_2O_3$. Frequently carries titanium. In pure form contains 72.4 percent iron. Strongly magnetic and sometimes possesses polarity. Occurs in massive form with laminated structure, also granular. Isometric; with crystals commonly occurring as well-formed octahedrons and dodecahedrons. Color, iron-black. Streak, black. Luster, splendent metallic. Hardness, 5.5 and 6.5. Specific gravity, 5 to 5.2.

---

*Lake Superior Iron Ore Assoc., Lake Superior Iron Ores, p. 64, 1938.

---

*Siderite (Spathic Iron). $FeCO_3$. Contains 48.2 percent iron, when pure. May contain also manganese, calcium, or magnesium. Rhombohedral; crystallized as rhombohedrons, with faces often curved, like dolomite. Often cleavable, massive to granular; also botryoidal and globular, or compact and earthy. Excellent cleavage. Brittle. Color, ash-gray, yellowish or greenish-gray, and brownish-red. Streak, white. Translucent. Luster, vitreous to pearly. Hardness, 3.5 to 4. Specific gravity, 3.83 to 3.88.

*Lake Superior Iron Ore Assoc., Lake Superior Iron Ores, p. 64, 1938.

Three Classes of Ore- The Mines Experiment Station at the University of Minnesota divides the iron-bearing materials of Minnesota in general, and the Mesabi range in particular, into three classes: high-grade direct shipping ore, low-grade ore that can be concentrated by present commercial methods, and lean ore and taconite which is not being concentrated at the present time.

Class 1 - High-grade iron ore can be shipped directly from the mines to the blast furnaces without concentration or mixing with other ores. It contains between 50 and 60 percent iron and from 3 to 10 percent silica. Nearly four-fifths (79.5 percent) of the ore mined and shipped from Minnesota each year grades as class 1 (Table -).1/ Over one billion

1/ Average for the years 1931-1940. Computed from statistics in Mining Directory of Minnesota - 1941, table 8, p. 207.

tons of this ore have been shipped from the State since iron ore mining first began on the Vermilion range in 1884 (Table -).

Records of the Minnesota Tax Commission show an estimated 1,218,586,648 tons2/ of reserve ore in Minnesota as of May 1, 1940 of which more than a

2/ Does not include the tonnage of ore on State lands that are not under lease, nor certain comparatively small tonnages of ore, mainly low grade, which are carried on the tax records at nominal valuations.

billion tons is class 1 (Table -). Most of the high-grade reserve lies on the Mesabi range (Figure - and Table -). On the Cuyuna range approximately 53 million tons of class 1 ore are carried on the tax rolls and on the Vermilion range nearly 14 million. Of the approximately one billion tons of high-grade ore still available on the Mesabi, the U. S. Steel Corporation owns or controls more than 70 percent, and this 70 percent is the "cream" of the ore.3/

3/ Davis, E. W. Change in U. S. Steel ore marketing policy endangers range communities and state: Minnesota Municipalities, vol. 25, no. 3, pp. 78-82, March 1940.

CLASSIFICATION OF IRON ORE SHIPMENTS FROM MINNESOTA

Year	Direct Ore		Concentrates		Total Shipment
	Open Pit	Underground	Open Pit	Underground	
Mesabi Range					
(1931-1940)	(159,314,000)	(24,979,000)	(45,036,000)	(1,553,000)	(230,882,000)
1940	34,847,000	2,460,000	8,225,000	136,000	45,668,000
1939	22,138,000	2,603,000	5,530,000	44,000	30,315,000
1938	8,414,000	2,215,000	2,551,000	124,000	13,304,000
1937	33,954,000	3,279,000	8,353,000	347,000	45,933,000
1936	21,292,000	3,113,000	6,721,000	334,000	31,460,000
1935	11,381,000	2,906,000	4,256,000	334,000	18,877,000
1934	9,743,000	1,835,000	2,888,000	184,000	14,650,000
1933	8,155,000	2,489,000	2,817,000	10,000	13,471,000
1932	891,000	766,000	266,000	11,000	1,934,000
1931	8,499,000	3,313,000	3,429,000	29,000	15,270,000
1921-1930	217,798,000	60,914,000	52,142,000	1,099,000	331,953,000
1911-1920	208,521,000	89,256,000	34,178,000	973,000	332,928,000
1901-1910	125,469,000	67,359,000	652,000	16,000	193,496,000
1892-1900	19,505,000	11,885,000	-	-	31,390,000
Total	730,607,000	254,393,000	132,008,000	3,641,000	1,120,649,000
Vermilion Range					
(1931-1940)	(28,000)	(10,051,000)	(5,000)	(69,000)	(10,153,000)
1940	27,000	1,446,000	5,000	69,000	1,547,000
1939	-	1,417,000	-	-	1,417,000
1938	1,000	929,000	-	-	930,000
1937	-	1,453,000	-	-	1,453,000
1936	-	1,065,000	-	-	1,065,000
1935	-	857,000	-	-	857,000
1934	-	785,000	-	-	785,000
1933	-	741,000	-	-	741,000
1932	-	217,000	-	-	217,000
1931	-	1,141,000	-	-	1,141,000
1921-1930	1/	14,339,000	-	-	14,339,000
1911-1920	1/	13,860,000	-	-	13,860,000
1901-1910	1/	15,138,000	-	-	15,138,000
1891-1900	1/	11,968,000	-	-	11,968,000
1884-1890	1/	3,223,000	-	-	3,223,000
Total	28,000	68,579,000	5,000	69,000	68,681,000
Cuyuna Range					
(1931-1940)	(2,952,000)	(2,040,000)	(4,588,000)	(176,000)	(9,756,000)
1940	658,000	304,000	726,000	46,000	1,734,000
1939	450,000	194,000	634,000	13,000	1,291,000
1938	231,000	200,000	134,000	17,000	582,000
1937	724,000	59,000	907,000	85,000	1,775,000
1936	480,000	116,000	709,000	-	1,305,000
1935	234,000	-	564,000	-	798,000
1934	79,000	86,000	368,000	-	533,000
1933	-	433,000	308,000	-	741,000
1932	-	84,000	15,000	-	99,000
1931	96,000	564,000	223,000	15,000	898,000
1921-1930	5,949,000	8,201,000	3,727,000	-	17,877,000
1911-1920	4,757,000	8,666,000	392,000	35,000	13,850,000
Total	13,658,000	18,907,000	8,707,000	211,000	41,483,000
Minnesota Ranges					
(1931-1940)	(162,294,000)	(37,070,000)	(49,629,000)	(1,798,000)	(250,791,000)
1940	35,532,000	4,210,000	8,956,000	251,000	48,949,000
1939	22,588,000	4,214,000	6,164,000	57,000	33,023,000
1938	8,646,000	3,344,000	2,685,000	141,000	14,816,000
1937	34,678,000	4,791,000	9,260,000	432,000	49,161,000
1936	21,772,000	4,294,000	7,430,000	334,000	33,830,000
1935	11,615,000	3,763,000	4,820,000	334,000	20,532,000
1934	9,822,000	2,706,000	3,256,000	184,000	15,968,000
1933	8,155,000	3,663,000	3,125,000	10,000	14,953,000
1932	891,000	1,067,000	281,000	11,000	2,250,000
1931	8,595,000	5,018,000	3,652,000	44,000	17,309,000
1921-1930	223,747,000	83,454,000	55,869,000	1,099,000	364,169,000
1911-1920	213,278,000	111,782,000	34,570,000	1,008,000	360,638,000
1901-1910	125,469,000	82,497,000	652,000	16,000	208,634,000
1891-1900	19,505,000	23,853,000	-	-	43,358,000
1884-1890	-	3,223,000	-	-	3,223,000
Total	744,293,000	341,879,000	140,720,000	3,921,000	1,230,813,000

1/ Data not available on open pit shipments from early operation of Soudan and South Chandler Mines nor from milling operation of Section 30 Mine (1910 to 1923).

Source: Mining Directory of Minnesota, 1941.

ESTIMATED CLASSIFICATION OF IRON ORE RESERVES IN MINNESOTA, MAY 1, 1940.

Classification	Mesabi Range	Vermilion Range	Cuyuna Range	Total
Direct Ore:				
Open Pit	607,222,000	-	13,384,000	620,606,000
Underground	360,488,000	13,209,000	39,209,000	412,906,000
Total	967,710,000	13,209,000	52,593,000	1,033,512,000
Concentrates:				
Open Pit	104,478,000	-	10,768,000	115,246,000
Underground	50,405,000	-	1,665,000	52,070,000
Total	154,883,000	-	12,433,000	167,316,000
Total Ore:				
In Ground	1,122,593,000	13,209,000	65,026,000	1,200,828,000
In Stock-pile	16,721,000	633,000	405,000	17,759,000
Total	1,139,314,000	13,842,000	65,431,000	1,218,587,000

Note: The above figures do not include the tonnage of ore on State lands that are not under lease, and do not include certain comparatively small tonnages of ore, mainly low-grade, which are carried on the tax records at nominal valuations. The above figures include ore in reserve stock-piles and ore in current stock-piles as of May 1st.

Source: Mining Directory of Minnesota, 1941.

Class 11 - This intermediate ore is a mixture of iron minerals with sand, rock and other materials, in some places almost as good as class 1 and in others nearly as poor as lean ore. It assays from 40 to 50 percent iron and cannot be smelted without concentration or mixing with high-grade ores. It is relatively easy to concentrate by such processes as washing and jigging.

Total tonnage of this class shipped from Minnesota up to December 1940 was nearly 145 million (Table -). An average of 20.5 percent of the iron ore shipped over the past ten years has been of grade 11 ore.1/

1/ Average for the years 1931-1940. Computed from statistics in Mining Directory of Minnesota - 1941, table 8, p. 207.

The Mines Experiment Station has estimated that there is still about 1,300,000,000 tons of this ore in Minnesota (Figure -).

Class 111 - This comprises lean ore and ore-bearing taconite rock. The lean ore is too low in iron and too high in silica and other impurities for profitable processing. The taconite contains about 30 percent iron, but as the iron and silica are generally closely knit in a dense fine-grained rock, any concentrating process will be costly. For every ton of concentrate which may ultimately be obtained from class 111 material, about three tons must be mined.2/

2/ Report of the Committee on Mineral Resources (manuscript report in files of Minnesota Resources Commission), p. 51, August 1937.

The Mines Experiment Station has estimated that roughly 57,200,000,000 tons of concentrate could be obtained from grade 111 material on the Mesabi range by open pit methods at a depth not exceeding 500 feet (Figure -).

Chemical Composition - Because the chemical composition of iron ore is of utmost importance in smelting, chemical analysis is a routine part of mining, marketing and smelting operations. Analyses are taken to determine the percentages of iron, phosphorus, silica, manganese, alumina, lime, magnesia, sulphur, and the amounts of volatile matter and moisture. Successful operation of a blast furnace depends largely on thorough knowledge of the composition of the ore used, for the proportions of fluxing materials and fuel must vary with its make-up if desired grades of ore are to be produced.

Table - reveals the average composition of ores shipped from the Mesabi and Vermilion ranges in 1902, 1905, 1910, 1915, 1920, and 1925, from the Cuyuna range in 1915, 1920, and 1925, and from all three ranges in each year since 1930. All analyses are of ore dried at 212 degrees F. unless it is stated that they were taken in the natural state. It is seen that the iron content in 1910 shipments from the Mesabi and those of recent years test about the same, whereas for the Vermilion the iron in late years assays considerably lower than in 1902 and 1905 and somewhat under 1910. Reduction in the percentage of iron is most notable for the Cuyuna over the years 1915 to 1940. The phosphorus content has remained relatively constant over the years for Mesabi shipments, and until late years also for those from the Vermilion, but it has increased considerably in Cuyuna ores. In general, the percentage of silica has tended to increase on all ranges.1/

1/ Silica is an oxide of silicon of the same composition as sand.

.Silica - The silica content of ores shipped from the Mesabi range from 1931-1940 averaged 7.94 percent, from the Vermilion 7.08 percent, and from the Cuyuna 10.20 percent.2/ When silica exceeds 10 percent a penalty in price is usually

---

2/ Minnesota Mining Directory - 1941, table 7, p. 203.

---

imposed for each additional percent. Simply stated, removal of silica is the concentration problem. It occurs in large amounts in the low-grade ores and iron-bearing materials. Some operators possess very little, if any, low silica ore in reserve. Siliceous iron ore containing from 18 to 20 percent silica or more is used under certain conditions to increase slag volume for removing certain elements in smelting. Table- gives the average analyses of shipments of siliceous ores from the Mesabi and Cuyuna ranges in 1939 and 1940.

AVERAGE ANALYSIS OF TOTAL TONNAGE, ALL GRADES

Year	Tonnage	Percentage				
		Iron Nat.	Phos.	Silica	Mang.	Moist.
		Mesabi Range				
1902	13,166,000	56.07	.045	4.35	.52	9.71
1905	19,847,000	54.24	.057	4.86	.56	11.45
1910	28,427,000	51.42	.065	7.27	.76	12.05
1915	29,190,000	50.74	.066	7.96	.72	12.39
1920	36,123,000	51.84	.063	7.69	.73	11.81
1925	35,531,000	52.05	.061	7.99	.68	11.14
1930	30,955,501	51.20	.065	8.40	.71	11.74
1931	15,219,155	51.37	.062	8.42	.73	11.57
1932	1,915,272	52.09	.059	8.23	.70	10.80
1933	13,354,622	51.26	.062	8.77	.70	11.55
1934	14,531,289	51.23	.065	8.31	.77	11.71
1935	18,706,957	51.23	.064	8.57	.71	11.67
1936	31,115,058	51.38	.066	8.13	.71	11.70
1937	45,123,945	51.68	.063	7.63	.70	11.96
1938	13,159,381	51.97	.066	7.67	.70	10.41
1939	29,988,897	51.73	.061	7.70	.62	11.28
1940	45,234,476	52.23	.059	7.56	.65	11.39
		Vermilion Range				
1902	2,046,000	61.65	.052	3.95	.12	4.32
1905	1,649,000	61.14	.047	4.37	.13	4.95
1910	1,192,000	60.14	.054	5.18	.11	5.02
1915	1,705,000	58.02	.051	6.87	.14	6.28
1920	940,000	58.62	.057	6.79	.10	5.63
1925	1,424,000	57.82	.051	6.67	.14	6.46
1930	1,865,883	58.69	.054	6.30	.11	6.05
1931	1,129,189	58.69	.056	6.14	.10	5.96
1932	214,575	57.78	.047	6.67	.11	6.98
1933	732,996	58.67	.056	6.33	.10	5.93
1934	777,230	58.18	.053	7.01	.10	5.87
1935	848,531	58.07	.055	6.92	.10	6.14
1936	1,053,820	57.84	.059	7.28	.11	5.97
1937	1,398,463	57.92	.069	7.25	.10	5.72
1938	915,441	57.91	.069	7.25	.10	5.59
1939	1,430,560	57.39	.070	7.68	.11	5.73
1940	1,488,777	58.12	.069	7.38	.10	5.08
		Cuyuna Range				
1915	898,000	50.06	.224	9.06	.50	10.75
1920	2,108,000	46.61	.211	9.05	3.29	11.39
1925	1,497,000	42.26	.236	7.72	5.81	14.18
1930	1,719,474	45.20	.240	9.23	4.99	10.94
1931	807,436	45.96	.218	9.95	4.62	10.55
1932	97,574	51.07	.241	10.32	1.86	9.50
1933	715,886	46.75	.228	9.84	3.98	10.04
1934	498,809	47.00	.250	10.59	4.37	8.40
1935	764,867	42.20	.304	9.49	6.85	10.88
1936	1,269,311	40.74	.270	10.34	7.21	11.38
1937	1,687,887	40.16	.268	10.11	7.65	12.35
1938	592,463	40.25	.270	10.10	6.27	14.15
1939	1,273,789	42.33	.266	10.46	6.45	11.15
1940	1,736,592	42.09	.306	10.50	6.66	11.45

Source: 1902-1937, Lake Superior Iron Ore Association Journal, pp. 291-297, 1938.
1938-1940, Minnesota Mining Directory.

AVERAGE ANALYSES OF SHIPMENTS FROM MINNESOTA IN 1939-40, BY GRADE

Grade	Shipments Thousands of Gross Tons		Percentage											
			Iron (Nat.)		Moist.		Phos.		Silica		Mang.		Total Tonnage	
	1939	1940	1939	1940	1939	1940	1939	1940	1939	1940	1939	1940	1939	1940
Bessemer Ore (Phosphorus not exceeding .045)														
Vermilion	612	570	56.57	56.43	7.40	6.96	.042	.042	7.62	7.78	.12	.12	42.8	38.3
Mesabi	6,888	11,338	54.79	54.98	9.25	9.12	.038	.038	8.02	7.78	.36	.36	23.0	25.1
Low Phos.-Non-Bessemer (Phosphorus not exceeding .180)														
Vermilion	810	919	58.17	59.17	4.43	3.92	.091	.086	7.60	7.13	.10	.08	56.6	61.7
Mesabi	23,072	33,722	50.83	51.34	11.89	12.17	.068	.066	7.56	7.45	.76	.73	76.9	74.5
Cuyuna	-	10	-	49.90	-	9.00	-	.132	-	10.43	-	1.42	-	0.6
High Phos.-Non-Bessemer (Phosphorus exceeding .180)														
Cuyuna	156	252	51.13	49.69	9.00	11.10	.269	.264	8.54	8.14	.91	.76	12.2	14.5
Manganiferous (Manganese 2.00 and over)														
Mesabi	3	158	46.95	47.58	13.01	9.94	.092	.091	7.84	11.09	3.24	3.93	0.0+	0.4
Cuyuna	1,103	1,441	41.05	40.71	11.53	11.58	.266	.319	10.60	10.64	7.31	7.85	86.6	83.1
Siliceous (Siliceous 18.00 and over)														
Mesabi	26	16	42.36	39.71	8.79	6.50	.047	.052	25.59	32.59	.47	.56	0.1	0.0+
Cuyuna	15	31	45.09	42.37	5.55	8.83	.268	.127	20.24	23.34	.57	.60	1.2	1.8

Source: Minnesota Mining Directory, 1940 and 1941.

Phosphorus - This element cannot be removed by smelting in a blast furnace, hence most pig iron is acid or basic, depending primarily upon the phosphorus content of the iron ores used. The percentage of phosphorus determines the classification of ore into Bessemer, low-phosphorus non-Bessemer, and high-phosphorus non-Bessemer and is an important factor in the selling price.

Bessemer - Bessemer ore has a maximum average phosphorus content of .045 percent, for the content in the steel product must not exceed .100 percent and phosphorus cannot be removed by the acid Bessemer process. Table - presents the average analyses of shipments of Bessemer ore from the Mesabi and Vermilion ranges for 1939 and 1940.

Low-phosphorus Non-Bessemer - In this ore the phosphorus content ranges from .045 to .180 percent. In early years of Mesabi mining, the Bessemer ores were in greatest demand because steel could be most cheaply produced in acid Bessemer converters. With the vast quantity of non-Bessemer ores available at a lower price, however, the acid and basic open-hearth processes, in which phosphorus is removed in the slag as calcium phosphate, came to be utilized more and more. Less than 7 percent of the United States steel output is now made by the Bessemer process.1/ Gradually, along with

1/ Whitbeck, R. H. and Finch, V. C., Economic geography, p. 230, 1941.

increasing use of non-Bessemer ore in making steel, the market price differential between the two ores decreased to the 15 cents a ton which has prevailed since 1925. Table - shows the average analyses of shipments from the Mesabi, Vermilion and Cuyuna ranges in 1939 and 1940.

High-phosphorus Non-Bessemer - This ore contains in excess of .180 percent phosphorus. Special types of foundry pig iron such as that used for ornamental ironwork require a particularly high content of phosphorus - a minimum of .400 percent. Table - shows the average analyses of ore shipped in 1939 and 1940.

Other Impurities - Oxides of iron and manganese, contain many lesser impurities, notably, alumina, lime, magnesium, sulphur and volatile matter. Alumina is found in about the proper proportion to silica to fulfill requirements of the blast furnace. Lime, magnesia and sulphur occur in trifling amounts. Drying at 212 degree F. removes volatile impurities such as moisture, organic matter, and carbon dioxide.

new methods of concentration are urgently needed, for some operators must begin to use low-grade ores very soon.

2. Inventory - A new system of subsurface prospecting with delicate scientific instruments has been developed in recent years. Operating companies, through the use of these modern geophysical methods, have discovered profitable residues of ore in workings which they were about to abandon as exhausted. The same improved processes are available to the State, and might wisely be utilized, it would seem, for making a thorough and up-to-date inventory of Minnesota's remaining iron ore resources.1/

3. Exploration - University of Minnesota geologists suggest the possible existence of iron ore deposits south of the Mesabi range. There has recently been a change in the geological interpretation of that region. Heretofore, it was believed the ore-bearing Biwabik formation (Animikie group) was older than the slates beneath which it dips at the southern margin of the range. The overlying slate, it was thought, would preclude mining the ore (Figures - and -). The new theory is that the slate and gray-wacke formations are older than the Biwabik, in which case the iron-bearing strata may rise again, south of the Mesabi, to levels which are accessible from the surface. Such extensions of the Biwabik might be found to be as rich in iron as the Mesabi; on the other hand, they might not be ore-bearing at all. ~~It is believed that the presence or absence of such deposits outside the Mesabi could be proved or disproved beyond question by means of a comparatively inexpensive geophysical survey of the area. The State is being urged to undertake such a survey.~~ Survey of area & is conducted - summer of 1942 - under Prof. Schwartz of Geology Dept.

4. Tax Adjustment - Mining companies operating in Minnesota pay tax on the value of ore in the ground and in stockpiles. Each ton of ore removed from a mine therefore reduces its assessed valuation. Obviously, this is an inducement for operating companies to mine the high-grade and high-taxed ore as rapidly as possible so

---

1. Exploration drill holes, at about 300 foot intervals, have proved up most of the flat-lying ore bodies of the Mesabi, so that engineers can make both quantitative and qualitative estimates for purposes of taxation.

as to get it out of the State. As a result, the cream of the ore is taken and low-grade ores left behind. Obviously, the ad valorem tax discourages conservation. A new tax system is apparently needed; one which will foster wise use, and permit mining companies to husband their resources without penalty.

A 1940 State law is designed to encourage the development and use of taconite. Under this law, if the annual production of concentrate from any 40-acre tract does not exceed 1,000 tons, the tax on taconite land is limited to one dollar per acre. When mining and concentration are undertaken on a more substantial scale, a tax of 5 to 6 cents is imposed on each ton of concentrate shipped, depending upon the iron content. Except for the occupational tax and the tax on royalties, this tax is in lieu of all taxes on land, minerals, plant, and equipment.1/

1/ Joseph, T. L.; Recent developments in the iron ore industry and blast furnace practice: Blast Furnace and Steel Plant, vol. 30, no. 1, January 1942. The reader is also referred to Session Laws of the State of Minnesota for 1941, Chapter 375.

5. Natural Gas Reduction - Use of natural gas as fuel in processing low-grade ore is definitely feasible, according to testimony of Professor E. W. Davis, Director of the Mines Experiment Station, University of Minnesota, before the Federal Power Commission. The Commission has approved construction of gas lines into northern Minnesota, but no actual work has begun.2/ The effect of such development on the iron mining industry can only be guessed at this time.

2/ Natural gas was introduced in Minnesota in 1932. In 1940 nearly 13 million cubic feet were delivered to the State.

6. Statutory Regulation - It has been proposed that shipments of high-grade ore be limited by law to a certain percentage of the low-grade concentrate shipped, in order to lengthen the life of the State's ore reserves. The natural and probably shortsighted objection is that such restrictions might cause the

steel industry to seek a greater share of its supply from other ore fields. Moreover, those who would legislate on this point encounter the common problem of reconciling the desire for immediate revenue with the long-term public interest.

7. Regulatory Taxation - The United States Steel Corporation which owns or controls 70 percent of the State's high-grade ore and 62 active and inactive mines, as well as the railroad that receives most of the traffic to Duluth and Two Harbors, is able to produce and ship ore at a price far below the average costs to other producers.1/ A study of ore production cost figures, as reported to the State Tax Commission, and of the transportation cost figures, as reported by the Corporation's railroad, reveals that for the years 1936, 1937, and 1938, the Corporation loaded 47 million tons of Mesabi ore into boats at Duluth and Two Harbors at a cost of approximately $1.50 a ton, exclusive of iron ore taxes. All the other mining companies together, some twenty in number, produced 42 million tons at a corresponding average cost of $2.40 a ton.2/ These cost figures would seem to give the U. S. Steel virtual control of the ore market.3/

Most vulnerable to price reductions are the high-cost producers, those who concentrate low-grade ores. A system of taxation based more directly on production cost would encourage the mining of low-grade ores.4/

1/ Op. cit., Davis, E. W., pp. 78-82. The reader is also referred to the Mining Directory of Minnesota, 1941, part 2; and chart 1 in the Report of the Temporary National Economic Committee, part 18, Iron and steel industry, exhibit no. 1349, appendix.

2/ Davis, E. W., Change in U. S. Steel ore marketing policy endangers range communities and State, Minnesota Municipalities, vol. XXV, no. 3, p. 79, March 1940.

3/ A price cut of fifty cents a ton on iron ore at the Lower Lake Ports took place at the opening of the 1940 season when the U. S. Steel Corporation threatened to enter the iron ore market to sell ore.

4/ Idem., Davis, E. W., p. 82.

---

8. Control Of Production - Although the iron-mining industry is a comparatively well organized industry, unregulated or non-cooperative production has retarded certain technologic developments. Moreover, it results in waste of ore, periodic overproduction, and serious fluctuations in output. Overproduction not only hastens the exhaustion of ore reserves, but by depressing the prices, it obstructs and discourages the development of low-grade deposits.

Manganiferous Iron Ores - ~~Minnesota has~~ are found large deposits of ore containing 5 percent or more of manganese on the Cuyuna Range. They assume particular value in war time, when imports of manganese are threatened or cut off. Manganese is a vital strategic metal because about 12.5 pounds are needed to desulfurize and deoxidize every ton of steel, because the domestic supply is small (97 percent of the 1940 supply was imported), and because substitution is extremely difficult. 1/

1/ Minerals Yearbook, Review of 1940, U. S. Dept. of Interior, Bureau of Mines, p. 568.

The U. S. Bureau of Mines recognizes three grades of manganese-bearing material - manganiferous iron ore (5 - 10 percent manganese), ferruginous manganese ore (10 - 35 percent), and manganese ore (35 percent or more manganese). The three grades produce, in the order given, manganiferous pig iron, spiegeleisen (spiegel), and ferromanganese (ferro). Ferro and spiegel are used in smelting of steel for deoxidizition, to control the carbon content and introduce suitable amounts of manganese into the metal. 2/ Small quantities of manganiferous raw materials are also used in storage batteries and for special articles in the chemical,

2/ Report of the Committee on Mineral Resources (manuscript report in files of the Minnesota Resources Commission), p. 54, August 1937.

ceramic and glass industries.

The 320,006 tons of ferruginous manganese ore shipped from 3 mines on the Cuyuna range in 1940 averaged 13.02 percent manganese and 33.68 percent iron. The 816,541 tons of manganiferous iron ore shipped from 6 mines contained an average of 7.34 percent manganese and 38.28 percent iron. Table -- reveals the gross tonnage and value of manganiferous iron ores shipped from Minnesota from 1931 to 1940. The

320,006 tons shipment of ferruginous ore in 1940 contrasts significantly with the high of 624,009 tons in 1918. Recently, beneficiation of the manganese-bearing ore on the Cuyuna has been the subject of intensive study, which is expected to result in greatly increased production during the next few years. Tests indicate that the ores can be beneficiated to meet ferromanganese specifications.1/ Recent exploration has shown that large-scale production

1/ Davis, E. W. and Firth, C. V., Fefro-grade manganese ore from the Cuyuna range, Minnesota: Mines Experient Station, University of Minnesota, pp. 1-101, December 1, 1940.

in the United States is possible only through beneficiation of low-grade material. Of ferruginous manganese ore, Minnesota has an estimated reserve of 10 million tons that averages 12 percent grade, the so-called high-silica black ores which normally are not used for spiegel.2/ The tonnage of lesser-grade green ores has not been accurately estimated, but there may be as much as 200 million tons of this material.3/ It is estimated that Minnesota has about half of the reserve of 40 million tons of 7 percent manganiferous iron ore in the United States.4/

2/ Estimated by the Mines Experiment Station, University of Minnesota.
3/ Estimated by E. W. Davis, Director of the Mines Experiment Station, University of Minnesota.
4/ Report of the subcommittee on manganese of the Committee on Industrial Preparedness of the Am. Inst. of Min. Met. Eng. reported Minnesota had about 25 million tons of the 45 million tons estimated for the United States in 1933. The estimate given here was adjusted from these tonnages on the basis of shipments from 1933 through 1940.

Conservation Of Iron Ore Resources

At the average rate of approximately 28 million tons1/ of direct shipping iron ore a year, the State's present reserve of high-grade ore will last only about 35 years. If, however, the ratio of low-grade concentrate, now 20 percent of the total, can be doubled, the exhaustion date will be 47 years away, while if the ratio is raised to 60 percent, the supply will last 70 years.2/ If the accelerated wartime drain on reserves continues, high-grade ores in Minnesota may last but ~~15~~ 12 to ~~20~~ 15 years. Clearly, there is an urgent need to devise more efficient methods of utilizing the lower-grade ores, Classes 11 and 111. It may be possible by such means to postpone the time, perhaps for hundreds of years, when Minnesota's most important mineral resource will be commercially exhausted.

1/ Average for the thirty years, 1911-1940. Computed from statistics in Mining Directory of Minnesota-1941, table 8, p. 207.

2/ There can be no certainty or definiteness as to the length of time reserves will suffice for the mining industry. There are so many unknowns and variables in connection with their commercial availability that conclusions can be little more than rough estimates.

Much progress has already been made in using Class 11 ore. ~~Through 1940, nearly 145 million tons of concentrated ore were shipped from Minnesota. An average (1931-40) of about one-fifth of the yearly output is from this grade of ore.~~ Forty plants beneficiated 14,547,504 tons of crude ore in 1940 and recovered 9,439,921 tons of concentrate, a ratio of 1.541:1.

3/ Most of the concentrated ore shipped from Minnesota is obtained by

---

3/ Minerals Yearbook Review of 1940, Bureau of Mines, U. S. Dept. of Interior, p. 533.

---

treatment of simple wash ores from the western end of the Mesabi.4/ Beneficiation of the taconite of the East Mesabi by crushing, fine grinding, magnetic concentration, and sintering was begun in 1922 at Babbitt but the post-war decline in ore prices compelled the plant

---

4/ Idem., Minerals Yearbook, p. 533.

to cease operations in 1924.

Figure-apportions the estimated reserves of the three classes of ore. The estimated supply of 57,200,000,000 tons of lean ore and taconite constitutes the most valuable mineral resource of Minnesota, but it must be utilized now while there is still high-grade ore available for "sweetening". Several steel companies, realizing that future supplies must come from low-grade ores, have started accumulating reserves and developing methods to make them commercially available. Recently, the Division of Lands and Minerals announced that two large steel companies leased more than 3,000 acres of State ore land containing large deposits of taconite.1/

1/ Vessels, Jerry, New role for the range , Conservation Volunteer, vol. 3, no. 16, January 1942, p.24, See Minneapolis Star Journal, July 14, 1941.

There are many approaches to the problem of conserving iron ore resources. Some are already being followed, others have been proposed. Only brief mention of the more important ones need be made here.

1. Research - Valuable investigations are being carried on by the iron and steel industry, but most of them are of a private and immediately practical nature. On the other hand, long range research in the public interest is being carried on by various State agencies. The Mines Experiment Station at the University of Minnesota has been studying the treatment of taconite for a number of years. The Lands and Minerals Division of the Minnesota Department of Conservation maintains a research laboratory at Hibbing, with the primary purpose of developing new methods of concentrating low-grade ores. The Legislature in 1941 authorized partial use of 5 percent of the receipts of the occupation tax on the mining industry from May 1, 1941 to April 30, 1942 (10 percent after May 1, 1942) for the development of ~~the remaining~~ marginal ore resources.2/ Cheap

2/ Session Laws of Minnesota for 1941, chap. 544, p. 1077.

Competitive Position Of Minnesota Ore

Accurate appaisal of the iron ore resources of Minnesota is exceedingly complex and involves more than just a physical inventory of various grades of ore. None of the ores have any value at all, except as they can be commercially utilized. This depends upon the competitive position of each with relation to other sources of supply.

Before summarizing the opinion of authorities on this important matter, notice should be taken of the more important economic-geographic conditions which will tend to hold as well as to increase the importance of the interior ore consuming (iron and steel producing) region contiguous to the Great Lakes (Figure -). (1) The region comprises the Pittsburg, Upper Ohio Valley, and Mahoning-Shenango Valley iron and steel district, the Lake Erie district, and the Chicago-Gary district - the three principal iron and steel producing areas in the United States.1/ (2) Ore requirements of these districts are derived mainly from the Lake Superior iron mines, an average of 32 million tons, or 3 thousand shiploads annually. (3) Great coal fields of Pennsylvania, West Virginia, Ohio, and Illinois provide coking coal and cheap power coal in abundance. (4) The districts lie within the great manufacturing and marketing area of northeastern United States. (5) Tremendous sums of capital are invested in productive capacity in the iron and steel and associated industries. (6) The ore deposits lie near cheap water transportation and the iron and steel districts enjoy excellent rail and water transport facilities which originally required large investments to develop.

High-grade Ore

Domestic - Class I Minnesota ore is without serious competition from other mining districts in United States (Figure -). The old mines in New Jersey, New York, and Pennsylvania produce a comparatively small amount of ore - an aggregate of 4.8 percent of the United States total in 1940 (Table -). The ore, chiefly magnetite from underground mines, is beneficiated, usually by concentration, before shipment. In 1909, these magnetite deposits, located principally in the Adirondack region and Cornwall District of Pennsylvania, contained an estimated 200 million tons of available ore and an additional 25 million tons not available

1/ Jones, C. F. and Darkenwald, G. G. (Collaborator), Economic Geography, pp. 483-503, 1941

2/ Hayes, C. W., Iron ores of the United States, U. S. Geol. Survey Bull. 394, 1919.

Chart

PRODUCTION OF IRON ORE BY STATES AND DISTRICTS
FROM 1927 TO 1940, IN GROSS TONS

(Exclusive of Ore Containing 5 Percent or More Manganese)

By States

Year	Alabama	Arizona And Neveda	Calif.	Colorado	Georgia	Michigan	Minnesota	Missouri	Mont.	New Jersey	New Mexico
1940	7,316,127	-	1,071	-	101,286	12,472,448	47,736,810	53,638	-	659,425	-
1939	5,960,507	-	17,173	-	26,333	9,159,222	31,547,701	39,239	-	399,289	-
1938	4,303,329	-	28,380	-	9,221	6,004,311	14,449,304	28,544	-	185,639	1,826
1937	6,307,581	1/ 196	247	-	14,498	12,085,048	48,416,985	19,955	-	520,133	10,426
1936	4,179,967	1/ 340	31,395	-	5,740	9,177,629	31,634,064	3,272	-	159,906	17,621
1935	3,277,533	-	18,734	-	3,044	5,205,531	19,374,623	2,544	-	72,343	-
1934	2,343,819	-	16,334	-	164	5,039,144	15,389,870	4,104	-	138,685	-
1933	2,133,457	-	25	-	1,302	2,433,949	11,948,596	395	-	73,144	-
1932	1,374,534	-	-	-	925	2,554,996	5,154,291	29,797	-	30,844	-
1931	3,615,144	-	-	26,202	20,745	7,552,581	17,445,003	112,372	-	293,768	168,075
1930	5,738,478	923	-	32,247	52,221	13,544,277	34,517,748	132,749	-	394,639	173,432
1929	6,453,075	1/ 100	303	50,754	59,316	15,456,397	45,760,858	168,934	-	281,327	171,585
1928	6,307,844	-	-	52,713	73,052	13,676,964	37,564,005	94,899	1,640	250,332	184,623
1927	6,445,464	-	-	32,206	50,312	15,075,079	35,461,138	78,605	2,837	220,660	214,747

Year	New York	North Carolina	Pennsylvania	Tennessee	Utah	Virginia	Wash.	Wisconsin	Wyoming	Total
1940	2/ 2,900,499	-	2/ 2,900,499	3/ 28,640	326,500	3/ 28,640	5,386	1,262,065	831,314	4/ 73,695,899
1939	2/ 2,713,604	-	2/ 2,713,604	3/ 34,941	262,087	3/ 34,941	10,757	972,685	587,892	4/ 51,721,309
1938	2/ 2,121,271	-	2/ 2,121,271	13,179	167,933	13,179	3,555	854,795	275,995	28,447,282
1937	2/ 2,625,044	-	2/ 2,625,044	28,359	190,908	518	10,044	1,155,602	707,907	4/ 72,093,548
1936	777,643	57	1,132,215	27,617	154,191	1,206	9,082	969,522	507,278	4/ 48,788,745
1935	297,266	54	979,638	14,219	161,210	832	5,062	788,483	339,134	30,540,252
1934	244,962	-	525,297	3,345	161,109	297	1,920	602,005	116,582	24,587,616
1933	58,718	-	264,366	24,912	95,279	287	1,631	228,487	288,640	17,553,188
1932	31,327	-	102,838	-	137,224	-	-	430,140	-	9,846,916
1931	275,075	-	368,117	8,717	184,068	-	1,032	879,832	180,771	31,131,502
1930	889,405	100	964,638	27,710	279,118	19,596	-	1,321,360	320,023	56,408,664
1929	822,261	30,675	1,092,013	102,171	324,885	-	5,018	1,608,571	639,477	73,027,720
1928	712,757	-	1,023,870	128,928	320,655	27,902	1,012	1,284,592	491,280	62,197,088
1927	853,159	32,528	1,170,435	121,914	222,879	64,592	550	1,091,118	602,877	61,741,100

By Mining Districts

Year	Lake Superior 5/	Birmingham	Chattanooga	Adirondack and Cornwall	Northern New Jersey & Southeastern New York	Other Districts	Total
1940	61,470,725	6,890,193	250,419	6/ 2,899,986	7/ 659,425	6/ 1,525,151	73,695,899
1939	41,679,608	5,734,688	108,858	6/ 2,713,141	7/ 309,209	6/ 1,685,786	51,721,309
1938	21,308,410	4,156,080	53,171	6/ 2,120,823	7/ 185,639	6/ 623,159	28,447,282
1937	61,657,135	5,952,934	56,082	6/ 2,624,512	7/ 520,133	6/ 1,282,752	72,093,548
1936	41,780,889	4,007,867	59,320	6/ 777,643	159,906	6/ 2,003,120	48,788,745
1935	25,368,365	3,182,322	37,844	6/ 297,266	72,343	6/ 1,582,112	30,540,252
1934	21,030,756	2,225,810	34,178	6/ 8/ 244,962	138,685	6/ 913,225	24,587,616
1933	14,611,032	2,043,657	21,350	6/ 8/ 58,718	73,144	6/ 745,287	17,553,188
1932	8,139,427	1,336,305	7,936	6/ 8/ 31,327	30,844	6/ 301,077	9,846,916
1931	25,877,385	3,494,923	57,129	6/ 8/ 254,308	314,535	6/ 1,133,222	31,131,502
1930	49,382,652	5,551,684	74,251	6/ 8/ 833,225	450,819	6/ 2,116,033	58,408,664
1929	62,824,768	6,281,565	155,953	6/ 8/ 749,976	353,612	6/ 2,661,846	73,027,720
1928	52,517,175	6,167,194	192,506	6/ 9/ 963,089	6/ 9/ 963,089	6/ 2,357,124	62,197,088
1927	51,539,880	6,294,813	160,248	8/ 9/ 1,073,819	8/ 9/ 1,073,819	2,572,340	61,741,100

1/ Production in Neveda in 1929, 1936 and 1937 and Arizona in 1930.
2/ Includes both New York and Pennsylvania.
3/ Includes Tennessee, Virginia and Texas in 1939, and also Oklahoma in 1940.
4/ Includes 340 tons not shown under any state in 1936 because the Bureau of Mines was not at liberty to disclose identity. The total includes 50 tons in 1940 and 97 tons in 1937 that were produced in Mississippi and 640 tons in 1940 and 300 tons in 1939 that were produced in South Dakota.
5/ Includes only those mines in Wisconsin that are in the true Lake Superior District.
6/ Small quantities of hematite from "Other Districts" included with magnetite from Adirondack and Cornwall districts.
7/ No production from southeastern New York in 1937, 1938, 1939, and 1940.
8/ Ore mined in Adirondack District.
9/ Figures are for "Adirondack, Northern New Jersey and Southeastern New York".

Since the date of that estimate, about 53 million tons have been produced and much of the ore considered available in 1909 is not economically workable now, because of the growing localization of the industry at Lake Superior.1/ Except for paint ore, the "Clinton" deposit in this region, while containing a tremendous tonnage of potential ore,

1/ Leith, Kenneth, and Liddell, D.M., Mineral reserves of the United States and its capacity for production, National Resources Committee, p. 104, March 1936.

is not regarded as an available reserve.2/

2/ Idem., National Resources Committee, p. 104, 1936.

Output from Michigan comes from three ranges, the Marquette, the Menominee, and the Gogebic (Figure - and Tables - and -). About 88 percent of the 1940 production came from underground mines and future production will consist in the main of this relatively high-cost underground ore. Michigan reported a reserve of approximately 136 million tons of high-grade ore at the close of 1940.3/ Mining in Wisconsin, except for paint ore, is

3/ Mineral Yearbook, Review of 1940, Bureau of Mines, U. S. Dept. of Interior, pp. 544-45.

confined to the Gogebic range near Hurley. Production in 1940 was 1,262,065 tons. Reserves in Wisconsin have been estimated recently at 5,500,000 tons.4/ The reserves in Michigan and Wisconsin, and those given for Minnesota in table -, are conservative estimates by state tax commissions of the recoverable ore in sight, and may be said to represent the minimum expectancy of iron of present grades and limits. New discoveries in Michigan and Wisconsin may increase the total as much as 40 percent, and on the Minnesota ranges at least 15 percent.5/

4/ Idem., Minerals Yearbook 1940, p. 542.
5/ Idem., National Resources Committee, p. 98, 1936.

IRON ORE RESERVES OF MINNESOTA BY RANGES - 1915 TO 1940

(Estimated Reserve Tonnage Including Stock Piles)

Date	Mesabi Range	Vermilion Range	Cuyuna Range	Total
May 1, 1940	1,139,314,272	13,841,272	65,431,104	1,218,586,648
May 1, 1939	1,149,873,304	14,235,001	62,076,369	1,226,184,674
May 1, 1938	1,161,172,596	14,110,641	60,775,129	1,236,058,366
May 1, 1937	1,190,838,355	14,393,332	62,274,589	1,267,506,276
May 1, 1936	1,180,391,647	13,489,847	63,226,789	1,257,108,283
May 1, 1935	1,177,302,197	13,656,569	46,874,462	1,237,833,228
May 1, 1934	1,195,271,786	13,243,125	47,553,536	1,256,068,447
May 1, 1933	1,205,213,398	14,007,192	70,024,921	1,289,245,511
May 1, 1932	1,190,295,183	14,237,637	69,699,960	1,274,232,780
May 1, 1931	1,162,776,979	14,789,137	66,756,610	1,244,322,726
May 1, 1930	1,154,434,031	14,250,540	66,542,939	1,235,227,510
May 1, 1929	1,178,855,601	14,939,704	48,264,579	1,242,059,884
May 1, 1928	1,190,480,901	14,483,285	53,268,438	1,258,232,624
May 1, 1927	1,201,054,119	12,126,490	49,652,592	1,262,833,201
May 1, 1926	1,233,979,351	12,382,725	51,090,529	1,297,452,605
May 1, 1925	1,250,086,347	13,539,256	52,124,561	1,315,750,164
May 1, 1924	1,275,347,126	13,169,953	46,121,021	1,334,638,100
May 1, 1923	1,254,861,451	13,688,352	43,041,100	1,311,590,903
May 1, 1922	1,252,820,242	14,354,328	29,485,159	1,296,659,729
May 1, 1921	1,273,128,664	13,201,525	25,080,590	1,311,410,779
May 1, 1920	1,305,926,735	10,927,844	24,819,959	1,341,674,538
May 1, 1919	1,328,821,214	11,621,197	59,393,443	1,399,835,854
May 1, 1918	1,362,277,471	12,251,025	63,208,588	1,437,737,084
May 1, 1917	1,381,754,428	11,961,684	70,159,848	1,463,875,960
May 1, 1916	1,384,635,891	13,058,280	77,926,062	1,475,620,233
May 1, 1915	1,389,003,652	11,011,974	72,403,065	1,472,418,691

Note: The above figures do not include the tonnage of ore on State lands that are not under lease, and do not include certain comparatively small tonnages of ore, mainly low-grade, which are carried on the tax records at nominal valuations.

Source: Minnesota Department of Taxation.

It is a long haul from Alabama to the interior iron and steel areas. Alabama ores, moreover, are a little too high in phosphorus for the acid and basic open-hearth furnaces and Bessemer converters used in the interior districts. Total available ore in the Tennessee River Basin is 119,959,000 tons1/, but the ore is less accessible and poorer in quality than Minnesota ores.

1/ Burchard, E. F., Iron-ore reserves and production in the Tennessee Valley, House Document 185, 73rd Congress.

Only a slight shift in price, demand, or metallurgical specifications, would make some of these ore reserves "available". For the others, a profound change must take place in the industrial economy of the Nation before they can become economically workable. It seems probable that the present trends of industrial research, while increasing the amount of available iron ore, will tend at the same time to restrict iron ore mining even more narrowly to the present centers of principal activity.2/

2/ Op. cit., National Resources Committee, pp. 97-98, 1936.

Foreign - The high-grade ore of Minnesota is thought to be without serious competition from foreign ores, and is expected to remain so even if the St. Lawrence Waterway materializes.3/ The principal iron ore mines of Canada are remote from the major centers of iron and steel production. Canada has been importing Mesabi ore for many years. The very large ore reserves at Belle Isle, Newfoundland, 3.5 to 4 billion tons4/, are deep underground (mostly under Conception Bay) and will still be nearly twice as distant as Minnesota's, from the lower Lake Erie ports, even if access is provided by way of the St. Lawrence. According to Dr. C. K. Leith, not much Newfoundland ore is likely

3/ Davis, E. W., Change in U. S. Steel ore marketing policy endangers range communities and state, Minnesota Municipalities, vol. XXV, pp. 81-82, March 1940. Also, Warner, F. S., Future movement of iron and coal in relation to the St. Lawrence Waterway, p. 79, Univ. of Penn. Press, 1930.

4/ Estimate by Mr. Edwin C. Eckel for a legal case. See The Steel Corporation dissolution suit, Iron Age, Oct. 16, 1913.

to be imported, because the high phosphorus content of the deposits would necessitate complete remodeling of American iron and steel industry.1/ Three to five million tons is the maximum annual production, and of this not more than 2 or 3 million tons, at most, could be available for shipment up the St. Lawrence.2/

1/ Warner, F. S., Future movement of iron and coal in relation to the St. Lawrence Waterway, p. 79, Univ. of Penn. Press, 1930. (Taken from notes dictated by Mr. F. G. Tryon, U. S. Bureau of Mines, after a conference with Dr. C. K. Leith, Feb. 3, 1928.)
2/ Idem., Warner, F. S., p. 80. (Taken from notes dictated after a meeting with E. C. Eckel and F. G. Tryon in May 4, 1925).

Of the more distant ore deposits in North and South America, attention need be given only to the good ores of Cuba, Brazil, Chile and Venezuela. Added freight costs and new shipping facilities required for bringing any of these ores to the interior steel plants by way of a St. Lawrence Waterway would greatly exceed even those involved in the Newfoundland haul. The soft hematite ores in Cuba have a lower iron content than ClassI Minnesota ores, and their impurities of chrome, nickel, and alumina necessitate mixing with other ores before smelting. The Bethlehem Steel Corporation owns more than two-thirds of the estimated 3,610,000,000 tons of known reserve ore in Cuba and most of the remainder is owned by the United States Steel Corporation and the Eastern Steel Company.3/

3/ Hodge, E. T., Available raw material for a Pacific Coast iron industry: Corps of Engineers, U. S. Army, vol. 3, app. H., pp. 4-5, 1938.

Brazil, with an estimated 7.5 billion tons of hematite, is probably the world's greatest storehouse of high-grade ore.4/ The huge deposits lie on or near the surface and most of the ore averages between 65 and 70 percent of iron with little phosphorus. Unfortunately, however, they are found principally in Minas Geraes, 400 miles inland with rolling, rough country between them and the coast.5/ As yet, Brazil has exported little of this iron, but recent lease-lend agreements between United States and Brazil provide for completion of the Victoria-Minas railroad to the ore deposits. Water shipping distance from

---

4/ Outlook for foreign iron ore, Iron Age, vol. 115, pp. 1423-24, May 14, 1925.
5/ Idem., Corps of Engineers, pp. 11-13, 1938.

Brazil to the Lake Erie ports, if the St. Lawrence Waterway is built, will be about 6,700 miles. The principal holdings are controlled by the British-owned Itabira Iron Ore Company, Ltd., and the Brazilian Iron and Steel Company, an American concern.1/

1/ Bain, H. T., and Read, T. T., Ores and industry in South America.

Chile is the chief source of iron ore imports into the United States. The Tofo mines near La Serena, located only a few miles from the sea, yield high-grade hematite by simple open pit operations.2/ The ores are Bessemer, essentially magnetite

2/ Jones, C. F. and Darkenwald, G. G. (Collaborator), Economic geography, p. 419, 1941.

and hematite, low in silica, with an iron content that varies between 60 and 65 percent.3/ Lowest reported estimates place the reserve at 100 million tons. The Bethlehem-Chile Iron Mines Company, a subsidiary of the Bethlehem Steel Company, operates the mines.4/ With the long shipping haul and the Panama Canal toll of more

3/ Op. cit., Corps of Engineers, pp. 23-24, 1938.
4/ Op. cit., Corps of Engineers, p. 28, 1938.

than a dollar a ton, the Chile product is economically out of reach of the iron and steel districts supplied by Minnesota ores.

Venezuelan ore deposits, though small, are of excellent quality and of especial commercial promise. Estimated delivery cost per unit of iron, assuming the use of a St. Lawrence Waterway, is under present Lake Erie prices.5/

5/ Hunner, E. E., Minnesota's iron mining industry, Mining and Metallurgy, vol. 22, no. 416, p. 399, August 1941.

Low-grade Ore

Class 11 Minnesota ore, estimated as containing 1.3 billion tons of recoverable concentrate, is not secure from competition. From 100 to 200 million tons of this ore is thought to be merchantable; the remainder is marginal material.6/ The low-grade ore deposits of Canada, Wisconsin, and New York, from which rich ore can be

6/ Report of the Committee on Mineral Resources (manuscript report in files of the Minnesota Resources Commission), p. 133, 1938.

manufactured and transported to consuming districts largely by water, are strong competitors even though the cost of mining and concentrating is somewhat higher than in Minnesota.1/ Two large concentrating plants recently placed in operation,

1/ Op. cit., Davis, E. W., p. 82, March 1940.

one in Canada and the other in New York, are in direct competition with Minnesota's low-grade ore producers.2/ Opening of the St. Lawrence and entry of high-grade

2/ Op. cit., Davis, E. W., p. 82, March 1940.

foreign ores probably would have an adverse affect upon the utilization of low-grade ores.

The competitive position of low-grade iron-bearing material or taconite in relation to other domestic and foreign iron ore cannot be ascertained at this time. Future development which might affect the exploitation of this ore are the St. Lawrence Waterway, population and industrial shifts, new sources of power, technological advances, transportation changes, and new ore discoveries. In any case, research and experimentation which is designed to secure a favorable competitive position for Minnesota low-grade ores, when the higher grades are exhausted, should certainly be encouraged.

Employment In Mines

Of the many advantages derived by Minnesota from its rich store of iron ore, one of the greatest is the employment the industry provides for residents of the State. This benefit, however, is much less important now than it used to be. Even in the face of a general rise in production, mine payrolls have undergone a steady shrinkage, over a long period of years. Mine employment reached its peak in the fiscal year ending in June 1911, with 23,341 miners employed in the State. By contrast, the total in 1940, a near-record production year, was only 9,405.

Table - shows the number employed and the tonnage shipped annually per worker in St. Louis, Itasca, and Crow Wing Counties from 1910 to 1940. Highest five-year employment period was 1916-20. Generally, there has been a gradual decline since 1911 in total mine employment in St. Louis County, since 1921 in Itasca, and since 1919 in Crow Wing. Concurrently, there has been a remarkable increase in tonnage shipped per man, particularly in St. Louis County. Chiefly because most of the ore produced is from open pits (91 percent in 1940), the average hourly output of both crude and merchantable ore per worker reaches considerably higher in Minnesota than in other states (Table -). That Itasca and Crow Wing Counties ship a smaller annual tonnage per worker than St. Louis County is chiefly due to the larger proportion of beneficiated ore in the total shipments from the two former counties, and the smaller percentage of open pit ore found there.

The general increase, except in the worst years of the depression, of the tonnage shipped annually per man, even with the considerable increase in beneficiation of ore, is principally the result of:

1. Advances in mechanization, better mining methods, operation of larger units, and more efficient management of mines.1/ Recent years have witnessed significant changes in open-cut mining practices, such as the use of small tractor shovels, tractor wagons, scrapers, scraper hoists, heavy trucks, and conveyors.2/

1/ Kiessling, O. E. and Davis, H. W., Iron ore, pig iron, ferro-alloys, and steel: Bureau of Mines, Minerals Yearbook, 1934, p. 322.

2/ Mosier, McHenry and Gardner, E. D., Open-cut metal mining: Bureau of Mines Bull. 433, 1941.

NUMBER OF MEN EMPLOYED, TONS OF ORE SHIPPED, AND SHIPMENTS PER EMPLOYEE
1910 TO 1940.

Year Ending	Number of Men Employed 1/				Tons of Ore Shipped				Tons of Ore Shipped Per Year Per Man			
	Minnesota	St. Louis	Itasca	Crow Wing	Minnesota	St. Louis	Itasca	Crow Wing	Minnesota	St. Louis	Itasca	Crow Wing
Dec. 31, 1940	9,405	5,547	3,047	811	48,782,730	36,493,781	10,553,773	1,735,176	5,187	6,579	3,464	2,140
Dec. 31, 1939	7,805	4,589	2,567	649	32,815,525	24,156,258	7,368,501	1,290,766	4,204	5,264	2,870	1,989
Dec. 31, 1938	6,289	3,773	2,132	384	15,002,514	10,796,760	3,624,027	581,727	2,386	2,862	1,700	1,514
Dec. 31, 1937	10,894	6,356	3,644	894	49,027,621	36,536,326	10,715,451	1,775,844	4,500	5,748	2,940	1,986
Dec. 31, 1936	8,051	4,694	2,794	563	33,748,919	23,322,975	9,132,392	1,293,552	4,192	4,969	3,263	2,298
Dec. 31, 1935	6,206	4,079	1,822	305	20,527,281	13,704,015	6,010,385	812,881	3,308	3,360	3,298	2,665
Dec. 31, 1934	6,500	4,272	1,916	312	15,906,727	11,781,226	3,592,990	532,511	2,447	2,758	1,875	1,707
Dec. 31, 1933	5,403	2,847	2,027	529	15,022,477	10,809,167	3,472,176	741,134	1,278	3,797	1,713	1,401
Dec. 31, 1932	4,038	2,243	1,201	594	2,250,320	1,773,750	2/ 377,712	98,858	557	791	315	166
Dec. 31, 1931	8,545	4,825	2,940	780	17,300,294	12,270,866	4,124,779	904,649	2,025	2,543	1,402	1,160
Dec. 31, 1930	13,155	7,752	4,393	1,010	34,699,189	25,196,155	7,573,889	1,929,145	2,638	3,250	1,724	1,910
Dec. 31, 1929	12,752	8,008	3,544	1,200	47,091,613	35,680,720	8,717,453	2,693,440	3,692	4,456	2,460	2,245
Dec. 31, 1928	12,642	8,022	3,458	1,162	38,799,928	29,704,774	6,991,534	2,103,620	3,069	3,703	2,022	1,810
Dec. 31, 1927	13,514	9,033	3,401	1,080	36,429,060	28,052,363	6,454,937	1,921,760	2,696	3,106	1,898	1,779
Dec. 31, 1926	14,216	9,275	3,577	1,364	41,868,713	32,583,943	7,187,343	2,097,427	2,945	3,513	2,009	1,538
Dec. 31, 1925	15,242	10,180	3,847	1,215	38,680,931	29,077,679	8,092,020	1,511,232	2,538	2,856	2,103	1,244
Dec. 31, 1924	16,627	11,538	3,768	1,321	31,583,925	22,808,875	7,353,998	1,421,052	1,900	1,977	1,952	1,076
Dec. 31, 1923	17,758	11,896	4,526	1,336	45,236,787	33,147,517	9,868,796	2,220,474	2,547	2,786	2,180	1,662
June 30, 1922	12,978	7,878	4,222	878	18,825,264	14,024,290	4,059,547	741,427	1,451	1,780	962	844
June 30, 1921	18,357	12,043	5,011	1,303	33,887,617	27,165,386	5,191,244	1,530,987	1,846	2,256	1,036	1,175
June 30, 1920	20,829	14,121	4,962	1,746	34,088,944	25,349,924	6,580,063	2,158,957	1,637	1,795	1,326	1,237
June 30, 1919	21,440	14,212	4,481	2,747	40,843,983	31,828,809	6,752,598	2,262,576	1,905	2,240	1,507	1,824
June 30, 1918	22,000	15,307	4,573	2,120	46,840,382	37,535,705	6,716,571	2,588,106	2,129	2,452	1,469	1,221
June 30, 1917	20,206	14,479	3,628	2,099	43,517,886	35,902,516	5,684,948	1,930,422	2,154	2,480	1,567	920
June 30, 1916	19,528	14,639	3,267	1,622	37,549,356	30,782,181	5,337,997	1,429,178	1,923	2,103	1,634	881
June 30, 1915	13,999	11,436	1,321	1,242	22,295,530	19,931,271	1,395,764	968,495	1,593	1,743	1,057	780
June 30, 1914	20,247	16,610	2,583	1,054	31,618,372	27,409,441	3,534,415	674,516	1,562	1,650	1,368	640
June 30, 1913	20,087	16,048	2,712	1,327	36,018,550	30,101,451	5,464,649	452,450	1,793	1,876	2,015	3,410
June 30, 1912	17,619	15,389	2,230	-	25,372,090	20,749,899	4,622,191	-	1,440	1,348	2,073	-
June 30, 1911	23,341	19,981	3,360	-	26,553,339	23,107,130	3,446,209	-	1,138	1,156	1,026	-
June 30, 1910	20,613	17,613	3,000	-	33,358,684	31,245,375	2,113,309	-	1,618	1,174	704	-

1/ Number of men employed is a computed average figured on the basis of full employment for eight hours per day, five days per week, fifty-two weeks per year.
2/ Stocked 1,678,501 tons lean ore and direct concentrated.
Source: Minnesota Department of Labor and Industry. Compiled from county mine inspectors report.

EMPLOYMENT OF IRON ORE MINES AND BENEFICIATING PLANTS, QUANTITY AND TENOR OF ORE PRODUCED, AND AVERAGE OUTPUT PER MAN IN 1940, BY DISTRICTS AND STATES.

(Exclusive of ore containing 5 percent or more manganese)

District and State	Employment					Production									
	Average Number of Men Employed	Time Employed				Crude Ore (partly estimated) Gross Tons	Merchantable Ore			Average Per Man (gross tons)					
		Average Number of Days	Total Man-shifts	Man-hours			Gross Tons	Iron Contained		Crude Ore (partly estimated)		Merchantable Ore			
				Average Per Shift	Total			Gross Tons	Percent Natural	Per Shift	Per Hour	Per Shift	Per Hour	Iron Contained Per Shift	Iron Contained Per Hour
Lake Superior:															
Michigan	6,243	216	1,349,278	8.0	10,825,174	9,159,222	9,159,222	4,733,283	51.68	6.788	0.846	6.788	0.846	3.508	0.437
Minnesota	7,091	216	1,529,758	8.0	12,227,712	35,570,113	31,547,701	16,540,821	52.43	23.252	2.909	20.623	2.580	10.813	1.353
Wisconsin	634	248	157,027	8.0	1,256,218	972,685	972,685	,516,511	53.10	6.194	.774	6,194	.774	3.289	.411
Total	13,968	217	3,036,063	8.0	24,309,104	45,702,020	41,679,608	21,790,615	52.28	15.053	1.880	13.728	1.715	7.177	.896
Southeastern:															
Alabama	4,902	228	1,119,317	8.1	9,094,637	6,298,273	5,960,507	2,170,795	36.42	5.627	.693	5.325	.655	1.939	.239
Georgia	)					(40,393	26,333	12,615	47.91)						
Tennessee	) 192	155	29,803	8.5	253,517	( )			(46.41)	4.605	.541	2.056	.242	0.986	.116
Texas	)					( ) 96,852	34,941	16,774	(51.32)						
Virginia	)					( )			(53.28)						
Total	5,094	226	1,149,120	8.1	9,348,154	6,435,518	6,021,781	2,200,184	36.54	5.600	.688	5.240	.644	1.915	.235
Northeastern:															
New Jersey	664	230	152,425	8.0	1,217,268	897,059	399,289	252,813	63.32	5.885	.737	2.620	.328	1.659	.208
New York	)								(66.85)						
Pennsylvania	) 1,743	255	443,875	8.0	3,545,867	3,400,137	2,713,604	1,280,581	(40.15)	7.660	.959	6.113	.765	2.885	.361
Total	2,407	248	596,300	8.0	4,763,135	4,297,196	3,112,893	1,533,394	49.26	7.206	.902	5.220	.654	2.572	.322
Western:															
California	)					(17,873	17,173	9,685	56.40)						
Missouri	)					(39,239	39,239	20,606	52.51)						
South Dakota	) 201	182	36,656	7.9	291,041	(,300	300	138	46.00)	9.010	1.135	8.991	1.132	4.763	.600
Utah	)					(262,087	262,087	139,372	53.18)						
Washington	)					(10,757	10,757	4,785	44.48)						
Wyoming	189	227	42,991	8.0	343,928	587,892	587,892	312,876	53.22	13.675	1.709	13.675	1.709	7.278	.910
Total	390	204	79,647	8.0	634,969	918,148	917,448	487,462	53.13	11.528	1.446	11.519	1.445	6.120	.768
Total of districts	21,859	222	4,861,130	8.0	39,055,362	57,352,882	51,731,730	26,011,655	50.28	11.798	1.469	10.642	1.325	5.351	.666

Source: Minerals Yearbook Review of 1940, p. 551, 1941.

2. Expansion of open-pit operations as shown in table -. Comparison of mining operations in St. Louis County in 1926 and 1940 reveals a reduction of 25 underground mines, 3,062 underground workers, and 4,860,221 tons of output of underground ore, while there was an increase of 4 open-pit mines, a decrease of 3,728 open-pit workers, and a production increase of 3,909,838 tons of open-pit ore.

MINE OPERATIONS IN ST. LOUIS COUNTY

Year	Underground			Open Pit			Total		
	No. of Operations	Number Employed[1]	Tonnage	No. of Operations	Number Employed	Tonnage	No. of Operations	Number Employed	Tonnage
1926	36	5,739	8,457,939	36	3,536	24,126,004	2/72	9,275	32,583,943
1940	11	2,677	3,597,718	40	2,870	32,896,063	3/51	5,547	36,493,781

1/ Includes both surface and underground mine employees
2/ 55 of the mines were active and shipped ore.
3/ 47 of the mines were active and shipped ore. Four mines have both open-pit and underground operations.
Source: Hunner, E. E., Minnesota iron mining industry, Mining and Metallurgy, p. 397, vol. 22, no. 416, August 1941.

3. Stripping of proportionately less overburden in preparation for future mining. In 1933-39, about one-fourth cubic yard of overburden was removed for each ton of merchantable ore mined in Itasca and St. Louis Counties, whereas in 1923-32, about one-half cubic yard of overburden was removed for each ton of merchantable ore mined.1/

1/ Ridgway, R. H., Davis, H. W., and Melcher, N. B., Iron ore, pig iron, ferroalloys, and steel: Bureau of Mines, Minerals Yearbook Review of 1940, p. 549.

Figure - shows how much more work is required to produce a ton of concentrate than to mine a ton of direct shipping ore from a fully developed open pit. Clearly, unemployment on the iron ranges can be alleviated through increased utilization of lean ores. It is estimated that the low-grade iron ore industry already furnishes employment for nearly three-fourths as many men as are employed in high-grade open-pit operations.1/ Tables - and - compare total shipments of beneficiated ore with the total of all ore. It is estimated that production of 30,000,000 tons of taconite concentrate annually, should that become economically feasible, would require possibly $100,000,000 worth of equipment and 15,000 men.2/

1/ Op. cit., Davis, E. W., p. 79
2/ Davis, E. W., The iron country, Engineering and Mining Journal, vol. 146, no.8, p. 148, August 1941.

SHIPMENTS OF BENEFICIATED IRON ORE FROM MINNESOTA

Year	Total Iron Ore Shipments from Minn. in Gross Tons	Shipments of Beneficiated Ore in Gross Tons1/			Percent Beneficiated ore of Total Ore Shipments1/		
		Concentrated	Crushed and/or Screened	Total Beneficiated Ore	Concentrated	Crushed and/or Screened	Total Beneficiated Ore
1940	48,949,322	9,207,681	16,338,342	25,546,023	18.8	33.4	52.2
1939	33,022,890	6,221,363	9,843,244	16,064,607	18.8	29.8	48.6
1938	14,815,811	2,826,444	3,607,455	6,433,899	19.1	24.3	43.4
1937	49,161,064	9,692,091	9,566,723	19,258,814	19.7	19.5	39.2
1936	33,829,341	7,764,501	6,428,396	14,192,897	23.0	19.0	42.0
1935	20,532,222	5,153,574	1,977,460	7,131,034	25.1	9.6	34.7
1934	15,967,819	3,440,041	2,115,624	5,555,665	21.5	13.3	34.8
1933	14,953,168	3,134,657	1,805,677	4,940,334	21.0	12.0	33.0
1932	2,250,200	292,458	237,116	529,574	13.0	10.5	23.5
1931	17,309,211	3,696,189	2,353,167	6,049,356	21.4	13.6	35.0
1930	34,881,010	6,339,600	7,408,595	13,748,195	18.2	21.2	39.4
1929	47,478,167	6,566,269	9,597,100	16,163,369	13.8	20.2	34.0
1928	39,167,842	5,841,075	8,684,304	14,525,379	14.9	22.2	37.1
1927	36,504,854	5,072,685	8,537,347	13,610,032	13.9	23.4	37.3
1926	41,919,575	5,557,875	9,663,354	15,221,229	13.3	23.0	36.3
1925	38,841,968	6,567,133	7,144,178	13,711,311	16.9	18.4	35.3
1924	31,589,464	5,331,284	2,434,408	7,765,692	16.9	7.7	24.6
1923	45,305,647	7,612,458	1,300,988	8,913,446	16.8	2.9	19.7
1922	30,772,162	5,016,782	770,727	5,787,509	16.3	2.5	18.8
1921	17,708,789	3,060,881	182,980	3,243,861	17.3	1.0	18.3
1920	40,348,663	5,033,468	818,652	5,852,120	12.5	2.0	14.5
1919	34,791,866	4,578,395	658,356	5,236,751	13.2	1.9	15.1
1918	44,070,710	4,915,488	562,146	5,477,634	11.1	1.3	12.4
1917	45,393,882	4,513,824	564,837	5,078,661	9.9	1.3	11.2
1916	46,189,617	4,234,710	209,557	4,444,267	9.2	0.4	9.6
1915	32,618,653	2,968,617	195,008	3,163,625	9.1	0.6	9.7
1914	23,352,360	2,014,337	130,181	2,144,518	8.6	0.6	9.2
1913	36,339,962	2,249,257	191,012	2,440,269	6.2	0.5	6.7
1912	34,195,682	3,091,354	208,223	3,299,577	9.0	0.6	9.6
1911	23,336,127	1,978,337	92,276	2,070,613	8.5	0.4	8.9
1910	30,403,712	610,392	75,511	685,903	2.0	0.3	2.3
1909	29,286,876	43,485	74,862	118,347	0.1	0.3	0.4
1908	18,100,006	4,443	53,070	57,513	0.02	0.3	0.3
1907	29,177,420	9,816	102,977	112,793	0.03	0.4	0.4
1906	25,613,401	-	146,503	146,503	-	0.6	0.6

1/ By beneficiation is meant washing, jigging, crushing, screening, drying, sintering or any process by which the grade or structure of the crude ore is improved. By concentration is meant all of the processes of beneficiation except crushing and screening. The above figures represent the tonnage of the beneficiated iron ore and beneficiated manganiferous iron ore (i.e., shipping product) and not the crude ore. There were no shipments of beneficiated ore prior to 1906 except crushed ore from the Soudan Mine.

Source: Compiled by Mines Experiment Station, University of Minnesota. Minnesota Mining Directory 1941, table 10, p. 210.

SHIPMENT OF CONCENTRATED IRON ORE FROM MINNESOTA FROM 1930 TO 1940.

Range	Gross Tons of Concentrated Ore Shipped							Total Iron Ore Shipment	Percent Concentrated Ore of Total Shipment
	Washed	Jigged	Hi-Density	Magnetite Concentrates	Sintered	Dried	Total		
1940									
Mesabi	7,082,386	931,131	2/347,221	-	-	-	8,360,738	45,667,677	18.3
Vermilion	1,580	72,846	-	-	-	-	74,426	1,547,469	4.8
Cuyuna	149,685	1/110,927	33,651	-	222,710	255,544	772,517	1,734,176	44.5
Minnesota	7,233,651	1,114,904	380,872	-	222,710	255,544	9,207,681	48,949,322	18.8
1939									
Mesabi	4,440,748	955,634	2/177,835	-	-	-	5,574,217	30,314,857	18.4
Vermilion	-	-	-	-	-	-	-	1,417,360	-
Cuyuna	159,329	13,884	-	-	254,224	219,709	647,146	1,290,673	50.1
Minnesota	4,600,077	969,518	177,835	-	254,224	219,709	6,221,363	33,022,890	18.8
1938									
Mesabi	2,162,128	443,860	7,500	6,361	55,027	-	2,674,876	13,304,036	20.1
Vermilion	-	-	-	-	-	-	-	929,952	-
Cuyuna	72,909	16,698	-	-	13,322	48,639	151,568	581,823	26.1
Minnesota	2,235,037	460,558	7,500	6,361	68,349	48,639	2,826,444	14,815,811	19.1
1937									
Mesabi	7,279,170	1/1,339,217	-	23,520	58,179	-	8,700,086	45,932,539	18.9
Vermilion	-	-	-	-	-	-	-	1,453,080	-
Cuyuna	205,205	3/ 109,344	3/7,559	-	261,050	408,847	992,005	1,775,445	55.9
Minnesota	7,484,375	3/1,448,561	3/7,559	23,520	319,229	408,847	9,692,091	49,161,064	19.7
1936									
Mesabi	6,496,071	1/ 472,134	-	17,468	69,356	-	7,055,029	31,459,429	22.4
Vermilion	-	-	-	-	-	-	-	1,064,473	0.0
Cuyuna	197,031	-	-	-	247,044	265,397	709,472	1,305,439	54.3
Minnesota	6,693,102	472,134	-	17,468	316,400	265,397	7,764,501	33,829,341	23.0
1935									
Mesabi	3,685,211	838,212	-	11,143	56,147	-	4,590,713	18,877,537	24.3
Vermilion	-	-	-	-	-	-	-	857,099	-
Cuyuna	79,177	-	-	-	4/255,239	229,340	563,756	798,481	70.6
Minnesota	3,764,388	838,212	-	11,143	311,386	229,340	5,154,469	20,533,117	25.1
1934									
Mesabi	5/2,614,023	405,605	-	4,652	47,496	-	3,071,776	14,650,099	20.9
Vermilion	-	-	-	-	-	-	-	785,149	-
Cuyuna	5/ 42,292	-	-	-	6/219,254	106,719	368,265	532,571	69.1
Minnesota	5/2,656,315	405,605	-	4,652	266,750	106,719	3,440;041	15,967,819	21.5
1933									
Mesabi	5/2,331,328	489,387	-	-	6,605	-	2,827,320	13,471,625	21.0
Vermilion	-	-	-	-	-	-	-	740,404	-
Cuyuna	-	-	-	-	6/191,382	115,955	307,337	741,139	41.5
Minnesota	5/2,331,328	489,387	-	-	197,987	115,955	3,134,657	14,953,168	21.0
1932									
Mesabi	5/ 266,282	-	-	-	11,167	-	277,449	1,934,719	14.3
Vermilion	-	-	-	-	-	-	-	216,744	-
Cuyuna	-	-	-	-	15,009	-	15,009	98,737	15.2
Minnesota	5/ 266,282	-	-	-	26,176	-	292,458	2,250,200	13.0
1931									
Mesabi	5/3,160,677	267,787	-	-	29,276	-	3,457,740	15,270,411	22.6
Vermilion	-	-	-	-	-	-	-	1,140,710	-
Cuyuna	7/ 10,358	-	-	-	6/193,715	34,376	238,449	898,090	26.6
Minnesota	5/3,171,035	267,787	-	-	222,991	34,376	3,696,189	17,309,211	21.4
1930									
Mesabi	5/4,877,518	895,359	-	-	45,673	-	5,818,550	31,067,292	18.7
Vermilion	-	-	-	-	-	-	-	1,884,529	-
Cuyuna	5/ 70,323	28,451	-	-	275,266	126,003	500,043	1,929,189	25.9
Minnesota	5/4,947,841	923,810	-	-	320,939	126,003	6,318,593	34,881,010	18.9

1/ Includes jig tailing shipped as siliceous ore.
2/ Includes hi-density tailing shipped as siliceous ore.
3/ Corrected figure
4/ Includes 44,532 tons of sinter-dried ore.
5/ Includes some jig concentrates produced in conjunction with washing.
6/ Includes 103,045 tons of sinter-dried ore in 1934, 149,824 tons in 1933, and 124,009 tons in 1931.
7/ Includes 9,859 tons of table concentrates.
Source: Minnesota Mining Directory. Compiled by Mines Experiment Station.

A National Problem - What might be done in Minnesota is not the whole solution of the problem. The fact remains that the iron mining industry is directly affected by the prosperity of the steel industry, or lack of it. The great decline in 1938, after the record breaking output in 1937, well illustrates this close relationship. Accumulated stocks, together with a low level of steel operations throughout 1938 due to a slump in the capital goods industries, sharply reduced the demand for Minnesota and other Superior District ores.

State Mineral Lands

Shortly after the first ore was shipped from the Vermilion range in 1884, the question of administering State-owned minerals on trust fund lands confronted the legislature. It was realized that the value of minerals on unexplored lands could not be determined with sufficient accuracy for outright sale, so a leasing plan was adopted. Laws of 1889, chapter 22, provided for a system of 50-year leases, each of 160 acres or less. A royalty rate of 25 cents per gross ton was established, with an annual rental of $1,250 per lease if no ore was mined. Taxes were payable by the lessees.

Under this law, the State Auditor issued 872 mineral leases, 31 of which are still in force. Eight expire in 1942, one in 1943, two in 1949, eight in 1950, three in 1951, four in 1952, two in 1956, and three in 1957. Twelve of these have been sublet to mining companies at a higher royalty rate.1/ This law was

1/ Report of the Commissioner of the Department of Conservation: Annual report 1938.and fourth biennial report for the biennium ending June 30, 1938, p. 276.

repealed by Laws of 1907, chapter 14.

Laws of 1917, chapter 10, authorized leasing of iron ore deposits located under the waters of any public lake or river within the State for a period of 50 years at 50 cents royalty per ton or an annual rental of $5,000 when no ore is mined. Two such leases were issued, one on the Mesabi range and the other on the Cuyuna. There has been some exploration, but both remain undeveloped.2/

2/ Idem., p. 275.

In 1921, the legislature enacted a mineral lease law, chapter 389, Laws of 1921, which provided for payment of royalty on the iron content of crude ore and reduced the amount of land that could be leased to 80-acre units (in special cases to a maximum of 90 acres).1/ Only two small mines, now exhausted, operated under these laws.

1/ Op. cit., p. 275.

The 1921 law was amended by chapter 392, Laws of 1925, and chapter 389, Laws of 1927. Under provisions of the Mineral Lease Law of 1927, as amended in 1941, State mineral lands are divided into mining units of approximately 80 acres of contiguous land, unless fractional subdivisions are included, in which case the total may not exceed 90 acres, or, in the case of lands containing taconite or low-grade magnetite ore deposits, 120 acres. On the second Mondays of June and December each year, a sale of one-year permits to prospect mining units is held by the State Executive Council. Sealed bids state the royalty offered per ton of ore, based upon iron content, that the applicant proposes to pay to the State in case the permit is awarded to him. If a permit holder complies with all the provisions of his permit, a lease may be obtained by him for a period of 50 years. The royalties to be paid by the operator are based on the bid submitted, but thereis a minimum of 12 cents per gross ton on ore averaging 25 percent iron(dried at 212° F.) in the case of open pit direct shipping ore, open pit wash ore, and open pit concentrates, and 11 cents per gross ton on underground direct shipping ore, underground wash ore, and underground concentrates. There is also a minimum rate of 11 cents on taconite concentrates, but it is on ore averaging 40 percent or less. An increase of 5 percent in royalties is added to the minimum for each succeeding one percent of dry iron in the case of direct shipping ore, 4.5 percent for open pit wash ore, 4 percent for open pit concentrates, 3.5 percent for underground direct shipping ore, 3 percent for underground wash ore, 2 percent for underground concentrates, and 1 percent for taconite concentrates. Annual minimum payment when

no ore is minèd is $1,250 for the first year of the lease and $5,000 yearly thereafter, except as to taconite, on which the rental is $400 per year for the first 10 years.and $1,600 yearly, thereafter.1/ Only two lessees shipped ore

1/ Session Laws of Minnesota for 1941, chapter 546, pp. 1080-1092.

under the Mineral Lease Law of 1927 - the Wheeling Mine at Mountain Iron, which was exhausted in 1936, and the Smith Mine at Hibbing.2/

2/ Op. cit., pp. 275-276.

Thus, up to June 1942 34 mineral properties are under lease. Thirty-one of these were executed under Chapter 22, Laws of 1889, providing for a royalty of 25 cents per ton; 2(non-operating lake-bed units) under chapter 110, Laws of 1917, which provided for a royalty of 50 cents per ton, and 1 under Laws of 1927 which provided for a graduated scale of royalty based on the iron content (an average royalty in 1939 of 73 cents per ton; no ore shipped under this lease in 1940).

Shipments of ore have been made under 21 of the present leases. One other has been developed and is ready to produce ore. Twelve are undeveloped, and four of these have not been explored.3/ During 1940, the peak year, output from State mines totaled 13,948,762 gross tons, yielding $3,526,703 in royalties. Through 1940, a total of 179,694,472 tons of iron ore had been produced from State-owned mines. Table - shows the remaining tonnage and assessed value of ore in State-owned lands as of May 1, 1940:

REMAINING TONNAGES AND ASSESSED VALUES OF ORE ON TAX ROLLS OF STATE-OWNED LANDS OF MINNESOTA AS OF MAY 1, 1940

Taxing District	Tonnage	Assessed Vaue
School Land Leases	58,924,720	$9,125,555
Swamp Land Leases	13,274,880	1,692,823
University Land Leases	13,732,321	898,145
Total	85,931,921	$11,716,523

Source: Department of Taxation, State of Minnesota.

3/ Op. cit., p. 277.

Iron Ore Mining Taxes

The State of Minnesota levies three kinds of taxes - ad valorem, occupation, and royalty - on the iron ore mining industry. First is the ad valorem tax, levied on iron ore as real and personal property under the general property tax. It produces an average of about $16,759,000 annually, of which some $10,530,000 goes to local communities, $3,939,000 to counties, and $2,290,000 to the State (Table -).1/

Secondly, there is the occupation tax of 10.5 percent (9 percent after 1942) on the value of iron ore mined each year, after deduction for the principal costs of production. Certain credits are allowed, in order to increase employment and encourage utilization of low-grade, underground, and high labor cost ores.2/ All proceeds, amounting on the average to about $2,979,000 annually1/, go to the State.

Thirdly, a tax of 9 percent is levied each year upon royalties received by any person for permission given to "explore, mine, take out and remove ore from land in this State". In theory, this tax is a levy upon the persons receiving royalties, but in practice such taxes are generally paid by mine operators. The average yield to the State is about $666,000 a year (Table -). 1/.

Iron ore mining taxes have been a controversial issue for many years. Some tax problems affecting the conservation of iron ore resources have already been discussed in this chapter. Further consideration of this important subject need not be given here, as there are a number of recent publications which comprehensively deal with it.

1/ Average for the ten years, 1931-1940
2/ Session Laws of the State of Minnesota, chap. 544, p. 1077.

Iron And Steel Manufacturing

Practically all the ore mined in Minnesota, except for a small tonnage smelted in two Duluth plants, is shipped down the Great Lakes in large boats built especially to accommodate this traffic. Strangers to the area and to the

APPROXIMATE AMOUNT OF AD VALOREM TAXES LEVIED FOR STATE PURPOSES FROM 1906 TO 1913, AND APPROXIMATE AMOUNT OF AD VALOREM TAXES LEVIED FOR ALL PURPOSES FROM 1914 TO 1940, ON THE PORPERTY OF THE MINING INDUSTRY IN MINNESOTA; TOGETHER WITH AMOUNT OF OCCUPATION AND ROYALTY TAXES FOR YEARS IN WHICH THESE LAWS BECAME EFFECTIVE

Year	Ad Valorem Taxes				Occupation Taxes[1]	Royalty Taxes[2]	Grand Total Taxes
	State	County	Local	Total			
1940-1931, Av.	2,290,252	3,939,124	10,530,117	16,759,493	2,978,532	665,955	20,403,980
1940	1,810,014	4,374,856	9,394,986	15,579,856	6,387,700	1,107,926	23,075,482
1939	1,953,413	4,601,422	9,876,487	16,431,322	4,888,964	865,926	22,186,212
1938	2,004,850	4,123,766	10,126,596	16,255,212	1,618,439	607,988	18,481,639
1937	2,024,419	4,009,528	11,235,620	17,269,567	9,033,930	1,305,385	27,608,882
1936	2,798,071	4,459,946	10,754,161	18,012,178	2,637,977	547,048	21,197,203
1935	3,062,746	3,931,227	10,329,856	17,323,829	1,387,546	459,951	19,171,326
1934	2,762,996	4,059,152	10,843,984	17,666,132	1,228,626	364,129	19,258,887
1933	2,643,812	3,247,220	10,691,097	16,582,129	958,388	335,600	17,876,117
1932	1,959,006	3,201,138	10,697,346	15,857,490	260,604	415,793	16,533,887
1931	1,883,194	3,382,985	11,351,038	16,617,217	1,383,145	649,804	18,650,166
1930	1,366,684	3,262,329	12,456,632	17,085,645	2,782,361	921,167	20,789,173
1929	1,592,537	3,290,144	12,369,019	17,251,700	3,786,352	1,044,696	22,082,748
1928	1,347,033	3,129,570	12,367,746	16,844,349	2,466,257	879,520	20,190,126
1927	1,972,268	3,167,651	12,202,463	17,342,382	2,183,308	916,825	20,442,515
1926	1,458,007	2,912,173	12,897,499	17,267,679	2,725,312	910,636	20,903,627
1925	2,149,882	2,984,651	13,436,296	18,570,829	2,316,432	845,072	21,732,333
1924	1,682,383	3,143,135	13,910,838	18,736,356	2,859,735	895,825	22,491,916
1923	2,298,710	3,300,036	14,056,522	19,655,268	6,126,443	1,027,847	26,809,558
1922	1,161,288	2,951,031	14,299,181	18,411,500	3,440,597	-	21,852,097
1921	1,203,473	3,040,145	13,941,538	18,185,156	2,238,328	-	20,423,484
1920	1,607,491	3,208,335	16,024,401	20,840,227	-	-	20,840,227
1919	2,328,322	2,876,204	12,371,521	17,576,047	-	-	17,576,047
1918	1,056,441	2,330,623	9,715,429	13,102,493	-	-	13,102,493
1917	1,499,875	1,893,147	6,996,085	10,389,107	-	-	10,389,107
1916	1,033,435	1,435,123	5,791,702	8,260,260	-	-	8,260,260
1915	1,107,878	1,558,370	4,544,477	7,210,725	-	-	7,210,725
1914	1,314,538	1,091,052	4,318,887	6,724,477	-	-	6,724,477
1913	1,291,081	-	-	-	-	-	-
1912	933,193	-	-	-	-	-	-
1911	919,643	-	-	-	-	-	-
1910	609,984	-	-	-	-	-	-
1909	576,174	-	-	-	-	-	-
1908	604,264	-	-	-	-	-	-
1907	671,489	-	-	-	-	-	-
1906	179,272	-	-	-	-	-	-
1914-1940	49,082,766	84,964,959	297,001,407	431,049,132	60,710,444	14,101,138	505,860,714

1/ Beginning with the year 1923, only fifty percent of the occupation tax is available for state revenue purposes, the balance being apportioned to trust funds; forty percent to the Permanent School Fund; and ten percent to the Permanent University Fund.

2/ State General Revenue Fund.

industry often express surprise over the fact that iron and steel are not manufactured in greater volume within the State, and particularly at Duluth.

Duluth has important economic-geographic advantages. Iron ore, coke, and limestone are the principal raw materials used in the manufacture of pig iron, and the cost of assembling them is a critical locational factor in the iron and steel industry.1/ Because of Duluth's location near the iron mines(about 71 miles by rail from Eveleth) and at the head of Lake Superior, to which ore boats returning from the lower lakes bring coal and limestone as return cargo , the city has the advantage of low assembly costs (Table -).2/ Cost of assembling iron, coal, and limestone at Duluth is considerably lower than at Pittsburg, Youngstown, or Cleveland.

1/ According to the Report of the Commissioners of Corporations on the Steel Industry, 1913, the assembled cost of raw material - net metallic mixture (chiefly iron ore), coke and limestone - was 73 to 85 percent of the total cost of manufacturing pig iron. Data cited in Tariff Information Surveys, revised ed., F1-21, On articles in paragraphs 518-537 of Tariff Act of 1913 and related articles in other paragraphs: Iron ore, pig iron, and scrap, U. S. Tariff Commission, Washington, p. 64, 1921 and in Primmer, G. H., and White, Langdon, The iron and steel industry of Duluth: A study in locational maladjustment: The Geographical Review, vol. XXV11, no. 1, p. 85, 1937. Figures of five representative companies reporting to the Federal Trade Commission for 11 months, beginning February 1918, show that the basic raw materials constituted approximately 78-90 percent of the total furnace cost. Latter data also cited in Tariff Information Survey, revised ed., F1-21.

2/ Primmer, G. H., and White, Langdon, The iron and steel industry of Duluth: A study in locational maladjustment: The Geographical Review, vol. XXXVLI, no. 1, p. 85, 1937.

FREIGHT COST OF ASSEMBLING IRON ORE, COAL, AND LIMESTONE
AT SEVERAL DISTRICTS USING LAKE SUPERIOR ORE

District	Iron Ore ($ a gross ton)	Coal ($ a net ton)	Limestone ($ a gross ton
Duluth	.90 by rail	1.69 rail rate to lower lake port Connellsville (2.11, Pocahontas) .08 dumping charge .40 lake rate to Duluth .35 rail rate from docks to furnaces 2.52 Connellsville (2.84 Pocahontas)	.40
Cleveland	1.94	1.90 Connellsville 2.39 Kanawha 2.64 Pocahontas	.90 Marblehead .45 Calcite .40 Kellys Island
Pittsburg	1/ 2.97	1.26 rail (Connellsville) .25 barge (includes .10 barge unloading charge)	1.13 Kaylor, Pa.
Youngstown	1/ 2.64	1.42 Connellsville 2.39 Kanawha 2.64 Pocahontas	.55 Hillsville and Walford, Pa.

1/ "Direct" ore is placed in waiting railway cars under the unloaders and transported to inland districts, where it is placed in huge stock piles. "Dock" ore is retained at the rear of the unloaders in large storage piles and is transported to inland points during the winter. Furnaces so arrange their schedules as to absorb a steady stream of "direct" ore, since by so doing they save about 25 cents a ton over the equivalent "dock" ore rate.

Source: Primmer, G. H., and White, Langdon, The iron and steel industry of Duluth: A study in locational maladjustment: The Geographical Review, vol. XXXVII, no. 1, p. 85, 1937.

Since Duluth occupies such an advantageous position in the assembly of raw material, why is it only a negligible producer of steel? Figures - and - suggest that the principal reason is remoteness from iron and steel markets. Regarding the outlook for the future, Dr. Langdon White and Dr. G. H. Primmer, in a study of the economic-geographic factors of the iron and steel industry at Duluth conclude, "As local industries develop where an adequate market exists, as the territory tributary to Duluth seems destined to remain agricultural and pastoral, and as nearness to market is probably the most important location factor, it would seem that Duluth's metallurgical future is not promising. Duluth will not be abandoned as a

metallurgical center however; some steel will continue to be made, ***"1/

1/ Op. Cit., White and Primmer, p. 91.

The twenty million dollar Duluth plant of the American Steel and Wire Company normally manufactures steel fence posts, wire fences, nails, and semi-finished billets and rods. Slag from the furnaces is used by a large nearby plant in the manufacture of Portland cement. The Zenith Furnace Company plant consumes about 160,000 tons of ore a year and produces about 80,000 tons of pig iron, one-half of which is sold in this region while the remainder is competitive with the Chicago output. 2/ In connection with its blast furnace, this company operates a by-

2/ Mineral resources of Minnesota, p. 4, Minnesota Resources Commission, 1940.

product coke-oven plant.

Minor Metals of Minnesota

There are a number of minerals which can be referred to as minor metals in Minnesota because they are not produced commercially. One of these is gold. Minnesota had a gold rush in 1865 at Vermilion Lake. By 1867, however, it had become clear that the ore there was too lean for profitable working. Gold has since been found in small quantities at various other points in the state but operations in 1894 on an island in Rainy Lake, with a reported output of $4,635, was the source of the only significant gold production in the State. Drilling in 1936 near this mine found no extension of that ore body.

Copper has been prospected in the Keweenawan formations which are correlated with the productive copper bearing rocks of Michigan. Test pits have been opened at Taylors Falls, Hinckley, Pine City, and at various places along the North Shore from Duluth to Grand Marais. Metallic copper was found at all of them but not in volume and concentration to encourage further work. Various copper prospects also occur northeast of the Keweenawan flows.

Prospecting for silver, lead, and zinc has occurred near the Canadian border in northeastern Minnesota, but there is no record of any commercial production.

Approximately $30,000 in silver and copper were taken out of the old silver mine at the Point of Rocks in Duluth.

NON-METALLIC MINERALS

The non-metallic resources of Minnesota include principally dimension stone, broken and crushed rock, marl, clay, shale, sand, gravel, peat, and feldspar. Some of these resources occur in inexhaustible quantities, while others are found in limited amounts and the supplies should be conserved.

Dimension Stone[1]

Dimensional stone includes all types of rock which are used for constructing or facing buildings and for monuments. During recent years reinforced concrete has replaced dimension stone almost entirely for purposes such as dams, retaining walls, abutements, paving and curbing. Minnesota's numerous quarries produce over fifty varieties of stone which are cut, shaped, finished and shipped according to orders received from every part of the country. Since 1911, reports of the U. S. Bureau of Mines show that Minnesota has averaged eighteenth among the states in value of stone produced (Table -). The State normally ranks third among the states producing granite. Table - shows the quantity and value of stone sold or used by producers in Minnesota and the United States from 1911 to 1940. Minnesota stones enjoyed a national reputation for beauty and adaptability before their merits were recognized by local builders.

Granite 1/

Granite is the State's most valuable building stone. The stones of greatest economic value are found in three widely separated regions as shown in figure -: (1) Central Minnesota, particularly in the St. Cloud area. (2) Upper Minnesota River Valley from New Ulm to Ortonville. (3) Arrowhead Region of northeastern Minnesota. There were 30 quarries and mines belonging to 21 operating companies in Minnesota in 1939.2/

---

[1] Much of the material of this section is found in Thiel, G. A. and Dulton, C. E., Architectural, structural, and monumental stones of Minnesota; Minnesota Geol. Survey Bull. 25, 1935.

1/ The term "granite" here employed, as in the stone industry generally, includes granites, gneisses, diorites, gabbros and other igneous rocks.

2/ U. S. Census of Mineral Industries - 1939.

About one third of Minnesota's output is used for buildings and the remainder for monumental purposes (Table -). Table - gives the amount and value of granite stone produced in Minnesota by uses at 5-year intervals since 1920.

The major granite producing area in the State is the St. Cloud region - eastern Stearns County, northwestern Sherburne County, and southeastern Benton County (Figure -). Stone of this region may be grouped into three major types:- (1) Pink granite ~~which is~~ marketed under such trade names as "Rockville Pink", "Cold Springs Pearl Pink", "Original Minnesota Pink", and "Sauk Rapids Pink". This granite was used in ~~the construction of~~ such ~~distant~~ buildings as the ~~United States~~ Federal Court House in New York (the tallest granite structure in the world), Book-Cadillac Hotel in Detroit, Chicago Tribune Tower, Chamber of Commerce Building in Jacksonville, Florida, Cadillac Building in Boston, Bell Telephone Building in Dallas, and the Dollar Savings Bank in Pittsburg; and in such Minnesota buildings as the St. Paul Cathedral, Federal Reserve Bank in Minneapolis, State Office Building in St. Paul, Duluth City Hall, and Hotel Duluth. (2) Red granite which is marketed under a variety of trade names such as "Ruby Red", "River Red", "Indian Red", "North Star Red", "Melrose Red", "Standard Red", and "Mahogany Red". Most of the rock is used for monumental purposes but some architectural stone is also fabricated. (2) Gray granite which is marketed under a variety of trade names such as "Pioneer Gray", "Minnesota Dark Gray", "St. Cloud Gray", "Crystal Gray", and "Reformatory Gray" is finer grained than red granite and is used for both building and monumental purposes. St. Cloud gray granite was used in the new Minneapolis Postoffice.

Gray granite is also quarried in the Isle - Warman Creek region in central Minnesota (Figure -). The stone is marketed under the trade names "Isle" and "Cold Springs Pearl White" granite and is found in such far away structures as the Louisiana State Capital, Aviation Building at Fort Worth, ~~Texas~~, Price Building in Kansas City, ~~Missouri~~, and the Hurds County Courthouse in Jackson, Mississippi.

The granites of the upper Minnesota River Valley are all Archean outcrops, most of them being exposed by the great glacial River Warren which swept away the

overlying decayed and weathered rock debris and left the valuable fresh rock easily available at the surface. Especially desired for facings, doorways and columns because of their great strength and distinctive beauty are the pink and black laminated granite gneisses in the vicinity of Morton, known variously by such trade names as "Rainbow", "Oriental", "Tapestry", "Antique" and "Imperial". Morton stone is used in the Northwestern Bell Telephone Buildings in Minneapolis and St. Paul, the Dougherty-City Service Building in New York City, the Daily News Building in Chicago, and many other equally prominent structures. In the Montevideo-Sacred Heart area, a number of quarries, most of them small, have been opened in recent years, but only a few ~~of them~~ are now operating. The laminated black and white granite gneiss quarried at Seaforth is sold under the trade name "White Oriental". Quarries in red granite have been recently opened at Woodlake and Echo. Along the Minnesota River in the Granite Falls area rock crops out almost continuously but most of it is not ~~most of it is not~~ commercially useful. Rock of the many large granite outcrops in the Ortonville-Odessa area is of an attractive deep red color, and when polished it is one of the most attractive stones in the State. However, the several large quarries that formerly operated near Ortonville are now inactive and only one is ~~active~~ in operation at Odessa. Red and gray Odessa granite was used in the Aetna Life Insurance Building in Hartford and in the 21st Street Office Building in New York.

The pre-Cambrian complex of the Arrowhead Region contains many varieties of volcanic rocks (Figure -). Granites of two undeveloped areas are especially worthy of note - the Huronian granite of the Giants range in the Mesabi District (Figure -) and the granite of the Vermilion batholith ~~to the~~ found north of Vermilion Lake. The enormous quantities of rock suitable for structural stone in these two areas are not quarried because of their geographic location and the poor transport facilities. Duluth gabbro, commercially known as "black granite" and "trap rock" has been quarried for many years in the vicinity of Duluth, mainly for riprap, foundation stone, and crushed rock. During recent years a growing demand for polished "black

granite" as a structural and ornamental stone has resulted in the opening of a number of new quarries north of Duluth. The stone sells under names such as "Arrowhead Black Granite", "Hibbing Granite", "Green Granite", and "emerald Tone". Green basalt, sometimes called Ely greenstone, crops out on the Vermilion range, particularly at Ely, and it has been quarried to some extent for foundations, retaining walls, crushed rock, and until recently for the manufacture of roofing granules.

Limestone

Limestone is a sedimentary rock, ~~in which~~ with calcium carbonate ~~is~~ the principal constituent. It is deposited mainly on the bottom of seas of moderate depth by organic and chemical means. Most of the limestone in Minnesota, except that of Devonian age in the southern part of the State, is dolomitic; that is, it contains a relatively high percentage of magnesium carbonate. The limestones of Minnesota that have economic value belong primarily to the Paleozoic group which includes the Cambrian, Ordovician, and Devonian systems of rocks (Figures - and -).

Limestone suitable for many construction and architectural purposes has been quarried in the eastern and southeastern counties of the State (Table -). Important deposits obtain along the St. Croix, Mississippi, Cannon, Zumbro, Whitewater, and Root Rivers. Figure - shows the principal producing regions. The Oneota dolomite of Ordovician age has yielded the greatest tonnage and the highest quality stone. Mankato and Kasota stone and "Winona Travertine", chosen by many architects for both interior and exterior work because of their interesting and pleasingly warm colors, are quarried from ledges of this formation. Because of the steady demand for Minnesota limestone for architectural purposes and the growing desire for attractive, permanent, and dignified stone buildings, the limestone industry should continue to flourish. The refuse from limestone quarries can be used for broken and crushed stone and lime; in fact certain deposits may be worked primarily for this purpose. Table - presents the amount and value of limestone produced in Minnesota at five year intervals since 1920. Only two quarries in the State were

engaged primarily in the production of rough dimension stone in 1939.1/

1/ U. S. Census of Mineral Industries, 1939.

USE AND LOCATION OF LIMESTONE BY COUNTIES

Blue Earth	Quarrying for building stone, crushed rock, natural cement, lime and recently rock wool, is active in Mankato.
Dakota	Prospects for development at Hastings and Mendota.
Dodge	Extensive operations formerly existed at Wasioja and Mantorville.
Fillmore	Numerous quarries have been opened for building stone, crushed rock, lime and soil conditioners. Deposits exist all over the county.
Goodhue	Deposits formerly used in production of lime. Red Wing once was lime center of Minnesota. Frontenac stone once extensively used and possibilities for future development are suggested.
Hennepin	Mostly crushed rock, some very fine building stone in Minneapolis.
Houston	There are Quarries at Hokah, Brownsville, Caledonia and La Crescent. Stone used for crushed rock. The limestones should be increasingly important as soil conditioners.
Le Sueur	Home of the famous Kasota Stone which has been used in important buildings in all parts of the United States. (Some crushed rock also produced the lime formerly made at Ottawa.)
Mower	Deposits at Le Roy are exceptionally rich in calcium and have been used for production of lime as well as natural cement. The limestone at Le Roy is supplanting oyster shells for the poultry industry. It is also used for pharmaceutical purposes.
Nicollet	Formerly used for local building stone and lime production at St. Peter.
Olmsted	Important operations in vicinity of Rochester supply local building and crushed rock. Some limestone is suitable for manufacture of Portland cement- possible future development in this field. Of equal possibilities are deposits near Chatfield as well as at Galena and Pleasant Grove.
Ramsey	Crushed stone, some local building stone, in St. Paul.
Scott	Stone formerly quarried for local building and for burning of lime, kilns abandoned in Jordan and Shakopee.
Steele	Stone available at Clinton Falls and Medford - no development.
Wabasha	Small quarry development in the past. Opportunities seem good.
Waseca	Limestone too deep for present use.

Washington	Formerly widely quarried for local building in Stillwater. Now abandoned because of substitute building materials.
Winona	Extensive quarries near Winona operate for both cut stone and crushed rock, some is used for stone chips and for agricultural purposes.
Rice	Stone formerly quarried at Northfield, Dundas, Fall Creek and Faribault to supply building stone for Carleton College and Shattuck Military Academy. Has been used as a marble. One quarry remains open.

Source: Adapted from tabulation in Mineral Resources of Minnesota, Minnesota Resources Commission, 1940.

Many important buildings, both in Minnesota and in distant states contain Minnesota limestone. The exterior of the architecturally prominent Philadelphia Museum of Art was constructed of yellow and gray Mankato and pink Kasota limestone, and the interior of yellow Kasota. Over 855 carloads valued at $1,500,000 were shipped to Philadelphia for this structure.1/ Mankato and Kasota stones are also found in the Northwestern Bell Telephone Building in Minneapolis, the interior of the Minneapolis Auditorium, and State Capital in St. Paul, Loew's State Theater in New York, the Union Depot in Kansas City, and in numerous other buildings in Minnesota and other states. Much of the stone is sufficiently hard to take a polish and is therefore sometimes referred to as marble. Installations of "Winona Travertine" may be seen in the Young-Quinlan Building in Minneapolis, the State Teachers College in Winona, the Liggett Building in New York, the Mayflower Hotel in Washington, D. C. and in many other buildings both in Minnesota and elsewhere.

Sandstone

A durable pinkish sandstone has been exposed by the downward-cutting action of the Kettle River in Pine County (Figure -). At first used mainly for bridgework, flagging, curbing and paving, it was chosen later by builders for many structures in both eastern and western states. The finished building stone is sold under the trade names "Kettle River Standard" and "Kettle River Variegated". Because of the red, pink, and buff tints, attractive effects may be produced by skillful use of the stone. Some of the buildings in which the stone is used are the Baker Building in Minneapolis, Hill Reference Library in St. Paul, Brinker Block in Pittsburg, and

the Clubhouse in Spokane, Washington. Table - presents the amount and value of sandstone produced in Minnesota for selected years from 1920 to 1940.

Quartzite

Considerable commercial use is made of quartzite, known as Sioux quartzite, found in Pipestone and Rock Counties (Figure -). The stone varies in color from a pale pink to a deep, purplish-red and is strong and easily worked. Because of the uneven and irregularly spaced joints, however, the stone is not cut into large dimension blocks for basic structural purposes. The stone is used extensively for ornamental trimming, roofing chips, paving blocks, and crushed stone. It also has an industrial use as "flint" blocks and "flint" pebbles for lining of machinery that grinds minerals which should not come into contact with iron. Most of the latter two products used in the United States are quarried and fabricated from the Sioux quartzite at Jasper, Minnesota.

Broken And Crushed Rock

Waste from the granite dimension stone industry in Minnesota, particularly in the St. Cloud district, constitutes a source of crushed rock for concrete aggregate and road metal, railroad ballast, and rubble for rough masonry, retaining walls and other uses.1/ Gabbro is quarried at Duluth for road stone, concrete and road metal, rubble for retaining walls, and riprap. Basalts found at Taylors Falls, on the north shore of Lake Superior, and elsewhere in northeastern Minnesota are used for concrete aggregate, road stone, ballast for railroad grades, rubble, and riprap.1/

Refuse of the sandstone quarries near Sandstone is crushed for construction purposes. Sioux quartzite of southeastern Minnesota, some of it a by-product of building stone and other industries, is converted to crushed rock at Pipestone, Jasper, Luverne, and New Ulm. Some quartzite screening sells as ganister for the manufacture of silica brick and furnace lining, and as furnace sand. Chips for roofing granules are also produced at Pipestone. Table - presents the quantity, value, and uses of broken granite, basalt, sandstone, and quartzite sold or used by producers in Minnesota since 1928.

1/ U. S. Census of Mineral Industries of 1939 revealed there was only one quarry in Minnesota engaged principally in the production of crushed and broken granite and one in the production of crushed and broken basalt.

2/ U. S. Census of Mineral Industries, 1939.

Comparison of tables - and - reveals that most of the crushed and broken rock sold ~~annually~~ in Minnesota is extracted from limestone and dolomite formations in southeastern ~~Minnesota.~~ In 1939, ten quarries were operated principally for the production of crushed and broken limestone. Table - gives the quantity, value, and uses of crushed and broken limestone sold or used by producers ~~in~~ Minnesota since 1928.

Sand And Gravel

Minnesota ~~was~~ endowed with widespread sand and gravel deposits suitable for structural use and road building by the six glacial sheets that encroached upon the State. ~~There are~~ several broad areas, however, ~~with~~ comparatively poor in ~~scarcity of~~ these resources: (1) The Driftless Area in southeastern Minnesota, (2) The loess mantled, old glacial drift areas in southeastern and southwestern Minnesota, (3) the central Red River Valley, (4) the Glacial Lake Minnesota plain in south central Minnesota, and (5) ~~the~~ extensive swamp-lands in Beltrami, Lake of the Woods, and Koochiching Counties (Figures - and -).

Pits and plants producing sand and gravel are so numerous throughout the State that complete coverage and mapping of the industry would require and extensive survey. Figure - shows only the principal sand and gravel pits. The State Highway Department on July 1, 1939, owned on long term lease, covering 4,176 acres, 394 sand pits in 72 of the 87 counties in Minnesota.1/ In 1940

1/ Mineral Resources of Minnesota, p. 10, Minnesota Resources Commission, 1940.

Minnesota ranked as sixth highest producer of sand and gravel in the Nation. Table - gives the quantity and value of sand sold or used by Minnesota producers from 1928 to 1940.

The use of sand for concrete, plaster, mortar, and other construction purposes is familiar to everyone. An abundance of sand suitable for making molds in the founding of iron, steel, brass, and alumina exists in the Jordan and St. Peter sandstones at various places along the Minnesota, Mississippi, and St. Croix Rivers. Material for core work is taken from the young red drift

Sand Sold or Used By Commercial And Non-commercial Producers In Minnesota, 1928-1940.

Year	Molding		Building				Paving				Grinding & Polishing		Engine		Other	
			Commercial		non-commercial		Commercial		non-commercial							
	short Tons	Value	short Tons	Value	short Tons	Value	short Tons	Value	short Tons	Value	short Tons	Value	short Tons	Value	short Tons	Value
1940	11,747	12,704	807,727	299,109	893,45~	47,838	247,501	111,115	349,668	33,027	753	1,883	[1]	[1]	120,907	21,644
1939																
1938 [2]	12,546	13,125	623,334	233,870	174,810	31,362~	143,210	56,330	[1]	[1]	[1]	[1]	34,771	7,858	[1]	[1]
1937	16,273	22,879	[3] 766,401	[3] 250,358	[3]	[3]	[3] 166,096	[3] 74,070	[1]	[3]	[1]	[1]	40,729	9,219	2,380	50~
1936 [4]	8,618	10,748	[3] 937,082~	[3] 336,711	[3]	[3]	[3] 255,383	[3] 93,960	[3]	[3]	[1]	[1]	16,704	2,673	8,448	1,339
1935 [5]	[1]	[1]	[3] 669,375	[3] 222,446	[3]	[3]	[3] 147,344	[3] 50,293	[3]	[3]	854	2,135	6,120	979	[1]	[1]
1934	14,590	18,005	[3] 494,116	[3] 180,363	[3]	[3]	[3] 307,606	[3] 100,829	[3]	[3]	[1]	[1]	[1]	[1]	12,836	4,740
1933	6,887	10,509	[3] 289,734	[3] 87,894	[3]	[3]	[3] 267,996	74,826	[3]	[3]	[1]	[1]	17,525	4,068	18,344	4,075
1932 [6]	10,644	5,997	[3] 432,13~	[3] 150,51~	[3]	[3]	[3] 857,247	[3] 274,580	[3]	[3]	[1]	[1]	19,27~	5,411	83,148	18,480
1931 [7]	[1]	[1]	664,443	274,774	—	—	918,949	299,42~	—	—	[1]	[1]	[1]	[1]	127,790	28,775
1930 [8]	28,406	30,520	768,90~	270,756	—	—	848,278	265,653	—	—	2,259	5,545	24,454	6,689	190,50~	42,193
1929	29,919	23,259	968,369	346,239	—	—	554,310	219,604	—	—	[1]	[1]	64,323	20,83~	[1]	[1]
1928	19,026	16,924	741,391	232,971	—	—	537,717	201,248	—	—	[1]	[1]	50,760	17,257	[1]	[1]

Note: Tonnage & value of glass sand produced is included under "undistributed" by states in 1940 & 1932

Tonnage & value of railroad ballast sand is included under "undistributed" by states in 1940, 1937, & 1934

Tonnage & value of filter sand is included under "undistributed" by states in 1937, 1936, 1934, 1933, 1929 & 1928

Tonnage & value of core sand is included under "undistributed" by states in 1934

[1] Undistributed by states

[2] In 1938, 48,848 short tons of railroad ballast valued at $10,825 & 516 short tons of filter sand valued at $1,548 were produced

[3] Non-commercial production included with commercial

[4] In 1936, 7,476 short tons of railroad ballast valued at $645 were produced

[5] In 1935, 1,118 short tons of filter sand valued at $2,795 & 22,175 short tons of railroad ballast valued at $4,190 were produced

[6] In 1932, 1,287 short tons of filter sand valued at $3,205 were produced

[7] In 1931, 986 short tons of filter sand valued at $2,71~ were produced

[8] In 1930, 5,000 short tons of glass sand valued at $5,500 & 1,257 short tons of filter sand valued at $3,771 were produced

Source: minerals yearbook, Bureau of mines, U.S. Dept of Interior.

deposits of eastern Minnesota, especially near the Twin Cities (Figure -). There are over 40 foundaries in the Twin Cities area and perhaps equally as many scattered throughout the State. Screenings of plants using Sioux quartzite and Kettle River sandstone supply a sand valuable for refractory and sand-blasting purposes. During 1937, Minnesota produced 16,880,000 sand-lime brick valued at $127,829. Glass manufacturing from the white, friable, St. Peter sandstone ~~constitutes~~ is an important development of recent years (Figure -). The Ford Motor Company normally manufactures about 40,000 square feet of automobile window glass daily in its St. Paul plant. This sand is believed suitable also for plate glass, bottles, containers, structural tile, and bricks. Table - presents the quantity and value of sand sold or used by commercial and non-commercial producers from 1928 to 1940.

Gravel is used mainly for paving, concrete construction in buildings, road surfacing, and as railroad ballast. Table - reveals the quantity and value of gravel sold or used by commercial and non-commercial producers in Minnesota from 1928 to 1940. Minnesota ranks 11th among the states in the manufacture of concrete products.

Clays And Shales

Minnesota has ~~an~~ abundance ~~of a~~ variety ~~of~~ clay and shale deposits, resources ~~that are~~ still relatively untouched (Figure -). ~~Mining of~~ clay and ~~its~~ processing ~~into clay products~~ has declined in Minnesota but the ~~value of~~ output ~~still equals~~ over a million dollars annually (Table).

Geologic formations bearing clays in the State were tested in detail and reported in Bulletin 11 of the Minnesota Geological Survey (1914); and revised and reprinted as Bulletin 678 of the United States Geological Survey (1919). These reports may be referred to for more detailed information than is given here. Material for the following discussion of the geology of Minnesota clays was drawn freely from the latter publication and other works.

Gravel Sold or Used By Commercial And Non-commercial Producers In Minnesota, 1928-1940.

Year	Building				Paving				Railroad Ballast		Other		Sand & Gravel [1]	
	Commercial		Non-commercial		Commercial		non-commercial							
	Short Tons	Value	Short Tons	Value	Short Tons	Value	Short Tons	Value	Short Tons	Value	Short Tons	Value	Short Tons	Value
1940	515,466	457,306	149,513	56,257	506,726	234,362	3,817,565	307,019	916,242	58,977	287,679	47,453	8,729,205	1,924,716
1939														
1938	474,637	398,270	213,108	73,231	560,342	253,799	5,251,134	337,777	814,492	104,106	[4]	[4]	8,486,147	1,586,836
1937	[5] 495,968	[5] 477,929	[5]	[5]	[5] 5,276,656	[5] 659,180	[5]	[5]	980,954	300,902	[6] 5,215	[6] 2,606	7,781,830	1,905,441
1936	[5] 857,312	[5] 812,458	[5]	[5]	[5] 4,130,791	[5] 1,348,675	[5]	[5]	513,461	76,471	[4]	[4]	7,342,987	2,692,223
1935	[5] 570,453	[5] 562,709	[5]	[5]	[5] 4,179,031	[5] 1,213,850	[5]	[5]	511,437	81,202	[4] 19,290	[4] 14,079	6,166,064	2,169,332
1934	[5] 506,910	[5] 498,816	[5]	[5]	[5] 3,535,887	[5] 1,214,525	[5]	[5]	314,348	37,791	[4]	[4]	5,217,775	2,064,876
1933	[5] 208,262	[5] 154,344	[5]	[5]	[5] 1,800,629	[5] 404,449	[5]	[5]	107,422	23,225	—	—	2,719,282	768,714
1932	[5] 325,123	[5] 277,899	[5]	[5]	[5] 1,693,799	[5] 1,144,862	[5]	[5]	524,169	97,118	—	—	3,950,289	1,983,235
1931	500,111	449,770	—	—	1,644,036	1,220,076	—	—	608,481	114,701	—	—	4,496,777	2,404,718
1930	805,426	594,593	—	—	1,065,502	877,038	—	—	850,804	172,035	—	—	4,590,790	2,274,293
1929	629,310	583,839	—	—	1,223,487	919,314	—	—	1,482,348	275,407	—	—	4,990,256	2,412,776
1928	712,897	454,761	—	—	946,692	700,166	—	—	1,254,752	362,985	—	—	4,409,245	2,029,091

[1] may include ballast gravel produced by the railroads for their own use

[2] Commercial & non-commercial after 1931.

[3] may include gravel used by railroads for fills & similar purposes

[4] Undistributed by states

[5] Non-commercial production included with commercial

[6] may include some gravel used by railroads for fills & miscellaneous purposes

Source: minerals yearbooks, Bureau of Mines, U.S. Dept. of Interior.

120,345
562
120907

516
48,848

Residual Clays - Deposits resulting from weathering of Archean granites occur in southwestern Minnesota (Figure -). In some localities, there may be high-grade fire clays and possibly even China clays, but except in a few places the deposits are not exposed as glacial drift covers them to depths of 50 to 150 feet. The clays do crop out in the vicinity of Redwood Falls in Redwood County and at Richmond in Stearns County.

Marine Clays - Deposits buried beneath other sediments may be hardened to shales by compaction and cementation. The two shale formations best suited for ceramic uses in Minnesota are the Decorah shale of Ordovician age and the Cretaceous shales and clays (Figures - and -).

Glacial Clays - Deposits are of three types in Minnesota - till, river, and lake. Till deposited by the various ice sheets varies in character according to the source of the material. Gray drift brought in from the northwest has the greatest areal extent but the clays therein generally contain limestone pebbles and fragments that burn to lime and later slake and expand, breaking the product (Figure -). Because of this important defect, perhaps nine-tenths of all the attempts to use Minnesota clays have been abandoned.1/ The properties of the

---

1/ Report of the Committee on Mineral Resources (manuscript report in files of Minnesota Resources Commission), p. 193, August 1937.

---

clay taken from gray drift may be improved greatly by removal of limestone by washing or dry-cleaning processes. Red drift brought in from the north and northwest is less limey, but it is sandy and gravelly, and generally less ~~not as~~ plastic (Figure -). It contains locally valuable deposits of clay, however.

Along many streams in Minnesota, deposits of interstratified, gray or red glacial clays were laid down by sediment-laden floodwaters from melting ice sheets (Figure -). Such gray clays have long been known and used along the Minnesota River at Chaska and Jordan and along the Mississippi from Minneapolis to Brainard (Figure -). Around the west end of Lake Superior, there are large deposits of a very sticky, plastic, red clay containing some sand grains and pebbles. They

appear to have been formed during one of the high stages of glacial Lake Duluth (Figures - and -).1/

1/ Grout, F. F., Clays and shales of Minnesota: U. S. Geol. Survey Bull. 678, p. 73, 1919.

Post Glacial Clays - Thick beds of banded clay occur in the central portion of the Red River, and their position shows they were probably deposited both during and after the glacial period. Principal post glacial river clays occur in the alluvial terraces of the flood plains of the Minnesota, Mississippi, and St. Louis Rivers and their tributaries. They are moderately plastic, but most of them are sandy and supply only common brick material.1/

1/ Op. cit., Report of the Committee on Mineral Resources, p. 193, 1937.

Industrial Use Of Clays

Brick And Tile Clays - Clays suitable for making brick and tile exist in practically every county of the State. Largest producers of common brick are located at Chaska, Wrenshall, East Grand Forks, and Bemidji. These establishments operate principally in the summer when bricks are air-dried, and they produce light-colored brick for back-up purposes. Smaller plants make common brick at St. Cloud, Anoka, Willmar, Warren, and Winona. Of these only the Winona clay burns red.2/

2/ Op. cit., Report of the Committee on Mineral Resources, p. 199, 1937.

Large quantities of face brick and tile are manufactured in the 3 Twin City plants, principally from Decorah shale. Some roofing, face, and brick tile are also made. At Springfield in Brown County a bank of Cretaceous shale which burns to red and reddish brown color supplies the raw material for a large brick and tile manufacturer there.

Refractory Clays - Cretaceous clays occurring from Bowlus in Morrison County to Redwood Falls in Redwood County constitute the best refractory clays known in Minnesota.3/ They will stand an exceptionally high temperature and can be used

3/ Op. cit., Grout, F. F., p. 107, 1919.

in crucibles or in linings of furnaces and kilns, and for the manufacture of certain industrial products that are subject to high temperatures. Washing would improve the color and raise the melting point of most of them. More detailed exploration of the formations in which known refractories exist and greater labratory research would undoubtedly lead to the discovery of new deposits and encouragement of their industrial use.

Semirefractory Clays - Cretaceous shales are the only semirefractory light-burning clays in Minnesota.1/ Those mined at Clay Bank and Belle Chester in Goodhue County for the stoneware and sewer-pipe works at Red Wing are best known. West of these points much of the Cretaceous shale is non-refractory, but the character of the deposits at Austin in Mower County and near Essig in Brown County shows that conditions for the development of the semirefractory type were widespread and that there is every reason to expect similar clays to be discovered under the drift in intervening counties.2/ The important high-grade stoneware products industry at Red Wing places Minnesota third among the states in production. An average of approximately 1,000 carloads of sewer pipe are shipped annually from Red Wing.

In 1939 Minnesota produced about 154,763 tons of common clay and shale valued at approximately $113,802.3/ The value of Minnesota's clay products, exclusive of pottery, in 1940 reached $. The principal clay products of the State are face-brick, common brick, structural tile, stoneware, and sewer pipe. Other uses of clay are for porcelain, earthenware, paint fillers, paper filling, China dishes, Portland cement, refractory wares, and ornamental pottery. A great many uses have been suggested for Minnesota clays in a bulletin by the Minnesota Resources Commission.4/

1/ Op. cit., Grout, F. F., p. 107, 1919.
2/ Op. cit., Grout, F. F., p. 107, 1919
3/ U. S. Census of Mineral Industries, 1939.
4/ Mineral Resources Of Minnesota, Minnesota Resources Commission, 1940.

Limestones And Marls

Limestone and dolomites are found in the southeastern quarter of the State (Table -). Their origin and character have already been discussed under dimension stone. Marl resembles limestone in that it is composed essentially of calcium carbonate, but it is in a soft, powdery form. Deposits occur in lake basins, marshes, and low areas once covered with water. Water percolating through glacial drift leached calcium carbonate from this material and eventually it became a precipitate, either by chemical or biochemical action, on many lake bottoms. As often happened, marl filled or partially filled a lake basin, and luxuriant growths of moisture loving plants gained footholds which upon decay formed the overlying peat deposits. Figure - shows the distribution of marl deposits and localities of high calcium limestone.

Limestone, dolomits, and marls are used in the manufacture of lime. Magnesia present in dolomites and dolomitic limestones is not regarded as an impurity, except in the manufacture of high-calcium lime. The high-calcium lime produces a whiter plaster and can be spread more easily, but magnesian limes are less likely to ~~less on drying~~ as they dry. Conversion of limestone or dolomite to lime requires the application of intense heat (about 800° C.) in a kiln. The kiln products may be sold as quicklime, ~~for more or less immediate use~~, or they may be ~~allowed~~ subjected to react with water in special apparatus called hydrators, ~~and then sold~~ emerging as hydrated or slaked lime. Lime has been manufactured from almost all of the limestone formations in Minnesota and for many years Red Wing was known as the lime center of the State.1/ In 1937, only one firm in Minnesota, located at Le Roy in Mower County, was engaged in making lime from Minnesota limestone

---

1/ Report of the Committee on Mineral Resources (manuscript report in file of the Minnesota Resources Commission), p. 210, August 1937.

Marls, limestones, and dolomites are used to neutralize acid soils and are known as "soil sweetners". Since marl is unconsolidated, it can be spread on a field without preparation. Limestones and dolomites in many localities are

ground by portable crushers to pass a 60-mesh screen before they are used. Table - presents the tonnage and value of commercial limestone used for agricultural purposes in Minnesota from 1928 to 1940. Agricultural lime is particularly important to Minnesota since farming is a leading industry and because extensive areas in the State have acid soils.

Pulverized limestone and a good grade of marl may be employed as whitening to mix with paint or with linseed oil to form putty. Use of whitening in articles such as linoleum, rubber, shoe polish, and tooth paste is a possible development. Both limestone and dolomite could be used in paper-milling and low magnesian limestone might possibly be developed for sugar refining as well as in the pharmaceutical industry. Minnesota Geological Survey Bulletin 23, The Limestones And Marls Of Minnesota, lists seventy common commercial uses and manufactured products in which limestones or marls are used.1/

Minnesota has two natural cement plants, one at Mankato and the other at Austin. Clayey limestone provides the raw material. Portland cement has never been made in Minnesota from native limestones or marls. Most dolomitic limestones of Minnesota are not desirable forthis type of cement because of their excessive magnesia - limestone that contains more than 5 to 6 percent is considered unfit for use. Composition of the Cedar Valley limestone at Le Roy in Mower County and Prosser limestone in Olmstead and Fillmore Counties is suitable for Portland cement.2/ The Report of the Committee on Mineral Resources of the Minnesota State Planning Board in 1937 suggested investigation of the possibilities of using some of the larger marl deposits near Minneapolis and St. Paul for the manufacture of Portland cement.

Manufacture of "rock wool" is a new industry in Minnesota and there appears to be opportunity for growth. Recent analyses indicate that some layers of the Platteville limestone meet the requirements for conversion to rock wool and parts of the Platteville limestone, Oneota dolomite, and St. Lawrence

1/ Stauffer, C. R. and Thiel, G. A., The limestones and marls of Minnesota, Minnesota Geol. Survey Bull. 23, p. 1, 1933.
2/ Op. cit. p. 212, August 1937.

dolomitic stone are sub-wool rocks.1/

1/ Op. cit., Stauffer and Thiel, p.

Peat

Peat is partially carbonized vegetable matter that has accumulated in a bog. It varies from brown, coarse, fibrous material to a black, finely divided substance, depending upon the species of plants from which it formed and on the degree of decomposition and oxidation. Glaciation produced a topographic setting conducive of peat swamps and bogs, and a cool humid climate favored the profuse growth of the successive plant associations that formed the peat deposits.

Figure - shows the distribution of peat in Minnesota. The peat deposits vary according to the area in which they are found: ~~may be divided into the following groups: (1) Deposits in northern Minnesota, (2) Deposits in central Minnesota, (3) Deposits in southern Minnesota.1/~~

Northern Minnesota - The peat deposits here are of three general types:

1. Deposits in the "muskeg" swamps and open bogs are largely built up of successive layers of sphagnum, or peat moss. They comprise the largest, deepest, and best quality peat sources in the State. A single bog may cover over as much as 50 square miles. The peat averages seven to nine feet thick over wide areas.

2. Peat in the western portion of the northern area mainly ~~comprises~~ consists of built-up accumulations of vegetation such as sedge-grass, cattails, and rushes. The deposits may be extensive, but they are usually ~~attain~~ less than 4 feet in thickness.

3. Filled lake deposits consist primarily of sedge remains. A thickness of 20 to 25 feet may be attained in the center of ~~the~~ a bog.

Central Minnesota - North of an east-west line drawn through Minneapolis, the typical peat bog resembles those of northern Minnesota, except that it is smaller. To the south of this line, the peat bogs differ. Numerous deposits of both types occur in the transitional zone which is about 30 miles wide.

Southern Minnesota - Bogs in this part of the State are commonly both small and shallow. They occur in open meadows and include the filled

---

1/ Abstracted from the Report of the Committee on Mineral Resources (manuscript report in the files of the Minnesota Resources Commission), pp. 228-229, August 1937.

lake and partly built-up types. Principal plant constituents are the sedges, grasses, cattails, and rushes.

Table - presents the approximate amounts of peat fuel of good quality in Minnesota by counties. The estimates include only those deposits with a depth of five feet or more, as experience in the manufacture of peat fuel elsewhere in the world has shown that five feet is the minimum thickness which can be worked successfully. Total peat acreage in the State is estimated at 6,217,000 acres and the quantity of peat fuel of good quality at 6,835,300,000 tons.1/ This represents, roughly, 50 percent of the peat reserves of the Nation.

Principal interest in the tremendous peat reserve centers in its potentiality as a fuel for the reduction of iron ores. Such use, however, will require a great deal of additional research and development and at present does not seem to offer much promise. Another projected industrial use is production of power in northern Minnesota by peat fueled steam generating plants. Although the region possesses the large quantities of water needed for this type of power generation, ~~availability of coal and~~ the high labor cost involved make it ~~appear~~ unlikely that this use will materialize soon. Perhaps the greatest commercial possibilities for peat are in such uses as fertilizer filler, soil conditioners, litter for stock and poultry, packing material, insulation, and peat briquettes. It has been considered for use in paper manufacture, in coarse fabrics such as horse blankets, as a source of dyes and tanning material, and for antiseptic and deodorizing purposes.2/

For further information about the occurrence of peat in Minnesota the reader is referred to Bulletin 16 of the Minnesota Geological Survey under the title of "The Peat Deposits of Minnesota."

1/ Soper, E. K., "The peat deposits of Minnesota, Minnesota Geol. Survey Bull. 16, p. 33, 1919.

2/ Mineral resources of Minnesota, Minnesota Resources Commission, p. 13, 1940.

Feldspar

Feldspar is the most abundant mineral group in the earth's crust. Essentially, it is composed of potassium, sodium, and calcium aluminum silicate. Potash and soda feldspars are associated with granite, and the soda-lime feldspars primarily with the dark gray to black, granular, igneous rocks, such as the gabbro that outcrops in the vicinity of Duluth. It is in the pegmatite dikes or veins intruded into the igneous masses after they are more or less crystallized, that the feldspar is commercially available. Anorthosite, a coarse-grained igneous rock occurring in the Duluth gabbro, is almost entirely composed of soda-lime feldspar, but this type has no industrial importance at present. Numerous anorthosite outcrops occur along the north shore of Lake Superior in Lake and Cook Counties, often in the form of prominent white hills. The deposits are the purest large masses of feldspar known, and in spite of their objectionable iron content they receive considerable interest because of their possibilities as a source of alumina for glass. (Figure -).1/

Feldspar in recent years has been processed commercially by a mill located at Warroad in Roseau County from material shipped in by boat from a deposit found in the Northwest Angle. The feldspar occurs in masses up to three feet long, much of it being pink potash feldspar with irregular intergrowths of lighter colored soda feldspar. Potash-rich feldspar is used in largest quantities by industry, soda feldspar being employed primarily as an auxiliary flux.

Feldspars are used mainly as fluxes in the ceramic industries for they cause a gradual vitrification which can be regulated in kilns. At present it is used in making porcelain, china, earthenware, electrical porcelain, lavatory porcelain, wall and floor tiles, and other clay products. It is also used in the manufacture of glasses, glazes, and metal enamels. Some is used in scouring soaps and in the manufacture of false teeth.

1/ Schwartz, G. M., The calcic feldspar deposits of Minnesota, Bulletin of the American Ceramic Society, vol. 16, no. 12, December 1937.