WATER RESOURCES OF NEBRASKA

REVISED FEBRUARY 1941

GENERAL SECTION

PREPARED BY

NEBRASKA STATE PLANNING BOARD

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LETTER OF TRANSMITTAL

Lincoln, Nebraska
February, 1941

To His Excellency
The Honorable Dwight Griswold
Governor of Nebraska
Lincoln, Nebraska

My dear Governor:

On behalf of the Nebraska State Planning Board, I have the honor of presenting herewith a copy of WATER RESOURCES OF NEBRASKA - REVISED 1941. This report has been prepared by the staff of the Board with assistance from the many state and federal agencies active in fields concerned with the conservation and utilization of our water resources. The financial assistance of the Work Projects Administration through official project number 465-81-3-155 has made possible the preperation of this report.

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Nebraska Department of Roads and Irrigation

Nebraska Public Power and Irrigation Districts

Public Works Administration

U. S. Army Engineers

College of Agriculture University of Nebraska

Soil Conservation Service

Division of Conservation and Survey, University of Nebraska

Copies of this report will be distributed to public officials, public libraries, educational institutions and interested state and federal agencies.

Very respectfully,

Wardner G. Scott

Wardner G. Scott
State Engineer &
Chairman

STATE OF NEBRASKA

Dwight Griswold, Governor

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PURPOSE

Conservation of Nebraska's water resources is vital to the conservation and preservation of its economic and social resources. General distribution of information concerning the possibilities and methods available for the conservation of our water resources is highly desirable.

The purpose of this very brief summary of the water resources of Nebraska is to present a quick picture of the various methods of conserving those resources and the extent to which they have been put into operation in the state. Among the several official agencies interested in water conservation, particular emphasis has been given to one or another of a number of ways of conserving our moisture, the methods of conservation depending on the statutory purpose for which each particular organization has been set up.

Reference has been made to and material has been drawn from the work of many individuals and agencies in assembling the material in this report. There has been no attempt to work out detailed plans for any development, large or small. That appears to be the job of "action" agencies legally set up for the purpose. It does seem desirable, however, to outline some of the accepted methods of moisture conservation and the extent of the development of the use of those methods in Nebraska.

A SUMMARY OF THE REPORT WITH AN OUTLINE OF A WATER CONSERVATION PROGRAM FOR NEBRASKA

GENERAL DESCRIPTION

Nebraska, as an agricultural state, is dependent upon the conservation of its two basic resources soil and water for its economic security. The cumulative effects of the current devastating drought have threatened this security in some areas of the state, and have sharply decreased the agricultural income in others.

Occupying parts of the regions designated by geographers as sub-humid and semi-arid, Nebraska experiences years when the precipitation in all parts of the state is less than 20 inches. Since 20 inches of precipitation is considered the line of demarcation for the semi-arid region, the entire state, therefore, would fall in the semi-arid category during some periods of drought. Every part of the state at some time or another suffers from either a lack of total supply of moisture or a proper distribution or both.

Under ordinary conditions the amount of precipitation in the eastern third of the state is adequate without supplemental water for profitable agriculture, although there are years of crop shortages and even failures. Generally speaking, until the last few years, the periods of drought in this section of the state have not been of sufficient duration or intensity to cause interest to be aroused in large irrigation projects. In the western two-thirds of the state however, the normal supply of precipitation is inadequate for successful intensive agriculture. The only means of producing profitable yields in areas of specialized farming is through the conservation of the available water supply and its artificial application to crops.

Until comparatively recent years, it was believed by many that irrigation could be practiced successfully only in that portion of the state west of the 100th meridian. At present, as a result of the extenuating drought and with improved engineering and irrigation methods, experts believe that irrigation can be made feasible in every part of the state where the water supply is available and topography and soils are suitable. In fact, large-scale irrigation projects have recently been developed east of the 100th meridian and there are now extensive projects proposed in the extreme eastern part of the state. Generally speaking, local sentiment throughout the state seems to favor the changes in agricultural and farming methods which would be necessary under irrigation.

In the western two-thirds of the state, the paramount problem is providing supplemental water for irrigation in areas meeting all other requirements for successful irrigation. Adjusting land use practices in areas with limited and undependable precipitation is more or less a problem throughout the entire state. The control of flood waters in conjunction with irrigation is of major importance on the Republican River, in the southern part of the state, and in minor drainage basins in the eastern part. The need for abatement of pollution is somewhat localized and is not a major problem from a state-wide viewpoint.

Climate

The wide variation of Nebraska's climate is largely the result of its geographic position. The precipitation is fluctuating and undependable. It decreases from east to west across the state at a fairly constant rate. The records indicate that the annual precipitation varies from 9.47 to 27.48 inches in the western part of the state, and from 20.86 to 50.31 inches in the eastern part. There are a greater number of years with the annual precipitation below the mean than those above, therefore, the departures above the mean are greater than those below it. During June 16 per cent of the total annual precipitation occurs and in January 2 per cent. These are the months when the maximum and minimum amounts occur. About 69 per cent of the annual supply falls during the five months' period from May to September.

During the past 90 years Nebraska has experienced three major droughts with intermediate periods of sub-normal precipitation. These cyclical droughts culminated in the early Sixties, the early Nineties and the late Thirties - the one through which we are now passing. The current drought starting immediately following 1930 with its accompanying adverse economic conditions is considered the most devastating of record. Above normal temperatures and excessive rates of evaporation which usually accompany subnormal precipitation have caused added damage to crops and accentuated drought conditions. Only once, 1938, during this ten-year period was the total annual amount in excess of the mean. Since 1930, Nebraska has a cumulated deficiency of precipitation of 45.2 inches below the mean of 22.7 inches. This deficiency is equivalent to the total precipitation of two normal years.

Interest in irrigation increases proportionately with the decrease in precipitation, and each succeeding drought intensifies interest in developing new irrigation enterprises. This interest in the eastern, and to some extent in central Nebraska, however, has heretofore quickly subsided with the return to heavier precipitation. Past experience, therefore, emphasizes the importance of the proper attitude on the part of those people included within the limits of a proposed project as a factor contributing to the success of that enterprise.

Population Trends

It is doubtful if the settlement in any other state in the union has been more greatly influenced by a fluctuating and undependable water supply for agriculture than has Nebraska. Variable precipitation and inadequate water storage and irrigation facilities have resulted in periods of low agricultural production. Droughts with their accompanying crop failures and a depressed agriculture have caused restless population movements within the state and some migration from the state. Nebraska has shown a population decrease of 4.7 per cent between 1930 and 1940, as compared with an increase of 6.3 per cent between 1920 and 1930. Seventy-seven of the 93 counties showed decreases since 1930. Two of the nine cities in the state of more than 10,000 (Hastings and Norfolk) showed decreases during the past decade. The records reveal a close correlation between changes in precipitation and population. A more stabilized agriculture established on sound water conservation policies is absolutely essential to the maintenance of our present population. Irrigation development on some of these streams not only gave greater use to areas of profitable agriculture which otherwise would be nothing more than grazing land but it also created greater urban communities to serve the rural irrigated areas, thereby increasing the population capacity of those areas.

The size of farm units averages 190 acres in the eastern part of the state and 835 acres in the western part, with a state average of 365 acres. By excluding the irrigated section, the size of farm units in the western part of the state averages 970 acres. About 70 per cent of the 122,543 farms in Nebraska have from 100 to 175 acres. The Bureau of Reclamation indicates that the irrigated area per farm in the Great Plains Region should average about 80 acres, with a rural population of 4 persons and a town population of 8 persons per farm. With a maximum of irrigation development and the resulting readjustment of tenure, Nebraska will be capable of supporting a somewhat larger and more prosperous population.

WATER SUPPLY

Surface Water

The amount of surface water available each year for the state as a whole varies almost proportionately with the precipitation occurring over the drainage area even though some of the streams maintain a fairly constant flow from natural underground supply reservoirs. During the current drought the surface waters have been noticeably depleted. The annual surface inflow to the state averages about 2,000,000 acre-feet from the states of South Dakota, Wyoming, Colorado, and Kansas, through the Niobrara, North and South Plattes and the Republican rivers. Only an insignificant quantity is contributed by South Dakota and the area to the north - the largest contribution is from Wyoming. The outflow is about 6,800,000 acre-feet annually and moves generally in a southeasternly direction, where it ultimately reaches the Missouri River which forms the eastern boundary of Nebraska. Therefore, 4,800,000 acre-feet net originating within the confines of this state have passed out and on to the Gulf of Mexico. Not all of this water was unused, for some was return flow after having served its purpose for both irrigation and power. Upstream development in Wyoming, together with the operation of recently constructed irrigation projects in Nebraska will reduce the quantity of water leaving the state in an amount equivalent to the consumptive use on these projects together with evaporation losses. Ultimate irrigation development in Nebraska will not result in retaining all this outflow, but the additional areas susceptible of being served will utilize part of it.

Ground Water

No other state in the Great Plains has a greater abundance or a better distributed supply of underground water than has Nebraska. It is estimated by geologists that the total underground supply would be sufficient to cover the surface of the state to a depth of 20 feet. The Pleistocene sands and gravels are for the most part water-bearing and, where they can be encountered at relatively shallow depths provide excellent supplies for irrigation pumping. With the exception of certain small areas the largest of which is the glaciated area in the three tiers of counties along the Missouri River in the eastern part of the state, the geology of the state is such as to provide a large storage capacity for underground water in all parts of the state. The direction of movement of the underground water supply is much the same as that of the surface waters. Considerably more underground water leaves the state than enters it.

Groundwater is important not only as a source of supply for pump irrigation, but it is likewise a source for much of our surface supply as well. If it were not for the underground supply seeping into drainage courses, some of the present perennial streams would be only intermittent in character. The replenishment and conservation of the underground supply is therefore of major importance in any state water conservation program.

Streams

In contrast to the deficiency in precipitation, Nebraska is well served by a network of streams originating both outside and within the borders of the state. The Missouri and the Platte rivers which give life to many of the inhabitants of this state have their origins in the snowclad peaks of the continental divide. Other lesser streams such as the Loup, Elkhorn, Niobrara and Frenchman rivers originating in the sandy soils of the state give added security to the population in the areas they traverse, because of the dependability of their water supply. Streams with little or no dependable base flows such as the Republican River and most of its tributaries are dependent more directly upon the erratic precipitation.

IRRIGATION

Gravity

Irrigation practices in Nebraska began in the early Sixties and gradually extended westward along the Platte River system into Colorado and Wyoming with permanent settlement. Irrigation gradually increased from approximately 12,000 acres in 1890 to nearly a million acres at the present time. Developments have now been extended to all the principal water courses.

The most extensive irrigation development in Nebraska has taken place in the North Platte Valley in Nebraska where about 450,000 acres are irrigated. The next largest area is along the main stem of the Platte River east of the city of North Platte where approximately 171,000 acres are under irrigation. An additional 164,000 acres will be included in the section upon completion of the Tri-County project. There are 80,000 acres now under irrigation on the Loups and 29,000 acres on the Republican system in Nebraska. The remaining 106,000 acres under irrigation are distributed along the South Platte, Niobrara, White, Elkhorn and Blue rivers and other less important streams.

The major possibilities for the further development of gravity irrigation in the state are situated in the Republican Valley, the tributaries of the Loup and the Platte totaling approximately 500,000 acres.

Platte River

In general, the water supply of the Platte River Basin above Kearney, Nebraska is fully appropriated, thus leaving no possibilities for appreciable further development. In fact, irrigation has been developed to the point where it has exceeded the dependable water supply available for direct diversion. Below this point these are areas where the topography and soil types meet the requirements for successful irrigation, but the absence of an adequate water supply for direct flow irrigation from this point to the mouth of the Loup River renders the feasibility of additional developments questionable. Much of the land in this section of the basin upon which it is physically possible to conduct water has been included in previously proposed projects, some of which were considered impracticable, while other parts were later incorporated into new potential developments. The appropriation for storage at the Kingsley Reservoir claims all the residual seasonal and non-seasonal flow at the dam site. The release of storage water from the Kingsley Reservoir for developing downstream hydroelectric power and for delivering water to irrigation projects will result in return flow of sufficient quantity to have a stabilizing effect on the lower river flow so that at least a partial water supply will be provided for some projects which have been without water during recent drought years. In the North Platte Valley and the Platte Valley as far east as Cothenburg, the return flow is largely responsible for stabilizing the river discharge because the entire water supply, except that lost by evaporation and by consumptive use, is retained in the valley by impervious Brule clay and discharged to the middle portion of the river. The water is temporarity stored in the alluvium and returned to the river. Between Gothenburg and Central City the Platte River flows on a sand sheet which extends south to the Republican River. Since this is not a closed section and the direction of movement of the underground supply is definitely to the southeast, naturally large quantities of the Platte River water supply are lost by migrating to the Republican and Blue rivers. Geologists have estimated the annual amount at 200,000 acre-feet.

The Loup River is the source of supply for the proposed Lower Platte project embracing land on the north side of the Platte River between the Loup River on the west and the Elkhorn River on the east in Platte, Colfax, Dodge and Douglas counties. By assuming a diversion duty of 1.54 acre-feet, a total of 284,900 acre-feet would be required to deliver 1.00 acre-foot to the 185,000 acres. This is equivalent to 940 second-feet for the May to September period, or 808 second-feet of direct flow in addition to 40,000 acre-feet of supplemental storage. A study of the records indicates that there is adequate run-off to supply the irrigation requirements of the Lower Platte project over and above that needed for existing and proposed projects in the Loup River Basin.

Loup River

Based on the last ten-year mean of 1,710,262 acre-feet the annual shortage of the Loup River in supplying the Loup River Public Power District with 3,100 second-feet (the capacity of the feeder canal, although the appropriation is 3,500 second-feet) without storage facilities would have been 753,348 acre-feet or 33.5 per cent of the ultimate, while at the same time, there would have been a unattainable run-off of 219,280 acre-feet or 12.8 per cent of the total supply in the form of peak flows which could not have been utilized for power purposes as direct flow diversions. This quantity would have passed down the river unused by this project even if the 3,100 second-feet limit had been maintained. However, during the period of actual operation not all the divertable streamflow has been utilized by the Loup River project. For example, of the total annual run-off of 1,340,441 acre-feet in 1940, 1,211,859 acre-feet or 90.2 per cent were below the 3,100 second-feet limit, although only 760,353 acre-feet or 62.8 per cent of the divertable annual supply was actually diverted by the Loup River Power Project. With increased electric consumption, no doubt, a greater proportion will be used in the future.

A maximum storage capacity of 700,000 acre-feet would have been needed to reduce the discharge for the past ten years to the average of 2,360 second-feet. The development of storage facilities necessary to reduce the discharge to this average does not seem economically justifiable. The inter-connection of the three large hydro plants has a tendency to stress the importance of raising the minimum flow to a certain level rather than to reduce the total supply to an average. However, during the last 5 years, if all the peak discharges in excess of 3,100 second-feet had been stored and released to supplement the natural flow whenever the daily discharge fell below 2,000 second-feet, a storage capacity of only 260,000 acre-feet would have been needed. During the same period, there would even then have been a shortage of 450,000 acre-feet in supplying the 2,000 second-feet minimum. However, without storage facilities the shortage would have been 910,000 acre-feet. The annual flow at a channel reservoir site a short distance below the confluence of the North and Middle Loup rivers near the town of St. Paul averages 1,980 second-feet or 84 per cent of the Loup River discharge at Columbus. Satisfactory control of storage releases for either or both the power plant at Columbus and the potential irrigation project on the Lower Platte could be maintained at the potential St. Paul dam.

The appropriations for project proposals along the Dismal, Cedar, Calamus, and Middle Loup rivers will be junior to the Loup River District. The necessary reservoir capacity to retain all peak discharges in excess of the power district's 3,100 second-feet would make it possible to replace the natural flow diversion by the upstream irrigation districts, both existing and contemplated. Furthermore, the resulting greater uniformity of flow through the power plant at Columbus would enable the Lower Platte irrigation district to operate without a local storage reservoir, and would also be beneficial to other potential developments below the mouth of the Loup River. It is evident therefore that a channel storage reservoir of sufficient capacity above the Columbus project would stabilize the flow of the stream for the benefit of the Columbus Power Plant as well as any other projects developed in the future below the Columbus Power Plant.

The upstream contemplated projects propose to irrigate an additional 95,200 acres. Assuming a diversion duty of 1.54 acre-feet and a net delivery of 1.00 acre-foot per acre to the land, the stream flow would be depleted by 59,000 acre-feet after having credited the return flow as the result of these developments. The maximum daily diversion during July for these contemplated upstream projects would aggregate 680 second-feet which represent 16.3 per cent of the Loup River Power District's appropriation and 33 per cent of the mean discharge at Columbus for the month of July.

Republican River

The mean annual discharge of the Republican River near Hardy, Nebraska during the last eleven years with the flood discharges of May and June, 1935 excluded is 439,600 acre-feet. Above Hardy, Colorado contributes 26.4 per cent of the net water supply with 34.4 per cent of the area, Nebraska 56.5 per cent of the water supply and 43.2 per cent of the area, and Kansas 17.1 per cent of the water supply and 22.4 per cent of the area. The average run-off per square mile of drainage area in Colorado is 14.5 acre-feet, Nebraska 25.1 and Kansas 14.6. Fifty-five per cent of the total annual run-off above Hardy occurs during the May - September period, that is to say, the irrigation season. The annual inflow from the principal tributaries lying in Nebraska approximates 180,000 acre-feet annually. Practically all of this contribution is from the northwest.

Of the total of 37,800 acres now being irrigated in the Republican River Basin, 29,000 acres or 76.7 per cent are in Nebraska. Development on the Frenchman has been more extensive than on any other stream in the Nebraska portion of the basin with 16,000 acres under irrigation. The South Fork and the North Fork of the Republican are the tributaries next in importance with reference to the amount of land now irrigated, their irrigated areas being located in Colorado, Kansas, and Nebraska. If all the available water supply were conserved by means of storage facilities and released when needed for irrigation, the supply would greatly exceed the amount now needed for existing projects. The existing developments have depended almost entirely on direct flow diversion.

The irrigated areas of the Republican River and its tributaries in Nebraska can be expanded considerably if means can be found to provide storage facilities for supplying supplemental water for this acreage when the natural flow is inadequate during the summer months. In other words, it is estimated that there are 100,000 acres of land in the Republican River Basin in Nebraska which meet all the requirements for successful irrigation except available water supply during the irrigation season.

The three states of Colorado, Kansas and Nebraska are negotiating for a compact for the purpose of developing a plan for the allocation of the water supply of the Republican River Basin. Such a compact is essential before any developments for utilizing the water supply of this interstate stream so as not to cause any future conflict among these states in the equitable apportionment of the waters of the basin.

The Army Engineers are reviewing their previous report on a flood control plan for the Kansas River Basin which includes the Republican River in Nebraska in order to consider an alternative plan of development for the entire valley to include a channel reservoir near Republican City, Nebraska, in combination with the upstream tributary reservoirs. They are working in close cooperation with the Bureau of Reclamation for the best possible means of developing irrigation in combination with flood control on the Republican River. The Bureau of Reclamation studies include a determination of the areas that are physically capable of being served by gravity-type irrigation, the soil classifications in these areas, the availability of the water supply, and the best possible methods of conserving and utilizing the surface water supply in each basin.

A channel reservoir near Republican City in conjunction with certain tributary reservoirs is considered to be the most desirable plan of development because it would give some protection to the entire basin and complete protection to half of it. Such a plan is believed feasible, inasmuch as the benefits to irrigation on the Republican and flood control on the Republican and Kansas rivers would be substantially in excess of the costs to be involved. This plan is desirable because the tributary developments are needed in order that the maximum protection may be afforded the entire basin and the maximum use be made for irrigation. The need of the tributary reservoirs as a protective measure is further substantiated by the fact that 61 per cent of all damages suffered and 106 of the 110 lives lost during the 1935 flood occurred above the channel reservoir site.

During the devastating flood of 1935 the crest discharge at the Harlan County reservoir site reached 250,000 second-feet, although the discharge below that point could have been reduced to bank-full state with a reservoir capacity of 350,000 acre-feet. A determination by the Army Engineers of the design flood discharges based on the transposition of the maximum recorded storms in that vicinity which occurred in 1903 and 1935, revealed the need of a reservoir capacity totaling 1,008,000 acre-feet in order to provide complete protection to the area below the Harlan County site.

In the consideration of a basin-wide flood control plan for the Republican River, resources of all the agencies which might contribute under the authority of the Wheeler-Case act should be brought together to make possible the inclusion of the irrigation development in conjunction with flood control which might not be feasible if considered without the possibility of all agencies cooperating in its development. The most favorable reservoir sites for such consideration appear to be as follows: in Colorado, the Wray site on the North Fork of the Republican, Beecher Island on the Arikaree and the Hale on the South Fork of the Republican; in Nebraska the Enders on the Frenchman River and sites on Buffalo, Rock, Red Willow, and Medicine creeks, and the Harlan County on the Republican River. All these sites except the Wray, Buffalo and Rock Reservoirs which are for irrigation only, were selected by the Army Engineers as presenting the most favorable possibilities of development for flood control with reference to the ratio of cost to benefits. The eight tributary reservoirs would provide storage capacity aggregating 356,100 acre-feet of which 237,700 acre-feet could be utilized for flood control. Storage capacity in the proposed Harlan County reservoir could be reduced accordingly if the tributary reservoirs were developed.

Pump

The first pump irrigation, motivated by windmills, started soon after the initiation of gravity type irrigation in the early Sixties, although in 1912 there were only five irrigation wells in operation in the Platte River Valley. The number of well installations has increased in varying degrees, depending on the precipitation, until at present, there are more than 2,000 wells in operation. It is estimated that 100,000 acres are now being served by pump irrigation in 80 counties. The greatest concentration of such enterprises is in Buffalo, Dawson and Hall counties in Central Nebraska. They are located in the beds of Pleistocene deposits extending west from the western border of the till sheet.

Up until the past few years of the present drought, pump irrigation developments have taken place largely along streams with the lower lift and less expense encountered in applying the water, but recently, installations are being made in the Plains Area where the lifts are considerably greater.

Pump irrigation is gaining in popularity, because the areas to be served do not have to be favorably situated along the streams, nor do they have to rely on the uncertain and varying supply of water from those streams. Installations have been successful at many scattered points throughout the western three-fourths of the state.

There is a vast field for developing pump irrigtion in Nebraska where hundreds of thousands of acres meet all the requirements for successful irrigation. Practically all of the possibilities for the development of pump irrigation in the state are within areas comprising about 24 per cent of the total area of the state. This area supports 29 per cent of the total rural farm population of the state. Within this 24 per cent of the state's area, there are many areas both large and small which would be susceptible of successful pump irrigation because of favorable soil and topography and the availability of ground water.

Administration

Since the ground waters of Nebraska have not been declared public waters, there are no statutory provisions for their control or use. We have associated the underground water supply with the land for so long that now we regard the ownership of any land as including the underlying water supply as well. If no extensive uses were to be made of this supply, there would be no need of administrative measures. However, the demands made upon the underground water supply have shown a decided increase during recent years. Unregulated uses of this vital natural resource will eventually result in conflicting claims. The successful operation of new or amended laws will be better assured if the rights to use ground water have not become too extensively vested. Appropriate and timely legislation for the regulation of use will help greatly in eliminating probable future difficulties and will help in promoting the best use of this basic resource.

Likewise, according to Commissioner Page of the Bureau of Reclamation, Federal loans are available for pump irrigation only where the individual's right to appropriate the underground water is in accordance with proper statutory requirements for the regulation and protection of appropriators.

Without proper administration, the attempts to utilize the ground water may result in unsuccessful and costly experiments in attempts to irrigate in areas not suited for such enterprises. It may further prove harmful in depleting the supply much needed for domestic and municipal uses.

The successful administration of the ground water is by no means an easy task. In fact, it is one of the most intricate and complicated functions to come within the duties of any state agency. It must be considered in this light and undertaken in the most wholehearted and scientific manner.

With present-day techniques, it is now possible to determine the quantity of water available in any area and to identify such an area, to determine the source of supply, the direction of movement, specific yield, and the ultimate disposal of such water. The geologic factors affecting natural replenishment and depletions in each area must be carefully evaluated. Such a scientific study will reveal the amount of water that can be artifically withdrawn from a certain area without seriously disrupting the balance between inflow and outflow.

Appropriations should limit the quantity of water to be withdrawn in any season, the amounts corresponding with the duty of water in each particular area. The legal requirement for beneficial use in any area should be kept within the limits of the available supply. Provisions should be made to have the authorized state agency prepare annual statements of each well in operation showing elevations of water table, extent of draw-down, quantity and time water was used, methods of use and any other data which would be of assistance in administering effectively the laws relating to underground water. Legislation should prescribe penalties for wasting or contaminating the underground water supply.

Small Water Facilities

Nebraska with its thousands of miles of ravines and intermittent drainage courses has almost unlimited possibilities for developing small-scale water facilities to provide water for supplemental irrigation projects, water for farmsteads, and water for livestock. Water conservation facilities are of paramount importance in this state as a necessary aid to adjusting and improving existing land uses. This work should be undertaken only under the direction of technical assistants and on the basis of developing individual projects which form an integral part of the best plan possible for conserving and utilizing the water supply of the basin. Care should be exercised in order that each individual project will serve the greatest utility to the area involved.

The original approach to controlling and conserving water was to start with it after it had reached the stream channels. The more recent conception of water control in the interest of public welfare is to start where the rain falls - that is, before it has accumulated and while it is still in the controllable stage. The employment of one or more of the available methods of conserving moisture where it falls would materially increase individual farm feed and forage supplies, improve stock and domestic water supplies, and make possible large family gardens. Greater stability in these three items would make it possible for many farm operators to cope successfully with the prolonged droughts occurring in the western two-thirds of the state. Such control would also reduce the likelihood of floods.

Many devices, centuries old, could well be revived to accomplish the objectives listed in the foregoing paragraph. Small single or multiple field irrigation systems constructed on minor drainages, flood irrigation from many normally dry draws, local recharging of ground water supplies to make small pump irrigation projects possible, stock watering ponds, and stock and domestic wells are among the devices available for use in semi-arid regions.

The development of such devices is complicated by the fact that their design and construction often requires experienced or technical assistance not always readily available. As the need and demands for these small water facilities have been evidenced, agricultural agencies have developed organizations for the purpose of meeting the demand in a limited way as far as finances permit.

The early impetus to the development of small water facilities had originated from federal legislation authorizing such work to be undertaken cooperatively in a limited way by the agencies of the Department of Agriculture and through technical assistance furnished in areas included in Soil Conservation Districts. While assistance in areas designated for the small water facilities program is limited generally to those individuals without credit resources, there is no such restriction in the Soil Conservation districts.

FINDINGS AND RECOMMENDATIONS

Nebraska, comprising a part of the Great Plains, experiences all the agricultural risks common to this region. Since the land use problems of this state arise principally from undependable rainfall, thus preventing a secure establishment of agricultural economy, the effective conservation and utilization of the available surface and underground water supply becomes a matter of basic concern. Although individual and cooperative actions have resulted in notable progress during the current drought period, nevertheless, considerably more constructive action remains to be done. Rehabilitation and stabilization of agriculture in Nebraska can be accomplished only by the basic readjustments of the use of our land and water resources.

In general terms, a water conservation program for Nebraska should include:

1. Conserving moisture where it falls by use of the cropping practices developed by research and experience as particularly adapted to our soils and climate.

2. The extensive development of small water facilities with proper technical assistance. Such facilities to include small single or multiple field irrigation systems on minor drainages, flood irrigation from normally dry draws, local recharging of ground water supplies to make small pump irrigation developments possible, stock watering ponds and stock and domestic wells, etc.

3. Development of pump irrigation under statutory provisions to establish an orderly distribution of the underground water supply. Such provisions will insure maximum benefits from the available supply.

4. Construction of large-scale gravity irrigation projects (a) where feasible as to ability to repay total costs, (b) where the difference between the total cost and that portion of the cost which the land might reasonably be expected to repay could be financed by relief agencies under cooperative arrangements, or (c) where in the consideration of all possible phases of development of the water resources in a basin, such as flood control and irrigation, the portion of the total cost chargeable to irrigation is within the land's ability to repay.

5. Flood control dams as a part of a basin-wide plan of development for all water uses, including irrigation.

6. That some state agency be empowered to take an active part in the investigations and detailed planning necessary for the development of a comprehensive coordinated plan for the conservation of all available water wherever feasible.

The determination of the feasibility of large-scale gravity type irrigation projects as listed under item number 4 involves a number of factors some of which can be cleared up in existing records but many require detailed field studies to determine their effect on the feasibility of the project under consideration. The question of available water supply in the stream is generally a matter of record. Such questions as those of the best dam sites, acreage of suitable soils, and the portion with adaptable topography, require rather costly detailed field surveys. Such surveys have been and are being made by the several federal agencies with finances, organization, and legal authorization for such surveys. The conclusions contained in this report have been drawn from the best information available at this time, but, perhaps, further investigations will result in conclusions different from those herein presented.

In further explanation of item 4, it is noted that under the Reclamation law prior to 1939 all costs of reclamation projects were charged to irrigation with power revenues helping to repay the cost of construction and operation. Subsequent to the Reclamation Project Act of 1939, construction costs are allotted to irrigation, power and flood-control on the basis of probable benefits - with irrigation repaying only the amount allotted to it.

Also the Wheeler-Case law of 1939 authorizes the construction of projects with the aid of other Federal Relief agencies, but not to exceed the use of $1,000,000 for each project. This legislation providing for relief labor permits the construction of projects with costs in excess of repayment ability, and brings into the category of feasibility several projects which otherwise lack the necessary repayment ability.

PHYSICAL CHARACTERISTICS

LOCATION AND TOPOGRAPHY

LOCATION

The State of Nebraska is located a little north of the geographic center of the United States. The greater part of the State lies within the Great Plains; a vast eastward-sloping plateau located between the Rocky Mountains and the Central Lowland. In the eastern end of the State, a strip averaging 70 miles in width lies in the Dissected Till Plains section of the Central Lowland Province. This area approximately parallels the Missouri River. In Nebraska there are no well-marked surface features marking the boundary between the glaciated Central Lowland and the Great Plains. Along the eastern border in Nebraska the Great Plains merge into the more humid plains unmarked by any radical differences in altitude, topography, climate, or soil.

BOUNDARIES

The Missouri River is the only natural boundary of the State. It separates Nebraska from Missouri and Iowa on the east, and from South Dakota on the northeast. Political lines mark the boundaries between Nebraska and South Dakota on the north, Wyoming and Colorado on the west, and Colorado and Kansas on the south.

Nebraska extends from the 95th to 104th meridian west longitude and from 40th to 43rd parallel north latitude. The State is approximately 207 miles wide, 460 miles long with an area of about 77,520 square miles. The 100th meridian divides the State into 2 parts, approximately equal in size, and also into 2 different climatic regions.

TOPOGRAPHY

Nebraska has an expansive, gently rolling to rough topography. It is broken in places by low hills, occasional isolated buttes, mesas, "bad lands," ravines and several relatively shallow east-flowing streams. The most important streams of the State are the Missouri, Platte, Niobrara, Loup, Elkhorn, Nemaha, Blue and Republican.

The physical divisions of Nebraska as used in this report are the same as those developed by the United States Geologic Survey and Nevin Fenneman.

The surface of Nebraska slopes gently southeastward. The highest elevation of 5,340 feet is in Banner County, in western Nebraska, and the lowest point of 835 feet is in the extreme southeastern corner of Richardson County. The average decline in elevation from west to east is about 9 feet per mile. The average elevation of Nebraska approximates that of both the United States and the earth. These average elevations follow: (a) Nebraska, 2,547, (b) United States (excepting Alaska) 2,500 feet, and the (c) earth 2,800 feet.

PHYSICAL DIVISIONS

Nebraska lies wholly within a major physiographic division known as the Interior Plains, and is a part of the Great Plains and the Central Lowland provinces within the Interior Plains. Such divisions are based on similarity of surface features. Because of local differences in appearance, the area within the State is further divided into 4 sections known as the Missouri Plateau, the High Plains, and the Plains Border all within the Great Plains Province, and the Dissected Till Plains within the Central Lowlands.

(1) Missouri Plateau

The Missouri Plateau occupies only a small area in Northwest Nebraska amounting to approximately 3,400 square miles, or 4 per cent of the State. This region is so named because it is drained by the Missouri River and its tributaries. The Missouri Plateau has a topography resulting from degradation and extensive fluviatile terraces.

(2) High Plains

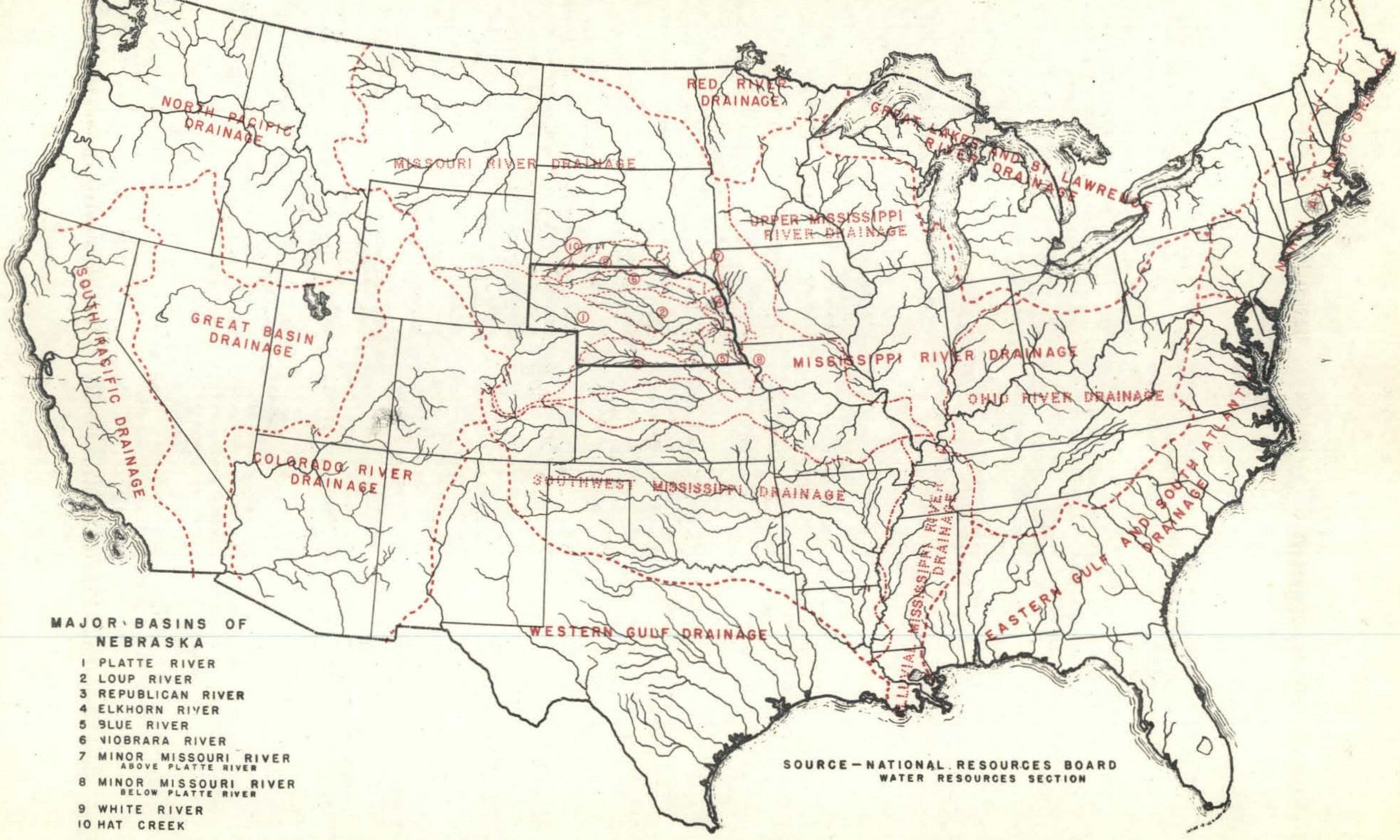
The High Plains Section as herein considered, comprises approximately 57,000 square miles or 74 per cent of the total area of Nebraska. This section extends from the 1,500-foot contour line, which approximately marks the eastern boundary of the Great Plains in Nebraska, to the base of the Rocky Mountains.

In the High Plains Section, flat-topped tablelands dominate the landscape. These are remnants of extensive depositional plains consisting of sands, gravels, and clays laid down by river outwash from the Rocky Mountains. The deposits range in thickness from 400 feet in the west to 100 feet in eastern Nebraska. In places the surface of the High Plains in Nebraska has been severely modified by erosion producing the Sand-Hill region by wind action and the Badlands by water erosion.

In western Nebraska the vertical walls bounding the Platte River Valley have been incised by tributary streams producing a series of promontories that project into the valley. Several such isolated buttes are known as Scotts Bluff, Chimney Röck, and Jail Rock. On the boundary between Wyoming and Nebraska, the North Platte River has windened its valley into a basin 20 to 30 miles across. This basin, surrounded by rather vertical walls, is known as Goshen Hole.

The Pine Ridge, a sandstone escarpment, forms a portion of the northern boundary of the High Plains. The abrupt drop to the north starts near Douglas, Wyoming and extends eastward for some 300 miles.

MAJOR DRAINAGE BASINS
NEBRASKA AND UNITED STATES

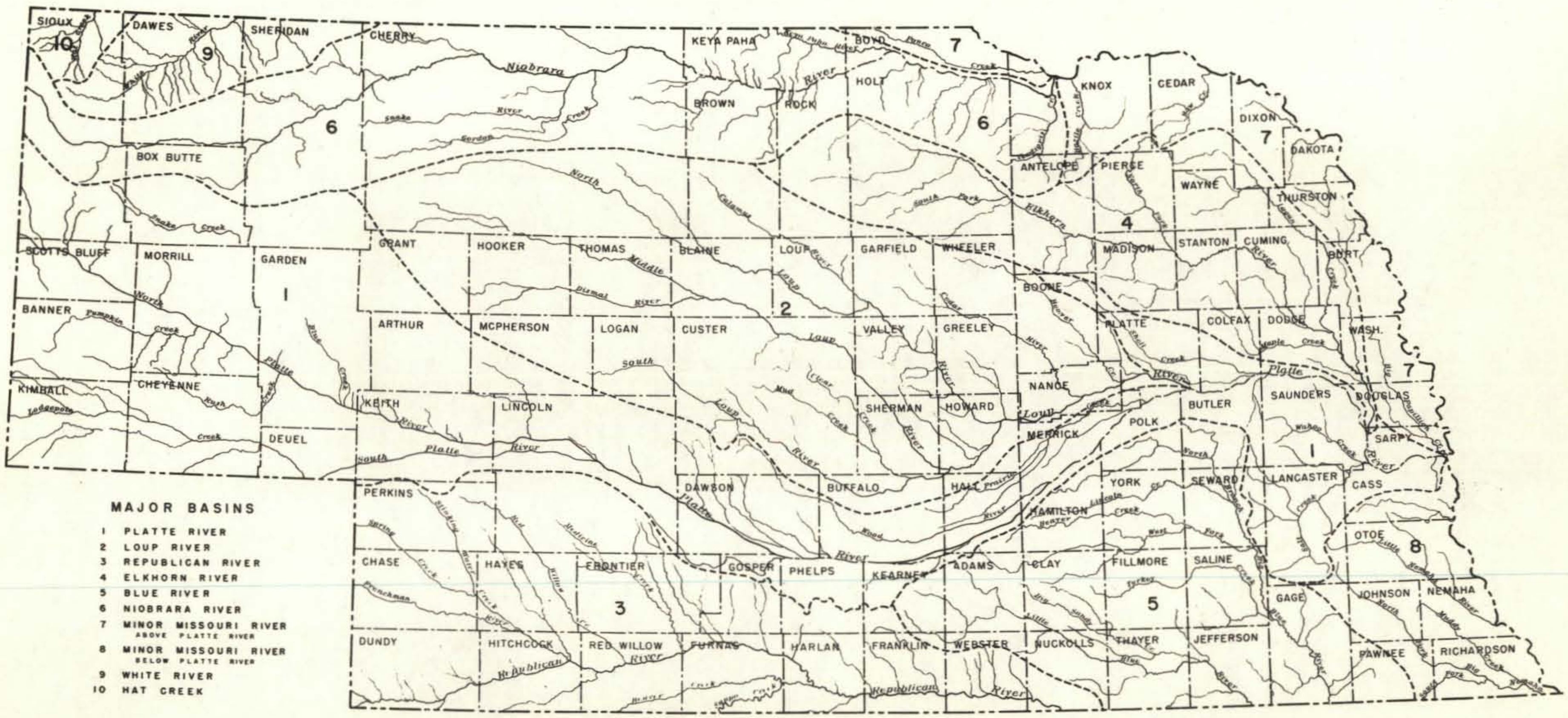


MAJOR BASINS OF NEBRASKA

1 PLATTE RIVER
2 LOUP RIVER
3 REPUBLICAN RIVER
4 ELKHORN RIVER
5 BLUE RIVER
6 NIOBRARA RIVER
7 MINOR MISSOURI RIVER ABOVE PLATTE RIVER
8 MINOR MISSOURI RIVER BELOW PLATTE RIVER
9 WHITE RIVER
10 HAT CREEK

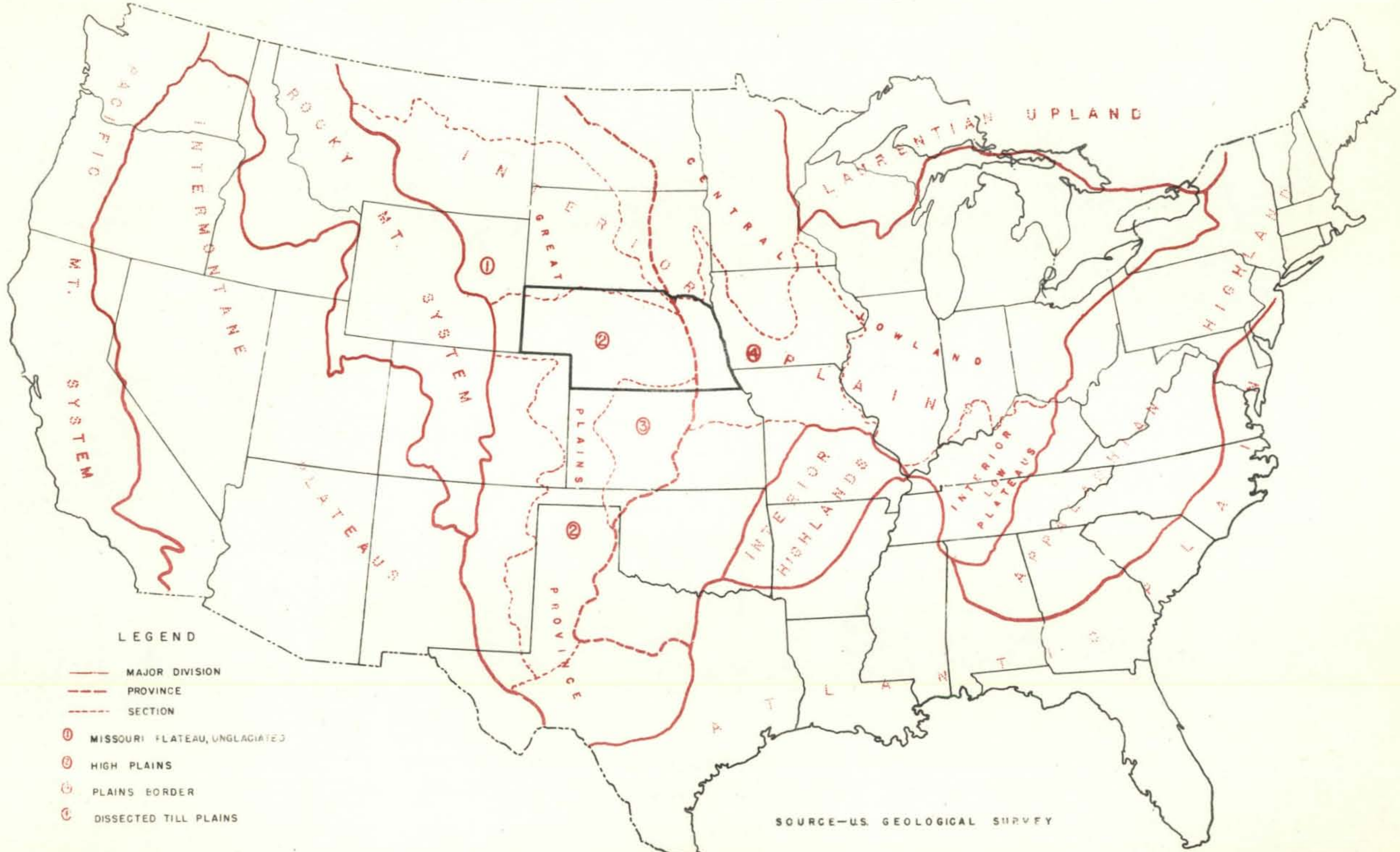
SOURCE — NATIONAL RESOURCES BOARD
WATER RESOURCES SECTION

MAJOR DRAINAGE BASINS
NEBRASKA



SOURCE: DRAINAGE BASIN DIVIDES AND STREAMS PLOTTED FROM U.S.D.A. AERIAL SURVEYS

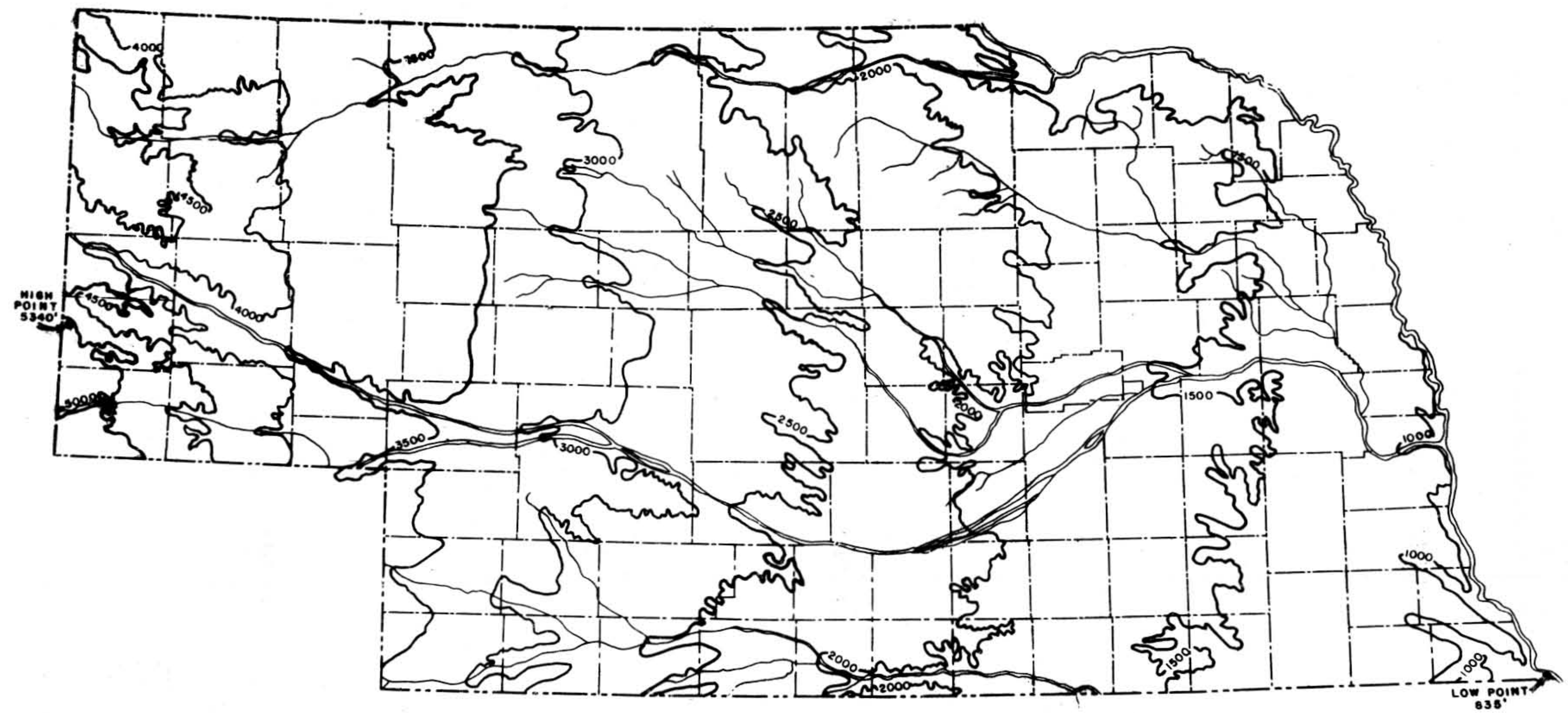
PHYSIOGRAPHIC DIVISIONS
NEBRASKA AND UNITED STATES



NEBRASKA STATE PLANNING BOARD

W.P.A. O.P. NO. 465-81-3-155

CONTOUR MAP OF NEBRASKA



SOURCE – DIVISION OF CONSERVATION AND SURVEY
UNIVERSITY OF NEBRASKA

From Pine Ridge to the Platte River the High Plains are comparatively level, except for valleys of secondary streams and sand hills. In north-central Nebraska the High Plains include an area of approximately 20,000 square miles of dunesand. The main surface features of the region are sand hills, small basins, dry valleys, wet valleys, marshes, and lakes. The sand hills were formed locally by the wind erosion of the sandy underlying bedrock and sandy mantlerock. They vary in height from 25 to 100 feet or more. The finer material was carried farther east by the wind, making loess deposits often 100 feet in thickness in eastern Nebraska, Kansas, and western Iowa.

The High Plains, from the Platte River to the southern boundary of the State, are gently rolling throughout. On the eastern margin they merge imperceptibly into the Central Lowlands with occasional exceptions. The western edge of the Central Lowlands is continually being pushed westward by the erosion of the eastern margin of the High Plains.

(3) Plains Border

A relatively small part amounting to 3,900 square miles, or 5 per cent, in southeastern Nebraska lies within the Plains Border. This area consists of a strip of rough country lying between the High Plains on the west and the broadening Central Lowlands on the east. It is an area from which the Tertiary Mantle has generally been removed by erosion, and which is now dissected but not reduced to the low, flat relief which characterizes the Central Lowland.

(4) Dissected Till Plains

Glaciation greatly influenced the geography of eastern Nebraska. Thick layers of glacial drift were deposited east of a line extending south of Boyd to York and Thayer counties coextensive with the drift of the Kansan and Nebraskan glaciers. These deposits occupy about 13,220 square miles or 17 per cent of the total area of the State.

The Dissected Till Plains were so named because they are chiefly occupied by hills formed in glacial drift. Some of these hills are thinly strewn with boulders and some are deeply gullied, but generally their surface is comparatively smooth.

The surface of the Dissected Till Plains is modified by numerous creeks and rivers and by uplands and hills capped with loess. Among the valleys which break the topography are those of Wahoo, Salt, and Weeping Water creeks, the Little Nemaha and Big Nemaha rivers, the lower courses of the Big Blue and Little Blue rivers in southeastern Nebraska and the Elkhorn River and Logan Creek in Northeastern Nebraska.

TOPOGRAPHIC UNITY

Although the topography of Nebraska shows considerable diversity, it presents marked geographic unity in compactness of area, general geologic structure, efficiency of rainfall, and utilization of the land. In these respects the different sections of the region have more similarities than dissimilarities.

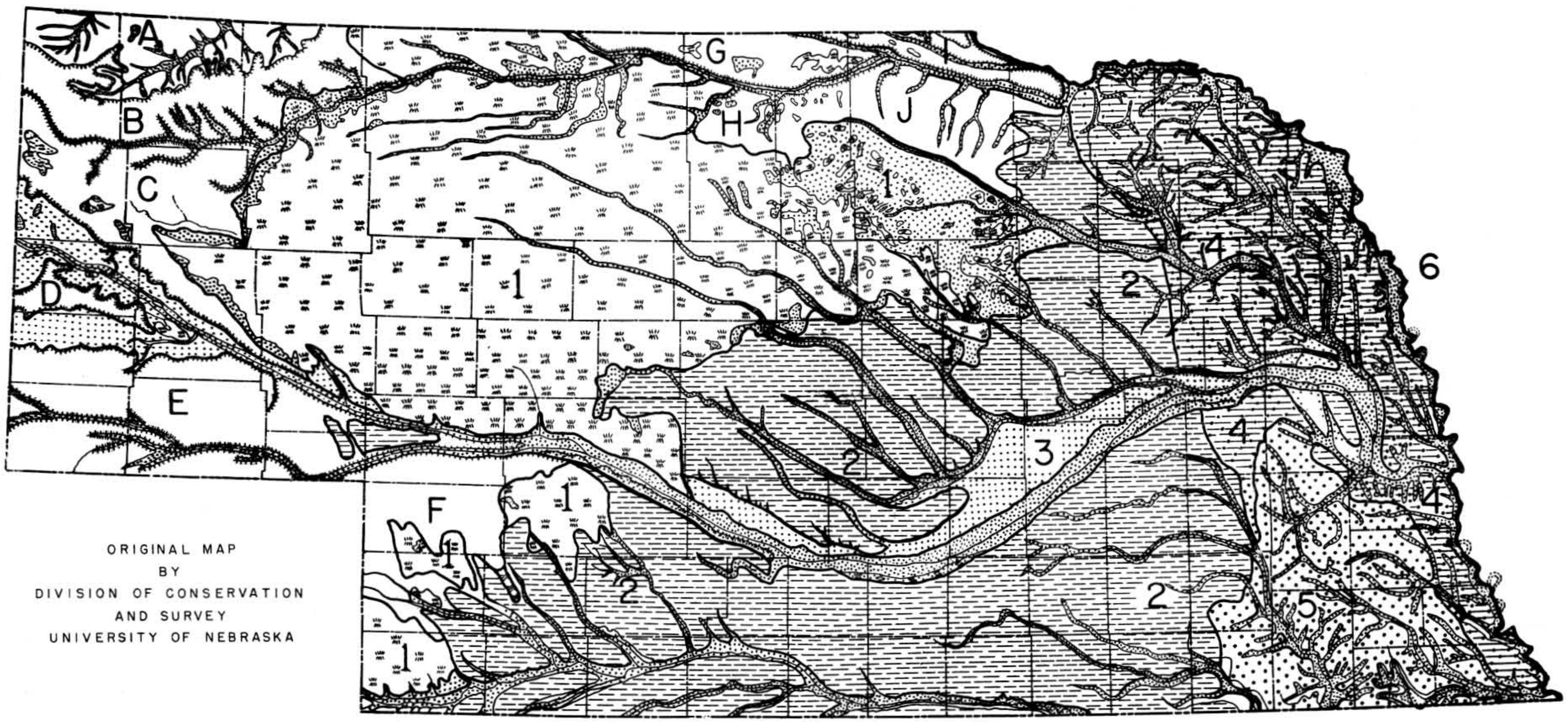
GENERAL GEOLOGY

A comparatively thick layer of mantlerock occurs over much of the State of Nebraska. Exposures of bedrock are limited to the tablelands and to the valleys of streams which have cut through the overlying mantlerock exposing the bedrock. The mantlerock, Pleistocene and recent in age, consists of relatively unconsolidated to loosely consolidated sedimentary material. During the Pleistocene Age eastern Nebraska was twice overridden by ice sheets; the first being known as the Nebraskan glacier and the second as the Kansan glacier. These ice sheets, upon melting and retreating northward, deposited the load of material which they had accumulated in their southward advance. The material thus deposited is a mixture of clay, silt, sand, and boulders known as till.

West of the area covered by ice, thick sands and gravels accumulated during the period of ice invasion. This accumulation was the result of increased precipitation, rapid erosion in the higher lands to the west, and deposition on the sloping plains of central Nebraska. The eastward-flowing streams were dammed by the advancing ice sheets, causing deposition of their load of sand and gravel. Subsequent to the second glacial advance, wind erosion increased during the dry periods of the Pleistocene resulting in the formation of the Loveland and Peorian loesses, which are accumulations of wind-blown dust. These extend over much of the area south and east of the Sand Hills. At the same time the dunesand of the Sand Hills was formed by the weathering and reworking of the sandy Tertiary bedrock and earlier Pleistocene sands and gravels.

The bedrock forms the platform upon which the mantlerock has been laid. The exposed bedrock includes, from oldest to youngest; the Permo-Pennsylvanian limestones and shales, the Dakota group of sandstones and shales, Graneros shale, Greenhorn limestone, Carlile shale, Niobrara chalk formation, Pierre shale, and Fox Hills-Laramie sandstones and shales. The above belong to the Cretaceous Age. The following bedrock formations; Brule-Chadron clays, Gering-Arikaree sandstones, and the Ogallala group limy sandstones, are of Tertiary Age.

MANTLE ROCK FORMATIONS
NEBRASKA

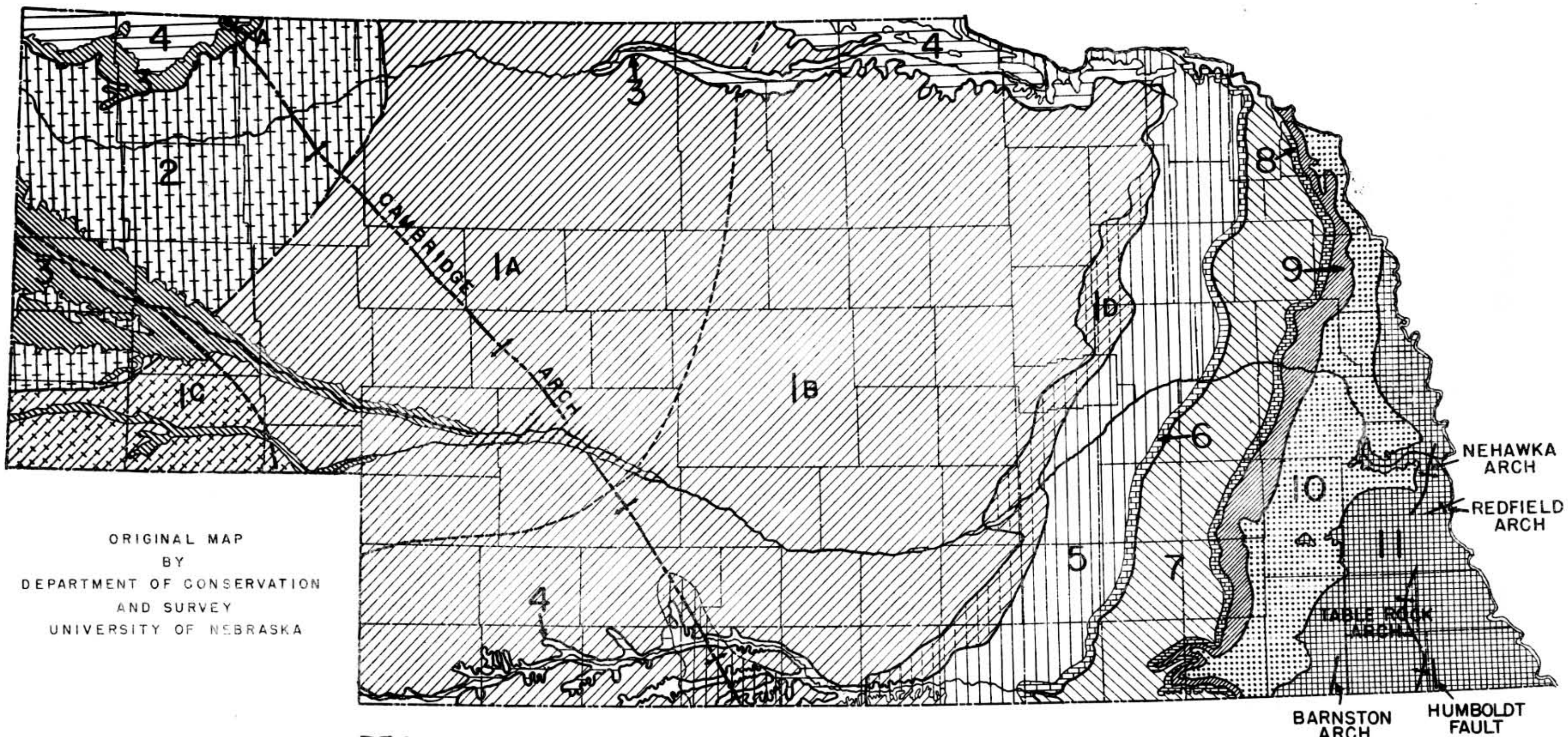


ORIGINAL MAP
BY
DIVISION OF CONSERVATION
AND SURVEY
UNIVERSITY OF NEBRASKA

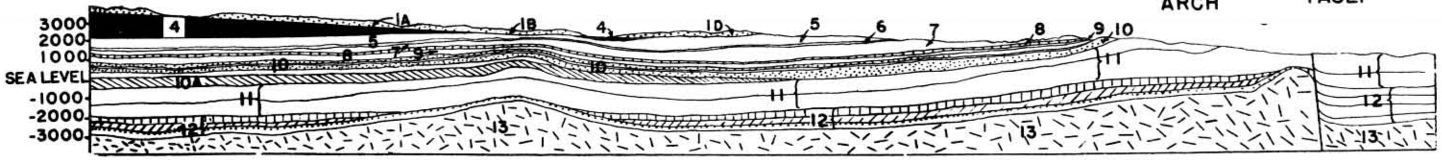
A-J AREAS OF LITTLE MANTLE ROCK: A-WHITE RIVER AND HAT CREEK BASINS, B-PINE RIDGE TABLE, C-BOX BUTTE TABLE, D-WILDCAT RIDGE, E-CHEYENNE TABLE, F-PERKINS TABLE, G-CROOKSTON-SPRINGVIEW TABLE, H-AINSWORTH TABLE, I-BOYD PLAIN, J-HOLT TABLE.

1-6 MANTLE ROCK AREAS: 1 DUNESAND AND SAND, 2-LOESS, 3-ALLUVIUM AND LOESS CAPPED TERRACES OF PLATTE VALLEY, 4-LOESS ON DRIFT, 5-DRIFT, 6-MISSOURI BOTTOMLAND ALLUVIUM.

BED ROCK MAP OF NEBRASKA



ORIGINAL MAP
BY
DEPARTMENT OF CONSERVATION
AND SURVEY
UNIVERSITY OF NEBRASKA



SECTION ON KANSAS—NEBRASKA LINE

MAJOR SOILS OF NEBRASKA

The earliest soil survey in Nebraska was made in 1903 by the Federal Division of Soils, now known as the Bureau of Chemistry and Soils. In 1912 the first appropriation was made by the Nebraska Legislature for use in classifying and mapping the soils of the State, by counties, in cooperation with the Federal Bureau. To date all of the counties are mapped in detail except 8 in the sand-hill region which have been covered by a soil reconnaissance and in which detailed work is now in progress.

As soil surveying is a relatively new science, it had to be learned step by step. The topographic relations, the great variety of parent soil materials, and the climate and vegetation, all of which affect the character of the soil, had to be evaluated as they were encountered in the field and the whole system of soil classification and mapping was perfected gradually. Some of the earlier surveys were rather general and are being revised. The recent work is on a sound scientific basis.

In the county surveys the soils are classified (1) according to their various characteristics such as color and depth of topsoil, lime content, texture, consistence or degree of compaction, moisture retaining capacity, and infiltration rate and other features which have a bearing on their productivity, use suitabilities, and cultural requirements. Areas of the different kinds of soil are delineated on soil maps which also show the location of cultural and drainage features.

The soil map is accompanied by a report which includes information concerning the topography, drainage, and climate of the county, the agricultural development, and the character of the soils. Information on relative productivity, management requirements, suitability for different crops, and susceptibility to erosion of each soil is also included in so far as determined by field experiments and observations.

In making a soil survey it is necessary to group the soils into mapping units on the basis of their external and internal features. The three principal units are: (1) series; (2) types; and (3) phase. In places 2 or more of these may occur in such a mixed pattern that they cannot be clearly shown separately on a map but must be mapped as (4) a complex. In addition there are areas of land, such as dunesand, river wash, et cetera, which have no true soil and are called (5) miscellaneous land types.

The most important of these units is the series which includes soils that have developed from similar, although not necessarily identical kinds of parent material and that have the same genetic horizons arranged alike in the soil profile. Thus, a series includes soils having essentially the same color, structure, and other important internal characteristics and the same natural drainage conditions and range in relief. The texture (2) of that portion of the soil commonly plowed may vary within a series. The series are given geographic names taken from localities near which they were first identified. Marshall, Carrington, Holdrege, and Crete are the names of important soil series in Nebraska.

Within a soil series are 1 or more soil types defined according to the texture in the upper part of the soil, usually to about the plow depth. The name of the soil texture to this depth, such as silt loam, clay loam, sand or fine sandy loam, is added to the series name to give the complete name of the soil type. For example, Marshall silt loam and Carrington fine sandy loam are soil types within the Marshall and Carrington series, respectively. The soil type is the principal unit of mapping, and because of its specific character is usually the unit to which agronomic data are definitely related.

A phase of a soil type is a soil which differs from the type in some minor feature, generally external, that may be of special importance in land use. Unusual variations in the relief or in the amount of stone on the land may necessitate the recognition of rolling, hilly, or stony phases of any given soil type.

To date, about 425 different kinds of soil, representing soil types and phases of 64 soil series, are recognized in Nebraska. In addition, several miscellaneous land types are mapped. These include badlands, dunesand, marsh, river wash, rough-broken land, and rough-stony land, all of which influence the agriculture in the localities of their occurrence.

The Generalized Soil Map of Nebraska, Plate VII, shows the general distribution of the more extensive soil series in the State. In the following paragraphs brief descriptions of these series are given and a few crop adaptions are explained.

BOYD SERIES

The Boyd soils have developed on bluish-gray, dense-clay shales of the Pierre formation over large areas in South Dakota and tracts of considerable size in northeastern and north-central Nebraska. They occupy areas ranging from nearly level to hilly and broken, but most of them, in this State, are on steep valley sides where run-off is rapid and erosion is severe. These soils receive enough precipitation to support a mixture of plains and prairie grasses and produce rapid vegetal decay but the moisture does not penetrate the ground deeply.

The soil section is composed mainly of heavy intractable clay although the surface layer, which averages about 8 inches in thickness, has an abundance of decomposed grass remains in the smoother areas where it is almost black. Its high organic-matter content makes this layer quite friable when moderately supplied with moisture. When extremely wet or dry, the Boyd soils are difficult to handle. Most of them are immaturely developed and rest on the parent shale within a depth of 3 feet. They are limy below 12 inches, and, except in severely eroded areas, there is a noticeable zone of lime accumulation in the subsoil. Their water-holding capacity is high but they absorb moisture slowly and the greater part of the precipitation runs off or evaporates without materially benefiting the vegetation.

Owing to their generally unfavorable surface features, slow moisture absorbing rate, and to their intractable nature except under favorable moisture conditions, most of these soils are better suited for the production of pasture and hay grasses than for cultivation. They contain variable quantities of selenium which is highly toxic to animals and which in some areas is taken up by plants in amounts injurious to livestock. Corn, oats, millet, and sorgo are grown on the smoother tracts where they do fairly well in seasons of normal or above normal precipitation, but the land is rather droughty and crop yields are lower than on more friable soils.

BUTLER, FILLMORE, AND SCOTT SERIES

These soils, only the larger areas of which are indicated on the accompanying map, owe their features mainly to poor or imperfect drainage. They are principally in small shallow basins, locally known as "buffalo wallows" or "lagoons", scattered throughout the finer textured and more nearly level-lying soils of the uplands and terraces. They have developed on loess, a light-colored floury silt, which has or formerly had, some lime. The Scott soils are also developed on limy clays and fine-grained sandstones. They have the poorest drainage of any soils on the uplands or terraces in Nebraska. Storm water collects in the basins where they occur and often remains on the surface for several weeks, disappearing slowly through seepage and evaporation. The Fillmore soils are in poorly drained basins but have not been subjected to such prolonged inundations as have the Scott. The Butler soils are mostly in barely perceptible basins, and on nearly level areas where drainage is imperfect but where water stands on the land only at places and for short periods. In eastern Nebraska some of the Butler soils are on slight slopes where surface drainage, although good, is slow.

Differences in the drainage conditions have caused marked differences especially in the subsoil layers of these soils. All of the subsoils have a well developed claypan due to the downward translocation of clay by percolation waters. In the Scott types the claypan is very thick, is bluish-gray and is thoroughly leached of lime, whereas in the Fillmore and Butler types it is much thinner, is almost black and has a well-developed zone of lime accumulation near its base. The surface soils of the Scott and Fillmore types are dark and mellow, especially in the upper part, and at most places rest on the claypan within depths of 6 and 8 inches respectively. The surface layers of the Butler types average about 15 inches thick, and are separated from the claypan by several inches of friable subsoil material. They contain an abundance of silt and are friable throughout.

Most areas of Scott or Fillmore soils are unsuited for cultivated crops on account of poor drainage and the shallow depth to the claypan. They are chiefly suitable for native pasture and hay land.

The Butler soils, as a whole, are well suited for the production of all crops commonly grown in the State. Their general productivity may be somewhat reduced in dry years by the relatively impervious claypan layer, but most of them are in southeastern Nebraska where the precipitation is sufficient to largely offset the deleterious effect of this layer.

CARRINGTON AND SHELBY SERIES

The Carrington and Shelby soils are on strongly rolling to hilly uplands in southeastern and northeastern Nebraska where they have developed from the weathered surface of glacial drift. They also occur in Iowa, Missouri, and Minnesota. The drift is extremely variable in texture but generally contains considerable amounts of coarse material including gravel and boulders of various sizes mixed with its more abundant silt and clay constituents. It was left by the ice during glacial times and was later covered by Peorian loess. The loess was subsequently removed over considerable areas by erosion, exposing the drift to weathering and soil development.

All areas occupied by Carrington and Shelby soils have adequate surface drainage. On most of the steeper slopes rapid run-off has caused considerable erosion in cultivated fields. The Carrington soils are in the less steeply sloping areas. They have maturely developed profiles including very dark, granular, and friable surface soils from 10 to 15 inches thick, underlain by brownish, moderately heavy subsoils which rest on weathered drift at about a 4-foot depth. The entire soil section has been leached of its lime. These soils are suited to any crop commonly grown in eastern Nebraska. Nearly all of them are under cultivation, chiefly for corn. They have a higher clay content and slower infiltration rate than some of the associated more friable soils developed on loess. However, they are in the highest precipitation belts of the State where moisture is sufficient for satisfactory yields, even on the heavier soils, except during the driest years. At places their surface layers are slightly acid.

The Shelby soils are on the steeper slopes and sharper hill and ridge-tops where rapid run-off has prevented the development of mature soils or has subsequently removed much of the developed soil material. They are everywhere immature with thin-dark to light-colored surface layers. At most places they rest on drift within a depth of 2 feet. Locally the drift is exposed. These soils are not well suited for cultivated crops owing chiefly to their shallow nature, unfavorable surface features, and rather low organic-matter content. Locally, they contain an abundance of coarse glacial gravel and boulders. They erode rapidly under tillage unless carefully managed but are well suited for pasture land.

CRETE SERIES

The Crete soils are on nearly level tablelands mainly in south-central Nebraska and the adjoining part of Kansas. They have developed on Peorian loess under the influence of a moderate precipitation, slow surface and under-drainage and a mixture of plains and prairie grasses. They have almost black, silty, and friable surface soils, from 12 to 14 inches thick. The upper part of the subsoil is a brownish, almost impervious claypan produced by fine mineral material released mainly from the overlying layer and carried down by percolating water. The lower part of the subsoil, a zone of lime enrichment, consists of friable silt or silty clay containing an abundance of lime. It rests at a depth of about 40 inches on the parent loess, which may or may not be limy.

Within areas of Crete soils are numerous shallow, poorly drained basins occupied by Scott, Fillmore, and Butler soils. Small undulating areas of Hastings soils and narrow steeply sloping strips of Colby soils are too small for differentiation on the accompanying map.

Prior to 1923 areas now known to be occupied by Crete soils were shown on the county soil maps as Grundy soils which are no longer recognized in Nebraska.

Although the Crete types include a claypan in their subsoils, they are in a region where the precipitation is sufficient for satisfactory yields of most crops and practically all of them are under cultivation. Wheat and corn are the principal crops. Wheat usually does better than corn because it matures earlier in the summer while the moisture stored above the claypan from winter and spring precipitation is sufficient to maintain normal or near-normal growth. The claypan and underlying layers of this soil probably do not supply much moisture to grain crops.

DAWES AND DUNLAP SERIES

The Dawes and Dunlap soils are on nearly level to gently sloping areas and in shallow sags or basins, scattered over the uplands in western Nebraska. They have developed under the influence of a low precipitation, short plains grasses, and slow surface and under-drainage, mostly from limy Tertiary sandstones and clays. Some of them have developed, in part at least, from wind-blown silts deposited since Tertiary times.

The surface layers of these soils are dark brown, being somewhat lighter in color than those of soils on similar relief farther east. They are everywhere friable, are composed at most places mainly of silt and range from 9 to 12 inches in thickness. The subsoils in the Dunlap types are thick and moderately heavy with a friable zone of lime enrichment beginning at about a 3-foot depth. Those in the Dawes soils are thin with a heavy claypan layer in the upper part and the friable lime zone begins at about a 2-foot depth.

Practically all areas of these soils are under cultivation. The Dunlap types, which are chiefly in the northwestern part of the State, are among the most productive dry-farming soils of the uplands in that region. They are used chiefly for growing winter wheat, rye, oats, and potatoes, which yield profitably except in the driest years. The Dawes soils, chiefly located in southwestern Nebraska, are used mainly for corn and winter wheat production, but to some extent for growing sorgo. Their heavy claypans limit the storage of readily available moisture largely to the surface soils which may become too dry for profitable corn yields in seasons of subnormal precipitation. Where they occupy depressions, however, the Dawes soils seldom dry out sufficiently to cause total corn failures. They are only slightly inferior to the Dunlap soils for wheat production and are well suited for growing sorgo.

DUNESAND AND THE VALENTINE, GANNETT, AND ANSELMO SERIES

Dunesand and the soils of the Valentine, Gannett and Anselmo series, collectively, occupy several thousand square miles in the vast sand-hill region of north-central and southwestern Nebraska and adjacent part of South Dakota and Colorado. Throughout this region the land is mantled with sand or extremely sandy soil absorbs practically all of the precipitation as rapidly as it falls. Despite the coarse texture of its surface this land is not droughty. The sandy materials act as highly efficient reservoirs for the storage of moisture for plants. They not only absorb the precipitation but permit little moisture to be lost through evaporation, and in the climatic region of their occurrence, are able to hold most of the absorbed water until it is needed by the vegetation. Even the most sandy material of the region can hold at least 6 inches of water within a depth of 6 feet where it is accessible to the roots of most plants. Since this material continually delivers moisture to the vegetation during the growing season, a close balance is maintained between the amount of water taken in from precipitation and the amount removed by plants. Thus, not much of the moderate rainfall can seep to the water table during that season. Most of the water reaching surface drainage in the sand hills percolates below the reach of plant roots when the vegetation is dormant. Were it not for their unstable nature under tillage and low supply of plant nutrients, many of the soils in this region would be better suited for cultivated crops than are most "hard-land" soils which lose more than half of the precipitation through run-off and evaporation even on the smoother areas.

Dunesand, although not a soil, is far more extensive than any of the soils in the sand-hill region. It consists of a monotonous succession of irregularly distributed hills and ridges which are composed entirely of gray sand or are thickly capped with this material. The higher intervening sand valleys, pockets, and swales are occupied by the Valentine soils, and the lower and moister ones by the Gannett soils which lie at or near the level of the water table. The Anselmo soils are in the broad well-drained valleys mostly between the sand-hill and loess regions, where they have developed on mixtures of sand and loess.

Owing largely to the resistance of their sandy parent materials, none of these soils have well developed zones or layers of true soil character. Aside from the Gannett types they are low in lime, have accumulated little organic matter, and have thin, light-brown surface soils. The subsoils in the Valentine types consist of incoherent gray sand, whereas the corresponding layers in the Anselmo soils are composed of light-brown fine, sandy loam to loamy sand. The Gannett types have developed under excessive moisture, and the rapid growth and decay of tall grasses, rushes, and sedges. These types have thick, highly organic and almost black surface layers overlying water-logged sand subsoils in which occurs a thin greenish-blue layer of sandy clay at or near the top of the water table. They are faintly limy in most places.

Except locally, the region occupied by dunesand and associated sandy soils is better suited for pasture and hay land than for the production of cultivated crops. The largest cattle ranches of the State are located in this region. The utilization of dunesand and the greater part of the Valentine soils depends almost entirely upon preservation of the grass cover. When cultivated, the sand drifts and the land becomes useless even for grazing purposes. The Sand Hills are well grassed at present, except locally. They include some of the most dependable grazing land in Nebraska.

The Gannett soils are too wet for cultivation but rank among the most productive for native hay in the plains region. They supply most of the hay used for carrying cattle through the winter months in the Sand Hills.

The greater part of the Anselmo soils is fairly stable under cultivation and is used chiefly for growing corn. These soils give profitable yields even in the drier years. They usually occupy only a small part of the ranches on which they occur.

EPPING AND ORELLA SERIES

The Epping and Orella soils are in northwestern Nebraska and adjacent parts of Wyoming and South Dakota where they occur over limy Tertiary clays and silty clays; chiefly in undulating to rolling areas. Many of them are on steep and gentle slopes. A part of the Orella soils in Wyoming are in valley-like situations. All types of these series are developing under a low precipitation, short plains grasses, and slow vegetal decay. The Epping soils are on the more silty and less variegated beds of the Brule and Chadron formations; whereas, the Orella types are mostly on the more variegated (gray, green, and red) clay and sandy clay beds of the Chadron formation which underlies the Brule.

These soils are very immature with thin grayish-brown to dark grayish-brown, silty to clayey surface soils that are low in organic matter and rest on the parent formations usually within a depth of 9 inches. They have slow infiltration rates and the greater part of the precipitation runs off or evaporates without greatly benefiting the vegetation. Most of them erode easily and the areas include exposures of the underlying parent material which give the land surface a spotted dark and light appearance. They are developing on the same formations from which the badlands of South Dakota have eroded and at places include patches of incipient badlands in Nebraska.

None of the Epping and Orella soils are well-suited for dry-land farming, chiefly on account of the thin surface soil and slow infiltration rate. Many tracts are too gullied for cultivation. Some of the smoother areas are used for growing wheat and rye but satisfactory yields of these crops are obtained only in years of high precipitation. The greater part of the land is still covered with buffalo and grama grasses and is included in pastures. The grazing value of the range on the Epping is slightly higher than that on the Orella soils. In Goshen County, Wyoming some of the lower and more nearly level-lying Orella types are used for growing sugar beets under irrigation.

HASTINGS SERIES

The soils of the Hastings series are transitional in character between the Crete and Holdrege soils. They are on the nearly level to undulating loess-mantled uplands in east-central Nebraska where they have developed under an annual precipitation of from 24 to 28 inches, good external drainage, and a vegetal cover consisting chiefly of prairie grasses.

The surface soils, which average about 14 inches in thickness, have accumulated much organic matter through the decay of grass roots, which makes them almost black. They are very friable. The silt loam texture predominates. The upper part of the subsoil has received considerable clay, carried down from the surface layer by percolating water. It is heavier than the corresponding layer of the Holdrege types but is not as dense as the claypan in the Crete soils. It is easily penetrated by air, moisture, and crop roots. The lower part of the subsoil, beginning at an average depth of 4.5 feet, is a zone of lime enrichment. It consists of light-gray, friable and highly-calcareous silt or silt loam which merges into the parent Peorian loess at about a 6-foot depth.

The Hastings types rank among the most productive soils on the uplands of Nebraska for corn, wheat, oats, alfalfa, and other crops commonly grown in the eastern and central parts of the State. Their silty stone-free nature, high organic-matter content, good drainage, and, except locally, their freedom from excessive wind or water erosion combine to make them well suited for general farming purposes.

HOLDREGE AND COLBY SERIES

The soils of these series occupy most of the loess-mantled uplands in central and south-central Nebraska, and cover large areas in Kansas. The Holdrege types are on the nearly level to gently rolling areas where conditions have been favorable for normal soil development. In most characteristics they are similar to the Hastings soils. The precipitation, however, is slightly lower, the grass growth is a little less luxuriant, and vegetal decay, although sufficiently rapid to supply an abundance of organic matter, is somewhat slower than in the Hastings soil region. As a result of these differences, the surface soils of the Holdrege types, although almost as black as those of the Hastings, are a trifle thinner, averaging only about 12 inches in depth. The subsoils have received less clay and are more friable than those of the Hastings soils and the zone of lime enrichment lies higher in the soil section, usually between depths of 36 and 48 inches. The Holdrege soils rest on limy Peorian loess similar to that on which the Hastings soils have developed.

The Colby soils of this State are mostly within larger areas of Holdrege soils, but occupy steeply sloping areas where rapid surface run-off removes the products of soil development almost as fast as formed, and keeps the raw, limy loess at or near the surface of the ground. In Nebraska, the Colby soils are chiefly in hilly areas adjacent to deeply entrenched streams and on the steeper slopes of valleys and canyons which have extended through headward erosion into the Holdrege soil areas. Their surface layers are silty but very thin and at most places are light colored. They rest, usually within a depth of 6 inches, on the parent loess. Many of the steeper slopes within areas of these soils, are characterized by short vertical breaks, known as "cat steps", caused by soil slipping.

In Kansas, the Colby soils, although formed on loess, are in a more westerly and drier region than they are in Nebraska, and on smoother terrain. There they are fully developed and owe their features more to the semiarid climate than to erosion.

The Holdrege and Colby soils of Nebraska, although closely associated, differ widely in use capabilities. The Holdrege types are well suited for general farming. They are as productive as any of the soils on the uplands in the climatic region of their occurrence and are used for growing all the staple crops commonly produced in the State. They give somewhat lower yields than are obtained on the best soils of upland areas farther east, but this is owing more to the lower precipitation in the Holdrege region than to any deficiency in the soils.

The Colby soils are not well suited for cultivation chiefly because of unfavorable relief, low organic-matter content, and susceptibility to erosion. Most areas of these soils are included in pastures, although hay and cultivated crops are produced on the more gradual slopes.

HOLT SERIES

The Holt soils are on soft, light-colored, and limy sandstone of the Ogallala formation in northeastern and north-central Nebraska and adjacent parts of South Dakota. They occupy uplands ranging from undulating to steeply sloping or hilly. In this State most of them are in areas of rolling to strongly rolling relief. The precipitation under which they have developed has been sufficient to support a mixture of prairie and plains grasses, and to promote moderately rapid vegetal decay.

The Holt soils are everywhere friable. In their more nearly level distribution, their surface layers are thick, well supplied with organic matter, and very dark. Loam, or one of the sandy-loam textures predominate in most places. The subsoils, which are rather thin, consist of light-colored, fine sandy loam to sandy loam with a pronounced zone of lime enrichment in the lower part. They gradually become coarser downward and at about 3 feet merge with the underlying sandstone, fragments of which may occur throughout the soil section.

In their more steeply sloping or hilly distribution the surface layers of these soils, although dark, are thin; the subsoils are rather poorly developed with barely perceptible zones of lime enrichment, and the sandstone bedrock is usually within a depth of 2 feet.

All types of this series absorb the precipitation readily. Considering their shallow profiles, they have high moisture-holding capacities. On the more nearly level areas they are admirably suited for general farming and practically all these areas are under cultivation. Corn is grown chiefly. The rougher areas are suitable mainly for pasture land. In some of them the surface soils are rather sandy and have a tendency to drift when the protective grasses are destroyed.

KEITH AND COLBY SERIES

The Keith soils are on the most westerly part of the smooth loess-mantled uplands in Nebraska; and occur extensively in western Kansas. They resemble the Holdrege soils in many respects but have developed under the influence of a drier climate, less abundant vegetation consisting mainly of short plains grasses, and slower vegetal decay. The rather low precipitation of from 18 to 20 inches, has not penetrated the ground deeply. As a result of these influences the surface soils, which average about 10 inches in thickness, are dark brown instead of almost black as in the Holdrege types. The silt-loam texture predominates. The upper part of the subsoil is composed of brownish-gray friable silt loam. The lower part; as in all normally developed soils of central and western Nebraska, is the zone of lime enrichment. It begins usually at about a 30-inch depth, consists of grayish-white limy and floury silt and extends downward 8 or 10 inches where it rests on the parent Peorian loess.

The Keith types are among the best dry-farming soils on the uplands in the western parts of Nebraska and Kansas. Nearly all the area occupied by them is used for growing corn, wheat, and oats. Some sorgo is also produced. The yeilds vary in proportion to the amount of available moisture, which is the chief farming hazard in this region. These soils have sufficient nutrient reserve to permit higher crop yields than the precipitation can maintain. In years of normal or subnormal rainfall they are considerably less productive than the Holdrege soils, which are farther east. In wet years, crops on the Keith types may produce more than double their average yields.

The soils of the Colby series bear the same relationship to both the Keith and the Holdrege soils. They occupy the rougher, more severely eroded parts of the loessial uplands in both the Holdrege and Keith soils areas, and are described in connection with Holdrege soils.

MARSHALL AND KNOX SERIES

The Marshall and Knox soils are mainly in eastern Nebraska and western Iowa where they have developed, or are developing, on upland areas of Peorian loess in a region of rather high precipitation and rapid vegetal decay--the Marshall under prairie grasses and the Knox under both grass and forest growth. A modified form of the Marshall types occurs locally in north-central Nebraska on unusually thin loess deposits overlying sand.

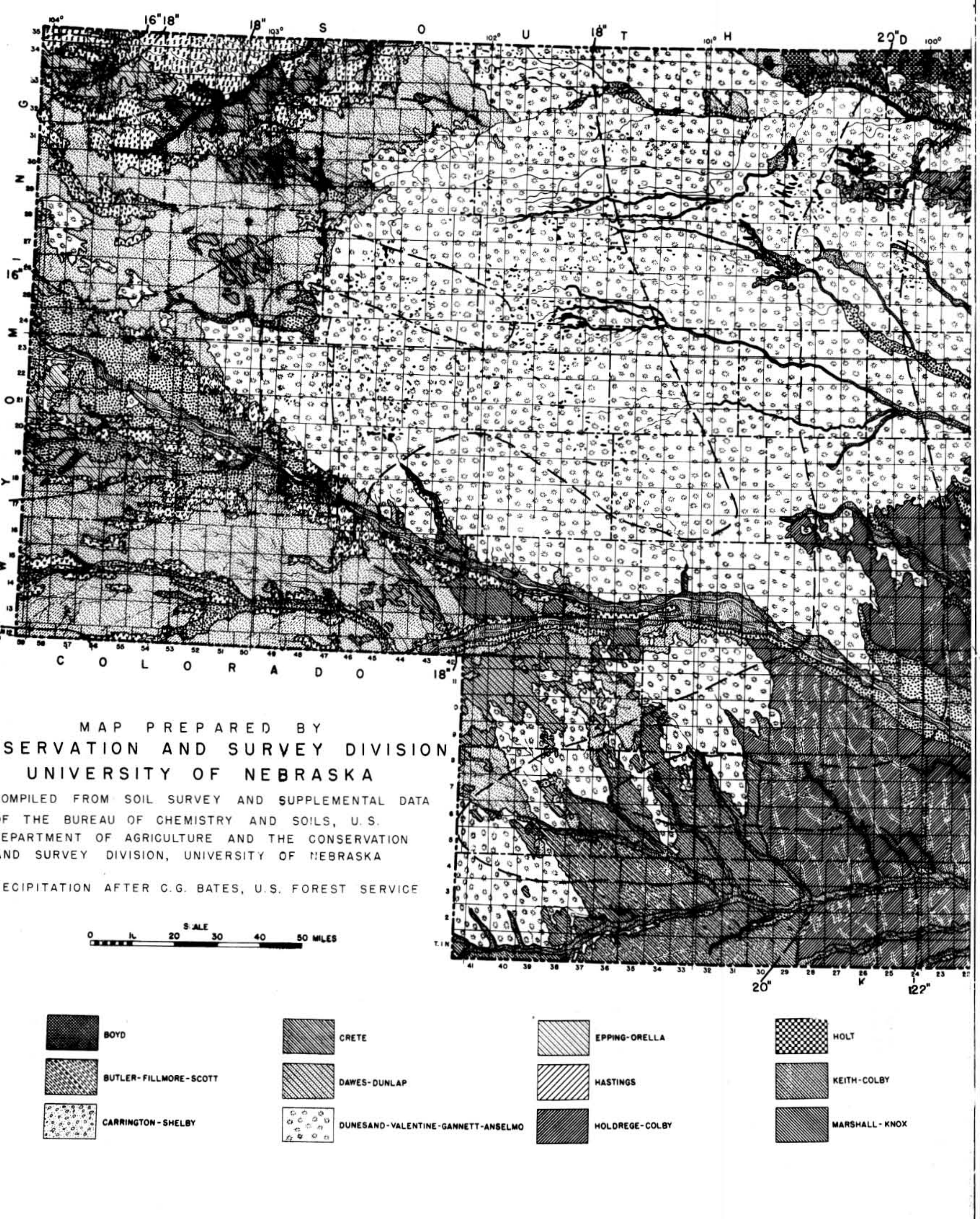
The relief in areas of these soils ranges from nearly level to extremely rough and broken. The Marshall types are in undulating to rolling areas where water run-off has not prevented the accumulation of organic matter. They are everywhere well drained. In many of the cultivated fields they are subject to considerable erosion. The surface soils range from about 10 to nearly 20 inches in thickness, the depth depending on the erosion conditions both during and subsequent to their development. They have accumulated an abundance of organic matter, are nearly black and are granular and friable throughout. The silt-loam texture predominates. The upper part of the subsoil is brown, and although less granular than the overlying layer, is very friable. It rests on light-brown silt loam of the lower subsoil which merges with grayish-white floury silt of the parent Peorian loess at depths ranging from 4 to 6 feet.

The Marshall soils are rather low but not deficient in lime. In most areas of these soils there are places where part of the lime, formerly present in the parent loess still remains in the lower part of the soil section.

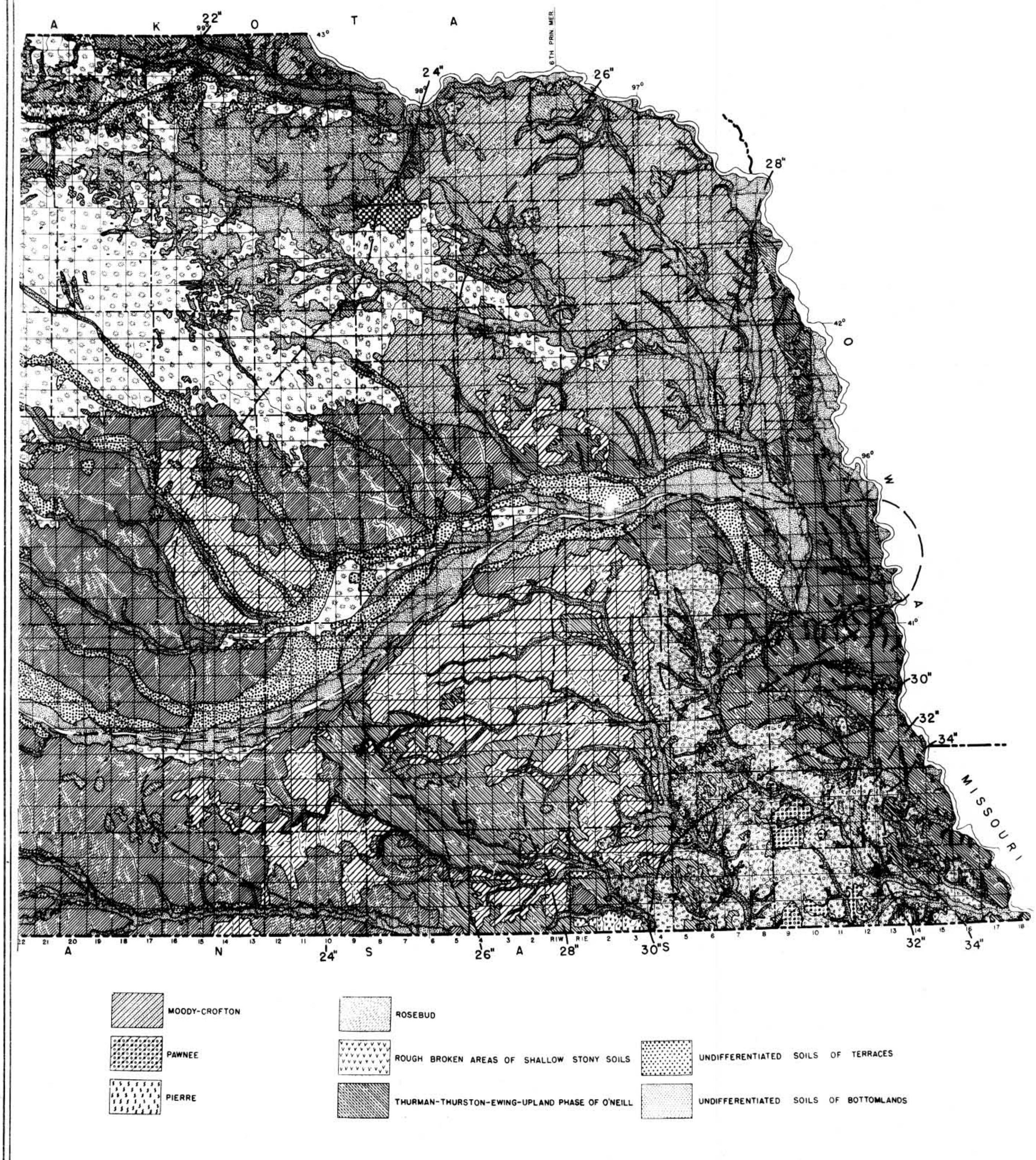
The Marshall soils are commonly regarded as the best general farming soils of the uplands in Nebraska. Most of the area occupied by them has been under cultivation since early settlement. They are well suited for growing all the staple crops commonly produced in the State.

The Knox soils occupy those parts of the loess-mantled upland where erosion has prevented the development of Marshall soil or has removed all or part of the Marshall profile subsequent to its development. They are chiefly in steeply sloping and rough and broken areas bordering deep drainage ways. Some of the largest developments are in the bluff-lands along either side of Missouri River. These soils are mostly timbered, although some areas in cultivated fields formerly supported a grass cover. They consist mainly of slightly oxidized, brownish-colored floury silt, the top 4- to 6-inch layer of which may or may not be darkened by organic matter. Most of the Knox soils are limy to or near the surface of the ground.

GENERALIZED
NEBR



SOIL MAP
ASKA



The greater part of the Knox soil area is included in pastures and woodlands although a large percentage is under cultivation or in orchards. These soils are highly productive considering their shallow character and low organic-matter content. Under careful management, designed to retard erosion and supply nitrogen, they are well suited for growing the staple farm crops wherever the land is not too steeply sloping for cultivation. They are admirably suited for apple and grape production.

MOODY AND CROFTON SERIES

The Moody soils have developed under mixed plains and prairie grasses from unusually limy loess deposits and are very dark and friable. They occupy nearly level to strongly rolling uplands over most of northeastern Nebraska and the adjacent parts of Iowa, Minnesota, and South Dakota. All of them have good surface and under-drainage, the former being rather rapid and causing considerable erosion in places. These soils have almost black surface layers and are somewhat similar to the Holdrege soils of south-central Nebraska and northern Kansas but differ from them in having slightly thinner surface soils and more limy subsoils. Their outstanding feature, and the one which serves to distinguish them from most other loess-derived soils, is a subsoil zone, which is unusually rich in small lime concretions. This zone, which is very light-colored, rests on extremely limy loess at about a 30-inch depth. The loess has few or no lime concretions.

The Moody soils are well suited for all the staple crops of the region with the possible exception of wheat, which seems to be more frequently injured by rust in northeastern Nebraska than elsewhere in the State. This probably is due to climatic influences rather than to the character of the soil. Nearly all the Moody soils are used for growing corn, oats, and alfalfa which yield about the same as on the Marshall soils, or only slightly lower.

The Crofton soils occupy severely eroded tracts within the Moody soil areas. They are simply Moody soils from which erosion has removed all or most of the upper soil material keeping the concretionary zone on or near the top of the ground. Any surface soil which may be present is silty, friable, almost black and does not ordinarily exceed 5 inches in thickness. The zone of lime concretions serves to distinguish the Crofton from the closely associated, but more severely eroded, Knox soils in which no concretionary zone occurs.

The Crofton soils are not very extensive. Most of them are on the steeper parts of cultivated fields. They grow the same crops as the surrounding Moody soils but require more careful management than the Moody and are not quite as productive. They can be profitably farmed if means are taken to curtail erosion and maintain an adequate nitrogen supply. Some of these soils in the blufflands along Missouri River are on slopes too steep for cultivation and are included in pasture land.

PAWNEE SERIES

The Pawnee series includes claypan soils on the weathered surface of glacial drift in southeastern Nebraska and northeastern Kansas. These soils occupy undulating to rolling areas in which the drift is composed mainly of clay with relatively small admixtures of sand and gravel. Surface drainage is everywhere good, and on some of the more rolling areas rapid run-off has caused considerable erosion in cultivated fields. Internal drainage is imperfect owing to slow infiltration through the claypan. The precipitation has been sufficient for prairie grasses and rapid vegetal decay. Most of these soils have accumulated an abundance of thoroughly decomposed organic remains. The surface soils average about 10 inches in thickness, and, except on the steeper slopes, are almost black. They are very granular but their clay content makes them less friable than the surface layers of most loess-derived soils. The silt loam, loam, and clay-loam textures predominate. The upper part of the subsoil is dark grayish-brown, heavy clay loam. This rests abruptly at a depth ranging between 14 and 20 inches on the claypan, which consists of almost impervious brown to dark-brown gritty clay from 8 to 15 inches thick. The claypan is underlain by a moderately friable, light-colored zone of lime enrichment which merges with the parent drift, usually within a 5-foot depth.

The Pawnee soils absorb water slowly, losing much of it through run-off. Their rather heavy surface layers make cultivation difficult except under a narrow range of soil-moisture conditions. In places these layers have been so thoroughly leached of lime that they are becoming injuriously acid for crops requiring a high lime content. The soils are not deficient in plant nutrients. Their location in a region of sufficient precipitation prevents them from becoming droughty except in occasional years. Under careful management they are almost as productive of the staple crops as are the most friable soils of the smooth, loess-mantled uplands. Some lime is needed to counteract acidity in places, especially if alfalfa is grown. The more rolling areas of these soils are best suited for pasture land.

PIERRE SERIES

The Pierre soils differ from those of the Boyd series mainly in having lighter-colored surface layers and thinner profiles. They have developed on bluish-gray, dense, clay shales of the Pierre formation as have the Boyd soils but are in a region of lower precipitation, shorter grasses, and a slower vegetal decay. They occupy well-drained, rolling to hilly uplands in the White River and Hat Creek drainage basins of Nebraska, and cover much of South Dakota west of Missouri River.

These soils, like those of the Boyd series, consist mainly of dense, almost impervious clay from the surface downward. They are limy to or near the top of the ground but do not have a well-developed zone of lime enrichment even on the smoother areas. The surface layers have accumulated only a little organic matter and are dark grayish-brown instead of nearly black as in the Boyd soils. The profile rests on the parent shale, usually within a depth of 2 feet. On some of the steeper slopes the shale is exposed.

The Pierre soils are unsuited for cultivated crops except where they receive supplemental water through run-off from higher levels or through irrigation. The native vegetation on them consists largely of western wheat grass which grows too sparsely to have a high grazing value but is one of the most nutritious hay grasses in the High Plains region.

ROSEBUD SERIES

The soils of this series have developed on parent materials, weathered in situ, from light-gray, soft, limy sandstones (Gering, Arikaree, and Ogallala formations) of Tertiary age. They occupy extensive areas of nearly level to strongly-rolling uplands in western Nebraska, and the adjacent parts of adjoining states. The Sidney soils, mapped in one of the earlier county surveys, are now included in the Rosebud series.

The Rosebud soils differ from those of the Holt series which are farther east in a region of higher precipitation, taller grasses, and more rapid vegetal decay, mainly in having lighter-colored and thinner surface layers. They have good external and internal drainage, and are not subject to destructive erosion, except on the steeper slopes where water run-off is rapid and in some cultivated fields where wind erosion has become serious. Within areas of these soils are numerous patches and narrow strips where the limy sandstone is at or near the surface of the ground. These patches are occupied by the severely eroded Canyon soils which are not sufficiently extensive to be indicated on the accompanying map.

The surface soils of the Rosebud types average about 10 inches in thickness. They are very friable, but have not accumulated much organic material, and are dark grayish-brown instead of nearly black as in the Holt soils. The principal textures are silt loam, loam, and very fine sandy loam, although coarser textures are common in some areas. The upper subsoil layer is grayish-brown. The lower one, the zone of maximum lime enrichment, is almost white. At most places it rests on partially disintegrated sandstone within a depth of 2 feet. On parts of the Dalton Table in Cheyenne County, Nebraska, the bedrock is below a 5-foot depth.

All the Rosebud soils are friable and absorb moisture readily. The infiltration rate is more rapid on the sandy than in the silty types but the former are rather unstable under cultivation and are used mainly for pasture and hay land. The silt loam, loam, and very fine sandy loam types of this series occupy probably 90 per cent of the dry-farming land in the "panhandle" section of the State. They are the chief wheat soils of western Nebraska although corn, oats, rye, and barley are also produced. The crop yields on these soils compare favorably with those obtained on the best soils of the uplands in this region.

ROUGH BROKEN AREAS OF SHALLOW STONY SOILS

These areas include rough stony land that is topographically unsuited for farming except on included strips of alluvium and in small tracts on the uplands which have escaped destructive erosion. Only the larger areas, such as Pine and Wild Cat ridges and the wider broken and stony strips on valley slopes along Niobrara, Platte, and Republican rivers, can be legibly indicated on the accompanying map. Numerous patches and narrow strips, too small to be shown on this map, are in the bluffs along Missouri River and along many of the drainage ways in the southeastern, western, and north-central parts of the State. Stone-free tracts of broken land developed on loess are not included.

Within these areas most of the soils, where sufficiently developed to be classed as such, are stony and extremely shallow. Throughout the western part of the State, the broken stony land has been carved mainly from Tertiary sandstone formations on which the Canyon soils represent the first states of soil development. In the southeastern and eastern parts, this land is occupied chiefly by Permian or Pennsylvanian limestones on which the shallow and stony Sogn soils occur and by exposures of Dakota sandstone where Lancaster soils are beginning to develop.

The rough, broken areas of shallow, stony soils are used chiefly for grazing land, although hay is cut in places and some of the more gradual slopes are under cultivation. None of the soils in these areas give high yields of grain or tame-hay crops, except in the most favorable seasons. Nearly all of them are subject to severe erosion when the native vegetation is destroyed. On some holdings, however, they occupy the only tracts that can be farmed.

THURMAN, THURSTON AND EWING SERIES AND UPLAND PHASES OF THE O'NEILL SERIES

The soils of these series have dark and moderately thick surface layers and sand or gravel subsoils. They are intricately associated on the smooth to gently rolling uplands of north-central Nebraska, where they collectively occupy large areas. They have developed on sand or water-worn gravels which were deposited in the region during Pleistocene times, forming broad sand-gravel plains west of the Kansan Glacier. The gravel and some of the sand came partly as inwash from westerly regions and partly as outwash from the glacial debris. Windblown material from disintegrating Tertiary sandstones probably contributed to the sand deposits.

Differences in the soils throughout this region are due mainly to local differences in the texture of parent materials and in drainage conditions. The soils of the Thurman and Thurston series have developed under good drainage from parent material composed largely or entirely of sand. In the Thurman soils the surface layers have accumulated an abundance of organic matter, are very dark and from 8 to 14 inches thick, whereas in the Thurston soils they have a lower organic content, are brown to dark brown, and exceed 8 inches in thickness only locally. The upper part of the subsoils of types belonging to these series contains enough silt and organic matter to produce a brownish color, and slight coherence. The lower part consists of incoherent gray sand.

Some of the areas mapped as Thurston soils in early surveys are on exposures of typical Kansas drift and would not be included with Shelby soils.

The soil types belonging to the Ewing series and the upland phases of the O'Neill series have very dark surface layers ranging from 8 to 14 inches in thickness. The subsoils are composed mainly of brownish, incoherent sand-gravel mixtures. In the Ewing types, however, which occupy slightly depressed areas where drainage is imperfect, the coarse material in the upper part of the subsoil is cemented with silt and clay and is moderately compact. The remainder of the subsoil is incoherent. The subsoils of types belonging to the upland phases of the O'Neill series are loose, gravelly, and incoherent throughout.

The soils of all these series are low in lime but do not seem to be lime-deficient so far as the vegetation is concerned. Many of them have such sandy and unstable surface layers or such porous and droughty subsoils that they are unsuited for cultivation, and remain in native pasture or hay land. Each of the series includes some types which give larger returns when used for growing corn, rye, and sweet clover than can be obtained from the native grasses. Part of the types are within or near larger areas of dunesand and, although not well suited for cultivation, must be farmed in order to produce grain for the work animals and to supplement the hay ration of cattle during the winter. The Thurman, Thurston, and Ewing soils are not droughty. Those having the finer-textured topsoils are highly productive under cultivation, if wind erosion is controlled.

UNDIFFERENTIATED SOILS OF TERRACES

The areas shown as undifferentiated soils of terraces, on the accompanying map, include the larger developments of terrace or bench lands in Nebraska. They lie at several different levels and were formed before the streams, along which they occur, became so deeply entrenched. Most of the older and higher terraces are from 40 to 100 feet above the present field plains. Several of them, in the eastern part of the State, are capped by windblown silts and only their basal portions are water-laid. The lower terraces, few of which are more than 20 feet above the flood plains, are entirely alluvial.

All the benches lie nearly level, except for a gentle slope down-valley and toward the trunk streams. The surfaces of the more silty ones are modified, here and there, by small, shallow depressions in which storm water accumulates, but the bench land as a whole is well drained. None of it is subject to overflow from the main streams. Some of the more sandy benches have wind-roughened surfaces at places but local differences in elevation do not ordinarily exceed 2 feet.

The terraces or benches in this State are occupied by soils of eight series; Waukesha, Hall, Tripp, Yale, O'Neill, Sioux, Sparta, and Cheyenne. The first four series named include soils which have developed on silty terraces and which are relatively fine-textured throughout. The last four include relatively coarse-textured soils with incoherent sand or gravel subsoils and substrata.

The Waukesha, Hall, O'Neill, and Sioux soils have accumulated an abundance of organic matter and have almost black surface layers from 10 to 14 inches thick. Most of them are in eastern Nebraska, although the Hall types are in the central part of the State. The Tripp, Yale, and Cheyenne soils are in western Nebraska, where they have developed under a rather low precipitation and slow vegetal decay. Their surface layers are only moderately supplied with organic remains and are dark grayish-brown. The soils of the Sparta series have very light-colored surface layers with practically no organic matter. They consist of gray almost pure sand or mixtures of sand and gravel. This series includes all soils formerly mapped in Nebraska under the name Plainfield.

An abundance of lime occurs in the Hall, Tripp, Cheyenne, and Yale soils. The last named have rather heavy upper subsoil layers. The other soils on the benches do not have much lime or unusual compaction in any part of the profile.

The finer textured soils of the terraces include some of the most valuable crop land in Nebraska. The Waukesha soils hold first place in the eastern part of the State for general farming purposes. They produce a little less corn and alfalfa than the best soils of the flood plains but are suited for a wider variety of crops and give higher yields of all crops than are obtained on any soils of the uplands. The Hall soils rank first for general farming throughout central Nebraska and the Tripp soils hold first place in the western part of the State. Most of the Tripp and a large part of the Hall soils are under irrigation; the former are used mainly for corn and sugar beets; the latter for corn and alfalfa.

Of the coarser textured soils on the terraces those of the O'Neill and Sioux series give the highest yields. All except the most sandy types of these soils are used chiefly for growing corn and alfalfa for which they are well suited, if care is taken to control wind erosion. The extremely sandy Sparta soils and the gravelly Cheyenne soils are included mainly in pasture land.

UNDIFFERENTIATED SOILS OF BOTTOMLANDS

The soils on the bottomlands or flood plains of the State are developing from a variety of recent stream sediments under conditions of restricted drainage. They lie only a few feet above the beds of the drainage ways and are subject to overflow during periods of unusually high water. The terrain is practically level except for a barely preceptible slope down the valleys and for minor irregularities caused by old and active stream channels, slight elevations, and shallow depressions.

The character of the soil at any particular place on the bottomlands is governed largely by the character of the sediment on which it is developing. Since the streams carry sediment of many textures, the recent alluvial material is naturally complex. The coarser materials are deposited near the channels and the finer farther back, owing to the assorting power of currents of varying velocities. In places, fine material is found near the stream. This is caused by a comparatively recent change in the position of the channel, which may also result in sand being deposited over clay or vice versa. Strata of widely varying textures may thus overlie one another, dependent upon the course of the stream and the character of its load at the time of deposition. At places, light-colored material may overlie a dark surface soil. Subsequent accumulations of decomposed grass remains have changed most of the sediments into productive soils.

The finer textured bottomland deposits in this State are classed with types of the Wabash, Lamoure, Laurel, Minatare, Genesee and Ray soil series; the sandy deposits with types of the Cass and Sarpy series. The Wabash, Lamoure, and Cass soils have accumulated an abundance of organic matter and have very dark surface layers. In the Wabash and Lamoure types the dark color continues to a considerable depth. In the Cass soils it gives way to gray, usually below 8 or 10 inches. The Laurel and Minatare types have dark-brown surface layers, whereas, the Genesee, Ray, and Sarpy soils are very light colored at the surface. The subsoils, are friable and silty in the Laurel and Genesee soils, moderately heavy in the Wabash and Lamoure, and very heavy and clayey in the Minatare soils. They consist of incoherent sand or mixtures of sand and gravel in all types of the Cass and Sarpy soils. The Ray soils are simply Wabash soils which have been covered by light-colored sediment, ranging from a few inches to about 2 feet in thickness. They are of local occurrence in Nebraska. Aside from types of the Lamoure, Laurel, and Minatare series, which are highly calcareous, the soils of the bottomlands in Nebraska contain little or no lime.

In the broader stream valleys of the State, the greater part of the soils on bottomlands have sufficient natural or artificial drainage for cultivation. In the narrower valleys most areas of these soils are either so poorly drained, or so dissected by stream meanders, that they are of value chiefly for pasture or hay land. Where adequately drained, the Wabash and Lamoure soils give higher yields of corn and alfalfa than can be obtained without amendments on any other soil in Nebraska. Well-drained areas of Laurel, Ray, and the finer textured types of Cass soils also give high yields of corn and alfalfa. A large part of the Laurel and Minatare soils are under irrigation and used for the production of sugar beets. In places these and the Lamoure soils are too alkaline for cultivated crops. The Genesee and Sarpy soils are too low in organic matter to be highly productive without amendments. Most of them, in this State, are either poorly drained or covered with forest growth, or both. They are used chiefly for pasture land and hay production. The soils of the bottomlands, as a whole, are not as well suited for small grain crops as for corn and alfalfa. Small grains thrive on most of the better drained and finer textured types of these soils but the abundant moisture supply tends to produce rank vegetative growth at the expense of the grain, and delays maturity. The abundant moisture also promotes the development of long, rather weak stems which may break and fall in windy weather.

(1) For a more comprehensive explanation of methods of classifying and mapping soils the reader is referred to the chapter "Soil Survey Methods and Definitions" in the later reports on county soil surveys, published by the Bureau of Chemistry and Soils, United States Department of Agriculture.

(2) Texture refers to the relative proportion of the various size groups of individual soil grains; silt, sand, clay, etc. This and other soil terms are defined in "A Glossary of Special Terms Used in the Soils Yearbook" pp. 1162-1180. Yearbook of Agriculture, 1938; United States Department of Agriculture.

EROSION

THE EFFECT OF EROSION IN NEBRASKA

When the white men first explored Nebraska, they found little erosion taking place. They found the hills, particularly in eastern Nebraska, covered with a dense growth of grass, underlain with a thick mat of decaying debris. The valleys were even more densely covered with grasses and sedges. The soil underneath the prairie was black and spongy, the result of centuries of accumulating humus. The valleys bordering the streams were boggy and abounded with springs. Clear water flowed constantly in the streams. The upland draws in the more favorable parts of the State were heavily covered with the big bluestem and slough grasses. Springs occurred in many of the draws.

This abundance of water, springs, and marshy flat lands was the natural result of the prairie cover. The tall grass with its underlying debris provided a condition of utmost effectiveness for rapid absorption of rainfall and for holding winter snows. Under these conditions, run-off could occur only from extremely heavy rains of more than usual duration. As a consequence, the deep subsoils of eastern Nebraska were filled to capacity with water throughout their entire depth. Excess water in the upper profile drained toward the draws and the valley land, thus creating springs and providing a constant and even source of water for streams.

After 40 to 60 years of farming, road construction and drainage, the native vegetative covering has been considerably changed. Only in a few scattered areas over the State can the original type of prairie now be found. It has been replaced by grain, forage crops, weeds, and grasses of introduced species. There has been imposed upon the land an intensive use through modern methods of cultivation and through heavy grazing of the lands left in native grass. The conventional methods of land cultivation have been conducive to rapid run-off and water erosion which, in many areas, has carried away a great portion of the dark topsoil. Deep gullies have formed in many of the once heavily-grassed draws and wind erosion is becoming an increasingly serious problem in some of the sandier areas. The resulting greater run-off carried away increasing quantities of topsoil. Rainfall, beating upon eroded and exposed soil, puddles its surface, seals its pores, and creates a condition conducive to maximum run-off.

The history of erosion in Nebraska for the past 40 to 60 years, indicates that unless control measures are used many now fertile fields will sooner or later be unfit for tillage. The history of farming has been that little attention is paid to erosion control until damage is so great that the original productiveness of the soil cannot be reclaimed. This has already happened on some fields in Nebraska and, since erosion accelerates itself, the rate of destruction can be expected to increase year by year.

EROSION PREVENTION AND CONTROL

The most effective methods of preventing erosion, practiced by a few farmers, consist of leaving grass and permanent vegetation in drainageways and on steep slopes. However, the number of farmers who have done this is relatively small. A few demonstrations were established by County Agents and the

Extension Service, by constructing brush dams and an occasional drop-inlet earth dam for gully control, and establishing a few terracing demonstrations. The CCC Camps, under the Forestry Service, established numerous farm demonstrations chiefly showing how to control gully erosion by temporary dams, permanent structures and tree planting.

The greatest impetus to soil conservation work in Nebraska was given by creation of the Soil Conservation Service by Congress in 1935. Twenty-three CCC Camps were assigned to the Soil Conservation Service to establish complete erosion control demonstrations in 1935.The demonstrations hold the rain on the slopes,insofar as possible, by practices that are fitted to the physical features of each farm such as degree of erosion and topography, and yet make the best use of the land. Moisture is conserved and sheet erosion is controlled by the use of crop rotations, farming on the contour, strip cropping, terracing, re-grassing and reforesting steep or severely eroded fields. Gully erosion in cultivated fields is being controlled by seeding the drainageways to a mixture of grasses and legumes. Erosion in pastures is being reduced by deferred and judicious grazing, contour furrowing and terracing, with the gullies fenced and in many cases, planted to trees.

Wind erosion has been controlled on areas lacking cover due to drouth or grasshoppers,by mechanical means such as contour, basin,or blank listing in the fall. Crop residues, such as straw, stubble, and cornstalks have been left on the fields to demonstrate wind-erosion control with a good cover.

In 1940 this type of demonstration was being carried on in 11 camp areas, 3 demonstration areas and a number of Soil Conservation Districts. Twenty-one Soil Conservation Districts have been voted upon favorably for organization under the law of the Nebraska Soil Conservation District. Landowners in such legally constituted Soil Conservation Districts, through the Soil Conservation Service of the United States Department of Agriculture, may obtain technical assistance in planning and putting into operation complete erosion control programs. Approximately 3,000 farm demonstrations have been established by the above-mentioned organization.

An educational program has been conducted cooperatively by the Soil Conservation Service and Extension Service, consisting of field tours, observing demonstrations.

Work has started under the Water Facilities program in 8 counties, which enables the farm operators to construct facilities designed to utilize supplemental water supplies. Complete surveys and conservation plans are developed in conjunction with the utilization of facilities established under this program. Such facilities consist of flood-spreading structures, retention, detention, and diversion dams, small reservoirs,stock-watering ponds, and irrigation pumps. A few demonstrations in 10 additional counties are contemplated during the year. This program is administered through the established agencies of the Soil Conservation Service, the Bureau of Agricultural Economics, and the Farm Security Administration.

Although precipitation has been abnormally low during the period of years the conservation demonstrations have been in operation, in many instances crop yields have been increased by soil conservation practices in addition to the saving of topsoil.

During 1938 there were more acres of contour planted and tilled crops, more contour strip cropping, and more successful seedings of adapted grasses on eroded lands than in any previous year.

CLIMATE

The climate of Nebraska results from its geographic location near the center of a large continent in the eastern rain shadow of the Rocky Mountains, its distance from the Atlantic Ocean and Gulf of Mexico, and its position in the general west-east path of cyclonic storms. Nebraska has two rather well-defined climatic belts; subhumid east of the 100th meridian, and semiarid west of it, with an intermediate or transitional zone between them. The climate is characterized by comparatively short, hot summers, by long, cold winters, and by fluctuating rainfall.

SUNSHINE

Nebraska has the high percentage of sunshine essential to crop development. Injury to crops usually occurs when there is a lack of moisture in the soil. When the soil is moist the sun evaporates a part of the moisture, thus cooling the soil proportionately.

TEMPERATURE

Nebraska experiences wide diurnal and annual temperature variations. These partially result from the rapid heating and cooling of the land surface. January is usually the coldest month, and July the warmest. Winter temperatures frequently drop to 25 degrees below zero. A few coldest winter temperatures fall to 40 degrees below zero. Temperatures of 100 degrees or more are registered during the hottest days of summer. The temperature in the greater part of Nebraska does not limit the growth of crops common to the temperate zone. In the north-central and northwestern sections of the State low, variable rainfall and a shorter growing season somewhat limit productiveness.

The mean temperature of the State decreases northward with latitude and westward with altitude. The following table shows the mean annual temperatures for four parts of the State:

Mean Temperatures in Degrees

Section of State	January	July	Annual
Northwestern	21	71	46
Northeastern	20	74	48
Southwestern	26	75	50
Southeastern	25	77	52

The average temperature of the State is 48.5 degrees. The highest mean temperature, 52 degrees, occurs in the southeastern portion of the State at an elevation of 900 feet. The temperature decreases westward along the southern border to 50 degrees in Dundy County at an elevation of 3,000 feet. However, the mean annual temperature is about 51 degrees in most of the southern tier of counties.The temperature decreases northward about one degree for each 38 miles throughout most of the State. The decrease is more rapid in the northwestern section and less rapid near the Missouri River in the northeastern section. Temperatures range from nearly 48 degrees in the northeast to less than 45 degrees in the northwest where the elevation reaches 1,300 feet and 3,700 feet, respectively.

GROWING SEASON

The growing, or frost-free season, is comparatively long in Nebraska, decreasing in length from about 175 days in the southeast to 125 days and more in the northwest portion. Records reveal that the first fall frost in Nebraska may be any time from early September to as late as November 5th. Fifty per cent of the time the last killing frost of spring may occur any time from April 25th in the southeast to May 15th in the northwest.

PRECIPITATION

Nebraska lies in the general path of the low-pressure storm area that moves across the United States from west to east.These large cyclonic eddies, 500 to 2,000 miles in diameter, bring the greater share of the precipitation to Nebraska. They move with an average speed of 600 miles in 24 hours. Each storm causes an average of 1 or 2 rainy days as it passes eastward, when the center of the storm is near enough to Nebraska.

There is an average of 2 of these storms passing across the country each week with fair weather between. If the center of the storm passes over the State, the change in weather conditions is rather rapid. However, if the center is some distance north or south of the State, the change in weather conditions is less rapid and less pronounced.

The precipitation of Nebraska is deficient and fluctuating. It decreases from east to west across the State at a fairly constant rate. The mean annual precipitation is generally less than 20 inches west of the 100th meridian and more than 20 inches east of it. Records show that the annual precipitation varies from 9.47 inches to 27.48 inches in western Nebraska, and from 20.86 inches to 50.31 inches in eastern Nebraska.

Rainfall records in Nebraska cover a period of more than 60 years. Fragmentary records are available for longer periods. Existing evidence indicates that the wet and dry years alternate in approximately regular cycles. However, factors determining these cycles and predictions are highly speculative.

There are years during which every part of the State suffers from deficient moisture, although the territory east of the 100th meridian usually has sufficient precipitation for profitable agricultural production. Long-time precipitation records reveal a greater number of years having deficient departures than those having excess departures. Therefore, the departures above the mean are greater than those below the mean. The records also show that dry and wet periods tend to alternate, resulting in a series of minor cycles within the major hydrologic cycles.

DISTRIBUTION OF RAINFALL

The amount of rainfall in Nebraska increases from early springtime to June, during which month it is the heaviest. It decreases gradually until December. The average rainfall of June is over 5 inches in the southeastern part of the State and slightly less than 3 inches in the extreme western part.

About 69 per cent of the rainfall occurs during the five-month growing period beginning with April and ending with August.

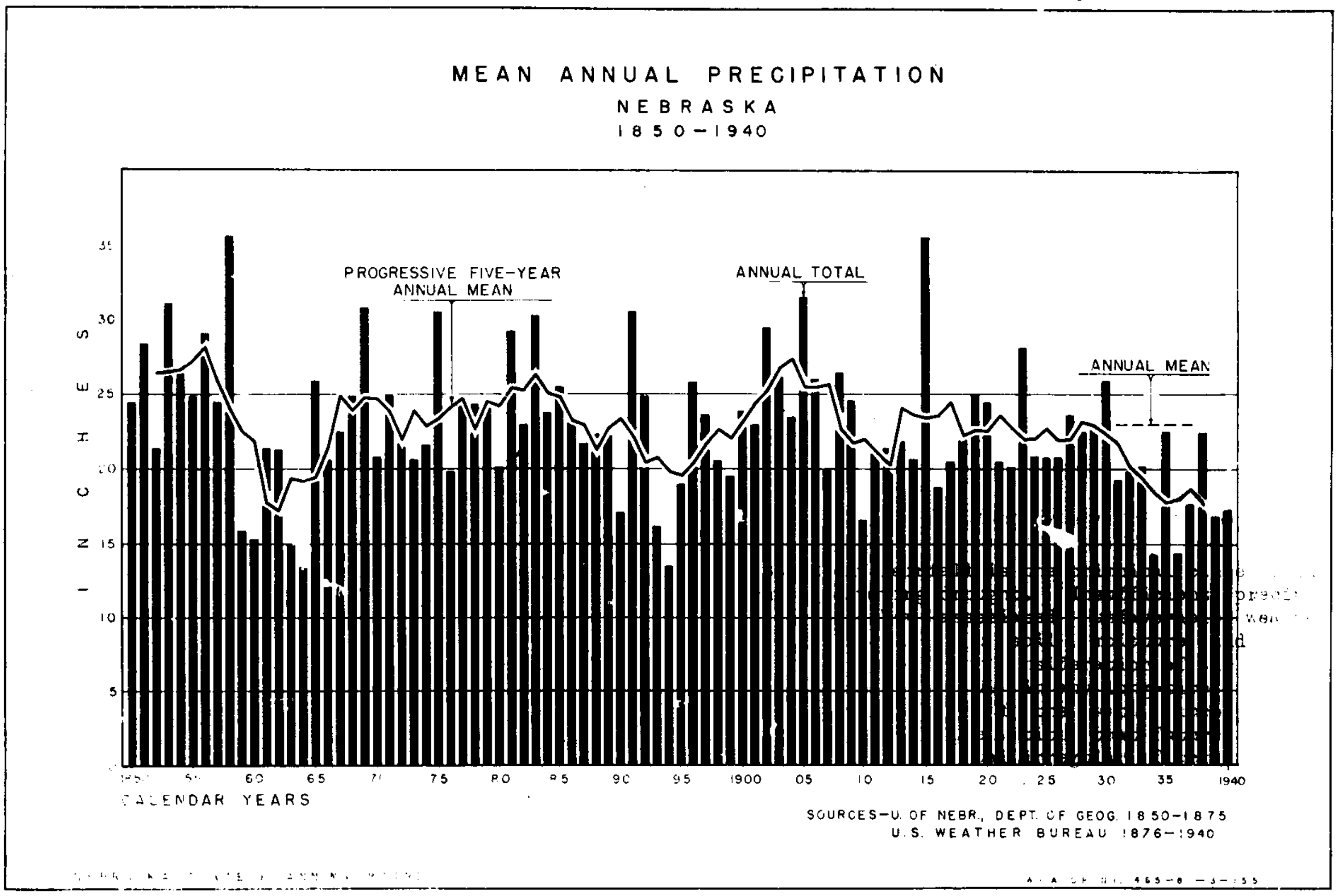
Many practices may be followed which will increase the effectiveness of the rainfall and reduce the hazards associated with unfavorable weather conditions. Continued research and planning in this field are imperative. In addition more extensive weather reports should be obtained. New drought - resistant crops such as soy beans could be introduced in Nebraska. Research in climatology should be encouraged.

DROUGHTS

Droughts in Nebraska usually occur during the summer and fall months. There have been 3 severe droughts in Nebraska and in adjacent states during the past 80 years. Less severe ones have come at relatively regular intervals. The fundamental cause of droughts has not yet been established. Scientists agree that the chief elements are low relative humidity, hot winds, high soil temperature, excessive evaporation, and deficient rainfall; the last being the dominant factor. The following summary shows the precipitation deficiencies in Nebraska during the recent drought period:

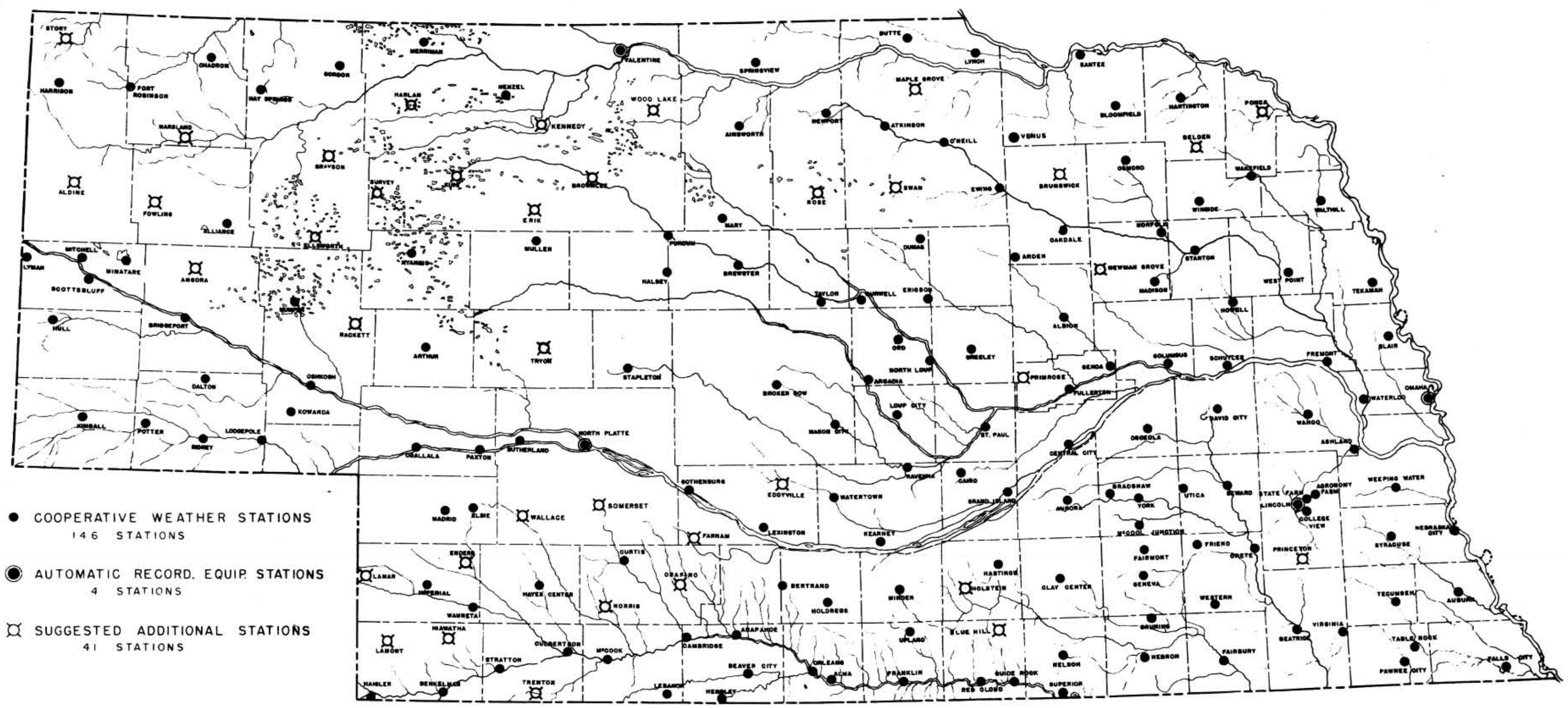
Year	Annual	Departure From Mean	Per Cent Deficiency
1931	19.27	3.63	15.9
1932	20.54	2.36	10.3
1933	20.23	2.67	11.7
1934	14.31	8.59	37.5
1935	22.64	.26	1.1
1936	14.42	8.48	37.1
1937	17.66	5.24	22.9
1938	22.23	.67	2.9
1939	16.28	6.62	29.0

Deficient rainfall is the principal cause of the current devastating drought. Insufficient precipitation and other associated unfavorable weather elements influence the soil moisture and water supplies generally. The consideration of the effects of drought is imperative in any long-time program for the conservation of the water supply. Past records justify the prediction that future decades will experience the usual irregular fluctuations in precipitation of dry and wet years.



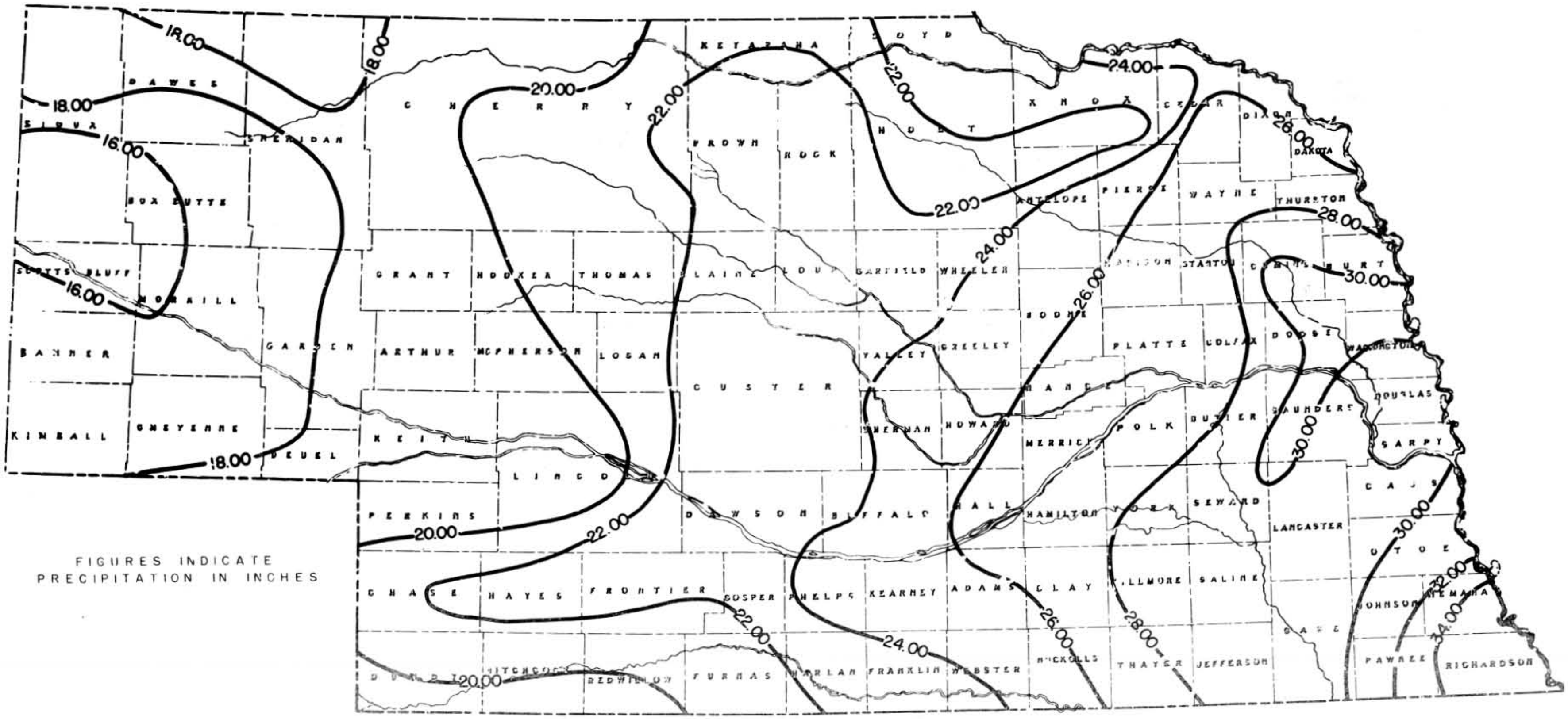
VIII

EXISTING AND PROPOSED WEATHER BUREAU STATIONS NEBRASKA JUNE 1939



COMPILED FROM U. S. WEATHER BUREAU "CLIMATIC SUMMARY OF THE UNITED STATES" FOR YEARS INDICATED

NORMAL ANNUAL PRECIPITATION
BASED ON 35 YEAR PERIOD, 1898-1932
NEBRASKA



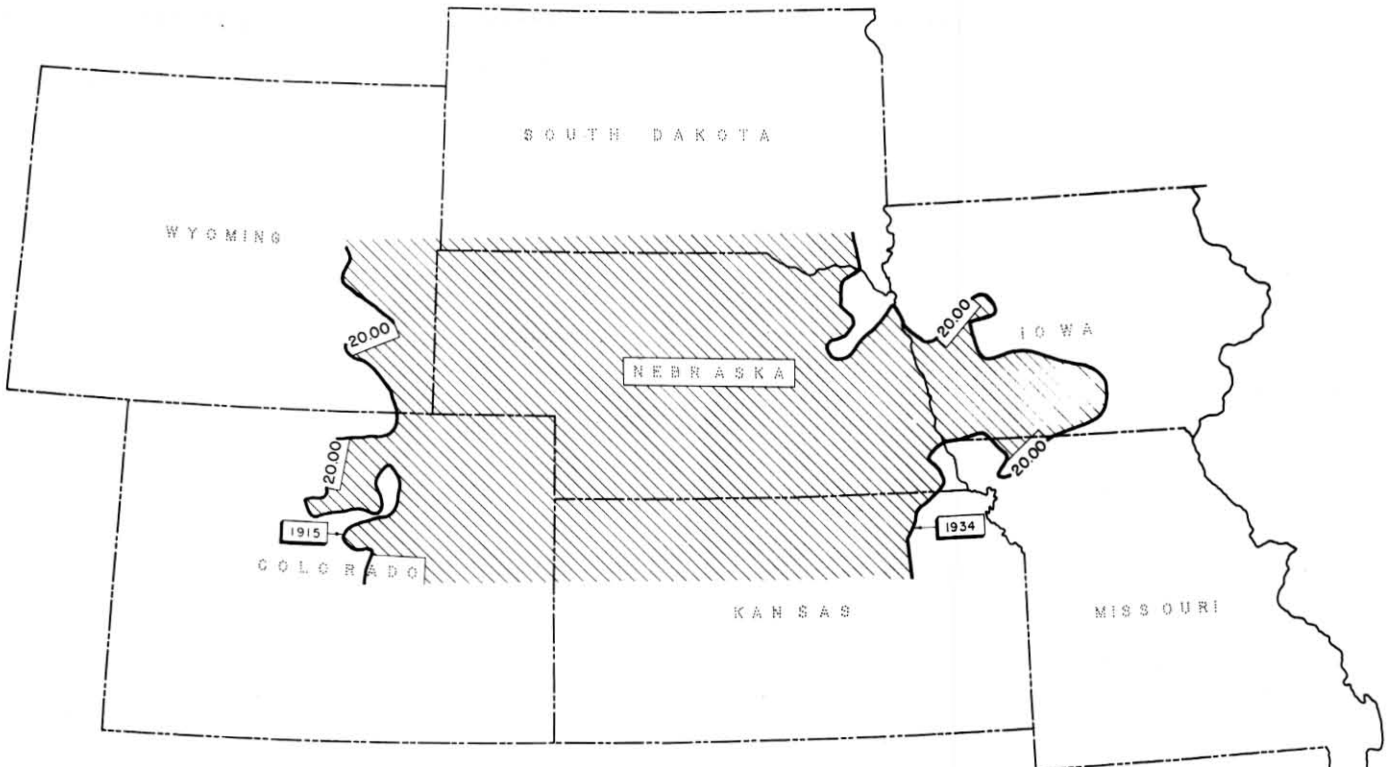
FIGURES INDICATE PRECIPITATION IN INCHES

COMPILED FROM U. S. WEATHER BUREAU "CLIMATIC SUMMARY OF THE UNITED STATES" FOR YEARS INDICATED

NEBRASKA STATE PLANNING BOARD

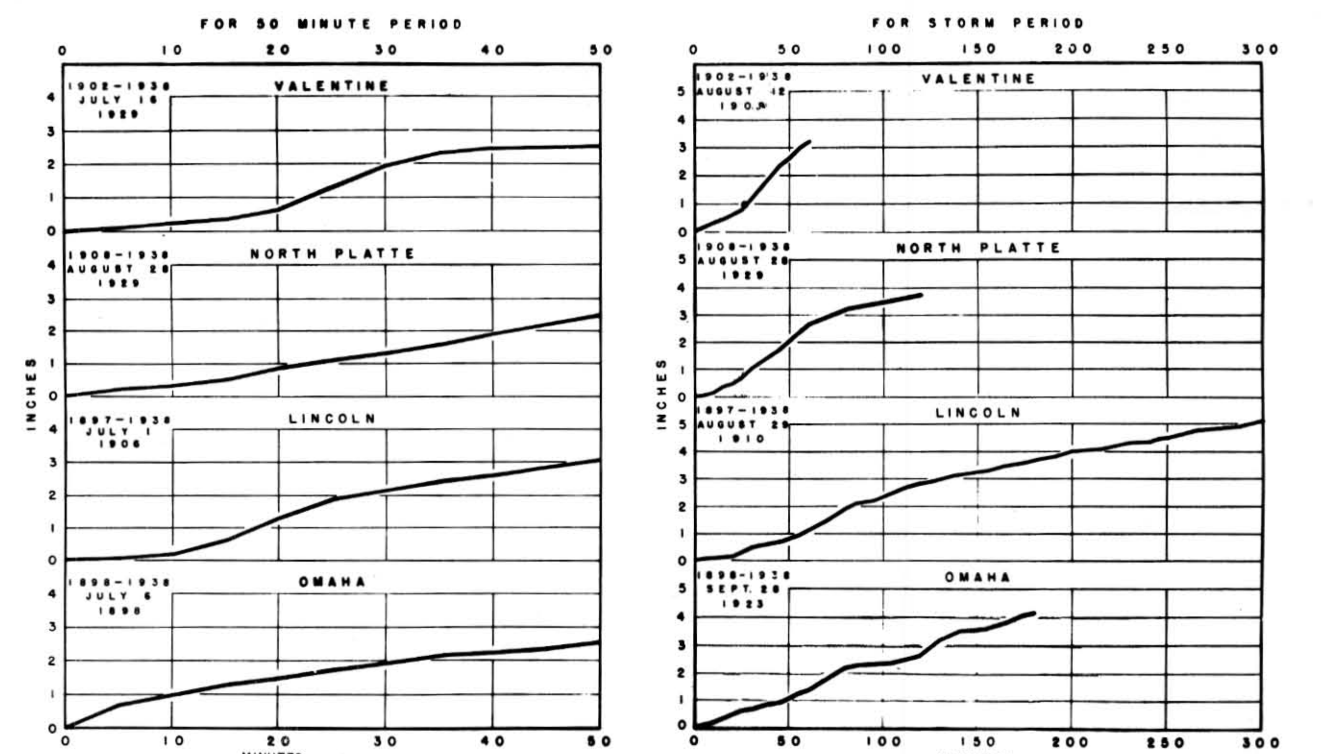
W.P.A. O.P. NOS. 165-81-6999 AND 465-81-3-155

EXTREME POSITIONS OF ISOHYETAL LINE FOR 20 INCHES ANNUAL PRECIPITATION 1876-1939



SOURCE— PUBLISHED RECORDS U. S. WEATHER BUREAU

MAXIMUM EXCESSIVE PRECIPITATION
FOR STATIONS WITH SELF-RECORDING GAGES
NEBRASKA



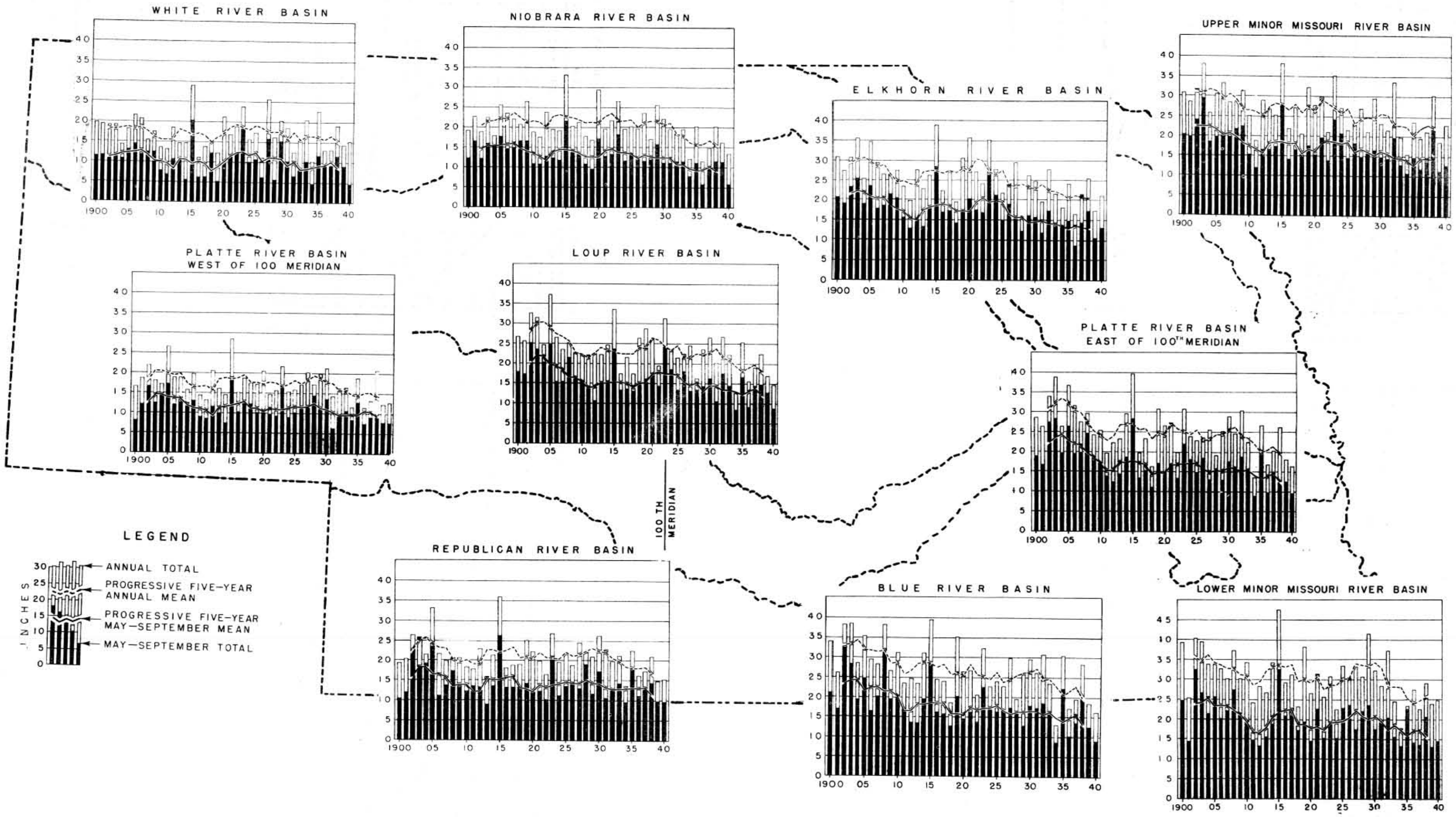
STORMS DURING WHICH THE RATE OF FALL EQUALED OR EXCEEDED 0.25 INCH IN ANY FIVE MINUTES OR .80 INCH IN ONE HOUR. ACCUMULATED AMOUNTS FOR FIVE MINUTE INTERVALS.

SOURCE — UNPUBLISHED RECORDS U.S. WEATHER BUREAU

NEBRASKA STATE PLANNING BOARD

WPA PROJECT OP. NO. 465-81-3-155

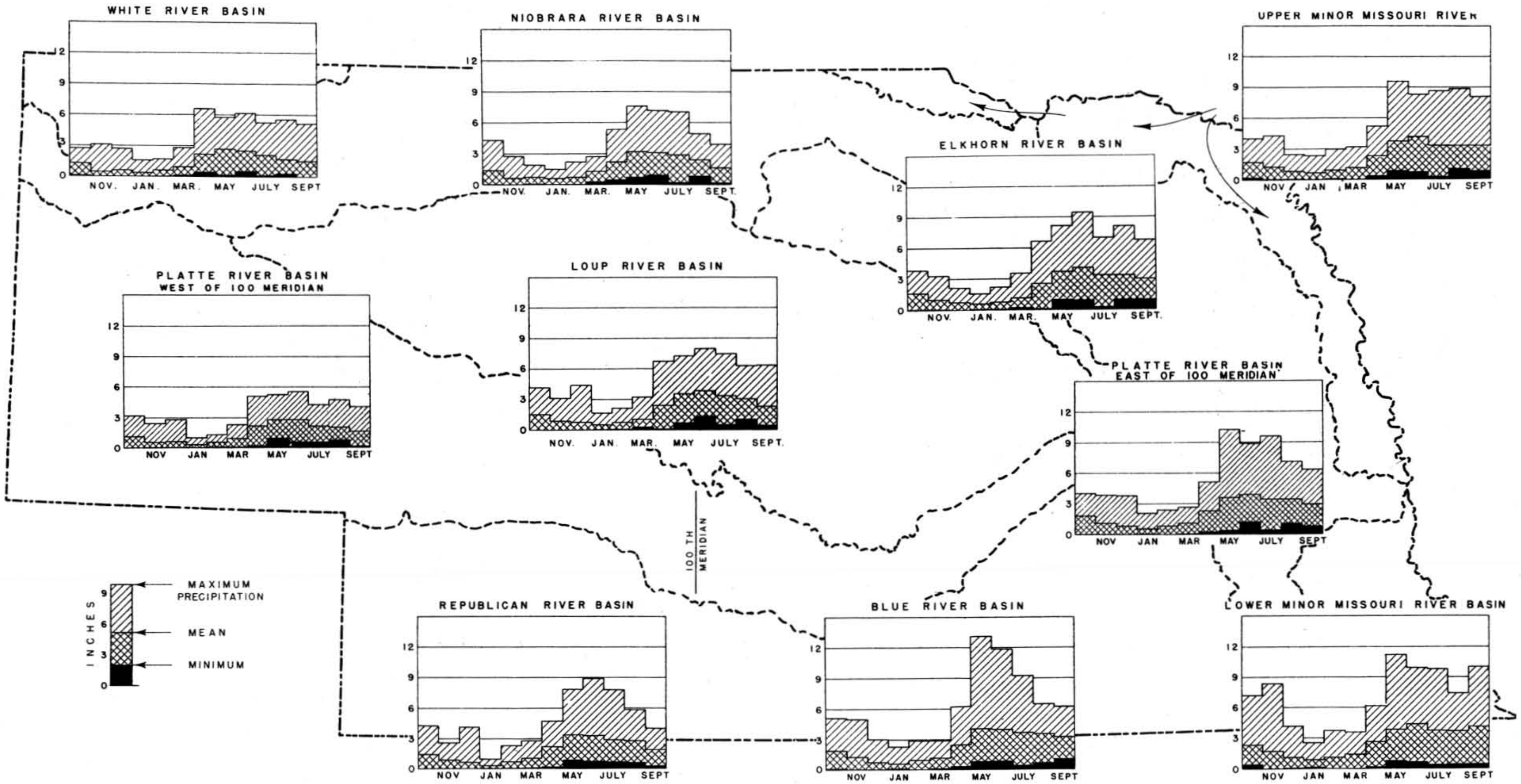
SEASONAL AND ANNUAL PRECIPITATION
BY DRAINAGE BASINS
NEBRASKA
1900-1940



NEBRASKA STATE PLANNING BOARD

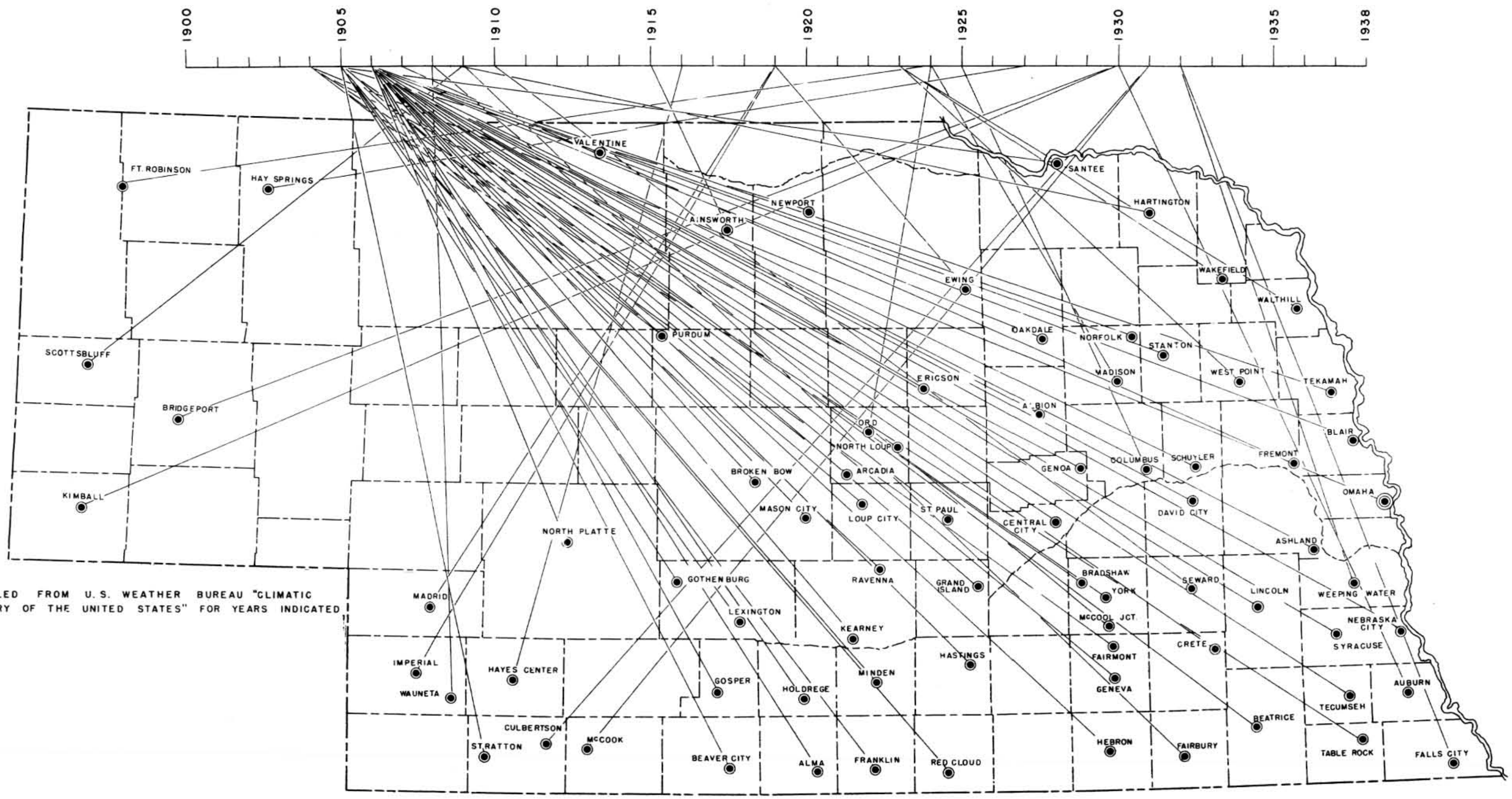
W.P.A. O.P. NOS. 165-81-6999 AND 465-81-3-155

MONTHLY MAXIMUM, MEAN AND MINIMUM PRECIPITATION
BY DRANIAGE BASINS
NEBRASKA
1900—1938



COMPILED FROM U. S. WEATHER BUREAU "CLIMATIC SUMMARY OF THE UNITED STATES" FOR YEARS INDICATED

YEAR ENDING FIVE YEAR PERIOD OF MAXIMUM PRECIPITATION
LONG TIME WEATHER BUREAU STATIONS
1900—1938

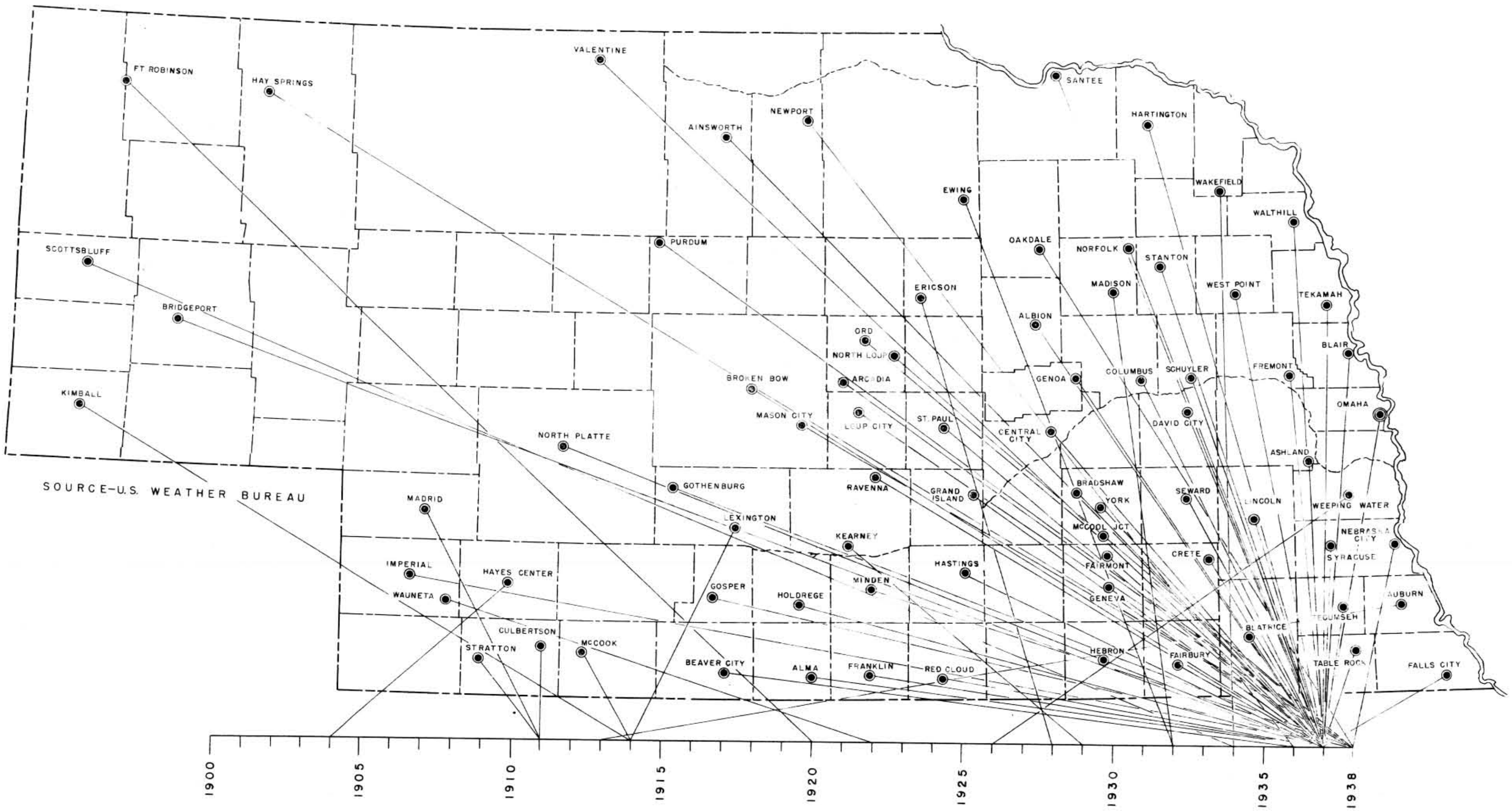


COMPILED FROM U. S. WEATHER BUREAU "CLIMATIC SUMMARY OF THE UNITED STATES" FOR YEARS INDICATED

NEBRASKA STATE PLANNING BOARD

W. P. A. O. P. NO. 465-81-3-155

YEAR ENDING 5-YEAR PERIOD OF MINIMUM PRECIPITATION
LONG-TIME WEATHER BUREAU STATIONS,
1900-1938



SOURCE—U.S. WEATHER BUREAU

NEBRASKA STATE PLANNING BOARD

W.P.A. O.P. NO. 465-81-3-155

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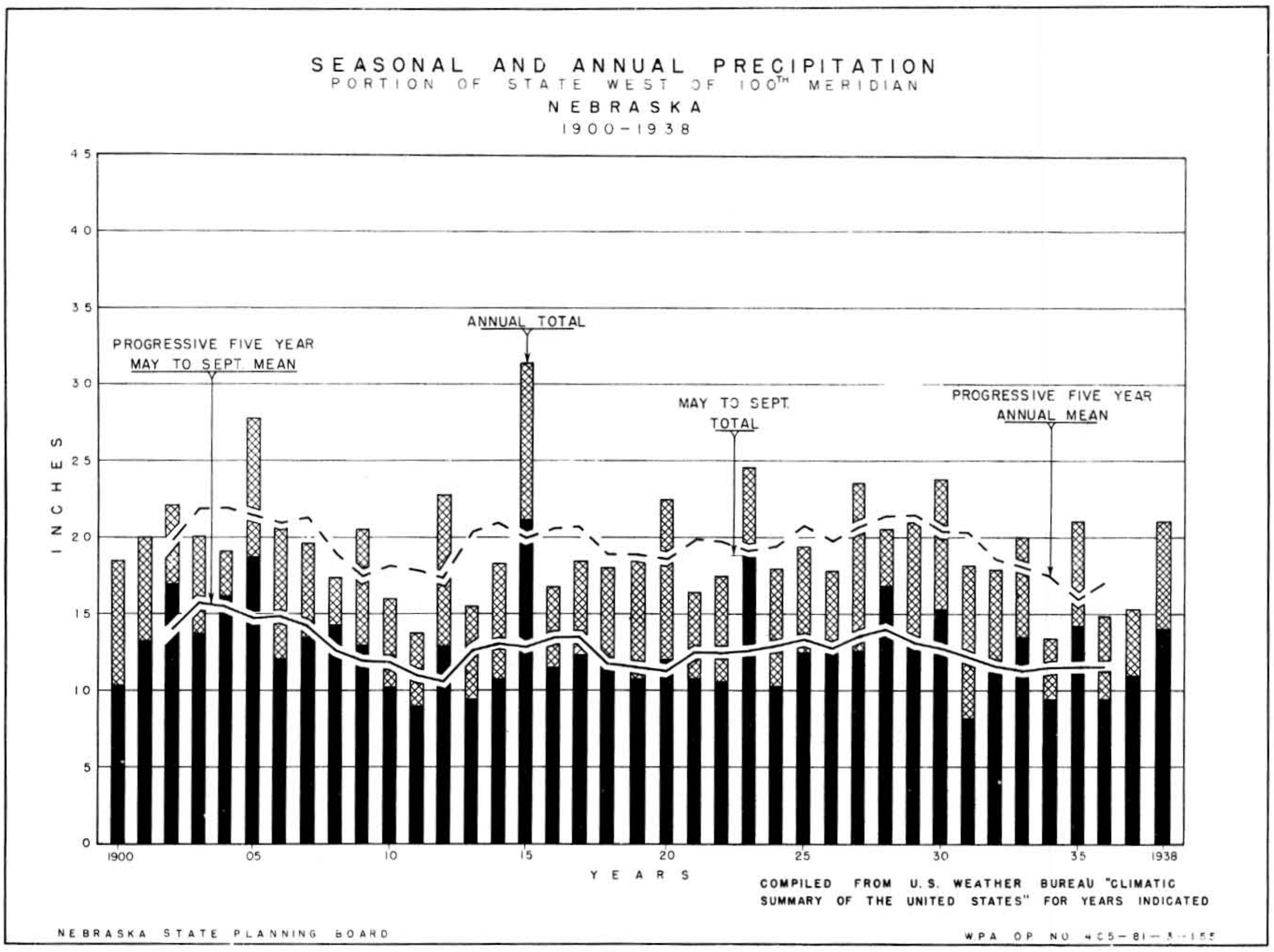
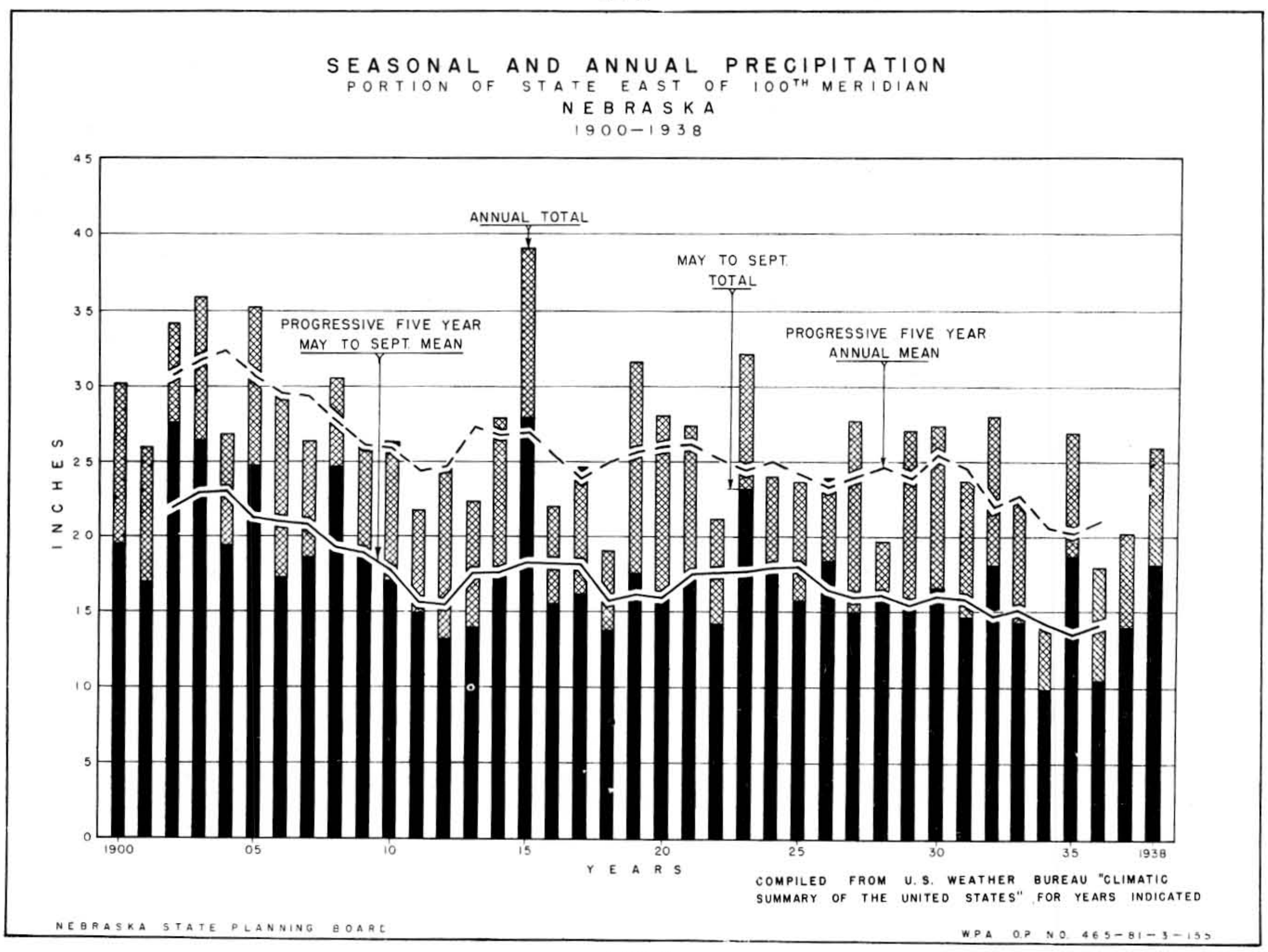
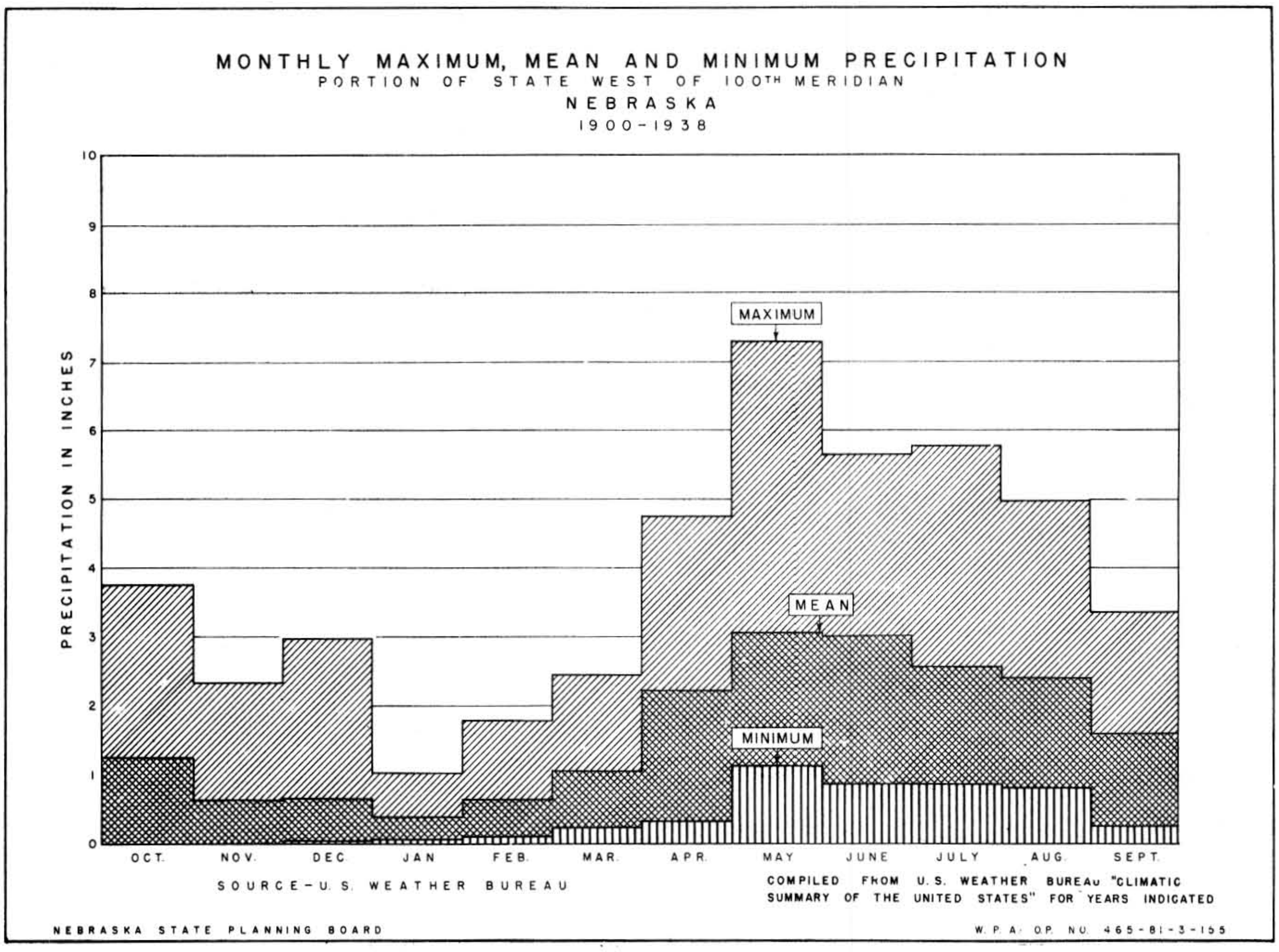
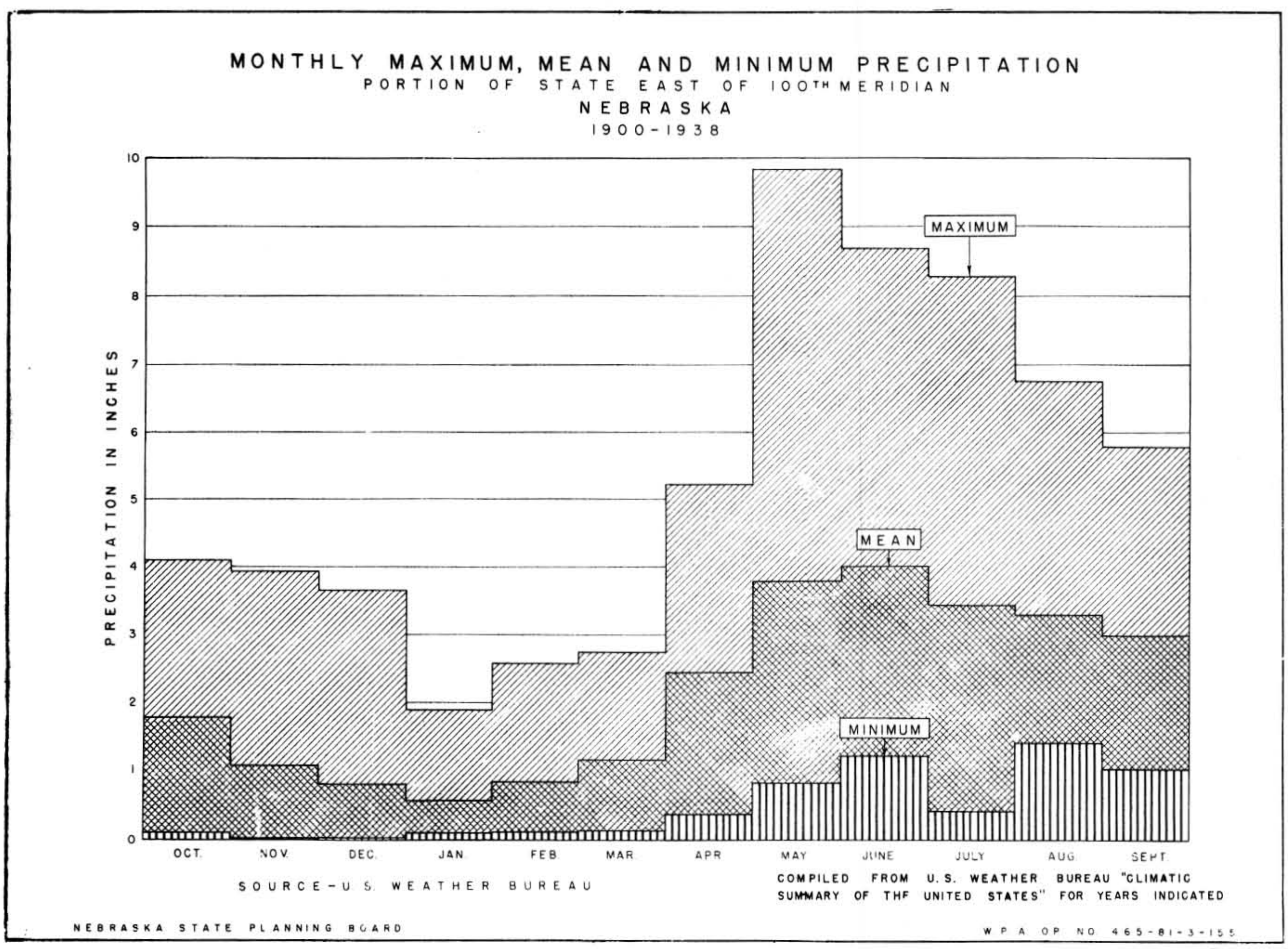

SEASONAL AND ANNUAL PRECIPITATION
PORTION OF STATE WEST OF 100TH MERIDIAN
NEBRASKA
1900-1938
INCHES
ANNUAL TOTAL
PROGRESSIVE FIVE YEAR MAY TO SEPT. MEAN
MAY TO SEPT. TOTAL
PROGRESSIVE FIVE YEAR ANNUAL MEAN
YEARS
COMPILED FROM U. S. WEATHER BUREAU "CLIMATIC SUMMARY OF THE UNITED STATES" FOR YEARS INDICATED
NEBRASKA STATE PLANNING BOARD
W.P.A. O.P. NO. 465-81-3-155

XVII

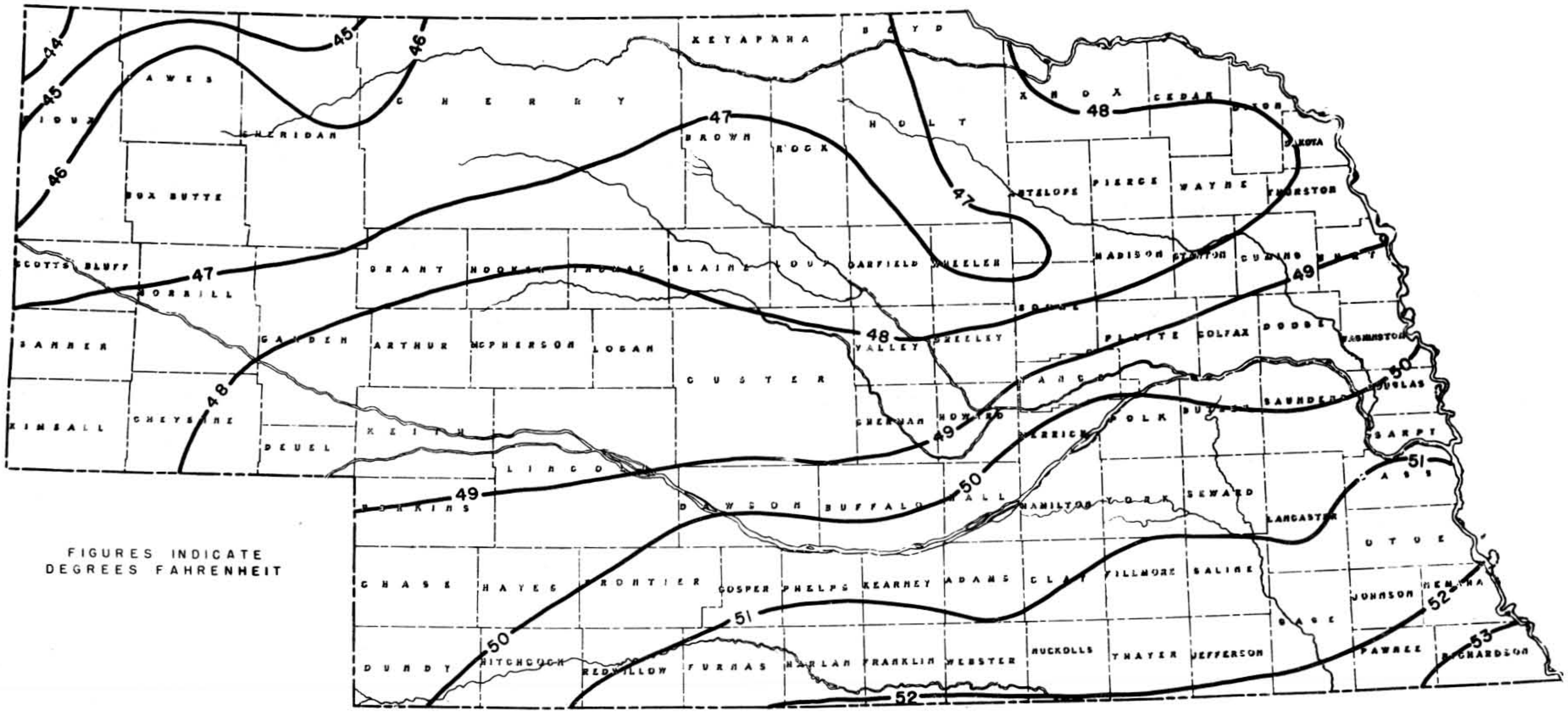

SEASONAL AND ANNUAL PRECIPITATION
PORTION OF STATE EAST OF 100TH MERIDIAN
NEBRASKA
1900-1938
INCHES
ANNUAL TOTAL
MAY TO SEPT. TOTAL
PROGRESSIVE FIVE YEAR MAY TO SEPT. MEAN
PROGRESSIVE FIVE YEAR ANNUAL MEAN
YEARS
COMPILED FROM U. S. WEATHER BUREAU "CLIMATIC SUMMARY OF THE UNITED STATES" FOR YEARS INDICATED
NEBRASKA STATE PLANNING BOARD
W.P.A. O.P. NO. 465-81-3-155

XVIII


MONTHLY MAXIMUM, MEAN AND MINIMUM PRECIPITATION
PORTION OF STATE WEST OF 100TH MERIDIAN
NEBRASKA
1900-1938
PRECIPITATION IN INCHES
MAXIMUM
MEAN
MINIMUM
OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT.
SOURCE-U.S. WEATHER BUREAU
COMPILED FROM U.S. WEATHER BUREAU "CLIMATIC SUMMARY OF THE UNITED STATES" FOR YEARS INDICATED
NEBRASKA STATE PLANNING BOARD
W.P.A. OP. NO. 465-81-3-155


MONTHLY MAXIMUM, MEAN AND MINIMUM PRECIPITATION
PORTION OF STATE EAST OF 100TH MERIDIAN
NEBRASKA
1900-1938
PRECIPITATION IN INCHES
MAXIMUM
MEAN
MINIMUM
OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT.
SOURCE-U.S. WEATHER BUREAU
COMPILED FROM U.S. WEATHER BUREAU "CLIMATIC SUMMARY OF THE UNITED STATES" FOR YEARS INDICATED
NEBRASKA STATE PLANNING BOARD
W.P.A. OP. NO. 465-81-3-155

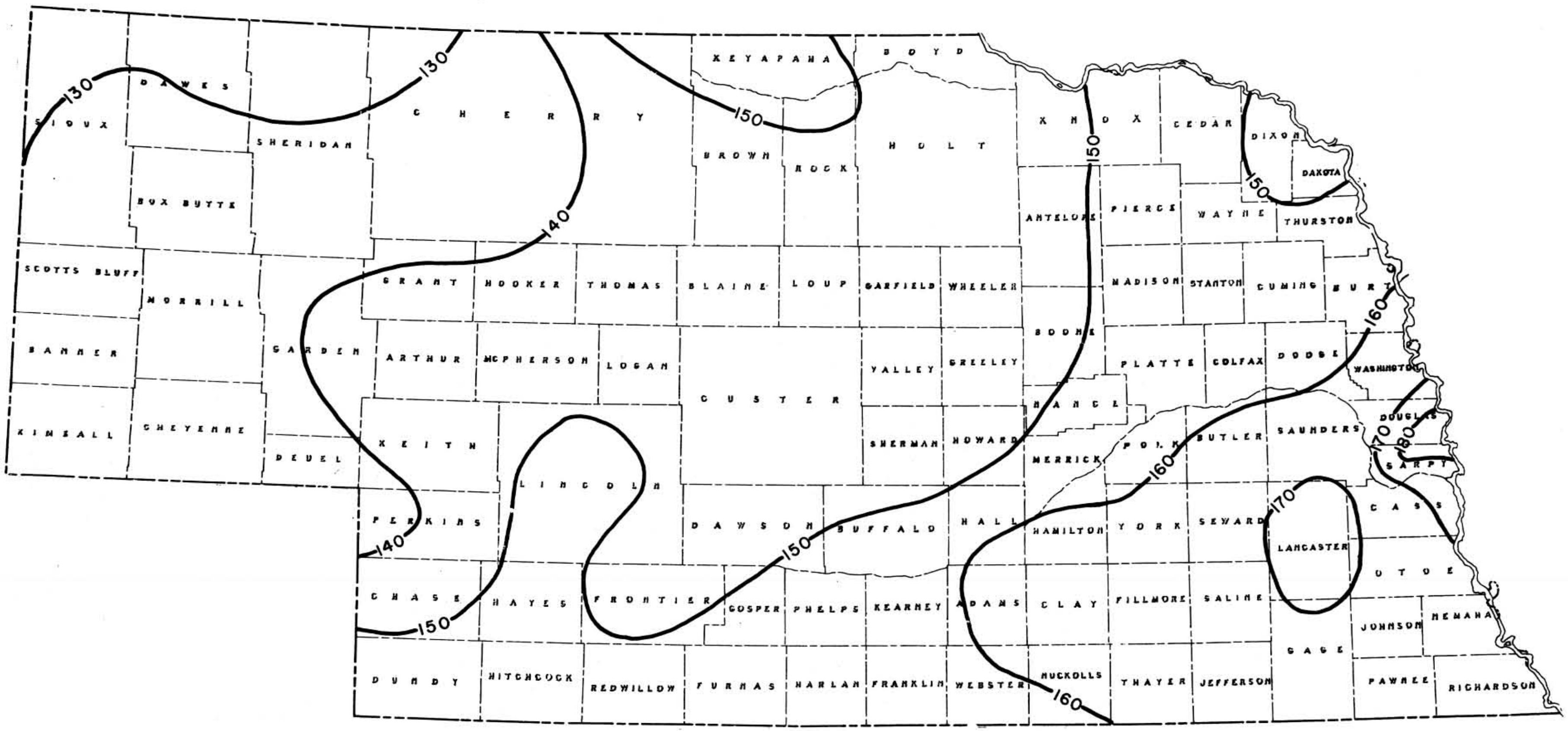
NORMAL ANNUAL TEMPERATURE
NEBRASKA



FIGURES INDICATE
DEGREES FAHRENHEIT

COMPILED FROM U. S. WEATHER BUREAU
"CLIMATIC SUMMARY OF THE UNITED STATES"

AVERAGE DAYS WITHOUT FROST
NEBRASKA

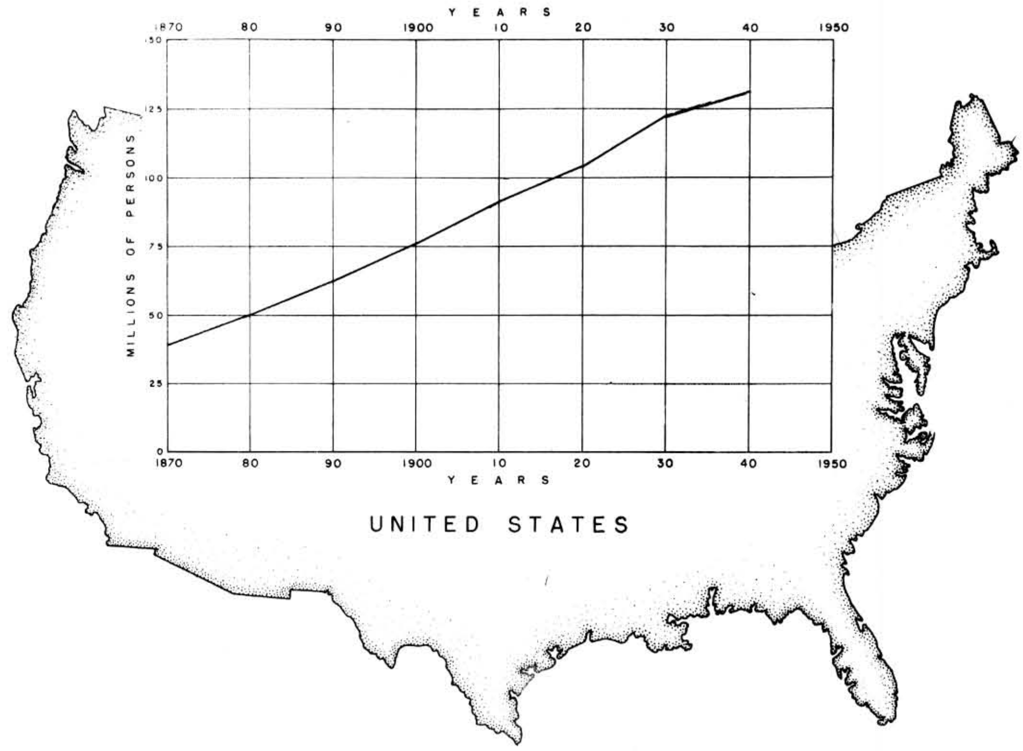


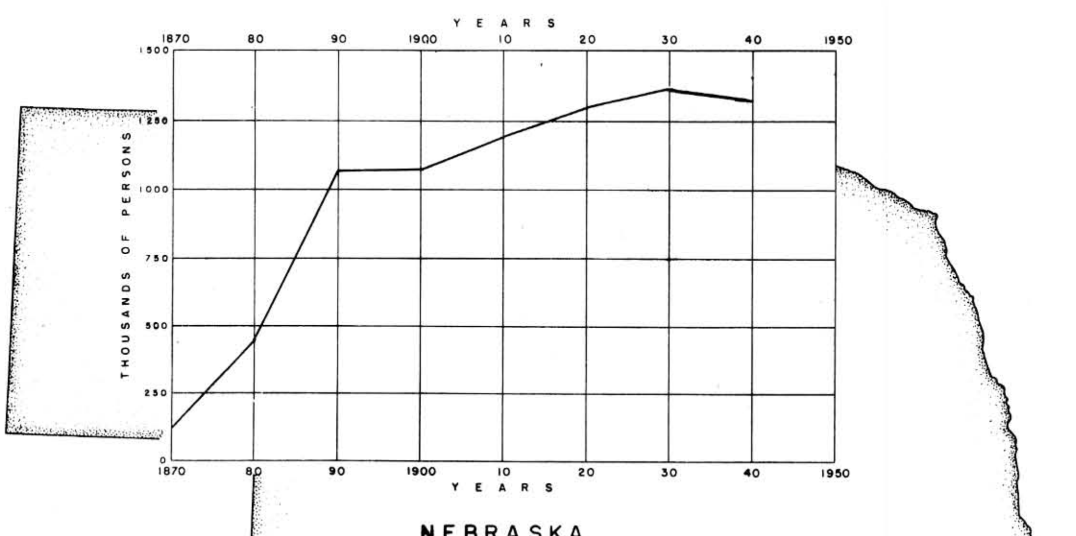
COMPILED FROM U.S. WEATHER BUREAU
"CLIMATIC SUMMARY OF THE UNITED STATES"

NEBRASKA STATE PLANNING BOARD

W.P.A. O.P. NOS. 165-81-6999 AND 465-81-3-155

GROWTH OF POPULATION
UNITED STATES AND NEBRASKA
1870 - 1940





SOURCES— 1870— 1940, UNITED STATES CENSUS

NEBRASKA STATE PLANNING BOARD W.P.A. O.P. NOS. 165-81-6999 AND 465-81-3-155

POPULATION

INFLUENCE OF CLIMATIC CONDITIONS ON SETTLEMENT

Nebraska has a heterogeneous population. The native-born population of Nebraska consists chiefly of people whose ancestors came from the New England, Middle Atlantic, and East North Central states. The foreign-born population of the State came from various European countries, although there are representatives of nearly every civilized country included in that group

Perhaps the settlement of no other State has been more greatly influenced by an undependable water supply for crop production than Nebraska. Variable precipitation and drought caused fluctuating agricultural production. The ebb and flow of the migrating population were directly related to poor and good crop yields. Abundant harvest resulted in periods of prosperity and encouraged immigration. Drought, crop failure, and a depressed agriculture caused a number of settlers to emigrate from the State. Slow growth or a static population followed such periods of crop failure and "hard times."

The following losses to the farm population are shown by the United States census for the years listed:

Year	Population	Change Per Cent
January 1, 1910	631,467	
January 1, 1920	584,172	7.5
January 1, 1930	581,300 (Estimated)	0.5
January 1, 1935	580,694 (Estimated)	0.1

These restless movements reflect faulty and unsound adjustments of the population to the land. A more stabilized agricultural production might have been assured and much suffering alleviated, had the early settlers realized that agricultural methods and crops adapted to the subhumid or humid climates from which they came were not suited to their new semiarid environment. Crop failure due to droughts, practically unknown in eastern United States, came too often in Nebraska.

The long, slow process of experimentation to develop agricultural methods and crops suited to semiarid climatic conditions begun by the early pioneers still continues. The conservation of water by all available means for Nebraska farm crops occupies a place of major importance in local, county, and State planning today. A variable water supply, resulting in a varying agricultural production, still profoundly influences the mobility of the population of the State.

The census records show a rapid growth in population in Nebraska up to 1890. For the next 40 years population increased slowly. The 1940 census indicates a 4.7 per cent decrease since 1930.

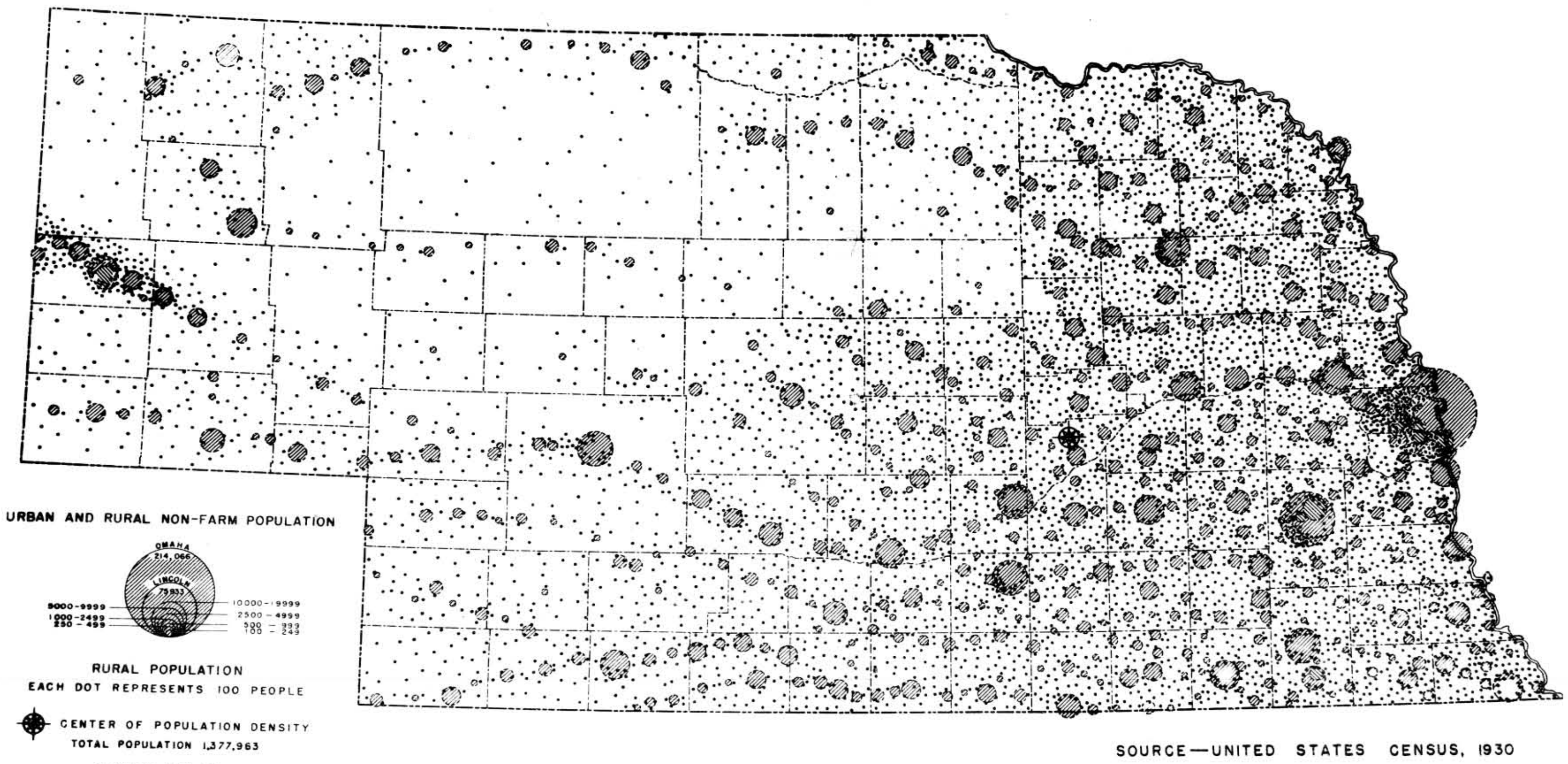
1910	1920	1930	1940
1,192,214	1,296,372	1,377,963	1,313,468

There has been a steady increase in the proportion of native-born Nebraska population which amounted to 70.4 per cent of the white population in 1930. Other percentages for the same year are listed as follows: 19.5 born in other states and outlying possessions, 8.4 foreign-born whites, and 1.0 negroes. The remaining 0.7 per cent were composed of various colored races. Nearly 60 per cent of the native-born white population came from the neighboring states of Kansas, Missouri, Iowa, and Illinois. The 479,853 persons of foreign parentage were classified in 1930 according to the following percentages:

Germans	35.1	Irish	5.5
Czechs	10.8	English	4.9
Swedes	10.4	Canadians	3.9
Danes	7.0	Polish	3.4
Russians	6.6		
Mixed And Other Nationalities			12.4

The trend toward urbanization has been steady since 1900. In 1900, 24 per cent of the population were classified as urban and this figure increased to 35 per cent in 1930. The 1930 census lists 35 towns with populations over 2,500 and 8 over 10,000. (See table in appendix for population and percentages by river basins.)

POPULATION DISTRIBUTION AND CENTER OF DENSITY NEBRASKA 1930

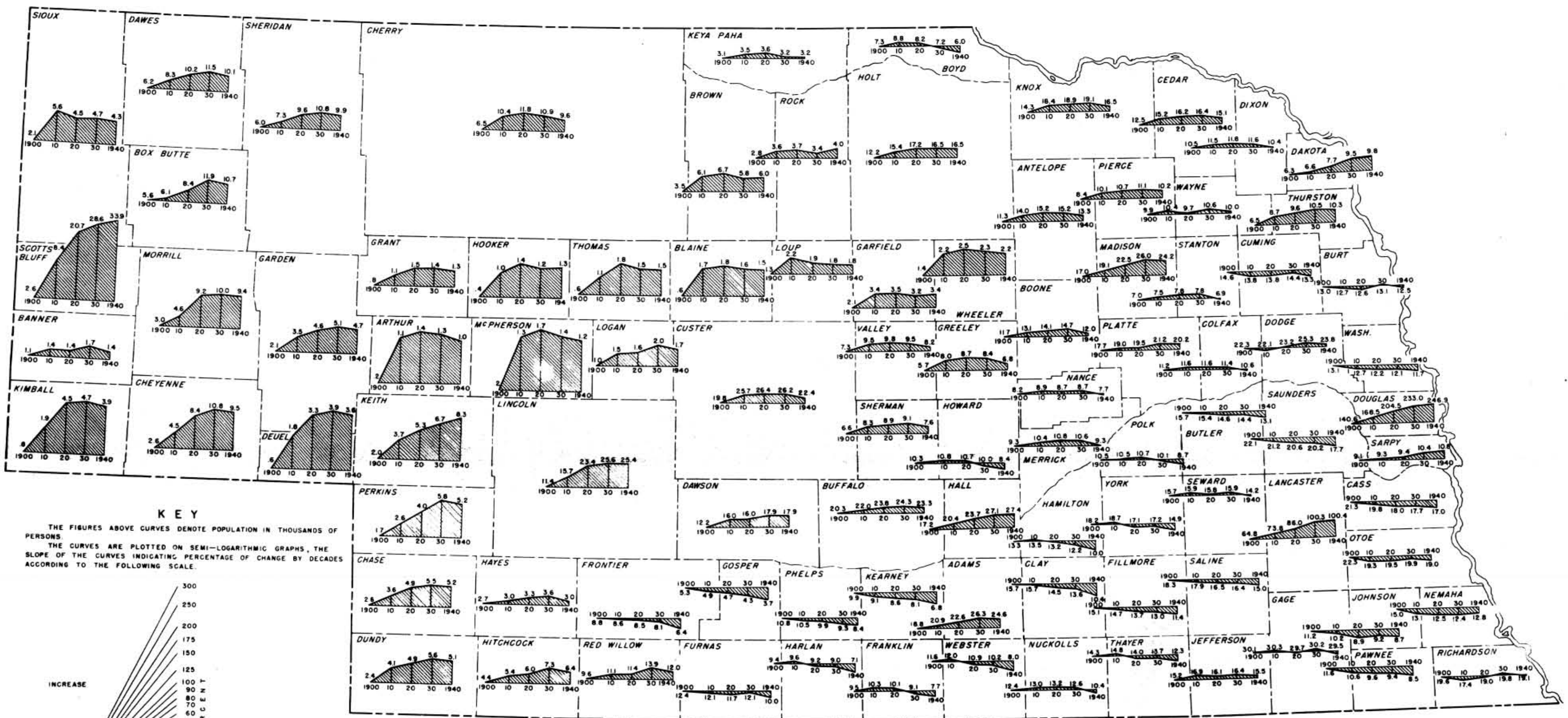


SOURCE—UNITED STATES CENSUS, 1930

NEBRASKA STATE PLANNING BOARD

W.P.A. O.P. NOS. 165-81-6999 AND 465-81-3-155

POPULATION TREND BY COUNTIES
NEBRASKA 1900–1940



KEY

THE FIGURES ABOVE CURVES DENOTE POPULATION IN THOUSANDS OF PERSONS.
THE CURVES ARE PLOTTED ON SEMI-LOGARITHMIC GRAPHS, THE SLOPE OF THE CURVES INDICATING PERCENTAGE OF CHANGE BY DECADES ACCORDING TO THE FOLLOWING SCALE.

TOTAL	POPULATION
1900	1,066,300
1910	1,192,214
1920	1,296,372
1930	1,377,963
1940	1,313,440

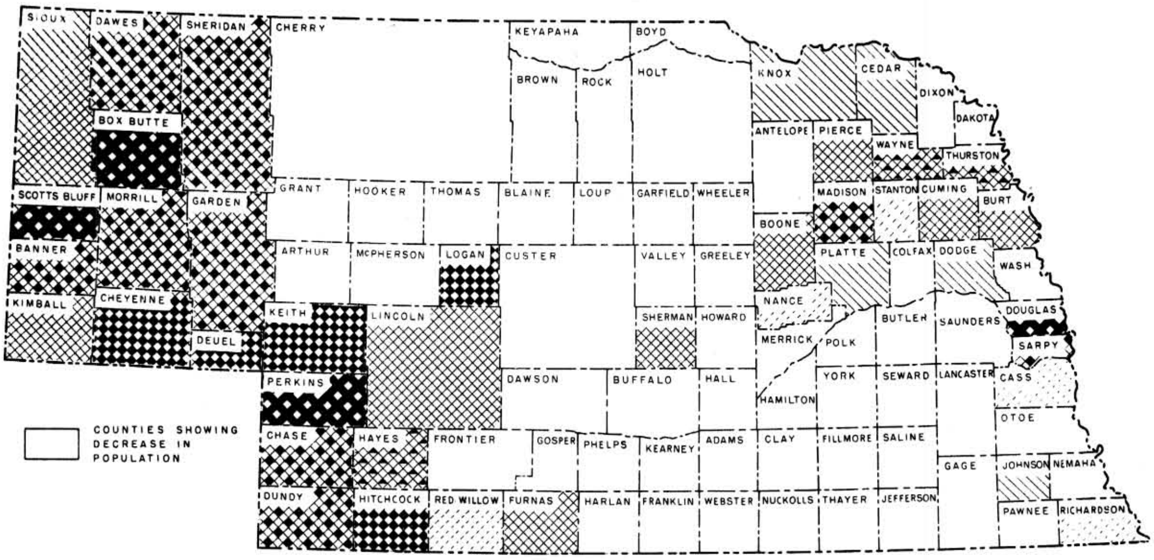
SOURCE—UNITED STATES CENSUS 1900–1940

NEBRASKA STATE PLANNING BOARD.

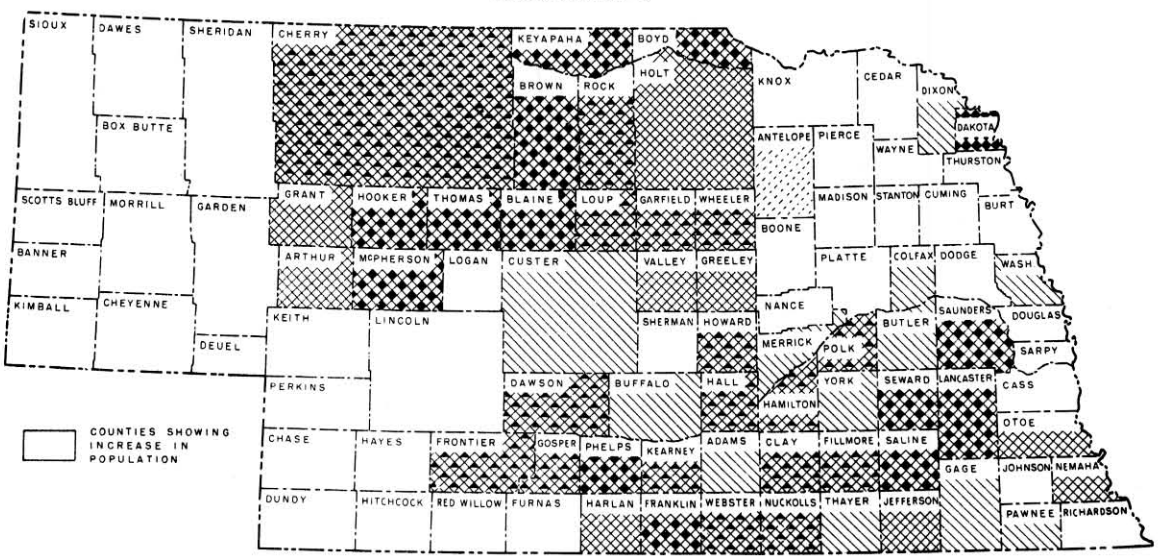
W.P.A. O.P. NOS.-465-31-3-36 AND 665-81-3-60.

RURAL POPULATION
PERCENTAGE OF INCREASE AND DECREASE
BY COUNTIES 1920 – 1930

INCREASE



DECREASE



PER CENT OF INCREASE OR DECREASE

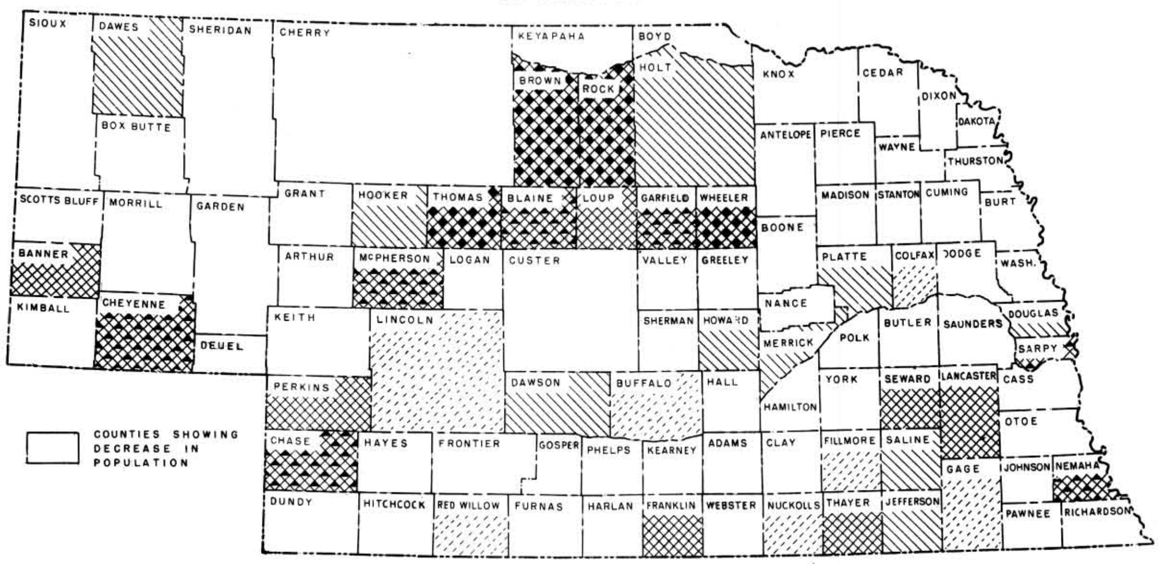
0 TO 0.9   1.0 TO 2.4   2.5 TO 4.9   5.0 TO 9.9   10 TO 19.9

20 TO 29.9   30 OR OVER

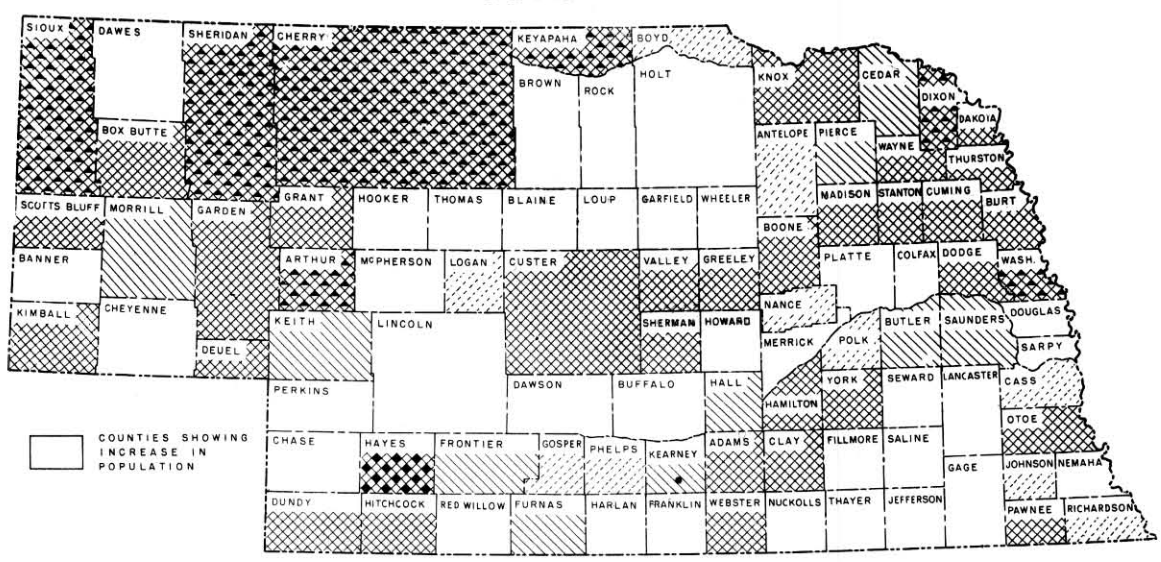
NEBRASKA STATE PLANNING BOARD   W.P.A. O.P. NOS. 165-81-6999 AND 465-81-3-155

RURAL FARM POPULATION
PERCENTAGE OF INCREASE AND DECREASE
BY COUNTIES 1930-1935

INCREASE



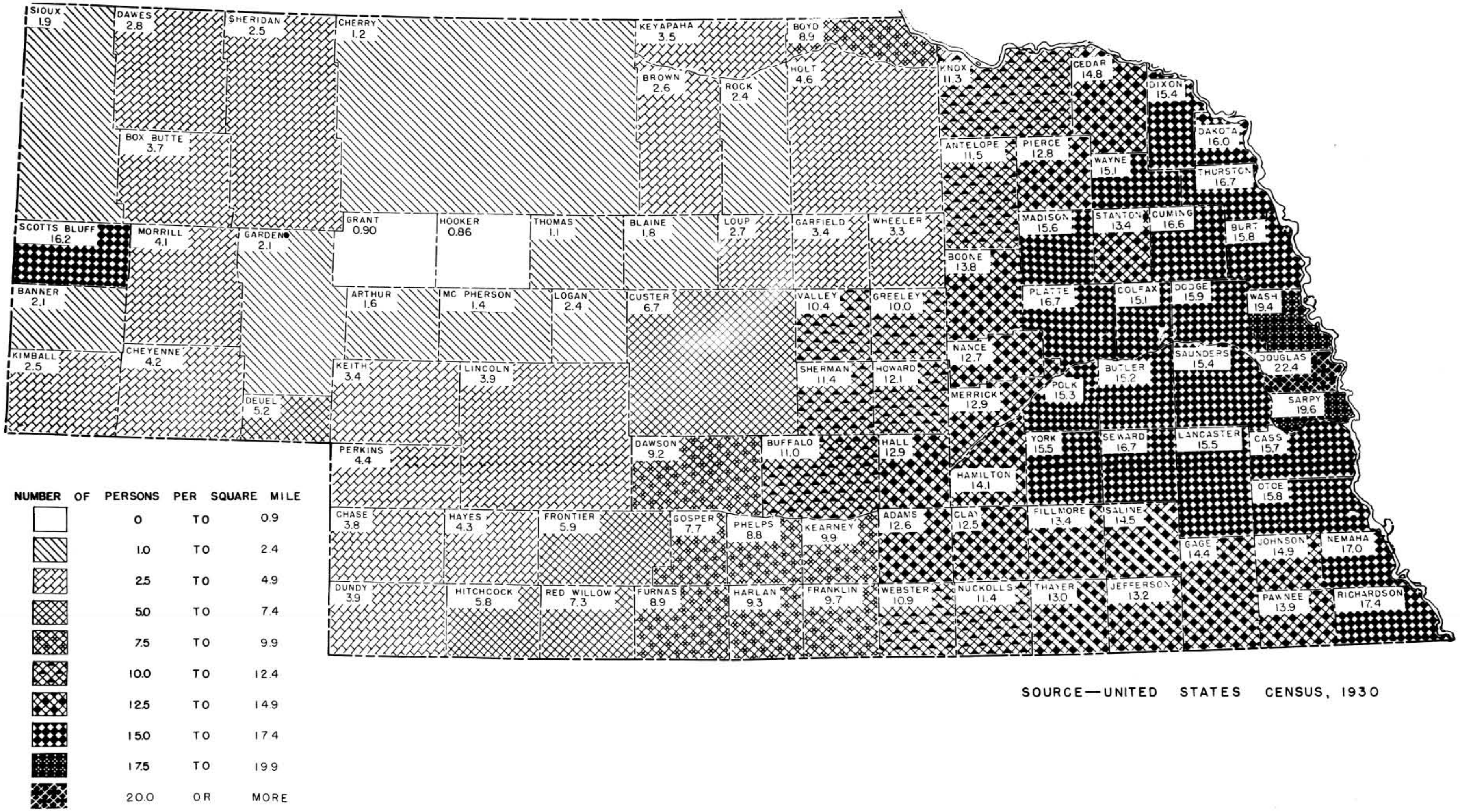
DECREASE



PER CENT OF INCREASE OR DECREASE

0 TO 0.9 | 1.0 TO 2.4 | 2.5 TO 4.9 | 5.0 TO 9.9 | 10. OR OVER

DENSITY OF RURAL FARM POPULATION
NEBRASKA 1930



SOURCE—UNITED STATES CENSUS, 1930

NEBRASKA STATE PLANNING BOARD

W.P.A. O.P. NOS. 165-81-6999 AND 465 81-3-155

AGRICULTURE, INDUSTRY, AND COMMERCE

AGRICULTURE

Nebraska is primarily an agricultural State. According to the United States Agricultural Census for 1935 approximately 95 per cent or 46,615,762 acres of the land area of the State was in farms. Of the land in farms, approximately 44 per cent was in cultivated crops, 53 per cent in pasture and native meadows, and 3 per cent in other use.

According to the 1930 census 39 per cent of all persons gainfully employed in the State were engaged in agriculture. The Department of Agriculture estimates the corresponding per cent for 1935 as 38. Of those gainfully employed in manufacturing and mechanical industries, in trade and service occupations, the majority was engaged in handling and processing farm products, or in giving service to those engaged directly or indirectly in agricultural production. Thus, it is evident that a large majority of the Nebraska population is dependent upon agriculture for a livelihood.

CLIMATE AND CROP YIELDS

Variable climatic conditions influence agricultural production in Nebraska more than any other factor. Precipitation, temperature, length of growing season, and evaporation govern, to some extent, the choice of the cropping system. The annual and seasonal distribution of the precipitation determine, in a large measure, the crops and agricultural practices.

The years of extreme maximum and minimum precipitation for the 39-year period, 1900 to 1938, occurred in 1915 and 1934 respectively and are shown on Plate XI. The line of 20-inch precipitation generally accepted as differentiating the subhumid and semiarid belts, lies west of Nebraska during years of abnormally high precipitation. For example, in 1915, the year of maximum precipitation, the 20-inch line was in eastern Colorado, and Wyoming. In 1934, the year of minimum precipitation, this line receded eastward touching only a few places in eastern Nebraska. Even the average or normal annual precipitation may be so poorly distributed or of such a type as to result in crop failures. Periods of heavy precipitation may be followed by extended droughts.

Precipitation also tends to run in cycles. For several years the total annual may deviate from the long-time average. For example, from 1910 to 1930 there was a general upward trend, reaching 25.63 inches in 1930. During this period the annual precipitation exceeded its normal only 6 times but an outstanding departure occurred in 1915 when the average precipitation of the State reached a record point of 35.60 inches. In 1914 the precipitation was only 20.78 inches, and in 1916 it dropped back to 19.08 inches. The latter remained the low point until 1934.

Following 1930 the general trend has been downward with 7 successive years of subnormal precipitation beginning with 1931. Weather Bureau records show a general similarity of trend in each of the 3 major drought periods, namely: 1864, 1894, and 1934. Each period was preceded by nearly a decade wherein the general trend was downward but was interrupted by isolated years of sharply increased precipitation. In each period the recovery from the low point was marked by a sharp rise in precipitation. Both 1865 and 1894 were followed by oscillations on gradually rising levels for a decade or longer. The fluctuations which have occurred in the past may be considered as typical and, therefore, may be expected to recur in the future.

The most significant fact about the precipitation in Nebraska is that it varies widely about a critical point. In the subhumid belt the average precipitation is sufficient if properly distributed to produce good yields of the common crops, and high yields in especially favorable years. In these areas, however, the crops may fail in years of subnormal or of poorly distributed precipitation. Even in the semiarid belt profitable crops can be produced in years of normal or above normal precipitation if well distributed, but generally yields are more variable and not as high as in the subhumid belt.

ADAPTATION OF AGRICULTURAL CROPS AND PRACTICES TO CLIMATE

Early settlers found that the natural relationships existing between plant, animal, and Indian life were closely associated with environmental factors. The kinds, distribution, and growth of grasses, shrubs, trees, and animals were long-time indices of natural land and water use, and climatic influence. The native vegetation in the State shows a definite adaptation to the precipitation, temperature, growing season, and soils. This relationship indicates the inherent agricultural possibilities of the different areas. Only within recent years have these relationships been generally recognized and applied. The introduction of farm crops and methods from regions generally unlike those in Nebraska proves hazardous and sometimes unsuccessful. Such crops and practices are generally either discontinued or modified.

The results from agricultural experiment stations and related agencies have been the basis for crop and animal improvement and production practices. The several agricultural associations of the State are furthering the cultural methods and farm enterprises that are best suited to the climatic conditions and needs of Nebraska. Experience and technical information have established a background for the practical application of conservation principles, which are essential to continued agricultural development.

AGRICULTURAL EXPANSION

Optimism, local pride, and commercial interests promote the settlement and development of a new land. Such influences frequently tend to bring about more intensive land use with its accompanying commercial and social development than the soils and climatic conditions will justify even during the more favorable years. Successive favorable years create the widespread opinion that climatic conditions have become permanently dependable. As a result, more intensive land use is stimulated, land prices rise, range lands are overstocked, and large farms and ranches are subdivided into smaller units. Crop acreage is expanded indiscriminately on both good and poor land. New business enterprises are established and roads and schools are built to serve the growing demand, all on inflated values.

High wheat prices and the patriotic appeal during the World War urged increased wheat production and exerted an important influence on the agriculture of the State. An influence greater than war prices was the tractor, the combine, and the large-scale plowing and planting machines introduced during and after the War. As a result, thousands of acres were plowed, which should have been left in permanent grass.

Inevitably, drought years recur with dismaying regularity, as illustrated during the period since 1930, and severe losses are experienced, especially where agriculture has been overextended and insufficient reserves provided. Crops, pastures, and water supplies dry up, and stock is rushed to market. Strong winds loosen, lift, and carry such quantities of the dry, light topsoil that the sky is darkened with dust. With the dwindling farm income, principal and interest payments and taxes become delinquent, and mortgages are foreclosed. Local governmental units find it difficult to raise sufficient revenue to continue operation. The federal government is called upon to make emergency feed and seed loans. Local business enterprises fail, and many families are forced to move to go on relief.

In 1930, 44,708,565 acres or 91 per cent of the total land area of the State was reported in farm land. Of this area 43 per cent of the land in farms was under cultivation, 53 per cent in wild hay and permanent pasture, and 4 per cent in other uses.

In 1935, 46,615,762 acres or approximately 95 per cent of the total land area of the State was reported as farm land. Much of the farm land of the State, however, because of unfavorable relief or soil, is held in permanent grazing or meadow land.

For the State as a whole, 44 per cent of the land in farms was under cultivation in 1935; 53 per cent was wild-hay land and permanent pasture; and 3 per cent was in other uses. In the eastern and southern parts of the State and other arable farming areas, from 50 to 90 per cent of the farm land within individual townships is commonly found to be under cultivation. In the sand-hill area of northern Nebraska and similar areas, where the land is used mainly for grazing and production of wild hay, many townships report less than 5 per cent of the farm land under cultivation.

It is rather generally believed that most of the land well suited to cultivation physically, and considerable that is poorly suited has already been brought into cultivation. The cultivation of marginal land which may prove profitable only under favorable conditions is a questionable practice.

Of the cultivated land, approximately 50 per cent is normally planted to corn; 36 per cent to small grains; 8 per cent to tame hay; and 6 per cent to all other crops.

TYPES OF FARMING

In every farming area there are fairly well-defined reasons for the development of the particular type of agriculture found there. Although the progress in any particular direction may not always prove profitable, it indicates that farmers have attempted to adapt their methods to the conditions confronting them and to secure maximum returns from the resources at their command.

As a result, farmers in various areas of the State follow different lines of production. They make an effort to adjust their crop production and methods to prevailing physical and economic conditions. This adjustment has proceeded to the point where the agriculture of the State can be divided into areas of rather distinct types of farming.

The various types of farming result from two general groups of factors. One of these includes that large body of factors, physical and biological, such as soil, topography, drainage, precipitation, evaporation, insect pests, diseases, and adaptation of plants and animals. The other group consists of economic factors such as availability of labor and capital, relative prices of farm products, relative costs of the items needed for production, and changes in technique.

INTENSIVE AND EXTENSIVE AGRICULTURAL METHODS

Crop production varies from relatively intensive production of corn and other feed grains in the eastern part of the State and crops in irrigated areas, to extensive production of grass and hay in the range areas of the sand hills. The eastern half of the State is devoted principally to the production of corn, small grains, alfalfa, hogs, and cattle. Sugar beets and potatoes are important crops in the irrigated sections of the west.

Livestock production ranges from intensive meat production in the eastern part of the State, and whole milk production near urban centers, to extensive production of range livestock in the sand hills and other range areas. Sheep production is an important livestock enterprise in the irrigated areas of western Nebraska, and the production of hogs in eastern Nebraska. For the entire State, hogs rank first and cattle second in importance. The only means of using pasture land is through the grazing of livestock. Furthermore, livestock usually provides the most economic means of utilization of much of the feed, grain, and forage crops which occupy such a large proportion of the arable areas of Nebraska. With the exception of wheat, only a small proportion of the most important crops of Nebraska are marketed in their original form.

FARM SIZE AND TENANCY

In 1930 there were 129,458 farms in Nebraska with a combined area of 44,708,565 acres, or an average of 345 acres per farm. In 1935, there were 133,616 farms with an average size of 349 acres. The

1937 Agricultural Census estimated that Nebraska has 134,000 farms, averaging 349 acres. The farms in the ranching and small grain areas in western Nebraska average much larger than this, whereas the farms in eastern Nebraska average considerably less.

The change in the size of farms has been more pronounced in some parts of the State than in others. During the period from 1900 to 1935 the number of Nebraska farms of less than 3 acres decreased while the number from 3 to 99 increased. There was practically no change in the number having from 100 to 174 acres. This latter group is the most common size, constituting 70 per cent of all farms. Excluding the irrigated sections, the farms in the western part of the State are much larger than those in the eastern part. Many of the farms in the west are from 500 to 1,000 acres, or even larger. There is a tendency for individual holdings in the Sand Hills to increase in size. From 1930 to 1935, farms ranging in size from 175 to 500 acres in some other sections of the State increased at the expense of those of 1,000 acres or over. In the irrigated areas the trend was toward a small acreage. From 1930 to 1935, farms from 175 to 500 acres in size gained in number, while the number in the 80 and 640 groups decreased.

Slightly less than 50 per cent of the farms in the State were operated by tenants in 1935. In addition, another 20 per cent of the farms consisted of land which was in part owned and in part leased. In some counties the proportion of farm tenancy was over 55 per cent, with the proportion of land operated by tenants running much higher. The increase in farms operated by tenants has been fairly steady during the past 25 years.

FARM INCOME

During the period from 1923 to 1934, 71 per cent of the Nebraska agricultural income came from livestock and livestock products, and 29 per cent from the sale of crops. Gross farm income has advanced steadily since 1932, the low point of the depression. Gross farm income for 1935 amounted to $252,449,000 as compared with $166,905,000 in 1932. However, gross income for 1935 was not much more than 60 per cent of the 1925-29 average. The severe drought of 1934 and the short corn crop in 1935 prevented the gross farm income from reaching higher totals. The failure of the corn crop in 1934 necessitated a drastic reduction in hog production, which is one of the leading sources of Nebraska farm income. Had production been near normal, the farm income during 1936 would have approximated the 1925-29 average, even with prices somewhat lower than those prevailing. Sugar beets and potatoes provide the western irrigated portions of the State with the largest cash income, although sales from sheep and cattle are important in the areas where feed is available. In the eastern part of the State, hogs and cattle provide a large percentage of the farm income with wheat as the principal cash crop. Some oats and barley are also sold.

CROPPING SYSTEM

Nebraska does not have a large number of important crops. Her crop production is confined mainly to the staple grain and forage crops. Corn, wheat, oats, alfalfa, and wild hay were of such importance that each occupied more than a million acres on Nebraska farms in 1937. In that year, which was not an unusual year, 49 per cent of the cultivated area of the State was occupied by corn, 20 per cent by wheat, 14 per cent by oats, 7 per cent by alfalfa, and 10 per cent by minor crops. The acreage of wild hay, which is not classed as a cultivated crop, was nearly two and one-half times that of alfalfa. More than 45 per cent of all land in farms was pasture land. This percentage has not changed materially since 1924. The most economical way of utilizing pasture land, forage and feed crops is through livestock. Consequently, the major part of such crops moves to market in the form of livestock or livestock products.

GRAIN CROPS

The grain crops of Nebraska include corn, wheat, oats, barley, rye, emmer (spelt), and the grain sorghums. The value of the annual production of these crops in the State averages about $247,000,000.

Corn

Corn occupies more than twice the area devoted to any other cultivated crop, and it has a gross value greater than that of any other crop. Nebraska is normally third in the United States in corn production with an average harvest of 224,000,000 bushels. It is in the western part of the great corn belt which extends from central Nebraska to central Ohio. Because of soils, relief, climate, and other conditions corn is not of equal importance in all sections of the State.

The largest area of concentrated corn production is in northeastern Nebraska, extending westward from the Missouri River, with the greatest density near the river. In this area several of the counties have from 50 to 60 per cent of their farm land in corn and a much larger number have from 40 to 50 per cent. Other areas of the State having high concentration of corn production are the east-central in the lower Platte River Valley, the north and east-central part, and along the Missouri River in the southeastern part. The north-central and western parts of the State have the lowest percentage of farm area in corn. This is largely accounted for by the small percentage of land under cultivation or that it ranks less important than the small grains in these arable areas.

The number of bushels of corn grown and its value vary greatly from year to year. (See table in appendix). The 5-year average from 1926 to 1930 was 9,010,000 acres yielding 24.79 bushels per acre, and the total production, 223,399,000 bushels. The average price was 64 cents per bushel; the value of the average crop $142,152,000 per year. The price of corn decreased markedly during the depression years of 1931, 1932, and 1933.

Wheat

Wheat is the leading cash crop in Nebraska. The State is second in the production of winter wheat, and third in all wheat, producing on the average 56,000,000 bushels annually. Wheat is largely grown on the hard lands of the plains and tablelands. About 92 per cent of the total wheat acreage is winter wheat. There is considerable spring wheat in the northwestern counties, but elsewhere in the State winter wheat is much more important, because it is a more certain and productive crop.

On the average about 85 per cent of the crop moves out of the county where grown and smaller portions are sold direct to local mills. A small part of the crop is utilized on the farm for other purposes than seed. Experiments show ground wheat to be equal, pound for pound, in value to corn, for fattening livestock. Only in cases of abnormally narrow spreads between prices of wheat and feed grains is much wheat used for livestock feed in Nebraska.

Wheat is essentially a southern and western Nebraska crop. It is confined largely to the "panhandle" and to the territory south of the Platte River. The principal area of concentrated wheat production is in the southern tier of counties of the "panhandle" section and in the adjacent counties to the east. The second area of important wheat production is in the counties just south of the Platte River in south-central Nebraska.

Hard winter wheat is the prevailing type grown in Nebraska, except in the northern counties of the "panhandle" where red spring wheat is important. In 1930 Nebraska ranked second among the states in production and value of winter wheat, and eleventh in spring wheat. Nebraska in 1923 ranked eighth for winter wheat and tenth for spring wheat. For the 5-year period, 1926-1930, its rank was: fifth in winter wheat in 1926, and second for the next 4 years. In 1930 winter wheat production reached an all-time high of 71,934,000 bushels. The production decreased for the next 4 years reaching a low point in the drought year of 1934. Since that time production has been gradually approaching normal.

Oats

Oats follow corn and wheat in importance as a grain crop in Nebraska. In 1927, oats occupied 14 per cent of the cultivated land and 5 per cent of the farm area of the State. Production of oats is of most importance in the eastern third of the State with the area of concentrated production in northeastern Nebraska where corn is the leading crop. Oats are rotated with corn, sweet clover or alfalfa, and are used principally as stock feed.

Barley

During the past few years, barley has increased in acreage especially in western Nebraska. In 1925, the barley crop occupied 233,000 acres; in 1927, 259,000 acres; in 1928, 430,000 acres; and in 1929, 688,000 acres.

There are two areas of concentrated barley production in Nebraska. The one is in the irrigated area of the North Platte Valley, centered in Scotts Bluff County; the other is in the southern tier of counties of this region.

Rye

Rye is better adapted to sandy land than are wheat, barley, and oats. In a belt bordering the sand-hill section of Nebraska, rye is rather important, occupying as high as 10 to 14 per cent of the farm area in a few townships in Holt and Antelope counties. Rye is one of the most profitable crops that can be grown on soils of light texture or low fertility.

Spelt and Grain Sorghums

Spelt and grain sorghums are grown in the southwestern and western counties for stock feed. The first is of minor importance whereas grain sorghums are increasing in importance.

Production and Value of Minor Grain Crops

The production and value of oats, rye, barley, spelt, and grain sorghums in 1930, when the prices were relatively low were as follows:

	Acres	Bushels	Value
Oats	2,485,000	80,017,000	22,405,000
Barley	725,000	22,330,000	7,816,000
Rye	333,000	4,995,000	1,898,000
Spelt (emmer)	43,000	1,006,000	382,000
Grain (sorghum)	17,000	340,000	272,000
Total Value			32,773,000

Forage Crops

The more important forage crops of Nebraska are the native pasture grasses, wild hay, alfalfa, sweet clover, red clover, timothy, sudan grass, millet, and forage sorghums.

Native Grasses

Nebraska is well supplied with native forage plants, especially in the sand-hill region and on wet bottom lands. These plants form our permanent pasture lands and native hay meadows which support extensive cattle raising in different parts of the State.

Wild hay occupies more than twice the acreage of alfalfa, but in tonnage it is less important. From the standpoint of feeding value, wild hay is about three-fourths as valuable as alfalfa. More than 3,000,000 acres of our native prairies are cut annually, yielding more than 2,600,000 tons of hay with a value of $16,200,000 or more. Cherry, Holt, Rock, and Lincoln counties lead in this production. The Prairie Plains country, the hay flats of the Sand Hills, and the wet bottom lands of the Platte, and other valleys in the State are the main sources of this hay. The principal area of concentrated wild hay production is in the north-central part of Nebraska. This is an area of light soils, where it is highly essential to maintain a grass covering to prevent wind erosion and the development of "blowouts". Such conditions necessitate a system of agriculture that will utilize to best advantage the native vegetation. This is done by grazing and cutting the native grass hay.

The largest centers for the production and shipment of native hay are at Newport, Bassett, Atkinson, O'Neill, and Ewing. Some of this hay is shipped to Wisconsin, Minnesota, Iowa, and Missouri, but most of it is fed to livestock within the State.

Alfalfa

The two outstanding leguminous forage crops in Nebraska are alfalfa and sweet clover, the former used mainly for hay and the latter for pasture.

Alfalfa is the leading hay crop of the State from the standpoint of tonnage produced. The main use of alfalfa and other hay crops in Nebraska is feed for livestock. For the 5-year period, 1923-1927, slightly less than 4 per cent of the hay crop of the State was reported as marketed. The greater part of the alfalfa crop went to livestock feeders within the State. The largest area of concentrated alfalfa production is in the Platte Valley of central Nebraska, where much of the land is subirrigated. In eastern Nebraska where precipitation is less a limiting factor heavy crops of alfalfa are grown on the upland, especially until the deeper seated subsoil moisture is exhausted.

For a few years, Nebraska ranked second among the states in the acreage and value of alfalfa. It is now first in acreage. From the 1,135,000 acres in this crop in 1930, about 2,973,000 tons of hay were cut, an average of 2.12 tons per acre. In addition, a large amount of pasturage was provided and from 30,000 acres, 84,036 bushels of seed were harvested. The value of the crop in 1930 was $25,130,211 for hay, and $997,420 for seed. The leading counties for seed production were Sioux, Dawes, Cherry, and Dawson, whereas the leading county for alfalfa-hay production was Scotts Bluff.

Sweet Clover

Sweet clover is rapidly increasing in acreage on the uplands where it fits into systems of rotation. The greatest value of sweet clover is for pasture and soil improvement. In 1930 there were 1,126,000 acres of sweet clover in the State. Much of this was pastured to cattle and other animals. From 21,000 acres of sweet clover 90,300 bushels of seed were harvested, and a considerable acreage was cut for hay.

Value of Hay

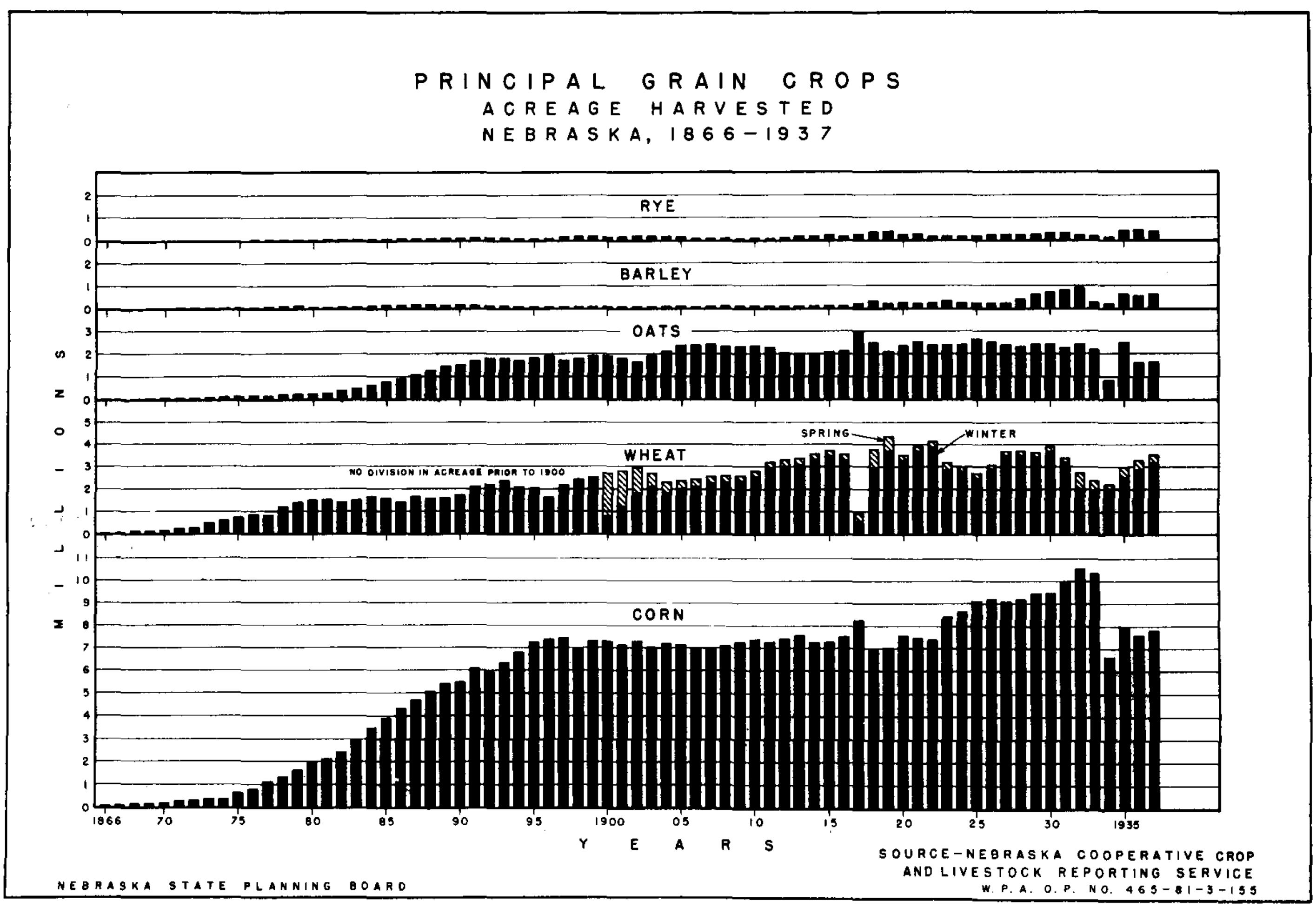
The total value of the annual hay production of Nebraska is about $50,000,000 of which alfalfa, wild hay, and sorghum lead in the order named.

Sugar Beets

The growing of beets in Nebraska for sugar production is confined largely to the irrigated areas of Scotts Bluff, Morrill, Dawson, Lincoln, Sioux, Garden, and Kimball counties.

There are seven sugar beet factories in Nebraska. These are located at Grand Island, Bayard, Minatare, Scottsbluff, Gering, Mitchell, and Lyman. With the exception of Grand Island the factories are all in the irrigated areas of the North Platte valley. They are operated for about three months of the year.

The production of beet sugar has advanced year after year in Nebraska until the combined annual output of the seven factories is now about 2,750,000 sacks or 275,000,000 pounds. Part of the Nebraska-made sugar is consumed within the State, but much of it is shipped in carload lots to out-state markets.



According to the census, the 1930 production and value of sugar beets in Nebraska were as follows: acres under cultivation, 81,000; average yield, 14 tons per acre; total tons, 1,132,000; value of crop, $7,924,000. Although the yield was increased, there was a reduction from the 1929 acreage.

The 1930 value of beets in the leading counties was: Scotts Bluff $5,100,000; Morrill $1,059,282; Dawson $315,567; Lincoln $194,164; Sioux $179,305; Garden $164,682; Kimball $115,388.

Potatoes

Potatoes are raised in gardens or in small fields in every county in Nebraska. They are grown commercially, principally in the western counties and in the central counties along the Platte River. The counties leading in the commercial production of food potatoes are Scotts Bluff, Sioux, Morrill, and Kimball, located in the irrigation districts. Those leading in the production of seed potatoes are: Box Butte, Sheridan, and Dawes. Scotts Bluff leads in the value of food potatoes, and Box Butte in production and value of seed potatoes.

Production in 1930 was as follows: acreage-94,000; average yield-100 bushels per acre; production 9,400,017 bushels; value- $7,990,017. The leading counties in the value of potato production in 1930 were; Scotts Bluff- $1,471,138; Box Butte- $1,367,711; Sioux- $666,830; Sheridan- $485,813; Kimball $440,813; Dawes- $362,957.

Combination of Crops and Livestock

The true significance of each crop becomes more apparent when considered in relation to other enterprises. The different crops are fitted together to make up the cropping system. Certain factors such as climatic conditions, soils, relative yields, variability of yields, labor requirements, and relation to livestock enterprises have an important influence on the choice of crops and their relative importance.

LIVESTOCK

Livestock holds an important place in Nebraska agriculture. As an average for the 5-year period 1923-1927, 75 per cent of the gross farm income of Nebraska farmers was derived from livestock and livestock products.

Long distances to markets make it desirable to convert much of the bulky farm products into products of less volume in proportion to value in order to reduce transportation costs. This process is partially accomplished through livestock. Livestock enterprises, however, are not of equal importance in all parts of the State. There are distinct differences in the geographical distribution and type of production of the several classes of farm animals.

Cattle

Beef cattle and dairy cattle play an important part in the agriculture of Nebraska. A favorable climate, abundant supply of clean water, and good marketing conditions make beef and dairy-cattle industries important factors in the life of the State.

Beef cattle are almost as important a source of gross income of Nebraska farmers as are hogs. For the 5-year period, 1923-1927, sales of cattle and calves make up 28 per cent of the income as compared with 30 per cent from hogs. Plate LIX shows the distribution of cattle in Nebraska in 1935.

The leading phases of the beef cattle industry in Nebraska are cattle breeding, raising, feeding, and slaughtering, and meat packing.

The heavy concentration of beef cattle is in northeastern Nebraska where the number of hogs per section is also highest. Another area of concentration of beef cattle lies to the west of north-central Nebraska. The most specialized cattle raising area is in the sand-hill region, because of its abundant grass for grazing and hay, its water supply, and because other forms of agriculture are poorly suited to the sandy soils of this area. The areas showing the fewest cattle per section are the southern "panhandle" and southwestern sections of the State where there is relatively little pasture and hay, and the proportion of land in feed grains is relatively small.

The kind and quantity of the feed grains, forage, and pasture largely determine the type of cattle enterprise - whether it is the production of feeding cattle, the raising and finishing of market cattle, or commercial feeding.

The cattle are trailed to shipping points and sent principally to Omaha, Kansas City, St. Joseph, and Sioux City as feeders or for slaughter. Other markets include Chicago and Denver, and small local markets. In 1930 there were 2,312,000 cattle of the beef type in Nebraska. Of these, 1,357,501 beef cattle and calves were marketed with a value of $114,707,838. Nebraska is not an important dairy state, although dairying is an important supplement to the general farming system. For the 5-year period, 1923-1927, receipts from the sale of dairy products made up about 8 per cent of the gross income of Nebraska farmers. The dairy enterprise has been gaining in importance. In 1935 it ranked next to hogs and cattle among the livestock enterprises and provided 11 per cent of the gross farm income. The highest concentration of milk cows is in counties adjacent to the large cities, especially in Douglas, Washington, and Lancaster counties.

Aside from the counties named above, the distribution of milk cows is fairly uniform in the eastern third of the State. The areas of low concentration are the north-central, southwestern, and western counties (excepting Scotts Bluff County), the lowest being in the sand-hill section.

Butterfat is the chief form in which dairy products are sold. Production of fluid milk is of major importance only near Omaha and Lincoln. Cheese manufacture is a growing industry in the North Platte Valley particularly in Scotts Bluff County. Throughout the State cream is separated from the milk on the farm and sold on the butterfat basis. In some localities where dairying is important, the butterfat is manufactured into butter. Omaha makes more butter than any other city in the world, averaging over 30,000,000 pounds annually. Nebraska has 108 creameries with an average annual production of 85,000,000 pounds of butter.

Hogs

Hog production is the most important livestock enterprise in Nebraska when measured in terms of gross farm income. For the 5-year period, ending in 1935, 26 per cent of the gross farm income of Nebraska farmers was derived from hogs. Plate LX shows that the distribution of hogs in the State coincides quite closely with the distribution of the corn acreage. Northeastern Nebraska is the most important area of hog production with Burt County having had 327 head of hogs per section of land in 1928, and 4 other nearby counties over 250 head per section. The Sand Hills and western and southwestern Nebraska have the fewest hogs per section. The sand-hill region has a large percentage of hay and pasture land and low production of feed grains. Western and southwestern Nebraska have more feed grain available, but the types of hay and pasture are more suitable for cattle production than for hog production. In eastern Nebraska where production of slaughter hogs is the prevailing practice, a large proportion of the hogs on hand are being fattened for market.

Sheep

Sheep are of importance in only limited areas of the State. For the 5-year period ending in 1935 about 2 per cent of the gross farm income of Nebraska farmers was derived from this source. The most important phase is feeding for market. Sheep are shipped into certain feeding areas largely from western range states and are finished for market. They are put into the feed lots in the fall and disposed of in late winter and early spring. Scotts Bluff, Merrick, and Sarpy counties are the most important feeding centers. Hall, Nance, and Burt counties also have large commercial feeding centers.

Commercial sheep feeding furnishes a means of marketing surplus feeds, usually to good advantage. Beet sugar by-products in the western, and alfalfa in the central and eastern Nebraska feeding sections, respectively, are the basic rations.

General purpose flocks are found most often in eastern and central Nebraska, and less often in the sand-hill area.

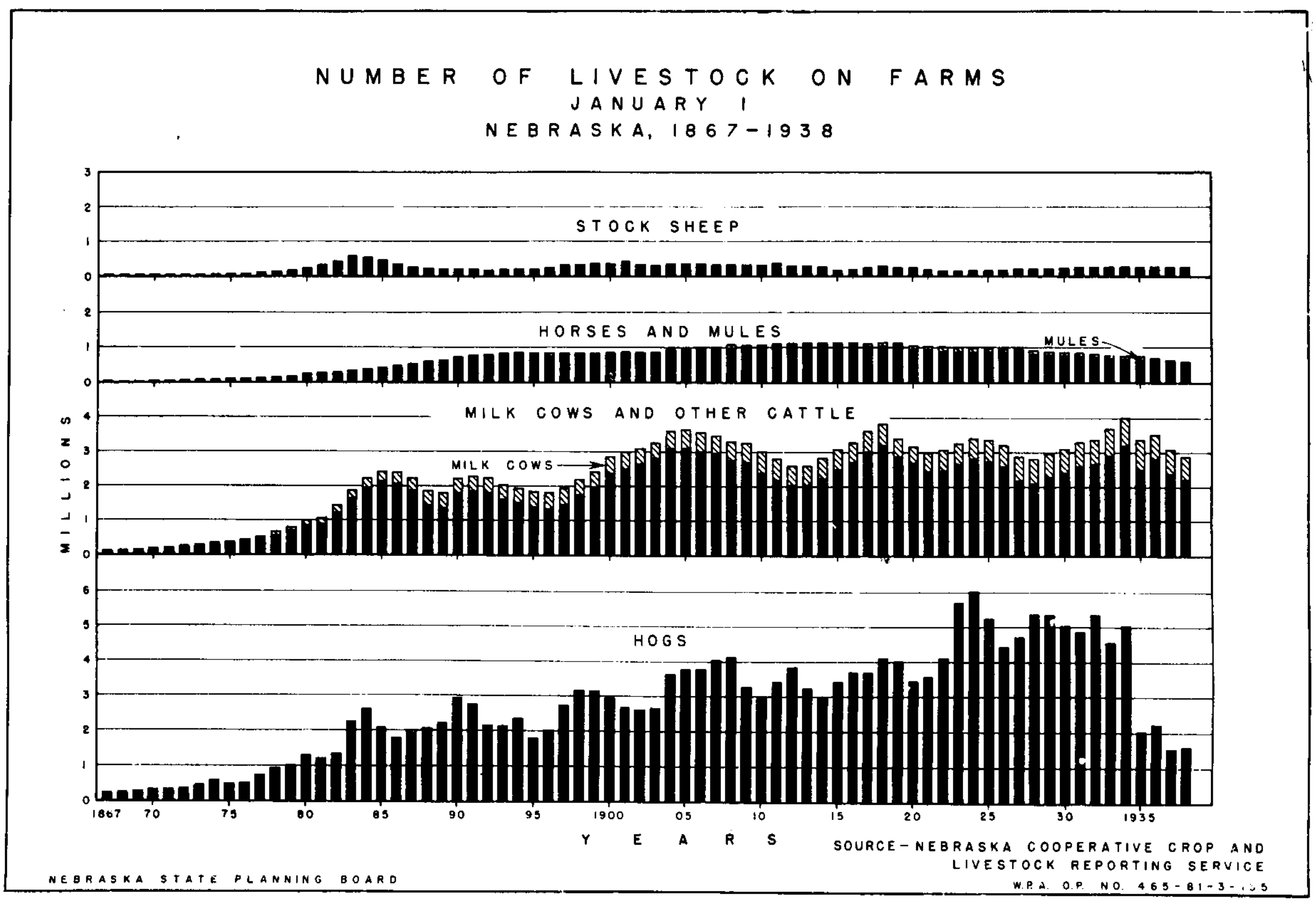
Poultry

Poultry ranked next below hogs and beef cattle as a source of livestock income during the 5-year period 1923 to 1927. The poultry industry is now surpassed by dairying. For the 5-year period, 1923 to 1927, sales of poultry products provided 6.5 per cent of the gross income of Nebraska farmers. Commercial poultry farms are relatively unimportant in Nebraska. The bulk of poultry products is produced on farms where the enterprise is handled as a side line.

The chief concentration of poultry is in southeastern and east-central Nebraska and the number per section decreases rather rapidly northward and westward across the State. The greater number of farms, the larger feed supply, and the better markets are factors accounting for more poultry in eastern and southern Nebraska.

AGRICULTURAL PROGRAMS

During the past few years a great deal of attention has been given to the organization of agricultural programs. The ultimate objective of these programs, whether on a county, state, or national

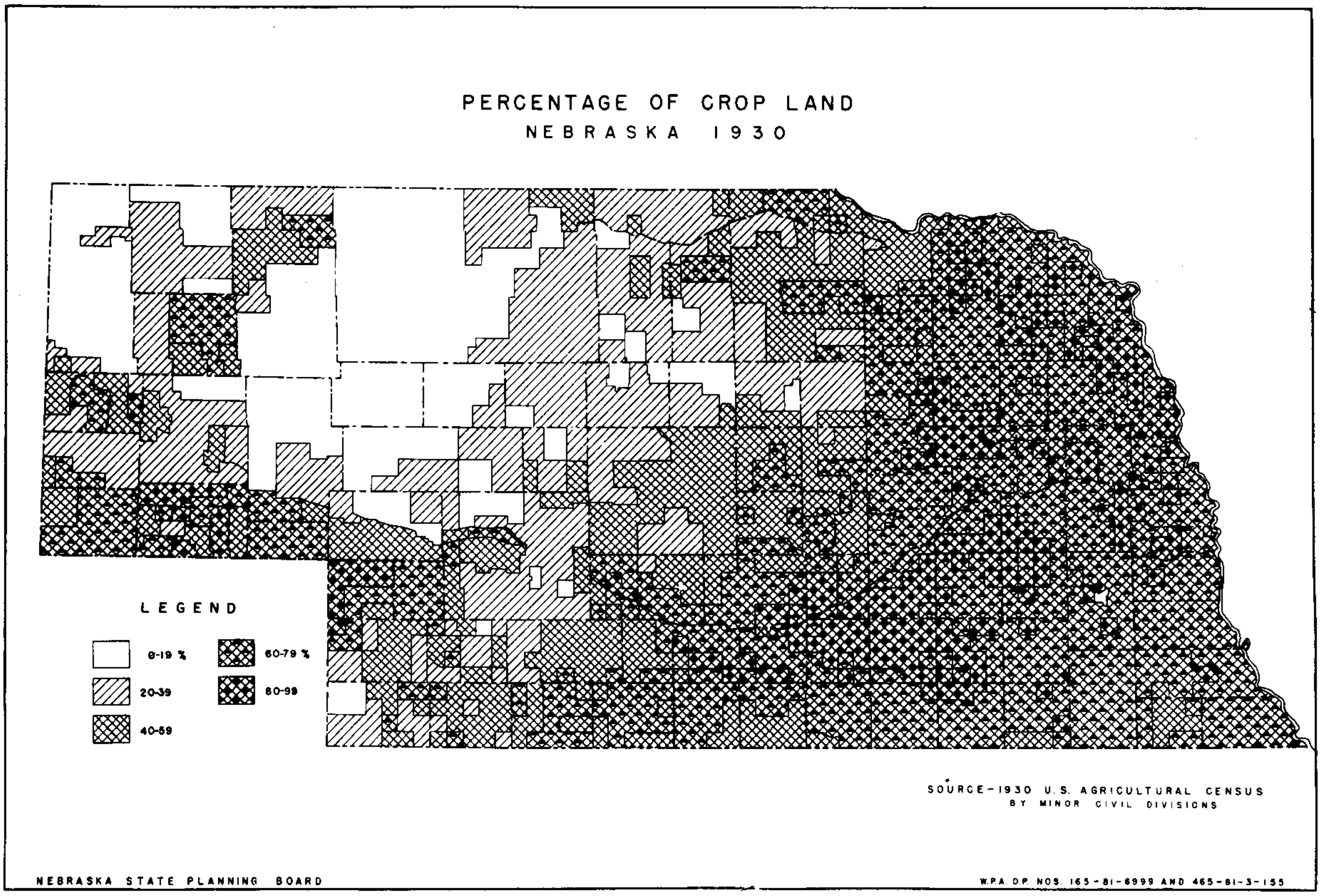


basis, is to aid farmers, both as individuals and as groups, to adopt practices and systems of farming which will conserve the resources more adequately and increase farm income. This is true whether the particular program be soil or moisture conservation, better crop rotations, improved varieties of crops, disease control, better feeding practices, or adjustments to market outlooks. Before much progress can be made in this direction, it is necessary to know what the situation is in each area of the county, state, and region and not only to obtain more accurate information on yields, production, and feeding practices, but also to determine what farming systems are best suited to the various situations in different areas.

Generalized recommendations have limited value and may be misleading. However, it is possible to make significant recommendations when farming systems are analyzed in terms of more specific conditions.

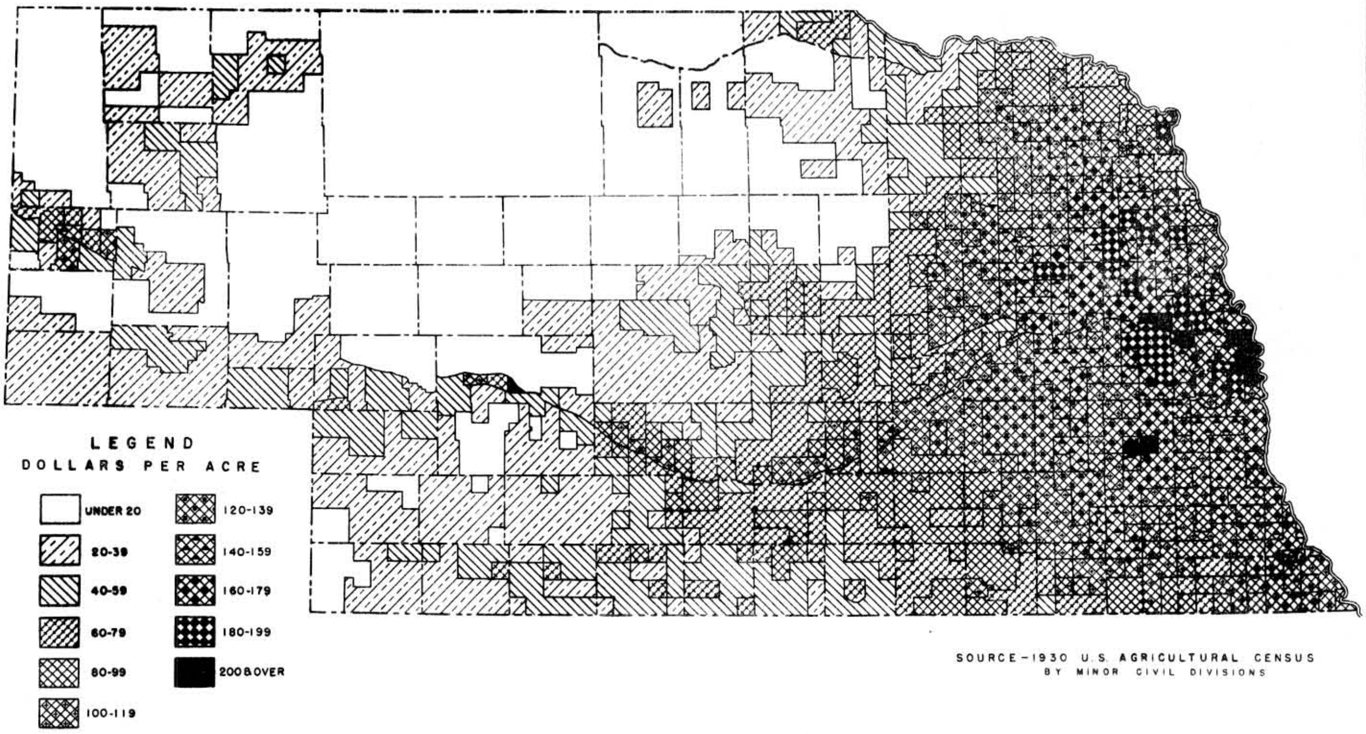
A farmer cannot stop with the selection of a fixed system of farming since it may not prove profitable to follow rigid production standards over a period of years. Because it is impossible to control production and prices, some short-time adjustments in the general plan are often desirable. As prices change, the returns to be expected from different organizations likewise change. If a farmer is to follow his economic advantage, he must take changing price and production relationships into account in making his plans for any particular year.

Studies made with the view of determining standards of performance, yields, and production practices, will be more reliable and trustworthy if confined to type areas in which there is a fairly high degree of uniformity of these factors. Likewise, income studies would be more realistic and suggestive if the results were analyzed from the standpoint of type-of-farming areas and further restricted to show returns from farms of the same size and type.



XXXI

VALUE OF FARM LAND AND BUILDINGS
NEBRASKA 1930



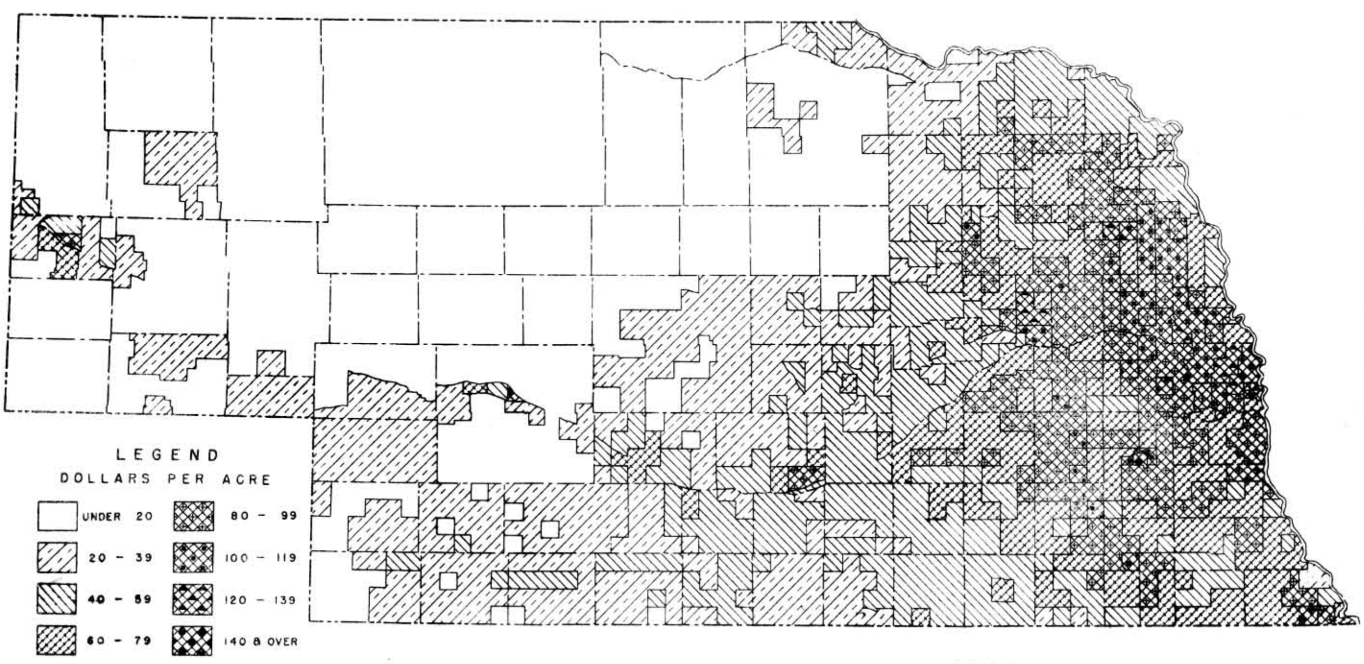
SOURCE—1930 U.S. AGRICULTURAL CENSUS
BY MINOR CIVIL DIVISIONS

NEBRASKA STATE PLANNING BOARD

W.P.A. O.P. NOS. 165-81-6999 AND 465-81-3-155

XXXII

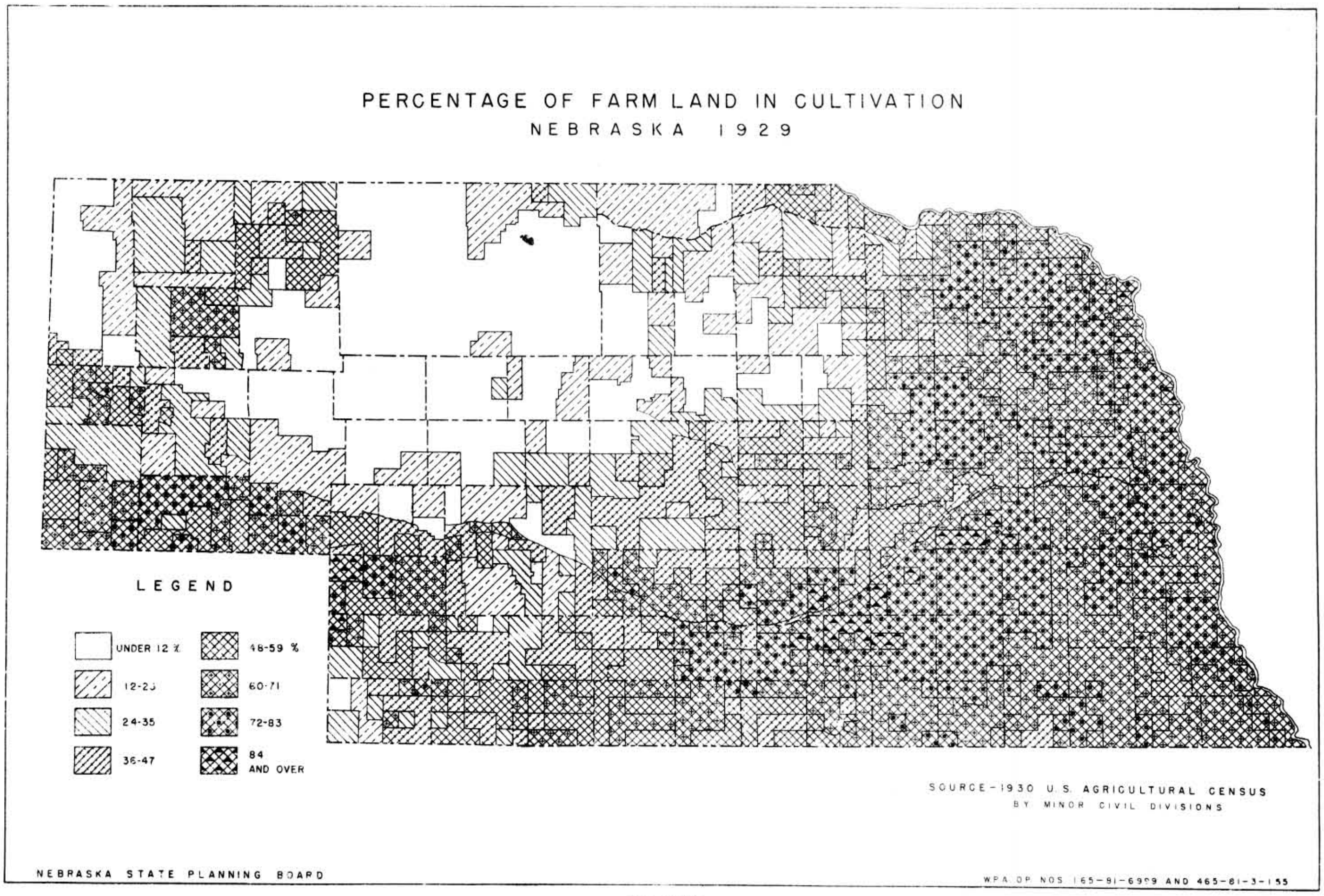
VALUE OF FARM LAND AND BUILDINGS
NEBRASKA 1935



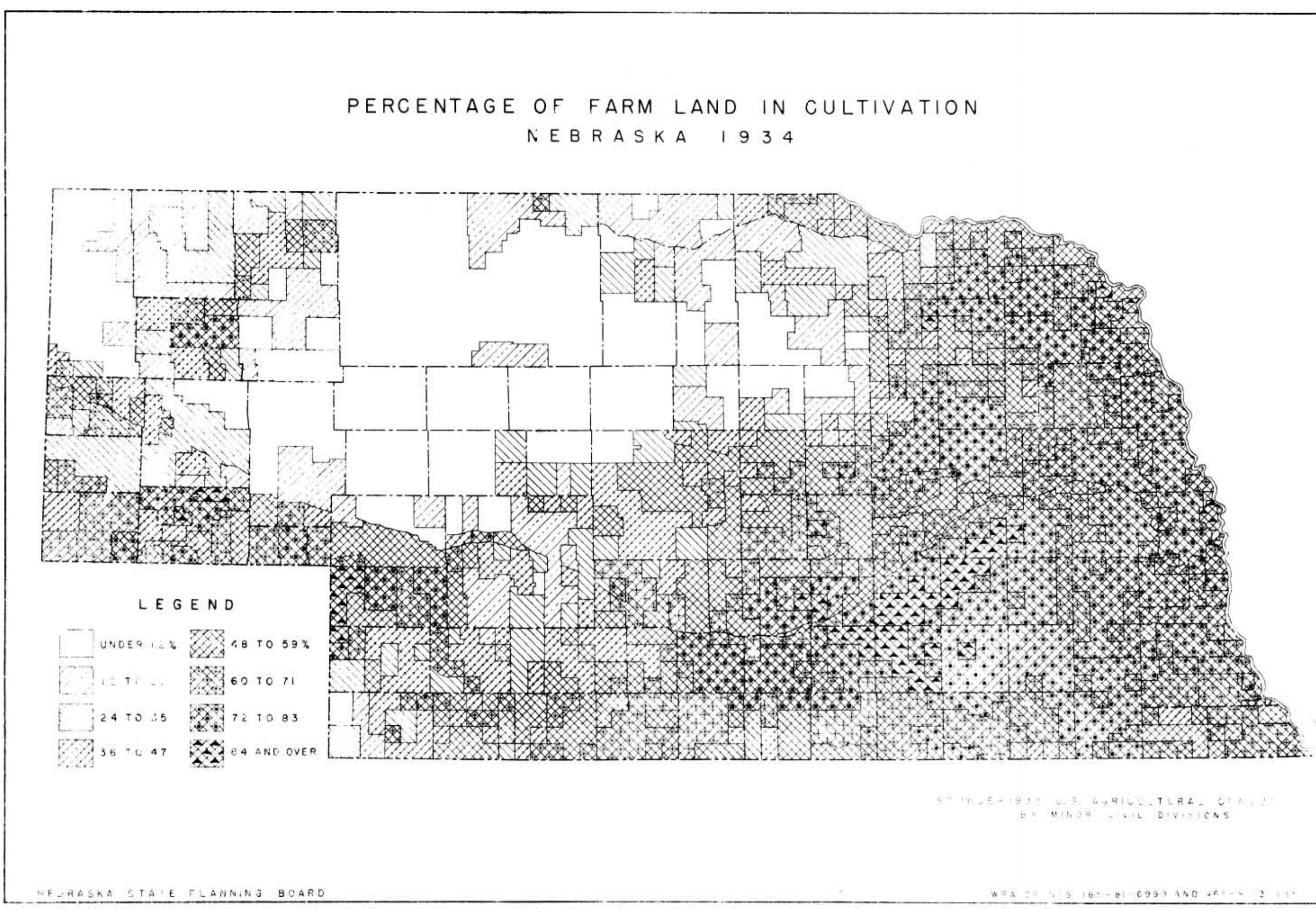
SOURCE—1935 U.S. AGRICULTURAL CENSUS
BY MINOR CIVIL DIVISIONS

NEBRASKA STATE PLANNING BOARD

W.P.A. O.P. NOS. 165-81-6999 AND 465-81-3-155


PERCENTAGE OF FARM LAND IN CULTIVATION
NEBRASKA 1929
LEGEND
UNDER 12 %
12-23
24-35
36-47
48-59 %
60-71
72-83
84 AND OVER
SOURCE-1930 U.S. AGRICULTURAL CENSUS
BY MINOR CIVIL DIVISIONS
NEBRASKA STATE PLANNING BOARD
W.P.A. O.P. NOS. 165-81-6999 AND 465-81-3-155

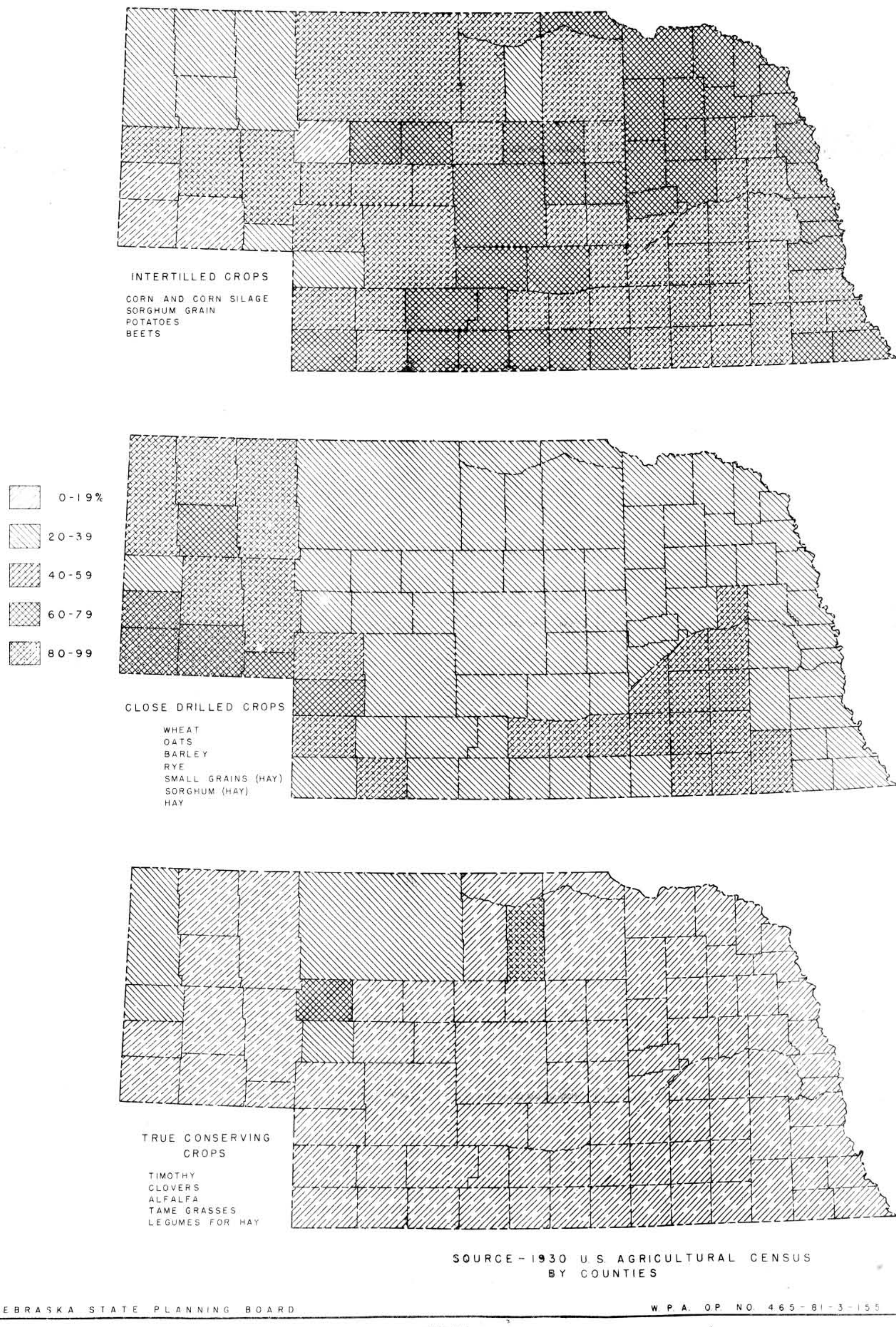
XXXIV


PERCENTAGE OF FARM LAND IN CULTIVATION
NEBRASKA 1934
LEGEND
24 TO 35
48 TO 59%
60 TO 71
72 TO 83
84 AND OVER
BY MINOR CIVIL DIVISIONS
NEBRASKA STATE PLANNING BOARD

XXXV

PERCENTAGE OF CROP LAND IN INTERTILLED, CLOSE DRILLED AND TRUE CONSERVING CROPS

NEBRASKA 1929

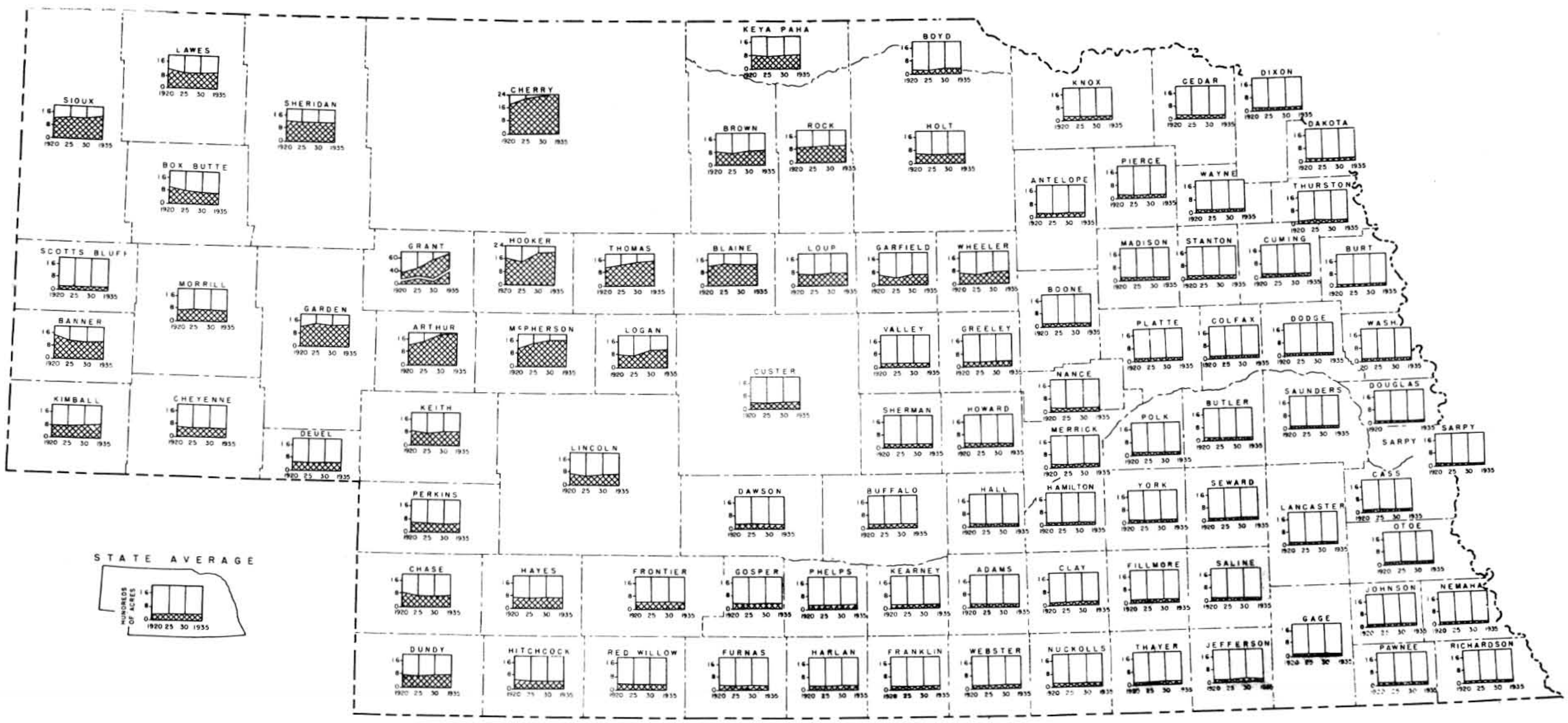


SOURCE - 1930 U.S. AGRICULTURAL CENSUS BY COUNTIES

NEBRASKA STATE PLANNING BOARD

W. P. A. OP. NO. 465-81-3-155

AVERAGE SIZE OF FARMS
TRENDS BY COUNTIES
NEBRASKA 1920-1935



COMPILED FROM PUBLISHED RECORDS U.S. BUREAU OF AGRICULTURAL ECONOMICS

NEBRASKA STATE PLANNING BOARD

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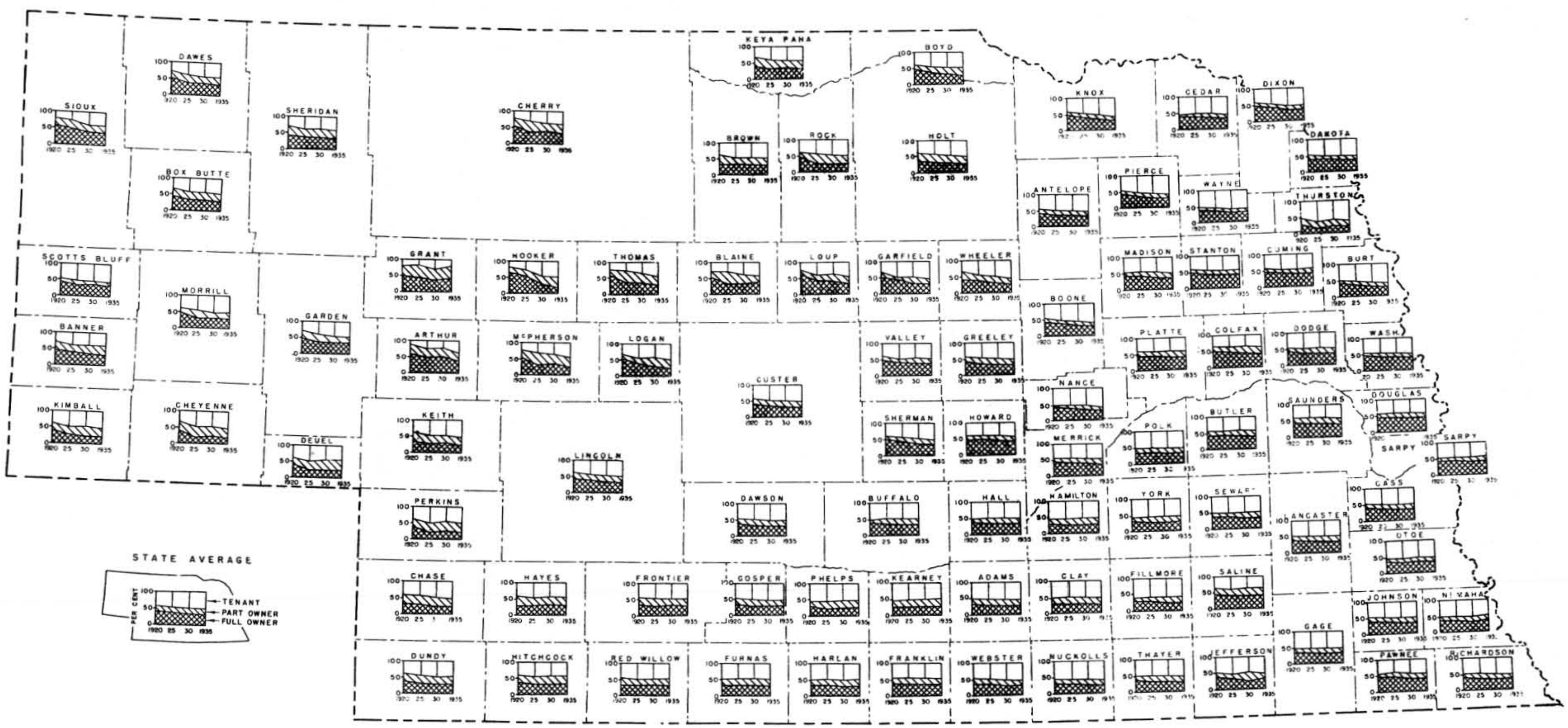
TRENDS IN TYPES OF FARM TENURE
NEBRASKA 1920-1935



COMPILED FROM PUBLISHED RECORDS U.S.
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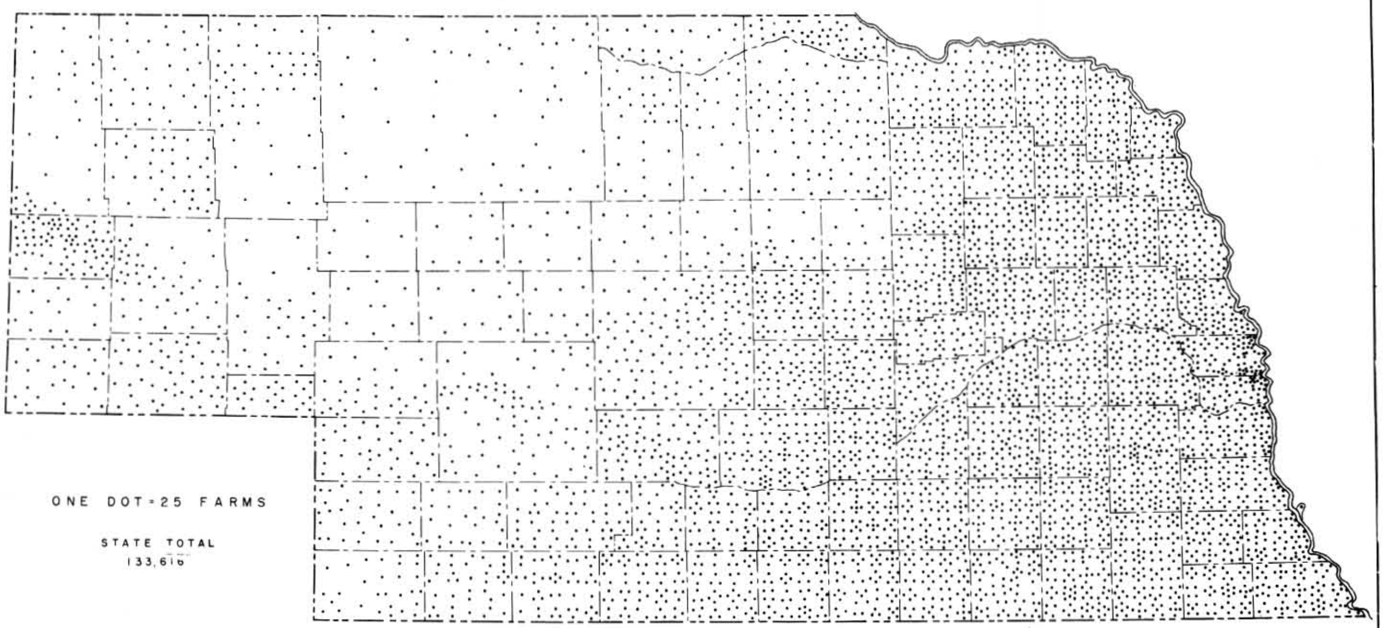
DISTRIBUTION OF FARMS
NEBRASKA
1935



ONE DOT = 25 FARMS

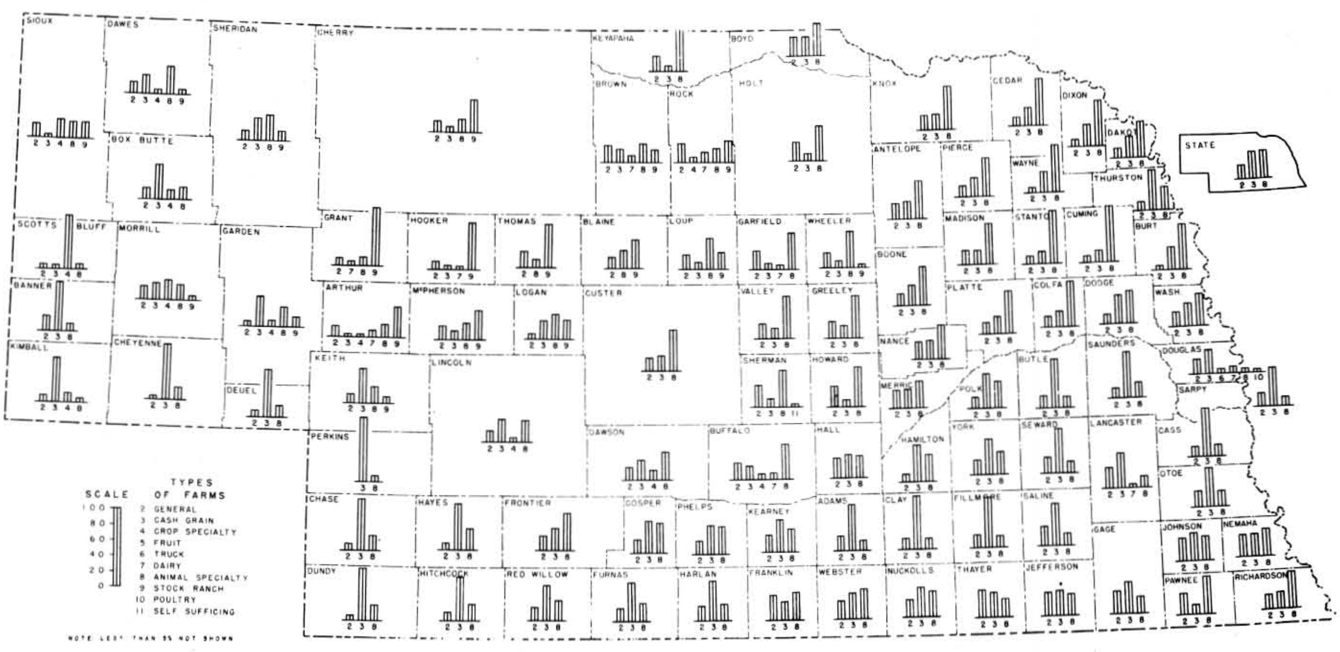
STATE TOTAL
133,616

SOURCE—1935 U. S. AGRICULTURAL CENSUS
BY MINOR CIVIL DIVISIONS

NEBRASKA STATE PLANNING BOARD

WPA OP NOS 165-81-6999 AND 465-81-3-155

PERCENTAGE OF FARMS BY TYPES
NEBRASKA 1929



COMPILED FROM PUBLISHED RECORDS U.S.
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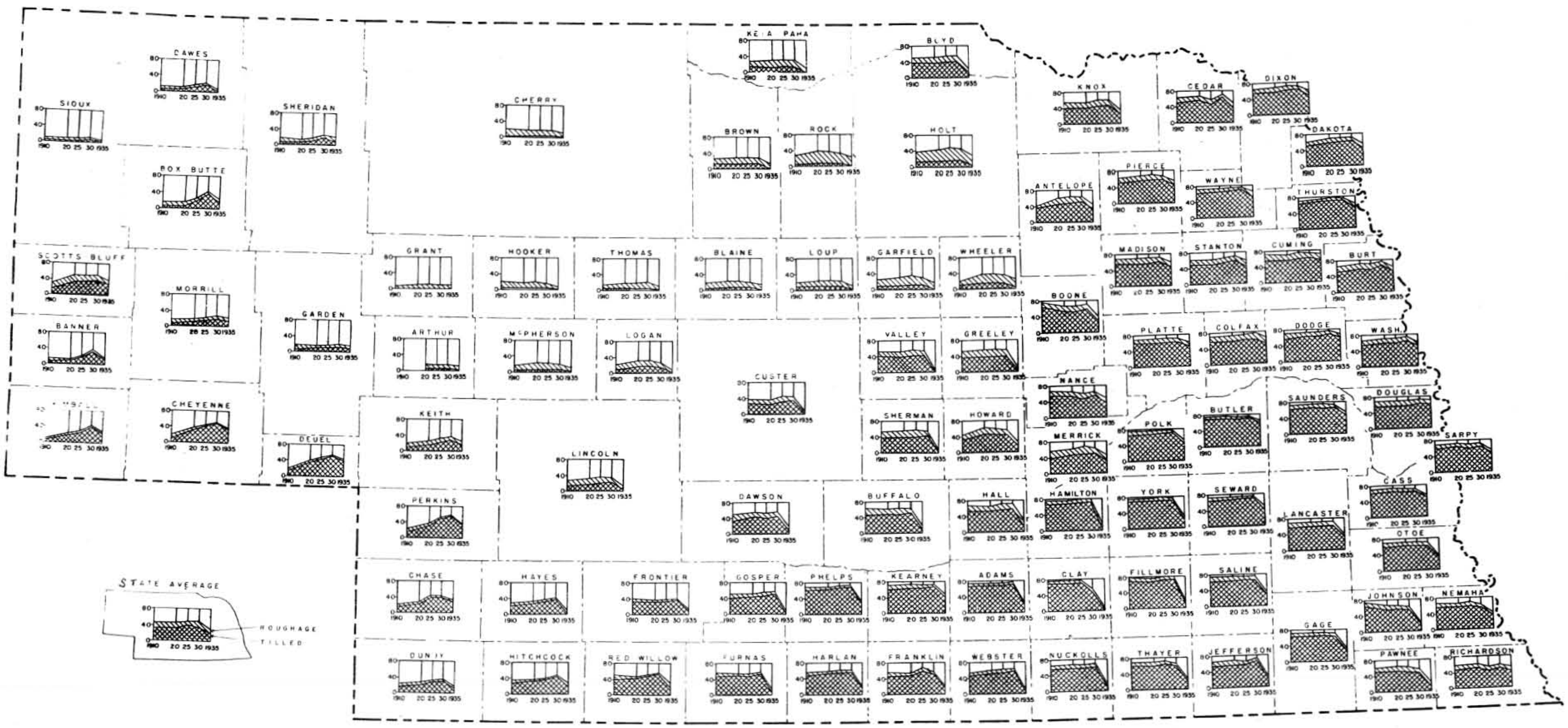
W. P. A. O. P. NO. 465-81-3-155

PERCENTAGE OF FARM LAND IN PRINCIPAL CLASSES OF CROPS
TRENDS BY COUNTIES
NEBRASKA 1910-1935

COMPILED FROM PUBLISHED RECORDS U.S. BUREAU OF AGRICULTURAL ECONOMICS

W.P.A. O.P. NOS. 165-81-6999 AND 465-81-3-155

TREND OF PRINCIPAL CROPS BY COUNTIES
TILLED AND ROUGHAGE IN ACRES
NEBRASKA 1910-1935



NEBRASKA STATE PLANNING BOARD

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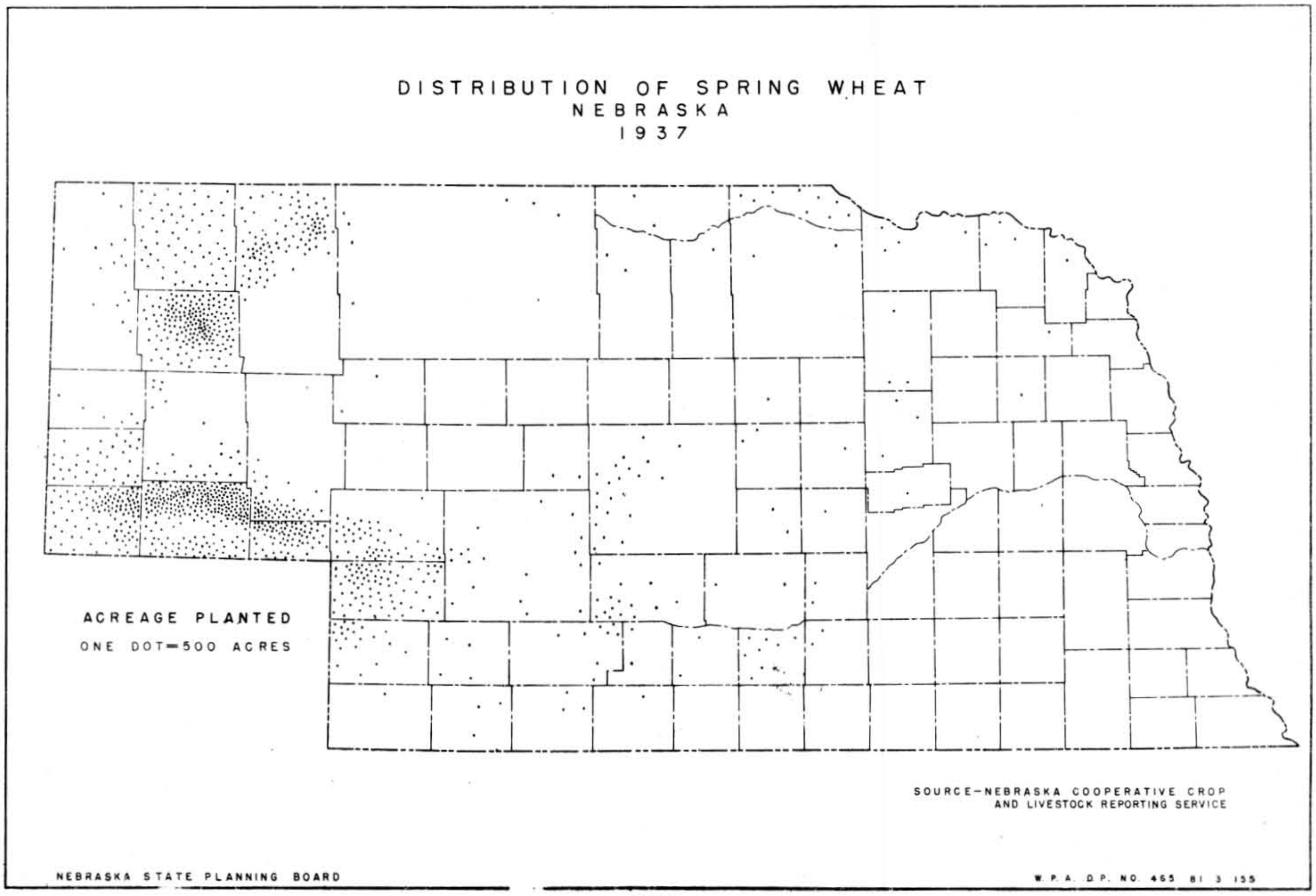
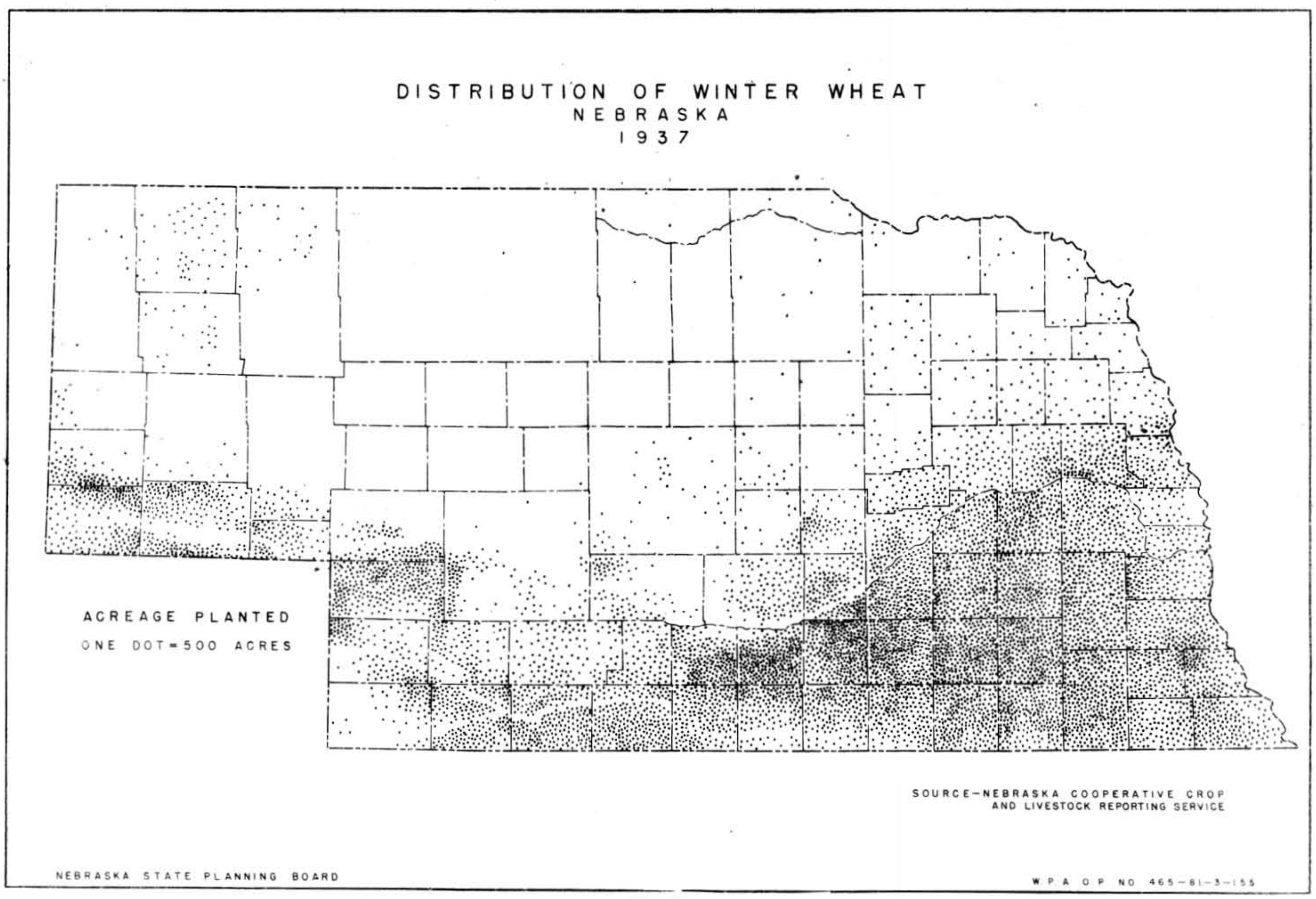
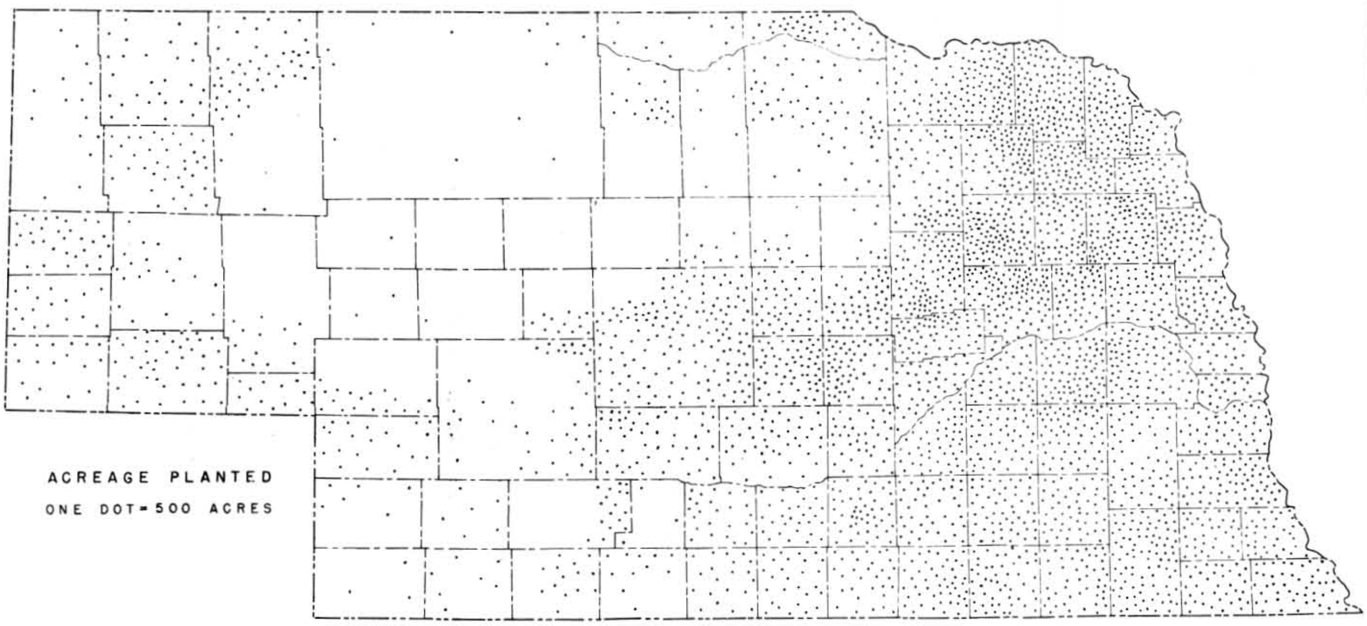

DISTRIBUTION OF SPRING WHEAT
NEBRASKA
1937
ACREAGE PLANTED
ONE DOT=500 ACRES
SOURCE—NEBRASKA COOPERATIVE CROP AND LIVESTOCK REPORTING SERVICE
NEBRASKA STATE PLANNING BOARD
W. P. A. O.P. NO. 465 81 3 155

XLIII


DISTRIBUTION OF WINTER WHEAT
NEBRASKA
1937
ACREAGE PLANTED
ONE DOT=500 ACRES
SOURCE—NEBRASKA COOPERATIVE CROP AND LIVESTOCK REPORTING SERVICE
NEBRASKA STATE PLANNING BOARD
W. P. A. O. P. NO. 465-81-3-155

XLIV

DISTRIBUTION OF OATS
NEBRASKA
1937



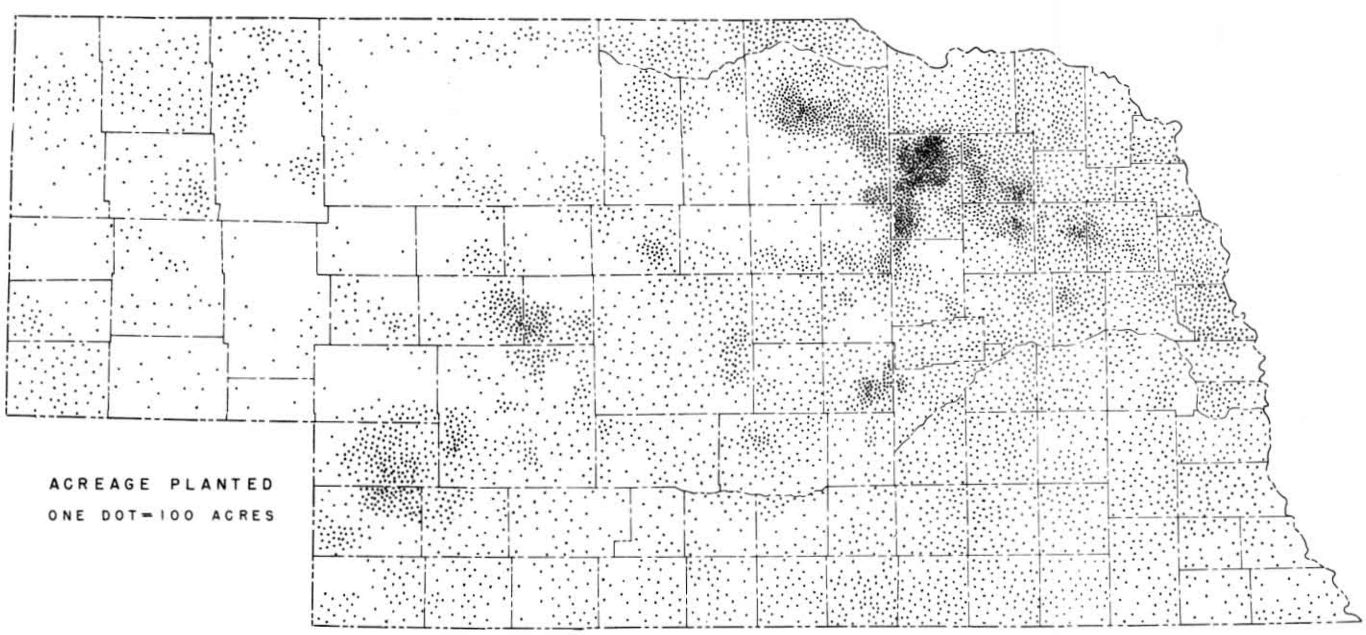
ACREAGE PLANTED
ONE DOT=500 ACRES

SOURCE–NEBRASKA COOPERATIVE CROP
AND LIVESTOCK REPORTING SERVICE

NEBRASKA STATE PLANNING BOARD

W. P. A. O. P. NO. 465–81–3–155

DISTRIBUTION OF RYE
NEBRASKA
1937



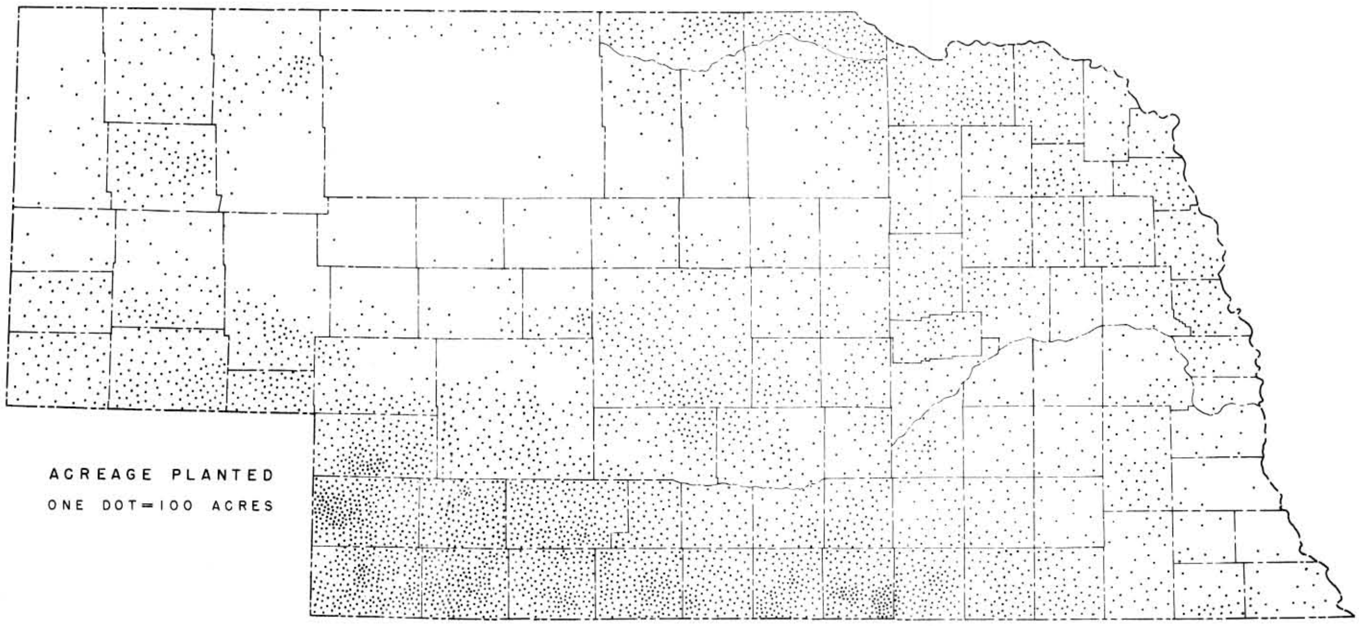
ACREAGE PLANTED
ONE DOT=100 ACRES

SOURCE–NEBRASKA COOPERATIVE CROP
AND LIVESTOCK REPORTING SERVICE

NEBRASKA STATE PLANNING BOARD

W. P. A. O. P. NO. 465–81–3–155

DISTRIBUTION OF SORGHUM
NEBRASKA
1937



ACREAGE PLANTED

ONE DOT = 100 ACRES

SOURCE—NEBRASKA COOPERATIVE CROP AND LIVESTOCK REPORTING SERVICE

NEBRASKA STATE PLANNING BOARD

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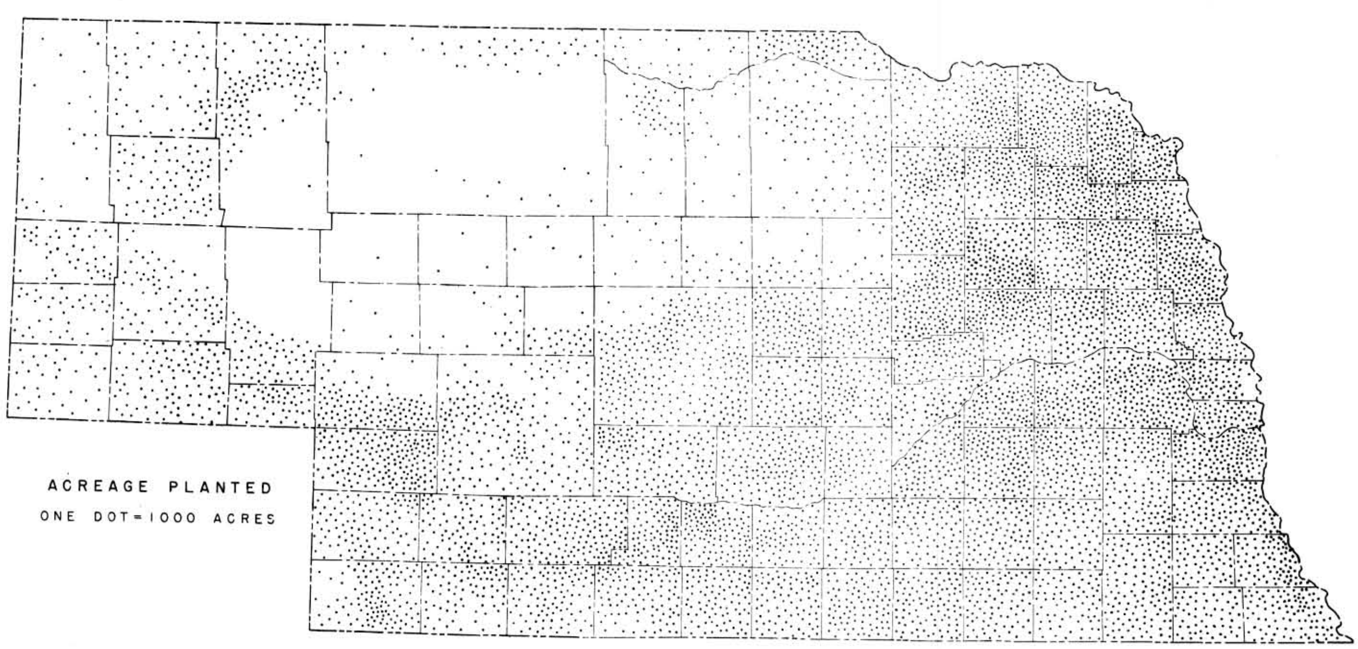
DISTRIBUTION OF CORN
NEBRASKA
1937



ACREAGE PLANTED

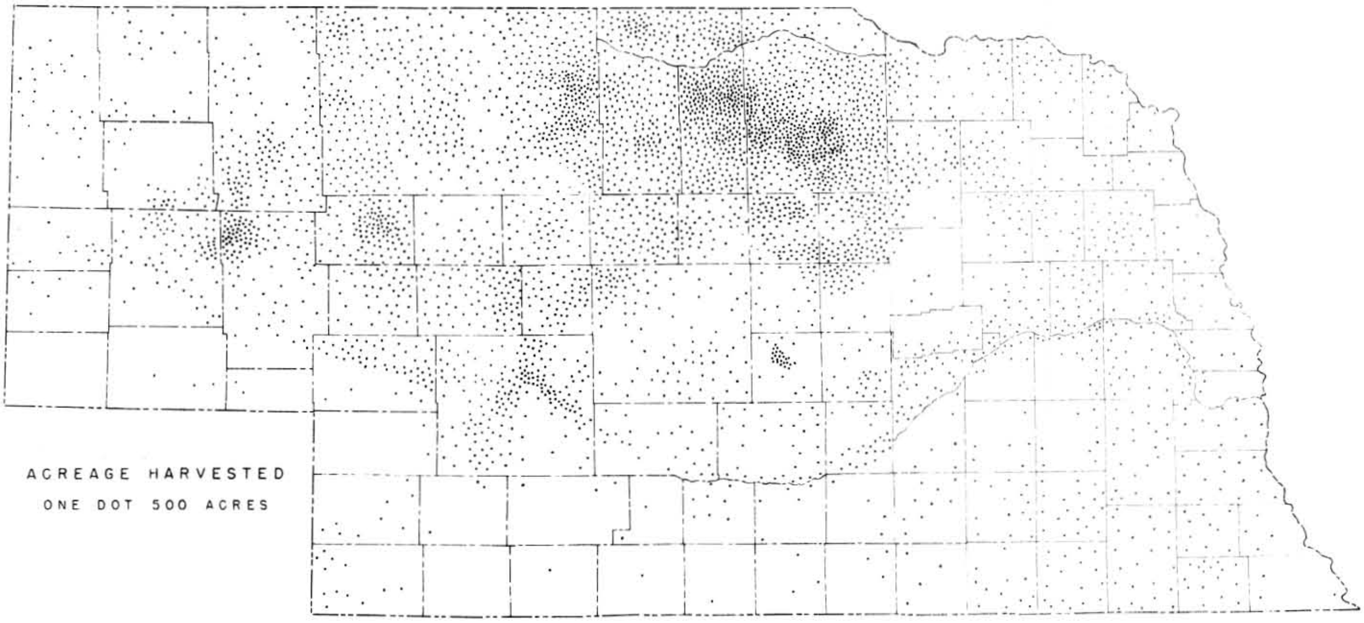
ONE DOT = 1000 ACRES

SOURCE—NEBRASKA COOPERATIVE CROP AND LIVESTOCK REPORTING SERVICE

NEBRASKA STATE PLANNING BOARD

W. P. A. O. P. NO. 465—81—3—155

DISTRIBUTION OF WILD HAY
NEBRASKA
1937



ACREAGE HARVESTED
ONE DOT 500 ACRES

SOURCE--NEBRASKA COOPERATIVE CROP AND LIVESTOCK REPORTING SERVICE

NEBRASKA STATE PLANNING BOARD

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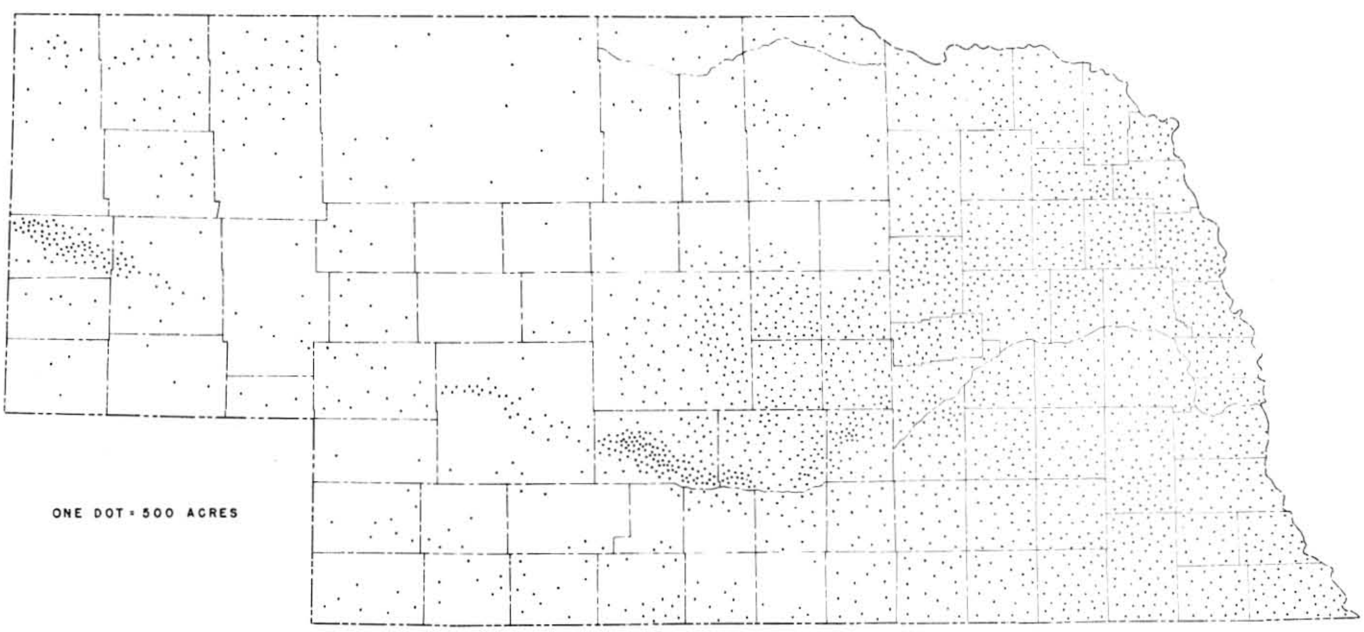
DISTRIBUTION OF ALFALFA
NEBRASKA
1937

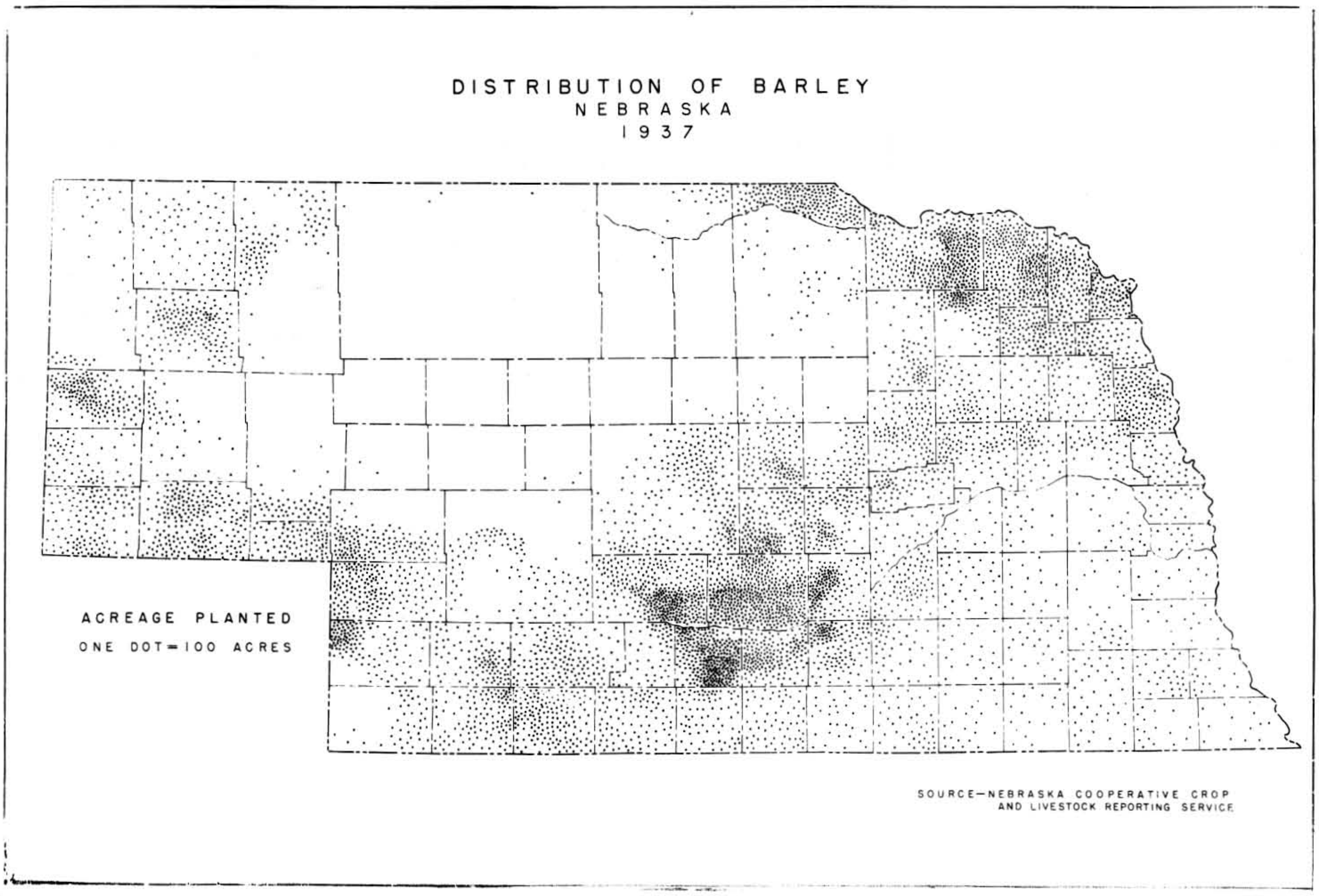


ONE DOT = 500 ACRES

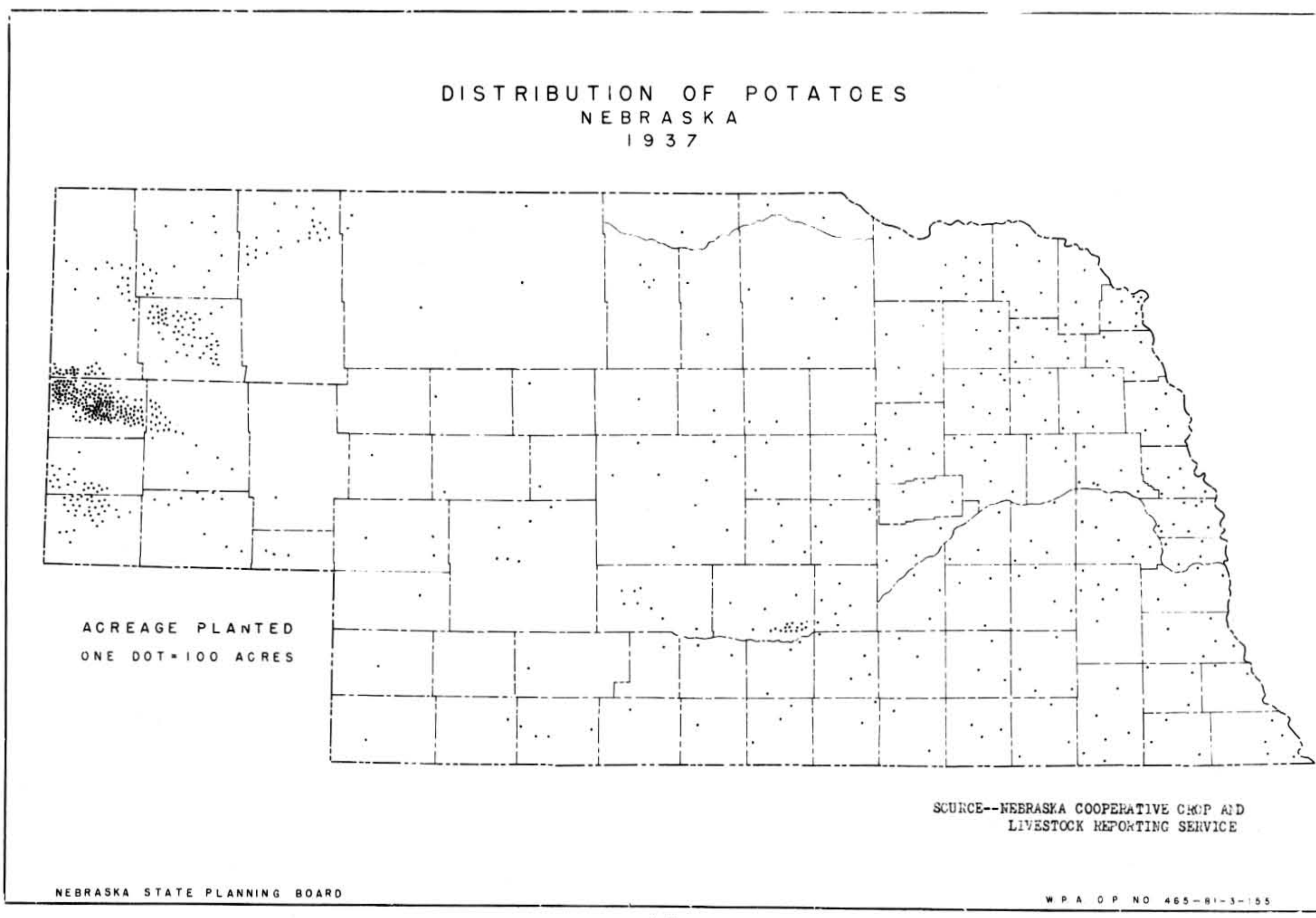
SOURCE-NEBRASKA COOPERATIVE CROP AND LIVESTOCK REPORTING SERVICE

NEBRASKA STATE PLANNING BOARD

W.P.A. O.P. NO. 465-81-3-155

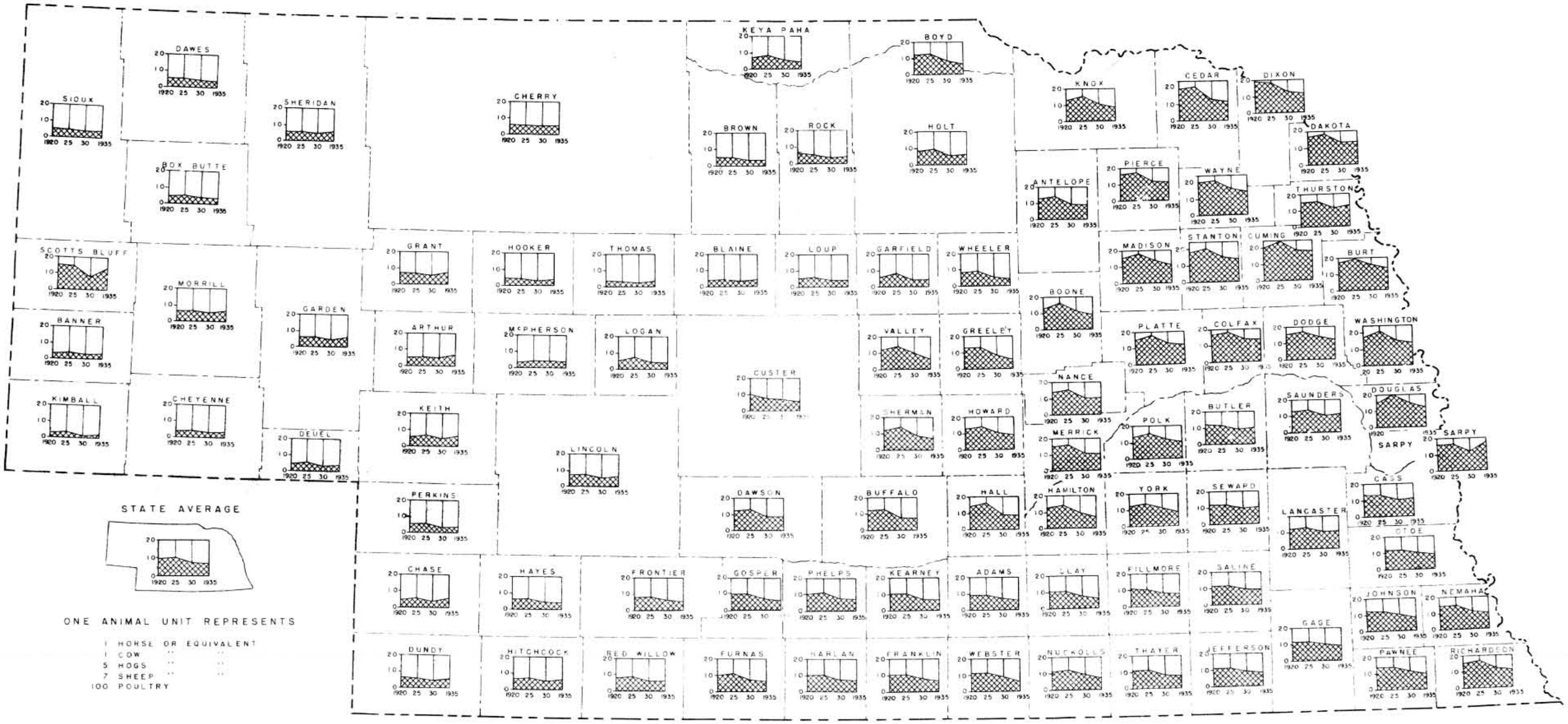

DISTRIBUTION OF BARLEY
NEBRASKA
1937
ACREAGE PLANTED
ONE DOT = 100 ACRES
SOURCE—NEBRASKA COOPERATIVE CROP
AND LIVESTOCK REPORTING SERVICE

L I


DISTRIBUTION OF POTATOES
NEBRASKA
1937
ACREAGE PLANTED
ONE DOT = 100 ACRES
SOURCE--NEBRASKA COOPERATIVE CROP AND
LIVESTOCK REPORTING SERVICE
NEBRASKA STATE PLANNING BOARD
W P A O P NO 465-81-3-155

LIVESTOCK PER 100 ACRES IN FARMS
BY ANIMAL UNITS

NEBRASKA 1920-1935



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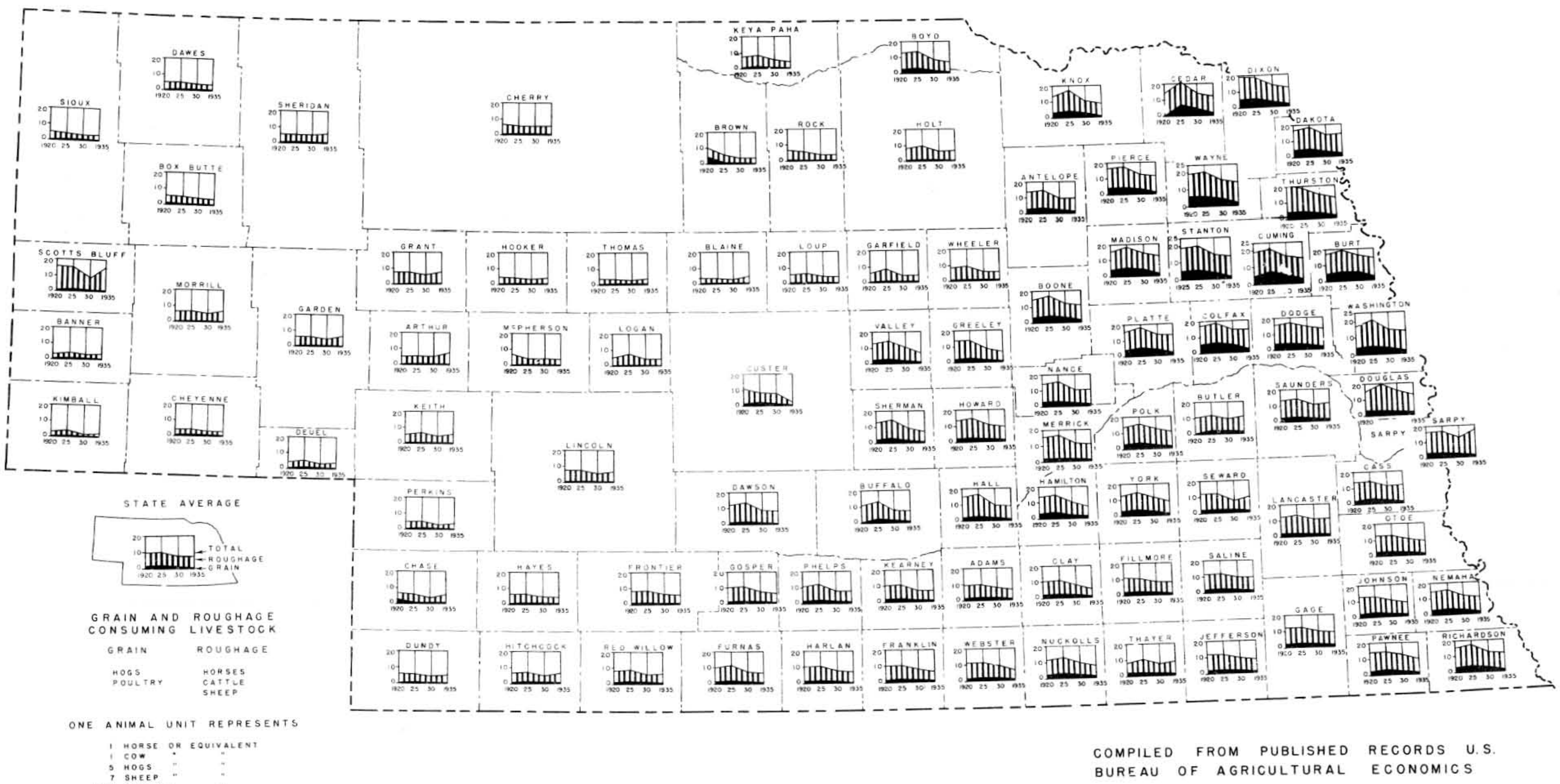
NEBRASKA STATE PLANNING BOARD

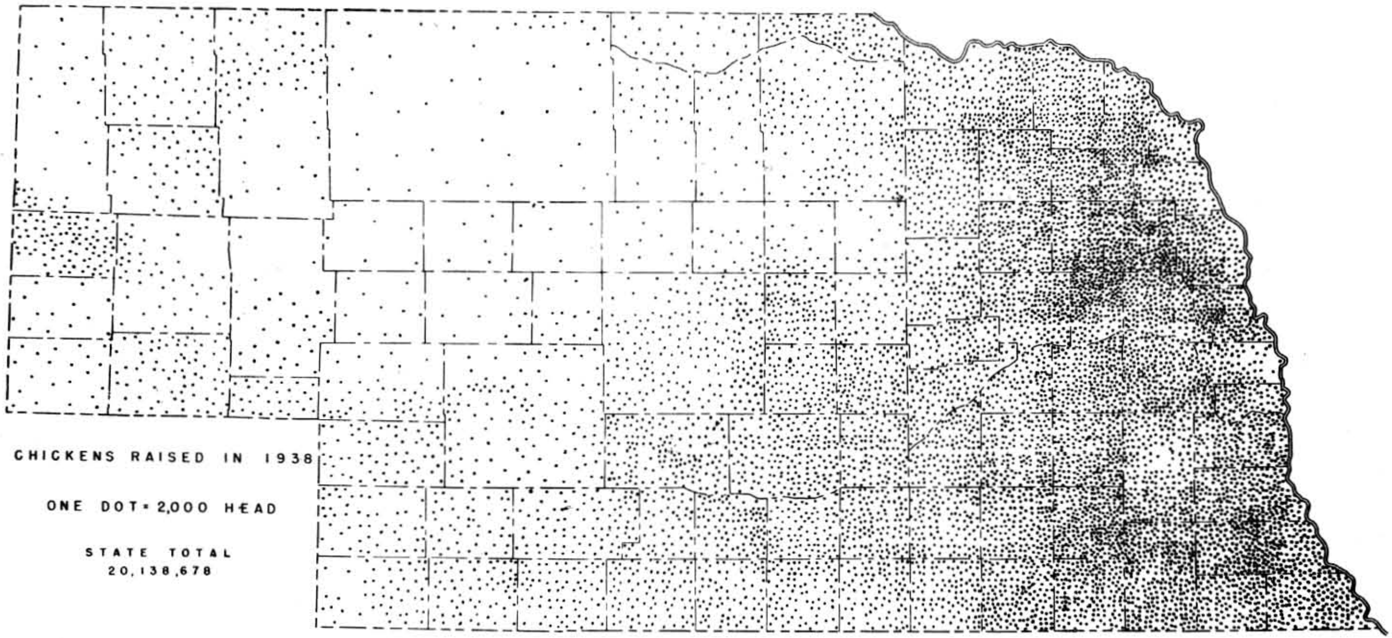
W.P.A. O.P. NOS. 165-81-6999 AND 465-81-3-155

NUMBER OF GRAIN AND ROUGHAGE CONSUMING LIVESTOCK
PER 100 ACRES IN FARMS
LIVESTOCK EXPRESSED IN ANIMAL UNITS
NEBRASKA 1920-25-30-35



COMPILED FROM PUBLISHED RECORDS U.S. BUREAU OF AGRICULTURAL ECONOMICS

DISTRIBUTION OF CHICKENS
NEBRASKA
1938



CHICKENS RAISED IN 1938

ONE DOT = 2,000 HEAD

STATE TOTAL
20,138,678

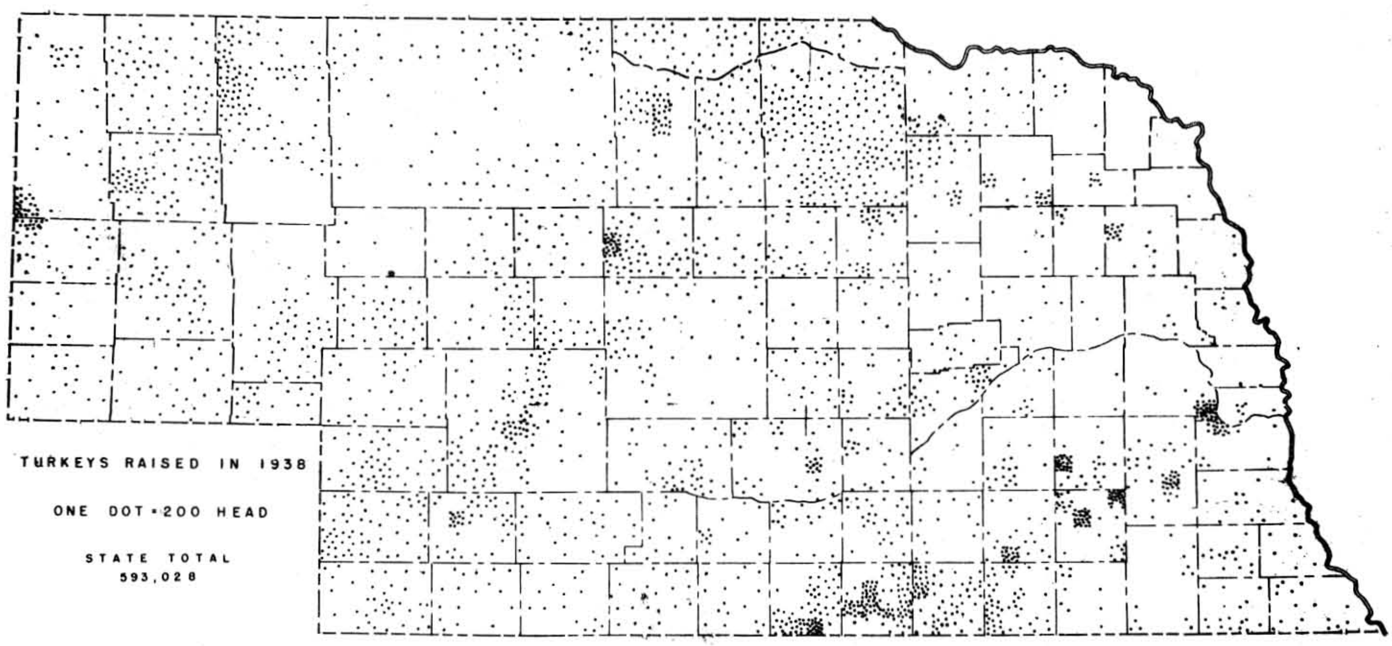
SOURCE—1939 STATE FARM CENSUS
BY MINOR CIVIL DIVISIONS

NEBRASKA STATE PLANNING BOARD

W.P.A. O.P. NO. 465-81-3-155

LV

DISTRIBUTION OF TURKEYS
NEBRASKA
1938



TURKEYS RAISED IN 1938

ONE DOT = 200 HEAD

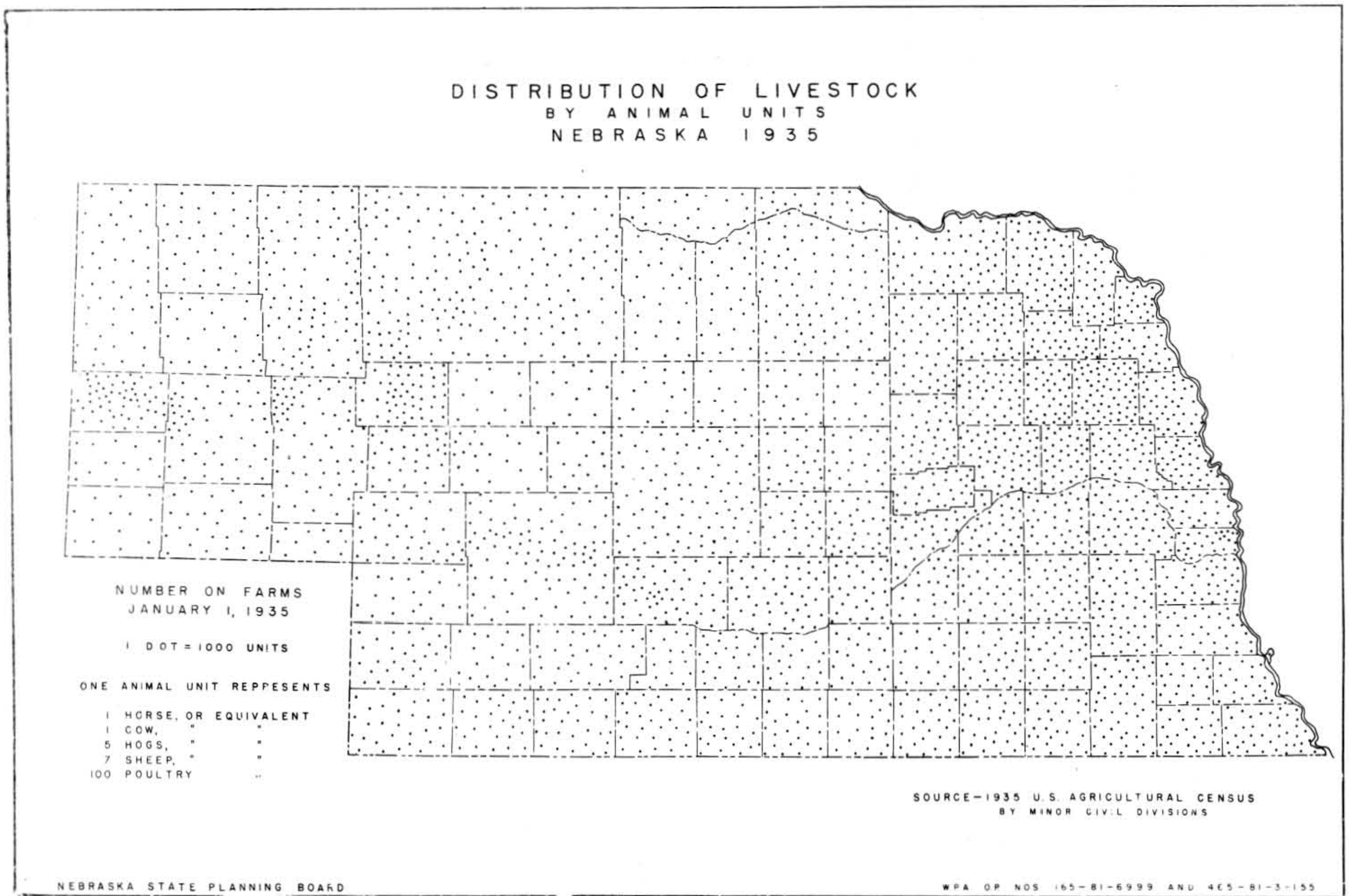
STATE TOTAL
593,028

SOURCE—1939 STATE FARM CENSUS
BY MINOR CIVIL DIVISIONS

NEBRASKA STATE PLANNING BOARD

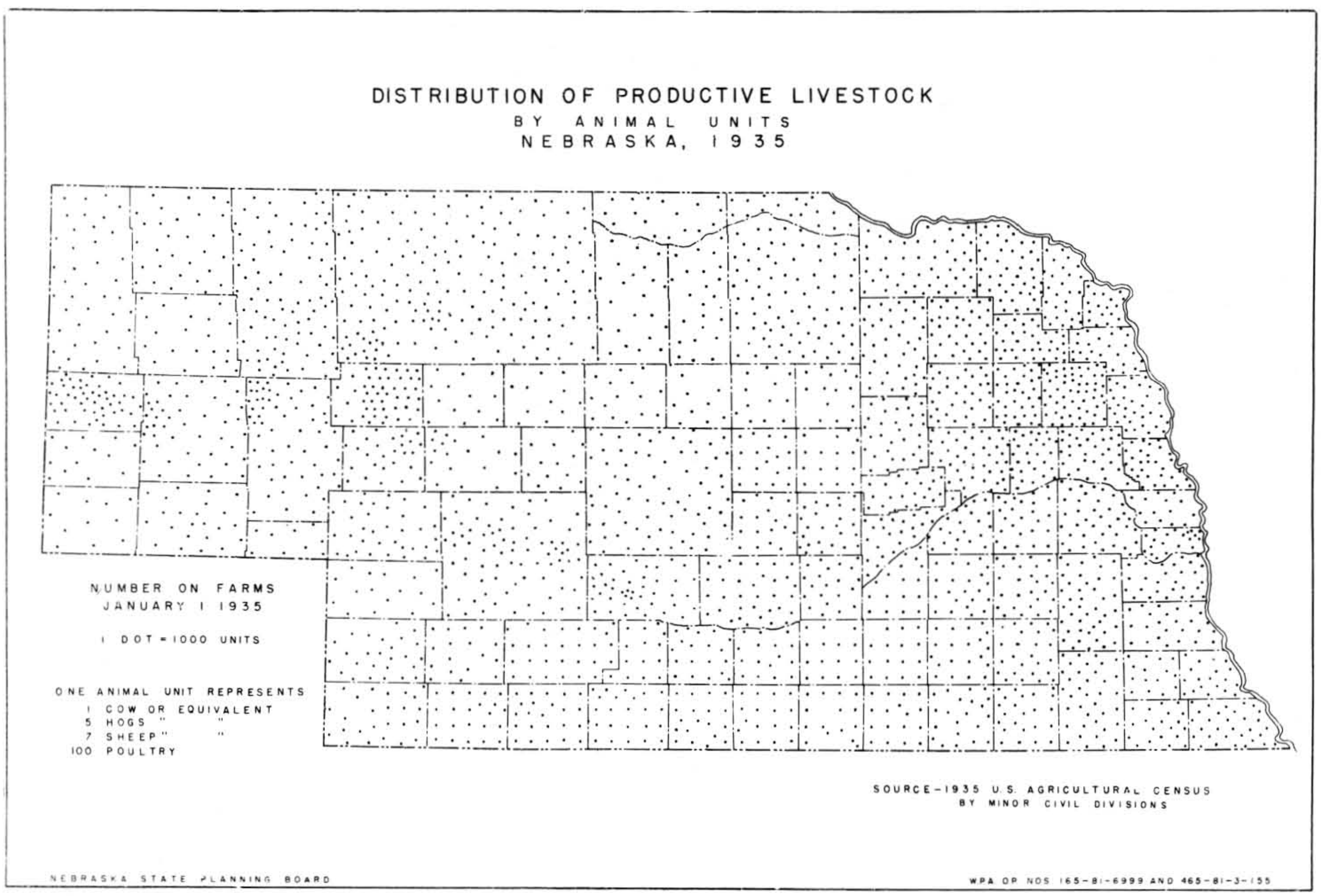
W.P.A. O.P. NO. 465-81-3-155

LVI



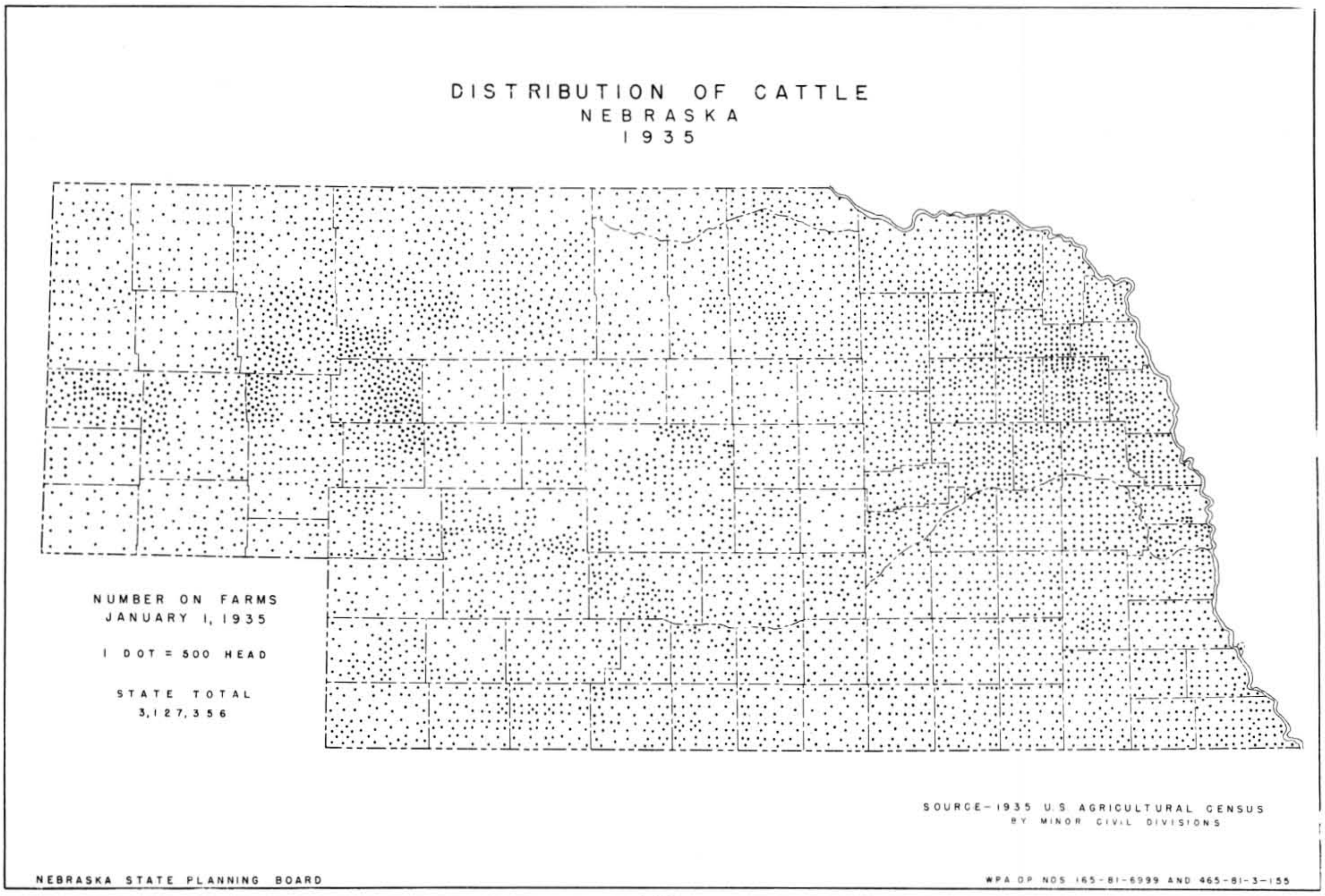
DISTRIBUTION OF LIVESTOCK
BY ANIMAL UNITS
NEBRASKA 1935
NUMBER ON FARMS
JANUARY 1, 1935
1 DOT = 1000 UNITS
ONE ANIMAL UNIT REPPESENTS
1 HORSE, OR EQUIVALENT
1 COW, " "
5 HOGS, " "
7 SHEEP, " "
100 POULTRY "
SOURCE–1935 U.S. AGRICULTURAL CENSUS
BY MINOR CIVIL DIVISIONS
NEBRASKA STATE PLANNING BOARD
WPA OP NOS 165-81-6999 AND 465-81-3-155

LVII

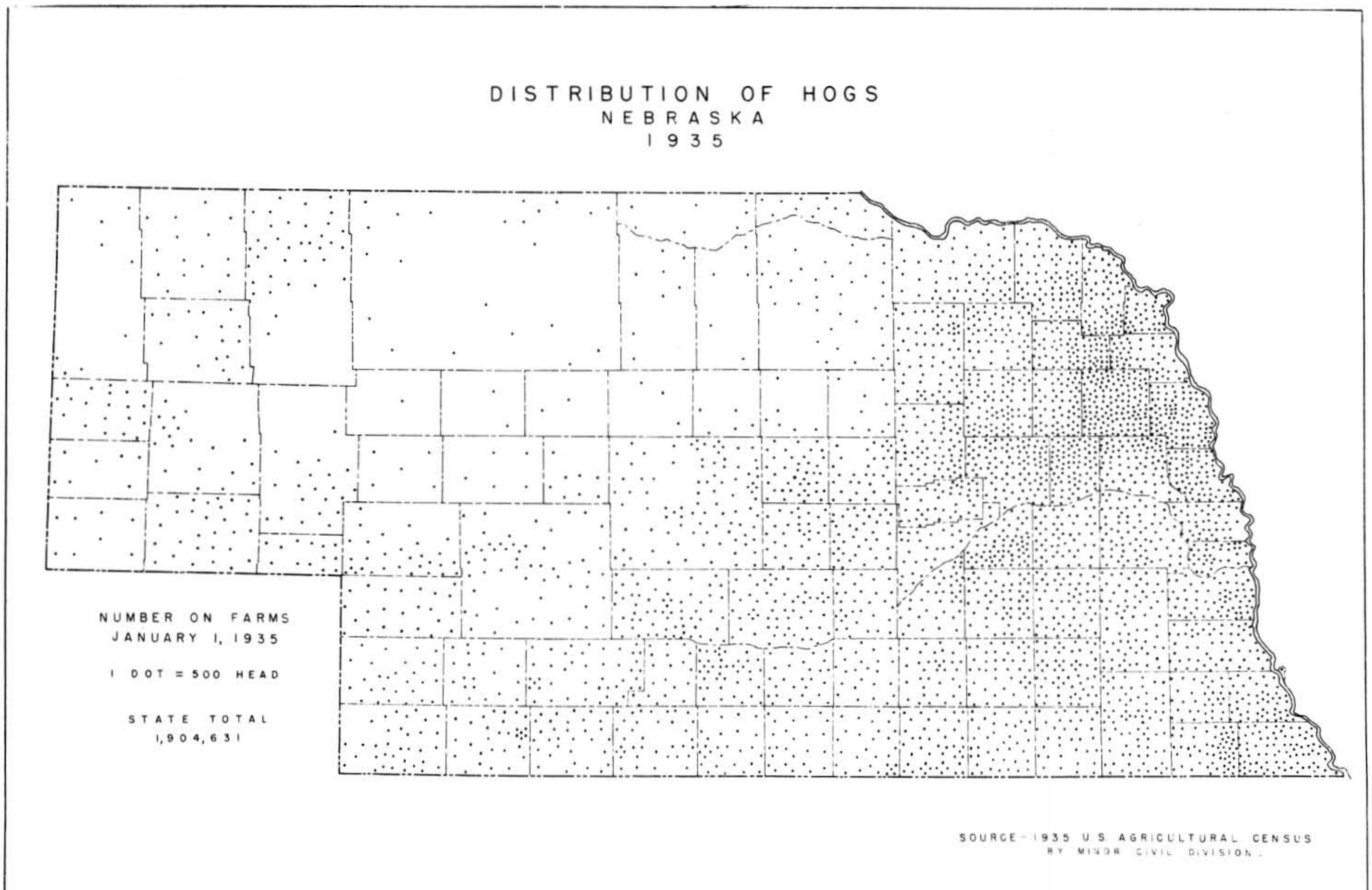


DISTRIBUTION OF PRODUCTIVE LIVESTOCK
BY ANIMAL UNITS
NEBRASKA, 1935
NUMBER ON FARMS
JANUARY 1 1935
1 DOT = 1000 UNITS
ONE ANIMAL UNIT REPRESENTS
1 COW OR EQUIVALENT
5 HOGS " "
7 SHEEP " "
100 POULTRY
SOURCE–1935 U.S. AGRICULTURAL CENSUS
BY MINOR CIVIL DIVISIONS
NEBRASKA STATE PLANNING BOARD
WPA OP NOS 165-81-6999 AND 465-81-3-155

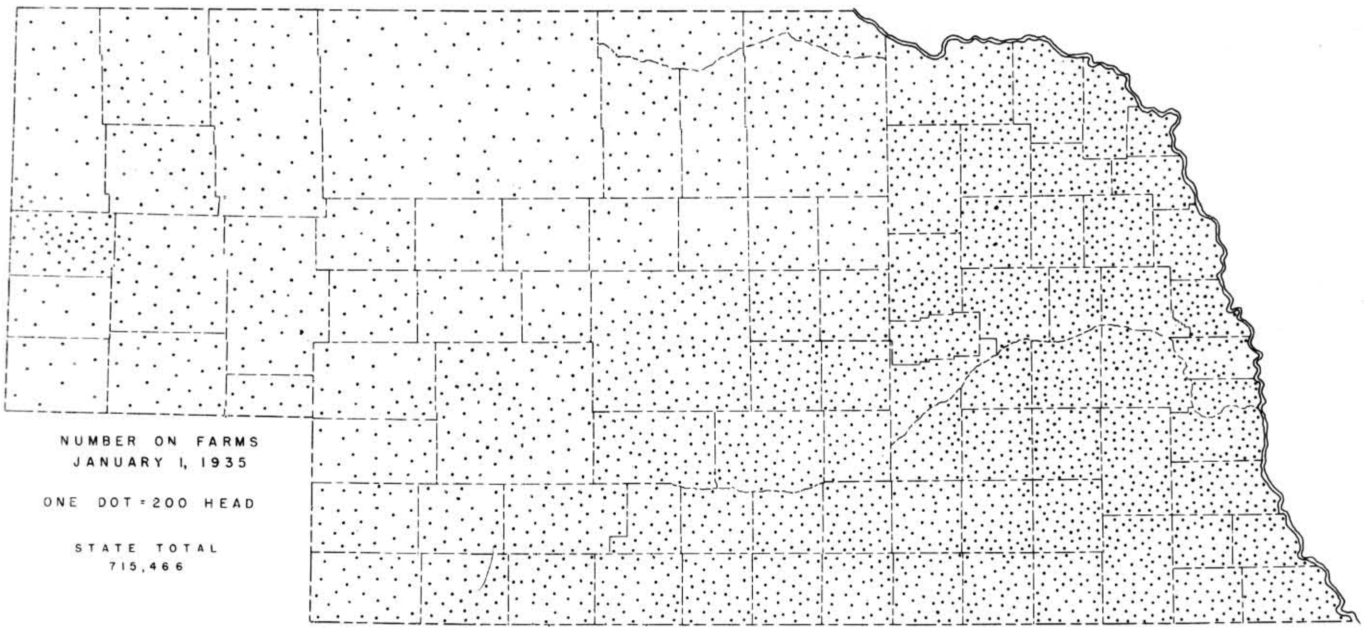
LVIII


DISTRIBUTION OF CATTLE
NEBRASKA
1935
NUMBER ON FARMS
JANUARY 1, 1935
1 DOT = 500 HEAD
STATE TOTAL
3,127,356
SOURCE–1935 U.S. AGRICULTURAL CENSUS
BY MINOR CIVIL DIVISIONS
NEBRASKA STATE PLANNING BOARD
WPA OP NOS 165-81-6999 AND 465-81-3-155

LIX


DISTRIBUTION OF HOGS
NEBRASKA
1935
NUMBER ON FARMS
JANUARY 1, 1935
1 DOT = 500 HEAD
STATE TOTAL
1,904,631
SOURCE–1935 U.S. AGRICULTURAL CENSUS
BY MINOR CIVIL DIVISIONS
NEBRASKA STATE PLANNING BOARD

DISTRIBUTION OF HORSES AND MULES
NEBRASKA
1935



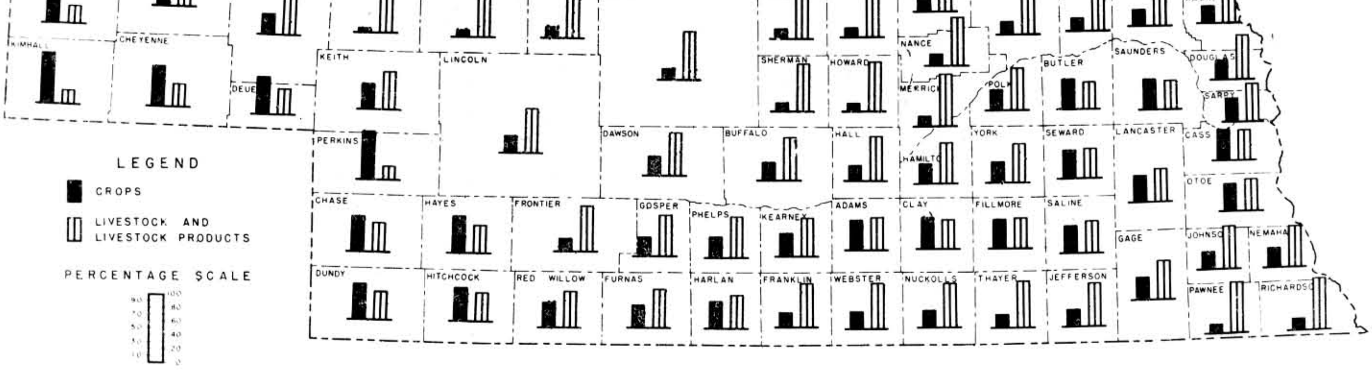
SOURCE-1935 U. S. AGRICULTURAL CENSUS
BY MINOR CIVIL DIVISIONS

NEBRASKA STATE PLANNING BOARD

W.P.A. O.P. NOS. 165-81-6999 AND 465-81-3-155

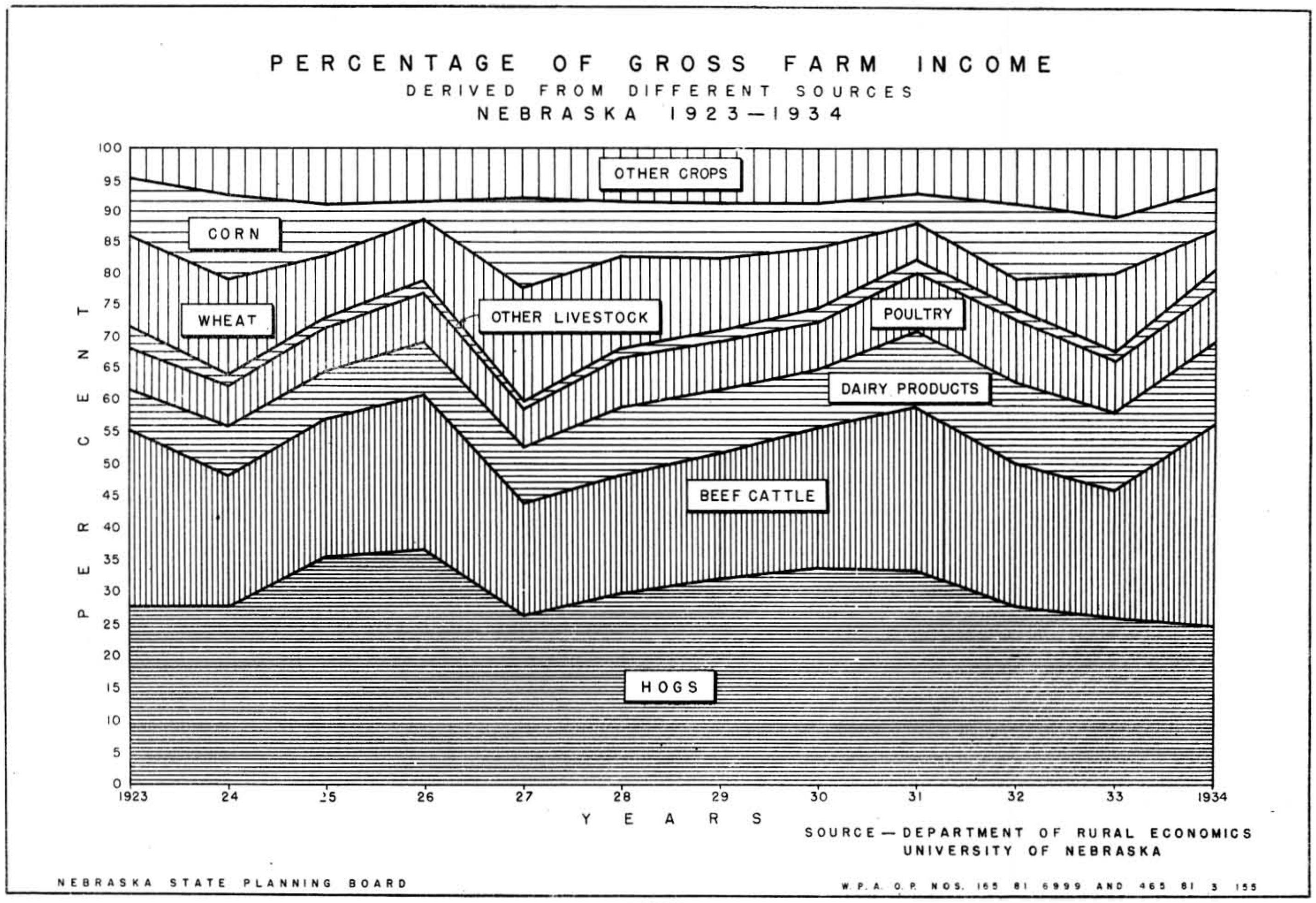
LXI

SOURCES OF FARM INCOME
PERCENTAGE CHARTS SHOWN
NEBRASKA, 1929

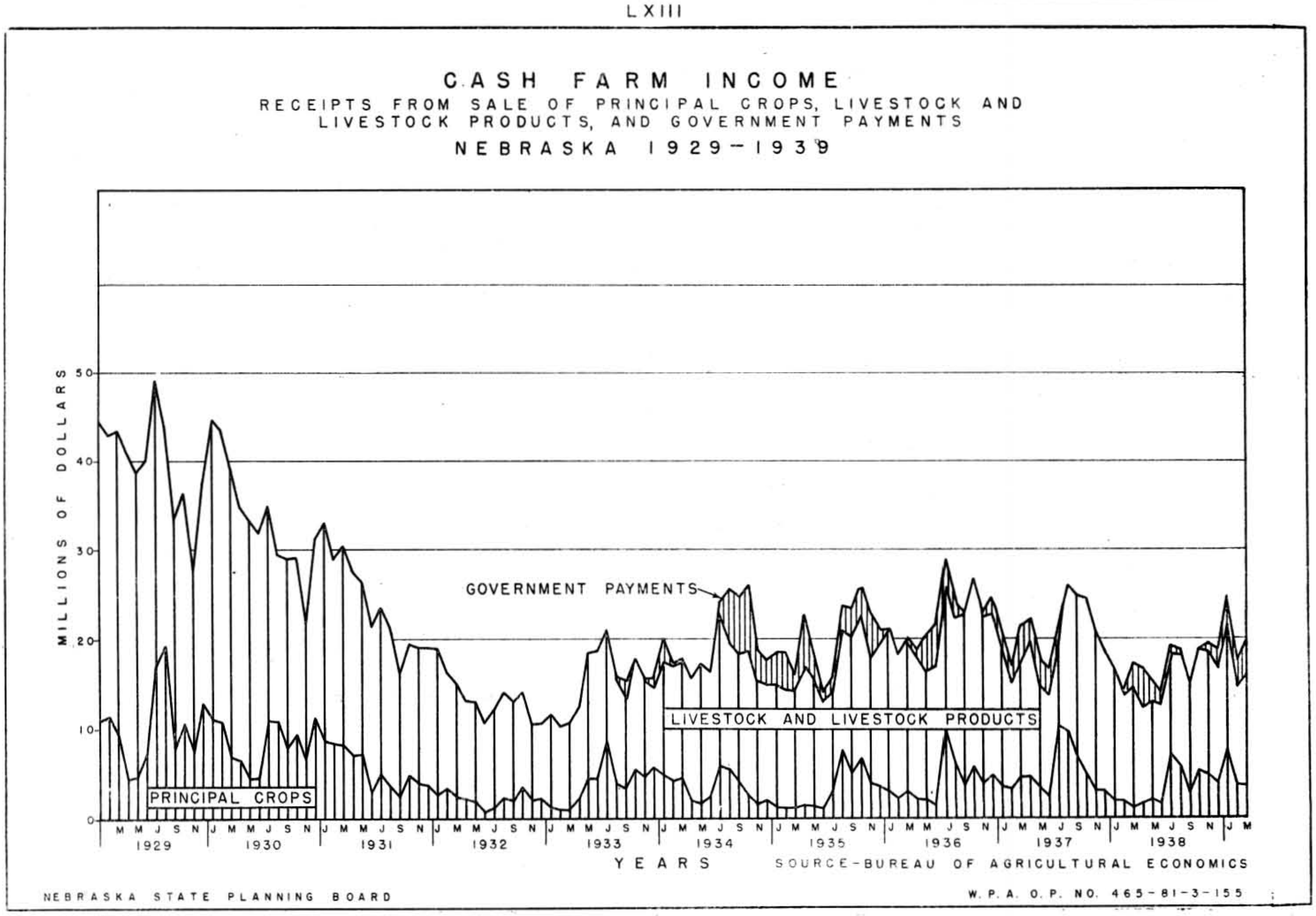


COMPILED FROM PUBLISHED RECORDS U.S.
BUREAU OF AGRICULTURAL ECONOMICS

LXII


PERCENTAGE OF GROSS FARM INCOME
DERIVED FROM DIFFERENT SOURCES
NEBRASKA 1923—1934
OTHER CROPS
CORN
WHEAT
OTHER LIVESTOCK
POULTRY
DAIRY PRODUCTS
BEEF CATTLE
HOGS
PERCENT
YEARS
SOURCE — DEPARTMENT OF RURAL ECONOMICS
UNIVERSITY OF NEBRASKA
NEBRASKA STATE PLANNING BOARD
W.P.A. O.P. NOS. 165 81 6999 AND 465 81 3 155

LXIII


CASH FARM INCOME
RECEIPTS FROM SALE OF PRINCIPAL CROPS, LIVESTOCK AND
LIVESTOCK PRODUCTS, AND GOVERNMENT PAYMENTS
NEBRASKA 1929—1939
MILLIONS OF DOLLARS
GOVERNMENT PAYMENTS
LIVESTOCK AND LIVESTOCK PRODUCTS
PRINCIPAL CROPS
YEARS
SOURCE-BUREAU OF AGRICULTURAL ECONOMICS
NEBRASKA STATE PLANNING BOARD
W. P. A. O. P. NO. 465-81-3-155

LXIV

MANUFACTURING

INDUSTRIES OF NEBRASKA

The manufacturing industries which were based and developed on the natural resources of the State in harmony with physical environment have prospered. The need and environmental conditions have been conducive to the successful development of meat packing, grain milling, beet-sugar manufacturing, and the manufacturing of stone, sand, and clay products.

There are more than 75 well defined industries and 1,150 manufacturing establishments in Nebraska. During normal years these industries provide work for approximately 390,000 persons. Agricultural and mineral products have an annual value of about a half billion dollars. Processing adds more than 25 per cent of total value and 25 per cent to the value of raw products.

STATISTICS OF REPRESENTATIVE MANUFACTURED PRODUCTS
NEBRASKA, 1935

Industry	Number of Establishments	Number of Employees	Nebraska's Rank	Value of Products (1,000 dollars)	Value added by Manufacture (1,000 dollars)	Location of Establishments	Description of Industry	Remarks
Meat Packing	17	5,849	8	105,511	12,733	Omaha, Lincoln, Grand Island, Hastings, Scottsbluff, McCook, and Falls City.	Processing fattened cattle, hogs, and sheep.	The most important manufacturing industry in Nebraska. Omaha is one of the largest meat packing centers in the world.
Wheat Milling	79	957	11	23,806	3,972	Omaha, Lincoln, Grand Island, Hastings, Crete, Ravenna, and others.	Wheat is milled and made ready for further processing.	The baking industry makes extensive use of Nebraska's milled wheat.
Butter	102	1,084	8	23,154	3,643	Omaha, Lincoln, Grand Island, Hastings, Fremont, Norfolk, Alliance, Crete, and Orleans.	Butterfat is collected at many stations throughout the State and shipped to the factories where it is manufactured into butter.	Nebraska creameries produce annually about 85,000,000 lbs. of butter.
Brewing	5	337	21	2,232	1,511	Omaha, Columbus, and Crete.	The manufacture of beer.	Subsequent to the repeal of prohibition, the manufacture of beer has become an important Nebraska industry.
Poultry	26	566	5	5,633	802	Well distributed throughout the State.	Dressing poultry.	About 25,000,000 chickens are produced annually in Nebraska.
Ice Cream	29	203	31	1,425	726	Well distributed throughout the State.	Dairies, creameries, and other establishments manufacture this product.	About 3,000,000 gallons of ice cream are made annually.
Stock Feed	14	139	28	1,985	505	Widely distributed throughout the State.	Grains, alfalfa, sugar-beet molasses, beet pulp, cotton cake, et cetera are milled into stock feed.	These products bring stock raising and meat packing into closer harmony.
Canning	6	464	27	1,940	416	Fremont, Norfolk, Scottsbluff, Nebraska City, and Plattsmouth.	The products canned are corn, tomatoes, beans, pumpkins, squash, cabbage, apples, and cherries.	Home canning is also of major importance.

Source: United States Census and Biennial Census of Manufactures

VALUE OF MANUFACTURED PRODUCTS
BY INDUSTRY GROUPS
Nebraska, 1900-1935
(Thousands of Dollars)

Industry	1900	1909	1914	1919	1921	1923	1925	1927	1929	1931	1933	1935
Food	86,964	126,896	151,925	433,891	217,562	262,818	295,870	294,644	334,086	215,368	135,371	180,442
Textiles products	2,564	2,049	1,427	6,993	1,305	2,046	4,046	3,010	1,142	1,185	670	232
Forest products	4,476	3,223	2,141	1,206	2,625	3,638	1,916	4,120	5,597	3,551	1,877	3,656
Printing and publishing	3,431	6,754	7,880	15,156	15,402	15,819	16,207	16,397	18,932	16,529	10,935	12,902
Chemicals	1,853	1,923	1,825	5,653	2,450	4,123	3,575	3,952	5,395	3,208	1,682	2,688
Rubber				930	2,184	2,649		2,695				
Leather	2,064	1,583	833	1,521	680	1,001	1,039	1,533	1,716			135
Stone and clay	2,754	3,108	2,288	3,486	2,489	3,383	3,342	2,275	2,430	1,433	523	1,138
Iron and steel	3,360	355	1,239	3,112	2,523	3,326	3,194	1,708	2,304	1,709	1,035	1,330
Nonferrous	954	624	650	2,233	1,105	1,258	2,416	1,305	1,094	773	349	665
Machines	1,083	3,143	3,295	8,213	4,224	3,523	3,745	5,832	6,068	3,829	1,436	1,167
Transportation	394	634	436	6,308	636	792	490	656	542	220	76	742
Railroad repair	2,624	4,642	6,737	17,909	16,900	18,727	15,408	14,991	18,888	9,389	6,217	
Petroleum and coal	525	1,415	1,928	2,446	3,094	3,185	3,241	3,605	3,939	2,397		173
Miscellaneous	30,944	42,670	39,012	86,985	60,486	88,769	88,819	63,361	82,135	34,504	34,139	50,175
Totals	143,990	199,019	221,616	596,042	333,665	415,057	443,308	420,084	484,268	294,095	194,310	255,445

Sources: United States Census and Biennial Census of Manufactures

Where no figures are given the products have been grouped under other industries.

TRANSPORTATION

EARLY ROAD SYSTEMS

The development of transportation in Nebraska reveals the successive evolutionary changes occurring in all progressive frontiers. As far back as 1855, the Territorial Legislature passed an act which provided for the surveying of public roads. The same year Congress authorized the construction of the first federal highway in the State, extending from Omaha to Fort Kearney near the present city of Kearney.

The first legislative authorization for a State Highway Department in Nebraska was in a 1913 law, which authorized counsel to counties concerning highway improvements. The first concentrated action of the State for highway improvement followed a joint meeting of representatives from the State Highway Department and the counties as provided by this statute. The present era of road construction was initiated by the passage of the Federal-Aid Road Act by Congress in 1916, and the acceptance of the terms of this Federal Act by the 1917 State Legislature.

RAILROADS

The transcontinental line of the Union Pacific Railroad was completed to the west coast in 1869. Other important railroads were constructed throughout Nebraska from 1870 to 1890. Even though there are a few points in the sparsely settled sand hills which are more than 30 miles from a railroad, Nebraska has an adequate railway system. Two high-speed transcontinental lines traverse the entire length of the State. Other main lines and numerous branch lines serve practically every community and are capable of handling all traffic originating in the State.

Plate LXV shows the railroad lines of Nebraska. The railroad mileage of various lines is listed below:

Railroad	Mileage
Chicago, Burlington, and Quincy	2,854.59
Union Pacific	1,356.97
Chicago and Northwestern	1,100.97
Missouri Pacific	359.31
Chicago, St. Paul, Minneapolis and Omaha	261.45
Chicago, Rock Island, and Pacific	250.46
Omaha Bridge & Terminal	1.45
Total	6,185.20

HIGHWAYS

The Nebraska State Highway System as outlined in the 1939-1940 Biennial Report of the Bureau of Roads and Bridges was made up of approximately 9,000 miles of marked and maintained roads and 2,220 miles of roads designated for the State system but not maintained by the State. This total approximates 11,220 miles.

Nebraska is well supplied with road-surfacing materials for all types of roads. Sand, gravel, crushed stone, and cement are produced in adequate quantities for road construction. It is necessary to import bituminous materials, lumber, and products from steel mills. However, steel is fabricated in the State.

Highway U. S. 20, U. S. 30, U. S. 6, and Nebraska 2 traverse the State in an east-west direction, and U. S. 73, U. S. 77, U. S. 81, U. S. 281, U. S. 83, Nebraska 14, 15, and 19 traverse the State in a north-south direction. All of the above-named highways traverse the Platte River Basin for a part of their length except U. S. 20 which crosses the northern section of the State including the Minor tributaries of the Missouri, the Elkhorn, the Niobrara, and the White River-Hat Creek Basin. U. S. 6 and U. S. 30 are surfaced throughout their length with concrete or bituminous materials.

Highway U. S. 30 follows the Platte River, South Platte River, and Lodge Pole Creek across the State. The major portion of this highway is in the Platte River Basin as illustrated by the highway map of the State Highway System, page 72. Other routes cross several river basins in traversing the State.

AIRWAYS

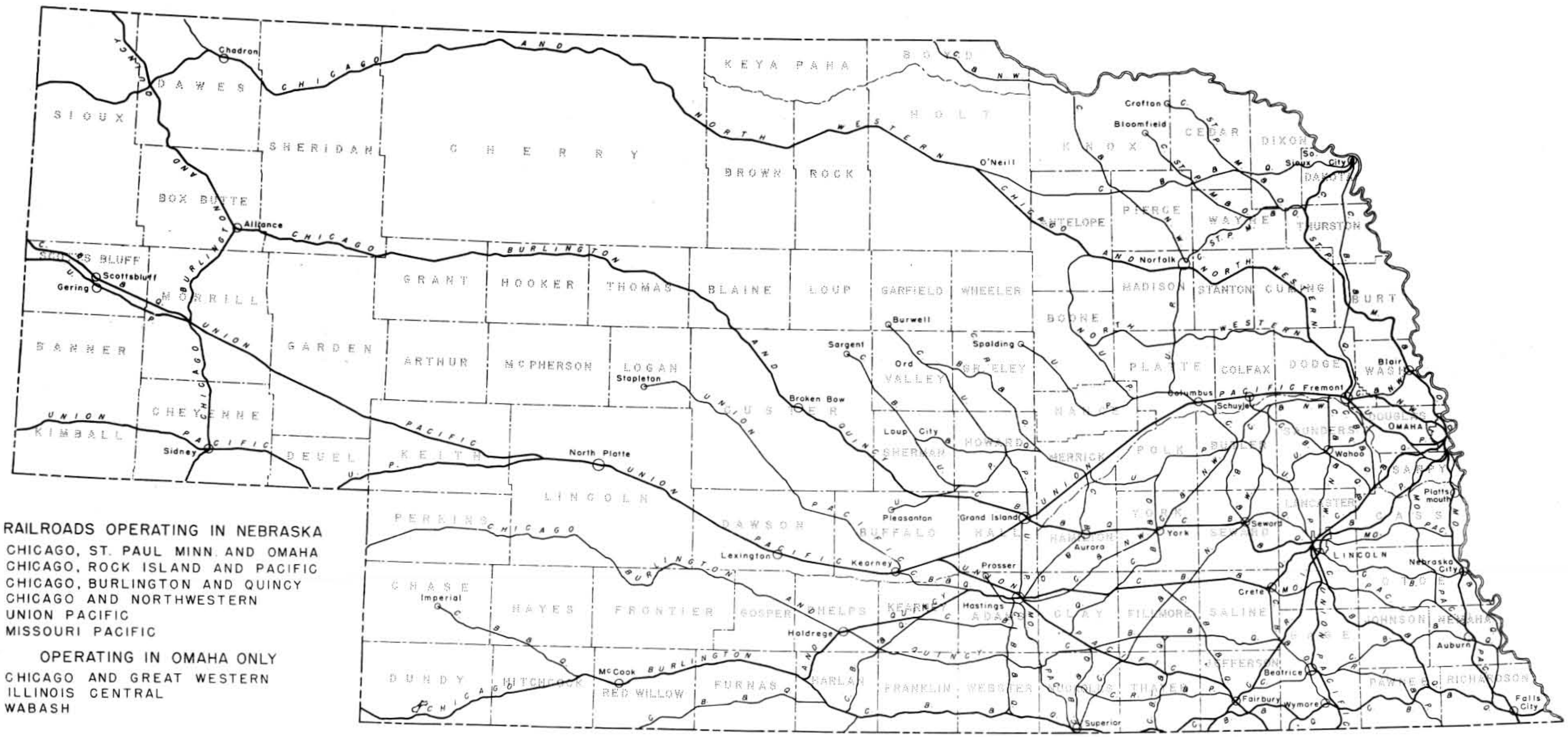
Three major airlines cross Nebraska: (1) The United Airlines, operating from coast to coast, crosses the State from east to west; (2) the Mid-Continent Airlines, operating from Minneapolis to Kansas City via Sioux City and Omaha, crosses Nebraska from north to south; and (3) the Inland Airlines operating between Cheyenne, Wyoming, and Huron, South Dakota crosses the panhandle. A branch of the United Airlines also operates between Denver and Grand Island.

As shown by the following table, 42 Nebraska towns have landing facilities for aircraft. The airports at Omaha, North Platte, and Grand Island are capable of handling the largest airliners now operating.

NEBRASKA AIRPORTS
January, 1941

Ainsworth	Gordon	Stuart
Alliance	Grand Island	Tecumseh
Atkinson	Hastings	Tekamah
Auburn	Hayes Center	Valentine
Beatrice	Hebron	York
Big Springs	Holdrege	Wayne
Blair	Kearney	
Bridgeport	Kimball	To be completed in 1941
Broken Bow	Lincoln (3)	
Chadron	Long Pine	
Chambers	Norfolk	
Columbus	North Platte	Clay Center
Crawford	Ogallala	Falls City
Crete	Omaha	Imperial
Fairbury	Rushville	Nebraska City
Ft. Crook	Scottsbluff	Neligh
Ft. Robinson	Sidney	
Fremont	St. Paul	

RAILROADS IN NEBRASKA
1939



RAILROADS OPERATING IN NEBRASKA

CHICAGO, ST. PAUL MINN. AND OMAHA
CHICAGO, ROCK ISLAND AND PACIFIC
CHICAGO, BURLINGTON AND QUINCY
CHICAGO AND NORTHWESTERN
UNION PACIFIC
MISSOURI PACIFIC

OPERATING IN OMAHA ONLY

CHICAGO AND GREAT WESTERN
ILLINOIS CENTRAL
WABASH

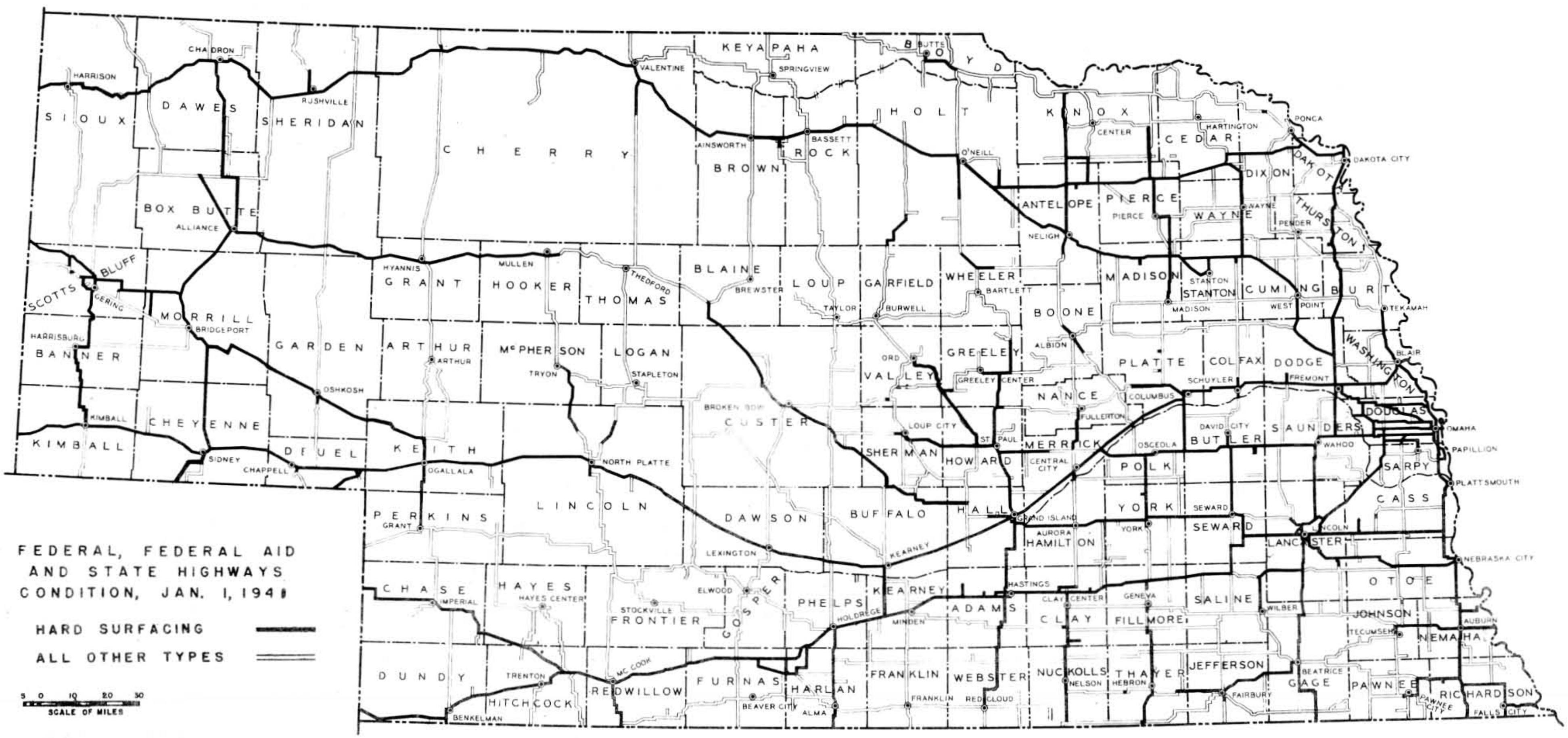
MAIN LINES
BRANCH LINES

SOURCE—NEBRASKA RAILWAY COMMISSION

NEBRASKA STATE PLANNING BOARD

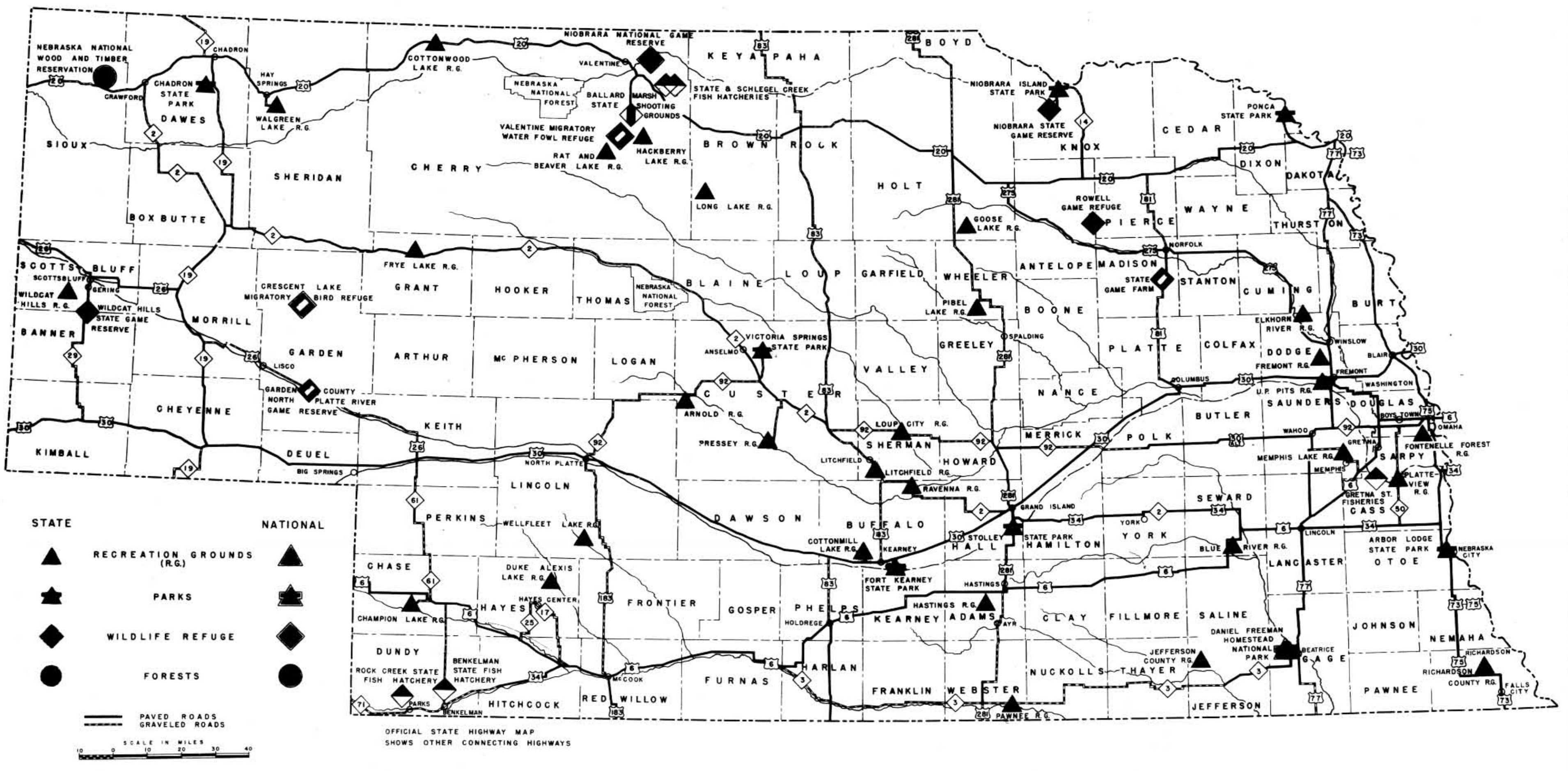
W.P.A. O.P. NOS. 165-81-6999 AND 465-81-3-155

NEBRASKA HIGHWAY SYSTEM
1941



SOURCE—DEPT. OF ROADS AND IRRIGATION

PARKS AND RECREATIONAL AREAS
NEBRASKA 1939

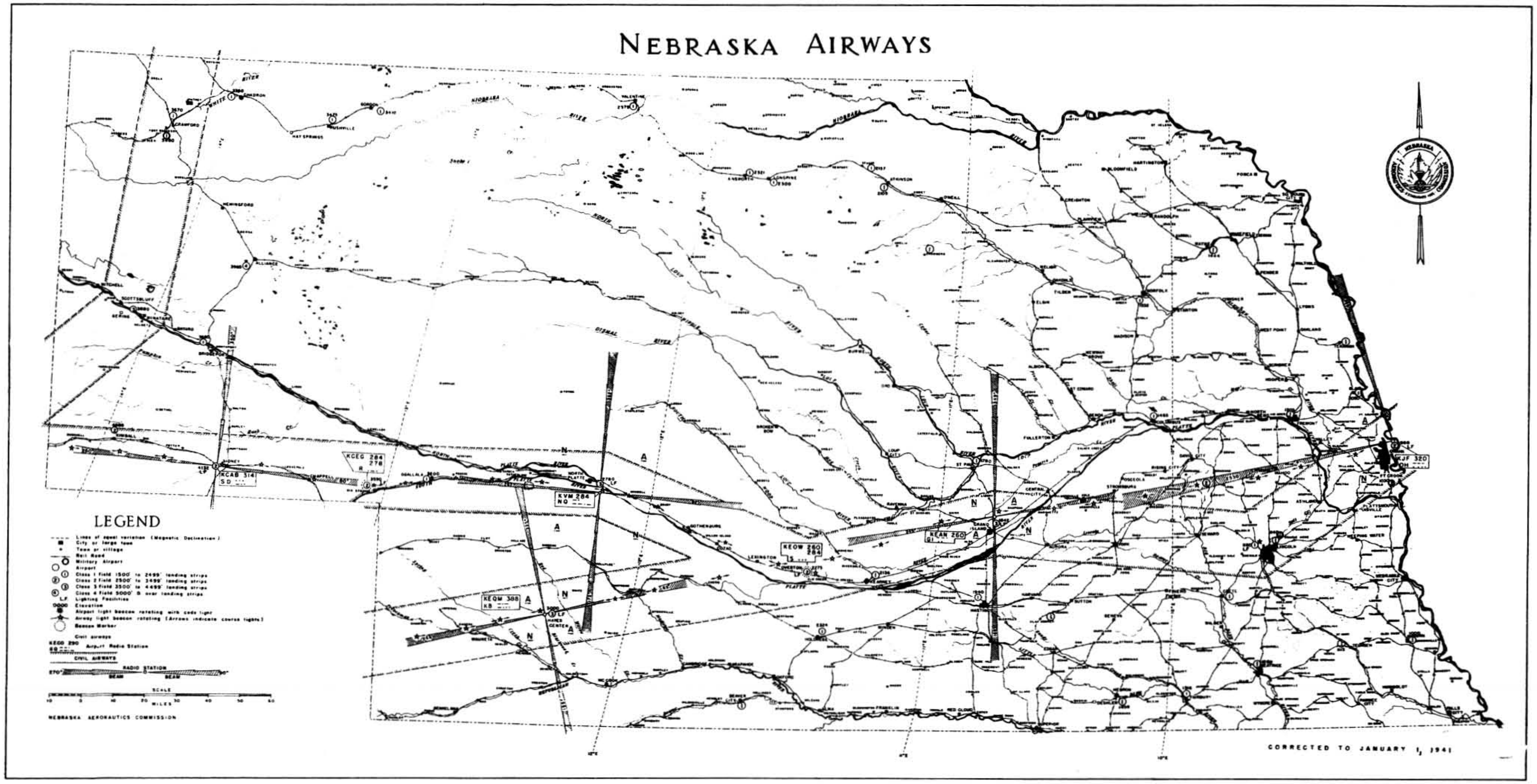


NEBRASKA STATE PLANNING BOARD

SOURCE—STATE GAME, FORESTATION, AND PARKS COMMISSION

W.P.A. O.P. NO. 465-81-3-37

NEBRASKA AIRWAYS



NAVIGATION

Commercial navigation in Nebraska is possible only on the Missouri River. The flow of the other streams is too irregular and shallow.

The existing navigation project for the improvement of the Missouri River from Kansas City, Missouri to Sioux City, Iowa was provided for in the River and Harbor Act adopted January 21, 1927. This project which provided for the construction of a 6-foot channel has been completed between Kansas City and Omaha.

There are 2 distinct units of improvement designed to stabilize and regulate the channel of the river. The Fort Peck Reservoir, near Glasgow, Montana regulates the downstream flow. This reservoir has a capacity of 20,000,000 acre-feet. The construction of bank revetments, permeable dikes, and the removal of snags stabilizes the channel.

Navigation above Kansas City is dependent upon the release of water from the Fort Peck Reservoir, since the normal low-water flow is definitely inadequate to maintain navigable depths. The navigation program depends, therefore, upon the rate of impounding at Fort Peck as determined by precipitation and run-off in the tributary area.

The proposed method of operating the Fort Peck Reservoir provides for a minimum flow of 30,000 second-feet at Yankton, South Dakota, except under unusual drought conditions, when a slight reduction in the amount may be required.

During periods of high water a satisfactory channel now exists between Kansas City and Omaha for barges and commercial tows loaded to a draft of 5.5 feet. During the low water period in the fall the channel in this section accomodates drafts of only 4 feet. With favorable progress the channel from Omaha to Sioux City may be opened to navigation in 1941. This will give Nebraska a total navigable water front of about 240 miles.

The recently completed 6-foot channel of the Missouri River between Kansas City and Omaha was officially opened to commercial navigation June 3, 1939 by the arrival of a Diesel tow boat which brought 2 barges containing 350,000 gallons of gasoline. The cargo was equal to 44 railroad tank cars of gasoline.

When commercial navigation was initiated on the river June 3, 1939, Army Engineers reported the channel in excellent condition. However, the channel is still being shaped into its final course. Finishing improvements are being put on the cut-off stretch near Plattsmouth.

The newly completed river channel between Rulo and Florence has been lighted and marked. One hundred buoys and 37 day markers were installed. The buoys indicate the course of the channel. After commercial navigation is established lights will probably be installed to permit night navigation. At present the river is lighted only below Kansas City for night navigation.

Army engineers have spent 12 years and nearly $140,000,000 to transform the Missouri River into a navigable stream. When the 764-mile stretch from St. Louis to Sioux City is completed approximately

$160,000,000 will have been expended.

An authorization by the River and Harbor Act May 31, 1939 includes additional improvement of the Missouri River and provides for the construction of a 9-foot channel not less than 300 feet wide from Sioux City to the mouth of the river. The first cost is estimated at $6,000,000. When the 9-foot channel is completed the type of equipment found in the remainder of the system will be able to operate to Omaha and Sioux City.

The improvement of the natural outlet should result in reduced transportation rates to the principal industrial centers of the East, and to the points of consumption for our agricultural products. These conditions should serve as stimuli to the industrial development within our State. Plate LXIX shows how Nebraska is connected with the navigable waterways of the United States.

WILD LIFE AND RECREATIONAL FACILITIES

STATE AND FEDERAL PARKS, RECREATION GROUNDS, AND GAME RESERVES
Nebraska, 1939

NAME	COUNTY	TOWN	ACRES
NATIONAL FORESTS			
Nebraska National	Cherry	Merriman)	217,808
Nebraska National	Thomas	Halsey)	
Wood and Timber Reservation	Sioux	Fort Robinson	*10,240
Total			228,048
STATE FISH HATCHERIES			
Benkelman	Dundy	Benkelman	30
Gretna	Sarpy	Gretna	50
Rock Creek	Dundy	Benkelman	120
Schlegel Creek	Cherry	Valentine	560
State Fish Hatchery	Cherry	Valentine	480
Total			1,240
STATE RECREATION GROUNDS			
Arnold Lake	Custer	Arnold	40
Ballard's Marsh	Cherry	Valentine	1,500
Blue River	Seward	Milford	14
Champion Lake	Chase	Champion	16
Cottonmill Lake	Buffalo	Kearney	100
Cottonwood Lake	Cherry	Merriman	160
Duke Alexis	Hayes	Hayes Center	100
Elkhorn River	Dodge	West Point	200
Fontenelle Forest	Douglas	Omaha	2,500
Fremont	Dodge	Fremont	307
Frye Lake	Grant	Hyannis	345
Goose Lake	Holt	Clearwater	350
Hackberry Lake	Cherry	Wood Lake	440
Hastings	Adams	Ayr	55
Jefferson County	Jefferson	Alexandria	30
Litchfield	Sherman	Litchfield	20
Long Lake	Brown	Ainsworth	80
Loup City	Sherman	Loup City	51
Memphis Lake	Saunders	Memphis	147
Pawnee Lake	Webster	Guide Rock	40
Pibel Lake	Wheeler	Spalding	80
Platteview	Cass	Louisville	190
Pressey	Custer	Callaway	80
Rat and Beaver	Cherry	Wood Lake	444
Ravenna	Buffalo	Ravenna	80
Richardson County	Richardson	Verdon	55
U. P. Pits	Dodge	Fremont	307
Walgren Lake	Sheridan	Hay Springs	130
Wellfleet	Lincoln	Wellfleet	110
Wildcat Hills	Scotts Bluff	Scottsbluff	1,000
Total			8,971
STATE PARKS			
Arbor Lodge	Otoe	Nebraska City	65
Chadron	Dawes	Chadron	804
Fort Kearney	Kearney	Newark	40
Niobrara Island	Knox	Niobrara	408
Ponca	Dixon	Ponca	200
Stolley	Hall	Grand Island	43
Victoria Springs	Custer	Anselmo	60
Total			1,620
STATE GAME RESERVES			
Burt County	Burt	Oakland	50
Cass County	Cass	Murdock	2,560
Columbus-Genoa	Platte	Columbus-Genoa	2,500
Dakota County	Dakota	Jackson	760
Dodge County	Dodge	Fremont	1,425
Douglas County	Douglas	Valley	750
Garden County	Garden	Oshkosh	7,000
Jefferson County	Jefferson	Fairbury	1,080
Lancaster	Lancaster	Lincoln	160
Lancaster	Lancaster	Lincoln	42
Lincoln County	Lincoln	North Platte	14
Loup County	Loup	Taylor	2,720
Madison	Madison	Norfolk	10
Niobrara Island	Knox	Niobrara	562
Nuckolls County	Nuckolls	Bostwick	1,850
Pierce County	Pierce	Pierce	160
Rowell	Antelope	Tilden	440
Saunders County	Saunders	Ames	72
Saunders County	Saunders	Ashland	500
Saunders County	Saunders	Cedar Bluffs	3,425
Saunders County	Saunders	Wahoo	1,760
Sheridan County	Sheridan	Hay Springs	2,660
Stanton and Cuming	Stanton and Cuming	Stanton	776
State Game Farm	Madison	Norfolk	160
Walton	Lancaster	Walton	5,188
Washington County	Washington	Fort Calhoun	1,450
Wildcat Hills	Scotts Bluff and Banner	Scottsbluff	800
Total			38,874

FEDERAL GAME RESERVES

National Water Fowl Sanctuary	Garden	Mumper	41,000
Niobrara National	Cherry	Valentine	16,681
Total			57,681
Grand Total			336,434

Wild life and recreational facilities in Nebraska have been affected by the development and use of the water resources of the State. Irrigation, drainage, and industries have had a tendency to diminish or pollute the lakes, marshes, and streams.

The depletion of bodies of water such as Crescent Lake in Garden County is a prime factor in reducing waterfowl and fish population. On a lesser scale perhaps wild life has been reduced by the drainage of small marshy and swampy tracts on farms. These were essential habitats for many fur-bearing animals and afforded feeding, watering, and resting places for a variety of other forms of wild life. However, the widespread development of farm ponds and stock-watering places is evidence of a change of sentiment about drainage. In some parts of the State farmers have constructed small dams to conserve surplus water supplies. Such supplies are conducive to the conservation and propagation of wild life.

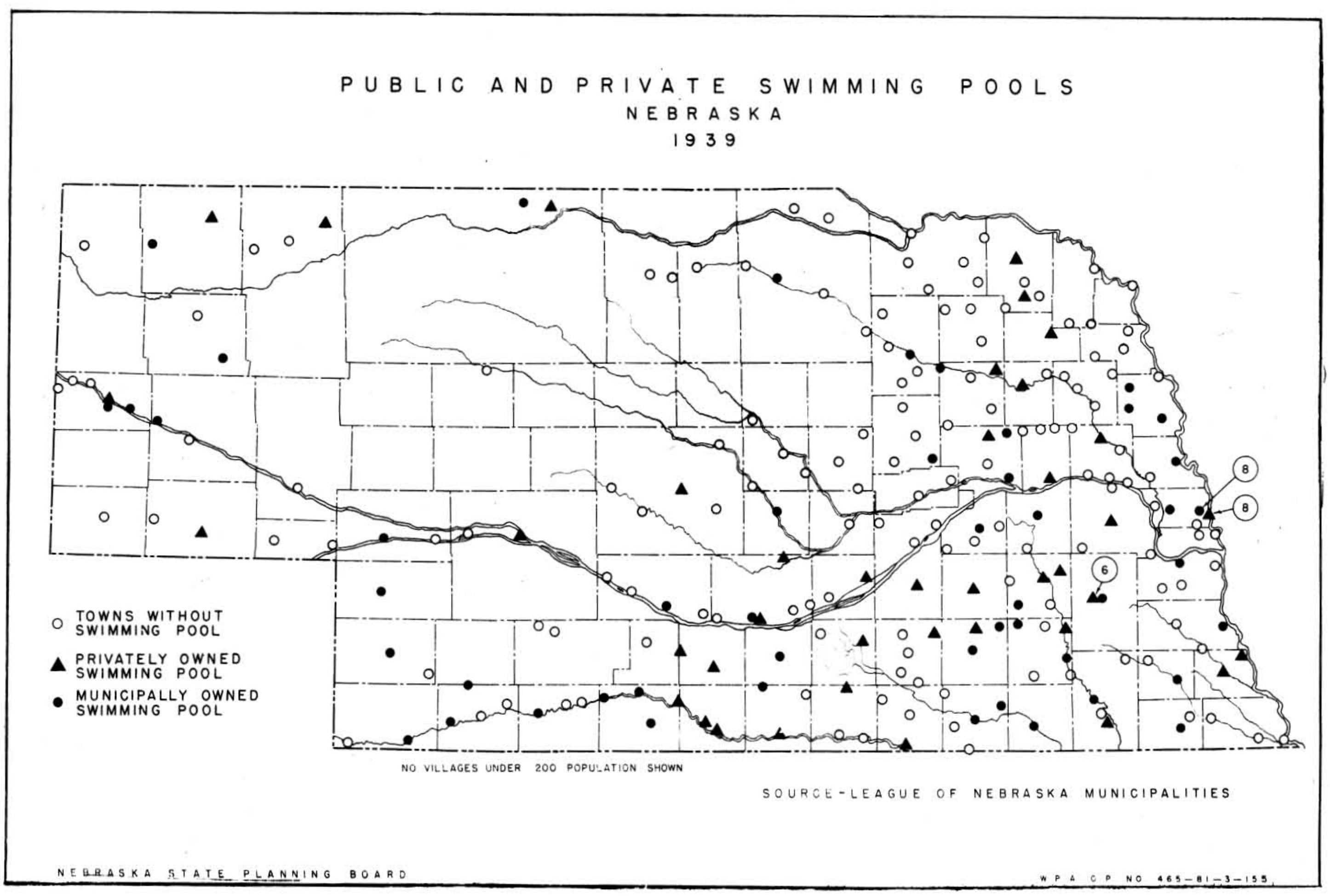
Recent droughts have seriously affected the aquatic habitat of wild life in Nebraska. During periods of low water the wild life of the marshes and lakes which cannot migrate perishes. Many fish lakes dried up reducing the normal hatch of game birds. There has been some progress in restocking fish and game in depleted areas. Severe winter conditions during drought periods freeze shallow lakes to the bottom killing large numbers of fish. Holes are sometimes cut in the ice or artesian wells are put down in the lakes to keep them open. To prevent loss, the fish are sometimes seined from the shallow lakes in the fall and transferred to more stable bodies of water.

The fluctuation of the water levels also affects the growth of various kinds of vegetation upon which migratory waterfowl, muskrats, beaver, and mink feed. Fitting wildfowl requirements into an engineering program is a promising field for study and investigation.

The creation of an adequate system of refuges along the principal routes of migration and at points of greatest concentration is desirable even though any worthwhile refuges are destined to interfere to some extent with boating, fishing, and shooting. To be effective any system of refuges should harbor througnout the open season the most important waterfowl species in shooting areas. Refuges and sanctuaries present excellent opportunities to stimulate interest in better wild-life management.

POLLUTION

Water pollution is destructive to fish, waterfowl, and their food and nesting materials. Pollution such as sewage and industrial waste results in toxic concentrations that are the causes of much



destruction. Sewage and industrial wastes should be treated before they are discharged into streams.

The summer low-water conditions are dangerous because of the reduced supply of water and the highly concentrated pollution substances. High temperatures also increase toxicity.

While pollution has reached the nuisance stage in only a few areas it should be considered an important factor in the utilization of our water resources. Increasing population and manufactures will intensify the problem to a point where water treatment will become imperative.

RESERVOIR LAKES

Lakes created by the construction of large power and irrigation dams are of great value to the conservation of wild life.

Restoration of wild life involves the re-establishment of their habitats. For aquatic birds and animals suitable waters must be made accessible. Improved methods of land use will tend to provide additional food and cover which is the first requirement for terrestrial animals.

WATER RESOURCES

SURFACE WATER AND GROUND WATER

SURFACE WATER

Surface water is the precipitation residue in excess of absorption and infiltration. Surface water may also be a portion of the ground water that reappears from the ground-water supply directly into the drainage courses. The wide variation of such elements as precipitation, evaporation, run-off, ground seepage, and transpiration also affect the surface-water supply. Although rainfall and run-off are the major factors determining supply of surface water, physiography and climate are also important factors.

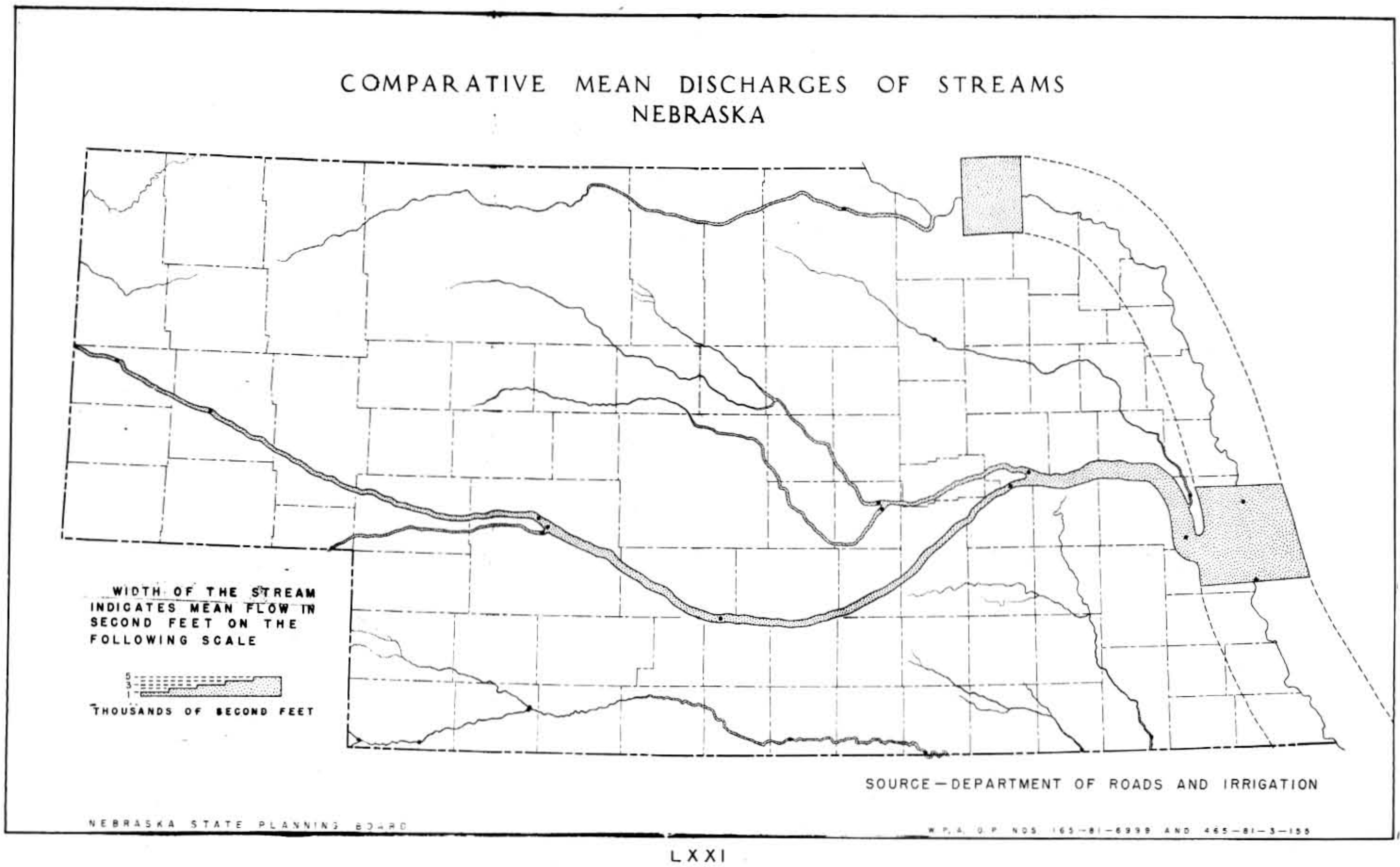
A natural balance of retarded surface flow, underground storage, and the seepage from underground-storage supplies tends to maintain a fairly regular supply of water in streams, lakes, and ponds. The replenishing sources for stream flow are precipitation, underflow of rivers, upstream contributions, and subsurface flow from adjoining land. The sectional contributions to river discharge vary according to the thickness of the water-bearing formation, the area, degree of saturation, and the permeability of the soils. The factors affecting the quantity of river-water loss are permeability and gradient of adjoining lands, the quantity of water in the rivers, and the rate and amount of evaporation. In some parts of the State surface water is augmented by irrigation practices, while in other parts it is depleted.

STREAMS

The general direction of the major stream courses of Nebraska is from northwest to southeast. The streams of the State vary considerably in quantity of water and uniformity of flow, because of geologic, soil, and climatic conditions of their basins. Those fed mainly by surface run-off vary more in discharge; those heading in the ground water of sandy lands, as in the Sand-Hill Region maintain a more uniform flow. All the larger streams within or adjoining the State have been gauged at regular intervals for several years. The discharges of these streams are quite well known. At the present time, the Department of Roads and Irrigation in cooperation with the United States Geological Survey maintains automatic-recorder equipment at 48 stations, in Nebraska. The resulting daily discharge records are invaluable in planning for the future utilization of the water resources of this State. Long-time records for Nebraska are perhaps more nearly complete than for any of the other western states where irrigation is practiced extensively. Our streams present problems relating to drainage, flood control, irrigation, power development, wild life, domestic water supply, and recreational use.

LAKES

The lakes are numerous but usually small and shallow. Counting those with areas of 15 acres or more, the State has more than 2,300 lakes, marshes, and artificial reservoirs. Most of the natural lakes and marshes are in the Sand-Hill Region. They are shallow, many of them intermittent. About 1,000 of them became dry during the recent drought.



LXXI

AREA OF SURFACE WATER

The combined area of the intermittent lakes and marshes averages about 163 square miles, and that of the permanent streams about 495 square miles. The maximum area of the surface water of the State, not including floods, is about 890 square miles. The average is about 640 square miles. The droughts of 1934 and 1936 reduced the combined area to about 300 square miles.

The area of the water surface of the State has been increased considerably during the past few years by the construction of reservoirs in connection with water power, irrigation, and erosion-control works. When the reservoirs are filled, the irrigation and water-power projects now under construction, or authorized for construction, will add about 42,600 acres of water surface to the State. The evaporation loss from the reservoirs and other free-water surfaces of the State is considerably less than the amount of direct rainfall they receive.

VOLUME OF SURFACE WATER

The amount of surface water, like the soil moisture, varies greatly throughout the year. Not including the discharge of the Missouri, the annual inflow is about 2,000,000 acre-feet from Kansas, Colorado, Wyoming, and South Dakota, through the Republican, South Platte, North Platte, and Niobrara rivers, and their tributaries. The outflow by Hat Creek, White, Niobrara, Little Blue, Big Blue, Republican, and Platte rivers, is about 6,800,000 acre-feet. This shows that the outflow exceeds the inflow by about 4,800,000 acre-feet, or an amount equal to slightly more than 5 per cent of the total volume of the mean annual rainfall of the State.

The annual discharge of the Missouri River varies between 25,000,000 and 52,000,000 acre-feet at Rulo. Of this, there are only about 5,800,000 acre-feet contributed by Nebraska creeks and rivers. About 1,000,000 acre-feet are contributed by Nebraska streams below Rulo, Nebraska. Consequently, the volume of surface water in the State is relatively small.

In 1931 the Surface Water Division of the United States Geological Survey entered into a cooperative agreement with the Nebraska Department of Roads and Irrigation in extending the study of the water resources of Nebraska. This study has been continuous.

FLOOD WATERS

Every large stream in the State reaches flood-stage in some part of its course. The streams in Nebraska which are subject to floods throughout their courses are the Missouri, the Republican, the Platte, and the Loup rivers.

Nebraska floods occur within the period April 1st to August 31st. More than 50 per cent of the floods come in June. The control of excess run-off tends to equalize maximum and minimum stream flow. Peak flows are retarded and reduced to provide dependable water supply for irrigation during periods of low flow and drought.

EARLY FLOODS

Destructive stream floods have occurred in Nebraska during its entire history. Several of the early floods are matters of legend and tradition rather than of historical record. One of the early floods occurred in 1785, a year known in Middle Western Regions as "The Year of the Big Waters". All the steams of the North and Middle West reached flood stages. These were recorded on the Mississippi in the vicinity of the present site of St. Louis. Probably very little damage was done because Nebraska was undeveloped at that time.

The next great flood occurred in 1826. The spring season of that year was characterized by excessive rainfall throughout the Middle West. The Missouri and Mississippi rivers were at high stage during April and May.

Another maximum flood visited this area in 1844. Sufficient evidence exists to establish it as one of the greatest floods in the history of this territory. Monetary loss was small because Nebraska was not yet settled.

Other general floods occurred in 1845, 1851, 1858, 1881, and 1886 although little is known concerning them.

One of the most important floods accurately recorded occurred during the latter part of May and the first part of June, 1903. It resulted in very high flood stages throughout the central and eastern part of the Missouri River Basin. It was exceeded only by the flood of 1844.

Floods in the Republican-Kansas River Basin subsequent to that of 1903 occurred in 1904, 1908, 1915, 1923, and 1935. None of them equaled the flood of 1903 in eastern Kansas, although the flood of 1935 in the upper Kansas River closely approached it.

At the crest of the 1935 flood, the discharge was approximately 9 times greater than had ever been previously recorded. Previous floods were as high as 24,500 cubic feet at Hardy, Nebraska, where the river crosses the state line into Kansas. The 1935 flood discharged 225,000 second-feet at this point.

After a month of greater-than-normal precipitation, exceptionally heavy rains during the night of May 30, and 31, 1935, followed by moderately heavy rainfall during the next 2 days, caused the greatest flood on the Republican River that had occurred there during a period of at least 70 years.

The Republican River Valley from the eastern part of Colorado to Junction City, Kansas, a distance of 350 miles, was flooded for a width ranging from three-quarters of a mile to 1.5 miles. More than 100 lives were lost and much livestock and many buildings were destroyed. Thousands of acres of rich farm land, covered by deposits of sand brought down by the flood waters, were greatly damaged. Nearly all the highway bridges over the river were either destroyed or rendered impassable. The highways along the valley were washed out in many places. On the main line of the Burlington Route from Chicago and St. Louis to Denver, about 40 miles of track were destroyed. Regular train schedules were not resumed for three weeks. The loss of the railroad, chargeable directly to the flood in the Republican River Valley, was estimated at $1,500,000.

The following data showing the crest of the flood at various Nebraska points are based on the investigations made by the Missouri River Division of the Corps of Engineers, United States Army, and The State Engineer of Nebraska.

Point on River	Crest of Discharge: Area of Cross-Section Sq. Feet	Mean Velocity in Feet Per Sec.	Crest Discharge in Cu. Feet Per Sec.
Newton, Colorado	23,900	4.30	103,000
Max, Nebraska	25,000	7.60	190,000
Bloomington, Nebraska	56,800	4.41	250,000
Hardy, Nebraska	45,900	4.91	225,000

The estimated maximum flow at any point on the river was at Cambridge, Nebraska below the mouth of Medicine Creek, where 280,000 second-feet was reached at crest discharge. At Bloomington, Nebraska the river rose from 7.5 depth at 6:00 P.M., May 31st, to a crest depth of 20.4 at 10:30 P.M., June 1st with a width of flow of 1.5 miles. At points on the river a 12-foot greater rise was recorded over that of any previous flood.

The following table shows losses based on investigations made by the Missouri River Division of the Corps of Engineers, United States Army, the State Engineer of Nebraska, the division of Water Resources of the Kansas State Board of Agriculture, and Colorado state and county officials:

Summary of Losses in Colorado and Nebraska

	Colorado	Nebraska
Lives Lost	6	94
Livestock Lost	300	8,100
Poultry Lost	*	46,500
Highways Damaged (Miles)	"5	341
Highway Bridges Damaged	'6	307
Crops Damaged (Acres)	**	42,000
Farm Land Damaged (Acres)	15,000	57,000
Total Value of Property Loss	o$790,000	#$7,532,000

* No Record
" Estimated
' Does not include county bridges
** Area damage in Colorado was chiefly hay land and is included under farm land damaged
o Includes damage to county bridges and roads
\# Includes $1,500,000 loss of Burlington Railroad directly chargeable to the flood, a small part of which occurred in Colorado

The largest single item of loss in Nebraska, and the one requiring considerable attention is the future land use in the flood plain. This area was severely damaged by deposition of sand and gravel and by the cutting away of top soil. Strong winds stir up dense clouds of sand which whip about cutting off vegetation. The result is much damage and discomfort in adjoining areas.

Two of the most destructive floods in the history of the State occurred in the Republican River Valley in May 1935, and in the Missouri River Valley in eastern and southeastern Nebraska July 1938. These floods were caused by cloudbursts and excessive rainfall. Both incurred great loss of life and property.

Several floods of considerable intensity have been recorded in the Republican River Valley and its tributaries; one in 1905 and 1915, and 4 in 1935, 3 of which occurred within a period of 17 days. The first of the 1935 floods occurred on May 28th, when the water at McCook, Nebraska reached about the same stage as the flood of 1915, which, up to that time, was the worst flood in the history of this area. The second flood, and the worst in the history of the river, occurred on May 30th, 31st, and June 1st. The third flood occurred on June 16th and 17th at McCook, but did not cause any additional damage.

In 1935 farmers planted a limited area of the flood plain to such crops as corn and cane, but returns were disappointing. An extensive well-planned, tree-planting program is being considered for the rehabilitation on lands rendered unfit for cultivation by floods.

MISSOURI RIVER FLOOD

The Missouri River Valley in eastern and southeastern Nebraska experienced a severe flood July 2 to 18, 1938. Complete and accurate data on the damages and losses in the affected area are not available at this time.

The flood was caused by excessive precipitation and melting snow in the Upper Missouri, and Yellowstone basins of Wyoming and Montana, supplemented by considerable discharges from streams farther down the river, including the Platte.

The Nebraska State Planning Board and federal agencies are considering plans for the development of ways and means by which a recurrence of severe flood damages may be avoided.

The plan for flood control includes the construction of reservoirs on the larger tributaries for the retention of maximum flood flows. Any plan for flood control should be supplemented by a proper adjustment in land use. The development of water-conserving tillage practices and water-retarding factors is a very important part of a comprehensive flood-prevention and control program.

The crest of the flood reached Bismarck, North Dakota on July 8th; Pierre, South Dakota on July 10th; and Omaha on July 11th. The United States Geological Survey has not made a final determination of the exact discharge at the crest of the flood, but at Omaha it was between 115 and 120 thousand second-feet. At Omaha the stage remained above 16 feet from July 3rd to July 17th, and above 18 feet from July 9th to July 15th. The partial operation of the Fort Peck Reservoir this year reduced the flood stages which would otherwise have occurred, by about 1.5 feet.

Official estimates of property loss in the Missouri River flood are not available at this time. No loss of life was reported. Unofficial reports estimate heavy losses of livestock and property. Thousands of acres of rich farm land were inundated, and crop loss reached into thousands of dollars.

GROUND WATER

Ground water is one of the most important resources of Nebraska. Some authorities suggest that it is of greater importance than the soil.

The more readily available ground-water supply is about 750 times the total volume of the surface water of the State. It is estimated at approximately 10 times the average annual rainfall or an amount sufficient to fill a rectangular tank about 390 feet deep and 10 miles wide, extending the length of the State. Much ground water has been lost in late geologic times because deep valleys tap the water-bearing mantlerock resulting in considerable underflow leakage.

Maintaining a permanent ground-water supply causes grave concern. Recent drought, waste, and drainage have resulted in heavy losses of ground water. Although the ground-water supply has not been seriously depleted in any part of the State, there are places where the water table has been lowered. Such conditions require the initiation of conservation measures.

WATER HORIZONS

There are many water-bearing horizons in the State. Their distribution is not uniform. Some areas have little or no ground water and other areas have vast quantities of it. In some sections the water horizons are shallow, and in others they are deep.

Mantlerock Horizons

Most of the surface of Nebraska is underlain by thick layers of soil and subsoil, and thick open-textured mantlerock. Thick layers of sand and gravel facilitate the accumulation and storage of relatively large quantities of the rainfall as ground water. The importance of these favorable conditions for ground-water storage is not generally understood or appreciated.

Relatively unconsolidated mantlerock covers large areas of Nebraska. A large part of the loess in south-central Nebraska is underlain by 2 thick sand and gravel deposits known as Holdrege-Grand Island sands and gravels which outcrop at places along the borders of the Republican, Little Blue, Platte, and Loup valleys. These deposits which carry much ground water, underlie the middle course of the Platte Valley and reach northward and westward for a considerable distance under the sand hills and at places into the hard lands. These water-bearing strata pinch out south of the Republican River in Nuckolls, Webster, Franklin, and Harlan counties.

The sand-hill areas are occupied at the surface by dunesand and other sandy materials. The materials of the alluvial lands vary greatly in texture, grading from silt to sand and gravel. In places along larger valleys such as the Platte, Loup, and Republican there are terraces capped with loess.

Glacial deposits of varying thickness occupy the drift-hill area in southeastern Nebraska. The 200 feet or more of drift, in Nebraska, includes 2 fairly persistent sand and gravel sheets and 2 boulder-clay deposits called till sheets. Both were formed by glaciers but differ thusly; till is ice-transported, and the associated sands and gravels are water-laid.

Bedrock Water Horizons

In Nebraska it is not generally necessary to tap the bedrock waters. However, there are places where comparatively deep wells must be made in order to obtain domestic water supplies and secure water for special purposes.

Salt Water Horizons

In some small areas of Nebraska there is a scarcity of good drinking water. In other areas shallow ground water makes weak wells that become dry or nearly so during droughts and increase in yield after wet years. In some places the water is saline or alkaline creating difficult water-supply problems.

The main sources of salt water occur as follows: (1) in the Dakota group; and (2) in zones of the Permian and Pennsylvanian System, as at Lincoln, and near Union and Unadilla.

ARTESIAN WELLS

Much of the State is underlain by formations carrying water under pressure. The pressure may be sufficiently strong to cause a flow when tapped by wells. The pressure is developed in aquifers confined between impervious strata.

All ground waters contain some salts in solution. The chemical qualities of artesian water seem to vary with the distance it has moved from the point of intake to the place where it is tapped by wells. Other contributing factors are: (1) the rate of movement; and (2) the continuity of the reservoir rock. The leading artesian aquifers are the sub-glacial gravels, Holdrege sand and gravel, Ogallala formation, Chadron formation, Dakota group sandstones, Mississippian limestone, Niagaran dolomite, Galena dolomite, St. Peter sandstone, and the Jordan sandstone. In order to secure a maximum supply of water the wells are usually left open to a number of different water horizons, hence the water from most of these wells is chemically and physically a mixture of them all.

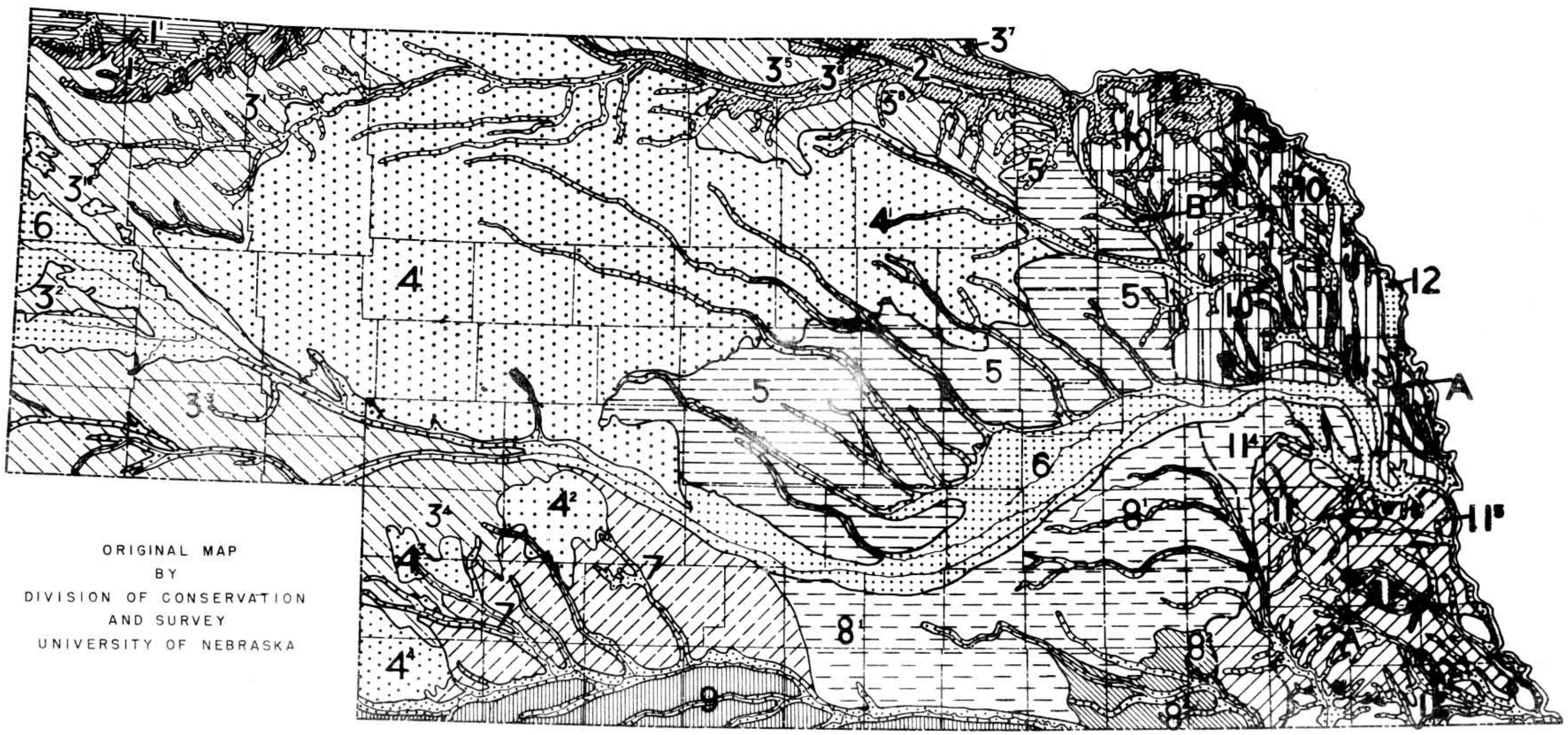
There are more than 1,500 flowing wells in the State. Many of them are located in the sand-hill region. They are used for about the same purposes as other wells. The waters from mineralized artesian wells are used for sanitarium, bathing, and other purposes.

There is a great waste of artesian well water. Many wells have ceased to flow because of the collapse of corroded casings, while others no longer flow because of a reduction in hydrostatic pressure. The artesian waters of the State have not been used to much advantage except in places where there is scant, shallow, well water, and in parts of the sand-hill region where the wells are shallow and inexpensive. At Beaver Crossing flowing wells are used in the development of small streams and ponds for trout culture, and a number of other uses. There are a number of places in the State where artesian water is impounded in fish ponds and lakes.

In 1935, the Legislature assigned to the State Geological Survey the duty of conserving the artesian waters of the State against waste.

At present there is a special demand for information concerning the distribution and configuration of water-bearing formations, and the origin, movement, quantity, quality, and availability of ground water. There is need for a water-table record showing depth, draw-down, and seasonal fluctuations. Since 1930 an investigation of the ground-water levels in Nebraska has been in progress by the United States Geological Survey in cooperation with the Water Survey of the Conservation and Survey Division of the University of Nebraska. The Central Nebraska Ground-water Survey, although a separate investigation, served to in-

GROUNDWATER REGIONS
NEBRASKA



ORIGINAL MAP
BY
DIVISION OF CONSERVATION
AND SURVEY
UNIVERSITY OF NEBRASKA

1^{1-2}-NORTHWEST SHALE LAND REGION, 2-NORTH SHALE LAND REGION, 3^{1-4}-WESTERN TABLELAND REGION, 3^{5-9}-NORTHERN TABLELAND REGION, 4^{1-4}-SANDHILL REGION & OUTLIERS, 5-CENTRAL REGION, 6-PLATTE VALLEY LOWLAND, 7-SOUTHWEST REGION, 8^{1-2}-LOESS PLAIN REGION, 9-REPUBLICAN VALLEY REGION, 10-NORTHERN DRIFT REGION, 11^{1-5}-SOUTHERN DRIFT REGION, 12-MISSOURI RIVER LOWLAND, A-SOUTHEAST EDGE DAKOTA SANDSTONE, B-WEST EDGE OF DRIFT.

augurate the fluctuation studies. Studies were made of the ground-water resources of the Platte River Valley in central Nebraska where periodic measurements of the water levels have been made on approximately 120 irrigation and test wells since August 1930, to determine their fluctuation in response to precipitation, irrigation, stream flow, and in some cases pumpage. The present State-wide water-level program incorporates a number of these original Platte Valley wells, so that the continuity of these records has not been broken.

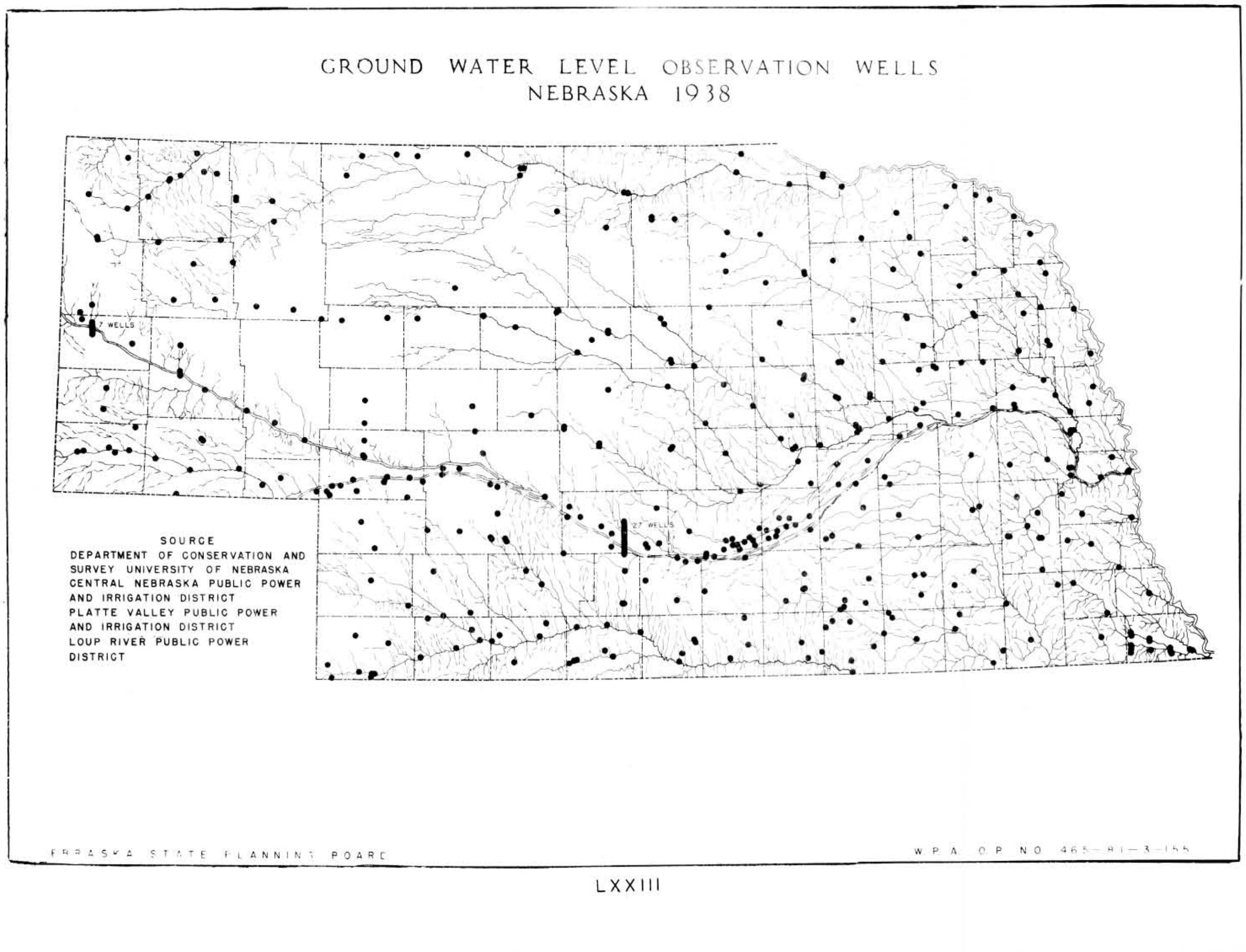
A resume of the periodic observations of water levels in central Nebraska since 1930 written by a member of the State Water Survey furnishes the following data: periodic observations were made in about 100 wells located in the Platte River Valley in central Nebraska between Grand Island and Cozad. These observations reveal that the water levels in the wells show a declining fluctuation range from 1 to 8 feet during the period October 1930 to October 1934. This indicates a general decline of the ground-water table throughout this part of the Platte Valley. The general decline cannot be interpreted as permanent but results from the interrelated factors of annual and monthly precipitation, temperature, depth of ground water, wind movement, barometric pressure, and the season of the year.

The greatest decline of the ground-water table occurred in parts of the valley between Cozad and Kearney. In this area, the principal cause for the decline was probably subnormal precipitation, combined with a relatively small amount of surface water available for irrigation in the last 4 years. The decline ranged from 4 to 8 feet in an area north of Cozad and Lexington, and from 3 to 4 feet in an area on the north side of the valley from Lexington to beyond Kearney.

East of Kearney the decline of the water table has been generally less than the decline west of Kearney. In the area east of Kearney the decline was less because the water table had not been built up to any great extent by surface irrigation prior to 1930. Such decline was due largely to subnormal precipitation and pumpage.

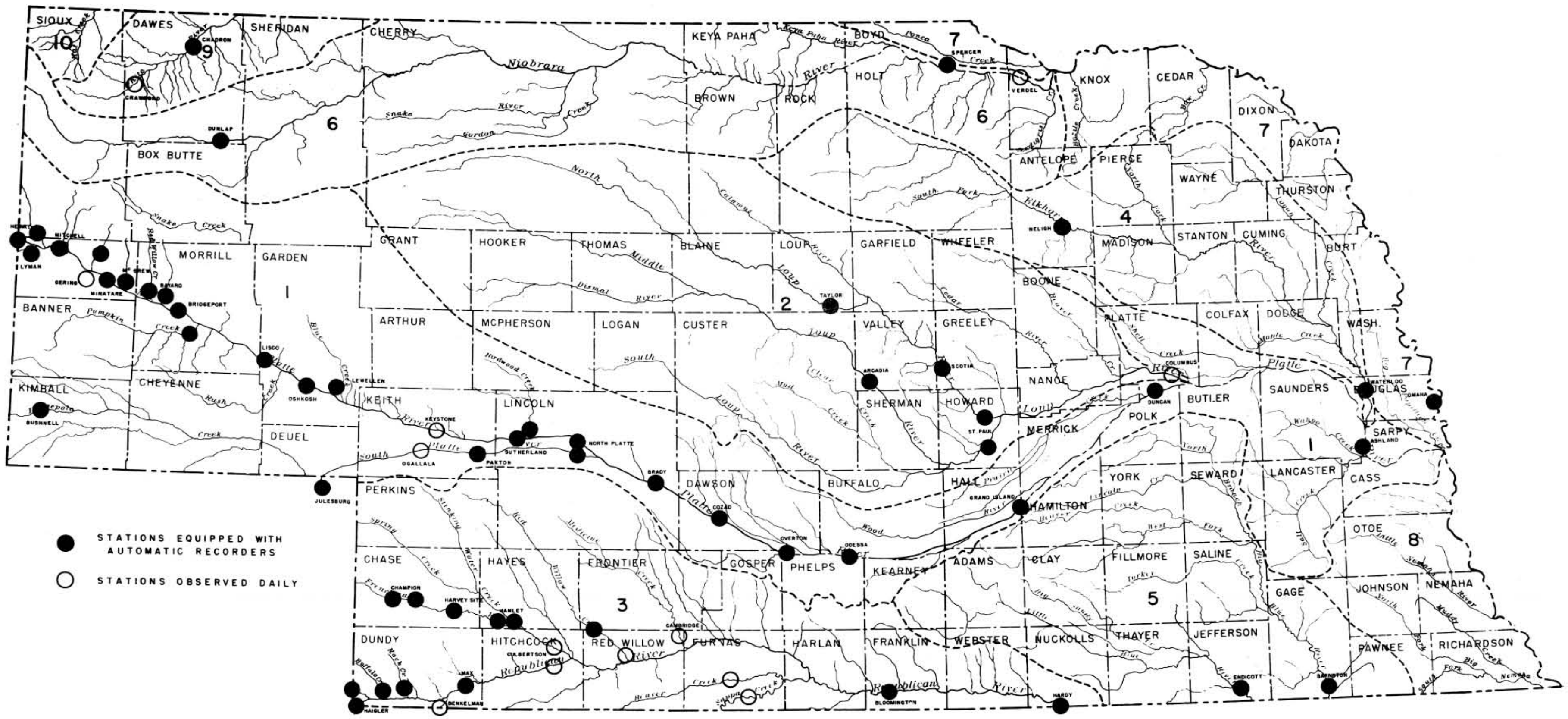
A comparison of the relation between fluctuating water levels in 20 wells between Grand Island and Kearney, and precipitation show that water levels in wells with water tables more than 10 feet below the surface generally rise and fall less than the water levels in wells where the depth to water is less than 10 feet. The wells are in the same stretch of the Platte Valley, but those of the latter group are located nearer the river where the elevations are lower, and the water table is not far below the surface.

The more active fluctuations in the shallower wells is due to recharge from precipitation which is more readily reflected where the water table is shallow, resulting in more pronounced fluctuations of the water level. The roots of plants draw water directly from the zone of capillarity (capillary fringe) just above the saturated zone causing appreciable declines of the water level during the growing season. In the winter and spring periods of 1931, 1933, and 1934 the average rise was less than 1 inch in the deeper but more than 1 foot in the shallower wells. Consequently, the net decline in the last 4 years was nearly the same in each group.



LXXIII

STREAM GAGING STATIONS
NEBRASKA 1941



SOURCE – BUREAU OF IRRIGATION

NEBRASKA STATE PLANNING BOARD

W P A O P NOS 465-31-3-36 AND 665-81-3-60

During the last half of 1932 the water levels in all wells in the Platte Valley showed rather high rises due to an above normal precipitation at that time. From October 1931 to April 1932 the average precipitation recorded at Grand Island and Kearney was slightly above normal, and consequently considerable water percolated into the ground and was added to the ground-water reservoir during this recharge period. As a result, the water level did not reach as low a level in 1932 as it did in 1931. Since July 1932, the precipitation has been about 22 inches below normal - almost the normal precipitation for 1 year. The water level in the valley has suffered annual declines.

In 1935, when precipitation was above normal during the fourth, fifth, and sixth months, ground water rose considerably. As rainfall decreased the water table dropped accordingly. During the summer of 1936, which was one of the warmest on record, the ground water declined more noticeably in the shallow wells, less in the terrace wells, and least of all in the deep wells.

Thus, the study of fluctuations of ground water requires a consideration of such factors as annual and monthly precipitation, atmospheric temperature, the depth to ground water, wind movement, barometric pressure, and the season of the year.

PRESENT STATUS OF GROUND-WATER LEVELS

At the time of the last readings in the fall of 1938, ground-water levels showed normal annual and seasonal fluctuations. Records for the bottom-land wells reveal a maximum fluctuation of 3.23 feet for the 5-year period. The high recording occurred in June 1935, and the low in August 1936. The fluctuation high in bottom-land wells for the entire State was 0.1 of a foot below the normal high, and the 1938 low was 0.3 of a foot above the normal low. At the last reading in the fall of 1938, the shallow wells were 1.35 feet higher than the low recording of 1936.

For the terrace-land wells (15 to 30 feet) the maximum fluctuation range for the 5-year period, 1934 to 1938 inclusive, was 1.87 feet. The high record occurred in June 1935, and the low in August 1937. The fluctuation high for 1938 in terrace-land wells was 0.18 feet lower than the normal high, and 0.05 feet lower than the normal low.

The maximum fluctuation range of deep wells (30 to 275) during the 5-year period, 1934 to 1938, was 0.55 feet. The high was reached June 1935, and the low August 1937. The fluctuation high for 1938 in these wells was 0.12 feet lower than the normal high and 0.16 feet lower than the normal low.

IRRIGATION AND RECLAMATION

Every section of Nebraska has one or more specific water problems. These may be related to irrigation, domestic water supply, flood, drainage, navigation, pollution, wildlife, or power. Some areas have a complexity of such problems.

The attempt of individual communities to solve water problems involving county, state, and interstate interests on a local, and sometimes temporary, basis often results in aggravating rather than solving the problem. Broader planning programs have been introduced from time to time by state and federal agencies. The most recent of these is organized and directed through the correlated efforts of the federal, state, and local divisions of the water resources committees.

However, interest in irrigation and reclamation throughout the history of Nebraska, increased or decreased in direct relation to the failure or success of agricultural production. Nebraskans have always experienced the effects of alternating humid and arid climatic cycles. Economic losses resulting from unstable climatic conditions have stimulated interest in planning for conservation and efficient use of the water resources of the State. Long-time records prove that floods and droughts are normal recurrences within climatic cycles.

Nebraska lies in two fluctuating climatic zones; subhumid east of the 100th meridian, and semiarid west of it, with a twilight zone between the two.

The settlement of Nebraska was made by people from the humid eastern states. They plowed, sowed, and cultivated too often without harvest. Agricultural crops and methods applicable in humid states were unsuited to the variable climatic conditions of this State. Consequently, the slow, difficult process of agricultural adjustment commensurate with the demands of the hazardous physical environment still remains unfinished. The economic security of Nebraska continuously expands or painfully contracts according to the alternating periods of adequate rainfall or withering drought. The future permanent economic and social stability of the State will be threatened proportionately to the deficiency of precipitation occurring within the hydrologic cycle.

Nevertheless, suggested irrigation programs to insure dependable crop production has met with considerable disapproval and condemnation throughout the history of the State. During the early years, irrigation was considered with much caution. The severe droughts from 1894 to the present have greatly influenced public opinion in favor of irrigation and the construction of new projects. The struggles and triumphs experienced by Nebraskans by which they became "water minded" will be developed in subsequent paragraphs.

HISTORY OF IRRIGATION

The droughts occurring in the 1860's and 1890's, and the 1930's focused attention of state and federal irrigation organizations on Nebraska. Each drought cycle brought greater disaster because of steadily increasing settlement and development stimulated during wet cycles. The struggle and triumph of irrigation in Nebraska are based upon human suffering, the untiring efforts of far-sighted individuals, and the cooperative planning between states and federal organizations.

The challenge of droughts has been met in various ways and degrees of permanency during the irrigation history of our State. As early as 1860, 4 miles of ditch canals were in operation. Since that time, interest in irrigation has been intensified with each recurring drought. Development of irrigation has been in progress to the present time.

IRRIGATION LEGISLATION

State legislation governing the development of irrigation was enacted slowly. It is apparent that the statesmen of territorial days did not foresee the necessity of providing for irrigation enterprises in the Constitution adopted in 1866.

In 1867 the territory adopted the common law of England except when it conflicted with the constitution of the United States or those of the separate states. Due to climatic differences between England and Nebraska, the common law was not entirely applicable to our State.

Provisions of law relating to internal improvements were extended to irrigation canals by a law of 1877. "This law empowered canal companies to issue bonds and condemn right-of-way canals". This included the common-law rule as to riparian rights, and the rule held until abrogated by statute.

The State Legislature passed the Saint Raynor Law in 1889 which provided that rights to use water for beneficial or useful purpose could be acquired by appropriation. The court held that this law abrogated the common law of riparian rights. This law of 1889 required the posting of notices on the bank of the stream at the point of intended diversion, and the location of diversion, but no provision was made for policing diversions in order of priority.

The first State irrigation convention was held February 11, 1891 in Representative Hall, Lincoln, Nebraska. Delegates from 36 counties attended. The important work of the convention was the appointing of a committee to prepare and present a bill on irrigation. The bill was defeated in the Legislature March 21st, 1891, with a vote of 35 to 32. Failure to obtain a constitutional majority ended all hope of legislation during the session of 1891. The bill prepared by this committee was finally passed as the "Parnell Bill", and appears in the statute books today with little modification.

A committee appointed at the Lincoln meeting arranged for an interstate convention composed of delegates from Nebraska, Kansas, Wyoming, Colorado, North Dakota, South Dakota, Texas, and the territories of Oklahoma and New Mexico. This convention was held in Kansas in 1892.

An irrigation bill introduced in the 1893 Legislature was bitterly opposed and defeated. The Saint Raynor Law was amended to permit the filing of water-rights on streams 20-feet wide or more.

Serious State-wide droughts occurring in 1894, and 1895 resulted in crop failure and heavy livestock losses. These droughts profoundly influenced irrigation legislation. On April 14, 1895 an irrigation code became a law in Nebraska. It was quite complete in nearly every detail, and was taken from the Wyoming Irrigation Code. This law dedicated the water of every natural stream to public use, and the right to divert unappropriated water for beneficial use was never to be denied. The law also provided that the priority of the use of water was to be administered and recognized as follows: (1) for domestic use, (2) for irrigation, (3) for power and manufacturing purposes. This law provided a State Board of Irrigation, with a membership of 3, namely: the Governor, Attorney General, and Commissioner of Public Lands and Buildings. A secretary who shall be a hydraulic engineer was employed as were also a number of assistant secretaries and water commissioners. Up to 1912 no irrigation company measured water to the users except the Farmers Canal, the extension of which was a United States Reclamation project. Its measurements were taken at the farmers' headgates.

In 1911 the State Board of Irrigation was replaced by the State Board of Irrigation, Highways, and Drainage. The law also provided for the cancellation of appropriations after 3 years of non-use.

When the Civil Administrative Code became effective in 1919, the Department of Public Works was created which took over the power and duties assigned to the old State Board of Irrigation, Highways, and Drainage.

In 1933 the Legislature changed the name Department of Public Works to its present name, the Department of Roads and Irrigation. The State engineer was given the additional duties of chairman of the State Planning Board, Director of the Motor Vehicle Division, and Director of Highway Safety and Patrol.

DEVELOPMENT OF IRRIGATION

The irrigation industry has made slow but extensive growth since the early nineties, but has not as yet developed the maximum use of our water resources. The objective of the State is to develop our irrigation possibilities as fully as possible but with every safeguard against failure. Since the land area suitable for irrigation far exceeds the amount of water available for reclamation, it is necessary for the State to control the allocation and distribution of water in order to secure maximum benefit from it.

WATER STORAGE

Marked improvements have been made in the methods of storage and use of water for irrigation in Nebraska. Pioneer irrigators experienced the hazard of a low, undependable water supply diverted from streams during the irrigation season. To insure a dependable irrigation flow when most needed, attempts were made to preserve the nonseasonal flood flows. Regulating reservoirs were constructed such as the Pathfinder and Guernsey in Wyoming, and Lake Alice, Lake Minatare, and others in Nebraska, making a total reservoir storage of about 1,300,000 acre-feet in the North Platte Valley in Wyoming and Nebraska prior to 1936. The capacity of irrigation reservoirs now under construction or completed are as follows:

Reservoir	Capacity (acre-feet)
Kingsley (under construction)	2,000,000
Sutherland (completed)	178,000
Total	2,178,000

Nonseasonal water impounded in the Pathfinder reservoir is released during the irrigation season and flows in the channel of the North Platte River to a point near Whalen, Wyoming where much of the storage flow is diverted for United States Reclamation projects in that state and also in Nebraska. In Nebraska there are 7 irrigation districts having claim to Pathfinder storage by virtue of their so-called Warren Act contracts. The application of this water builds up the ground-water storage in the terrace and slope lands of the valley from which there is an all-year return flow to the river. By reservoir and ground-water storage the flow of the upper course of the river is stabilized.

The Kingsley and Sutherland reservoirs will supply water for the irrigation districts between North Platte and Grand Island and will have a tendency to stabilize the flow of the river for power developments.

SAND-HILL STORAGE

The Sand-Hill area is an important water storage region. It lies between the Platte and Niobrara rivers in north-central Nebraska. The Sand-Hill country occupies approximately 22,000 square miles, or 14,000,000 acres. The area is generally covered with a loosely compacted, fine-grained, wind-blown sand. This formation ranges from 25 to 100 feet in thickness. Beneath the wind-blown sands, beds of loosely compacted sands and clays outcrop in most of the valleys.

The Sand-Hill area, like a great sponge, has absorbed and stored vast quantities of rainfall over a long period of time. In some parts of the area the ground is water-saturated to a depth of 300 feet or more. Thus, 300 feet of water-filled earth contains about 100 feet of water.

Sand-Hill ground water is the important regulatory factor in the projects on the Loup rivers, because it gives a uniform flow to the streams where they leave the sand hills. However, in their lower courses, the surface run-off to the rivers is less uniform and might be regulated by reservoir storage.

NEW IRRIGATION PROJECTS

Plate LXXV shows the existing and contemplated irrigation in Nebraska in 1940.

A Nebraska authority states that it would be possible to trace a fairly accurate weather chart by reviewing the applications made for water appropriations as recorded in the State engineer's office. During dry years there are many applications. During wet years the number is reduced to a minimum.

Recent droughts, especially those occurring in 1934 and 1935, again emphasized the need for more extensive irrigation. These droughts molded public opinion favorably for additional irrigation development. In 1933 the Nebraska Legislature passed Senate File number 310 which authorized the organization of public power and irrigation districts. Under this law the following self-liquidating, federal projects were organized, approved, and are now under varying stages of construction or in operation: (1) Central Nebraska Public Power and Irrigation District which will irrigate 200,000 acres; (2) the Platte Valley Public Power and Irrigation District developed primarily for power, will deliver supplemental water to 102,000 acres under previously existing irrigation projects below North Platte; (3) North Loup Public Power and Irrigation District to irrigate about 38,000 acres; (4) Middle Loup Public Power and Irrigation District to furnish water for 45,000 acres. When these federally financed projects are completed, Nebraska will have an additional area of more than 300,000 acres which represents an increase of some 43 per cent of the land now under irrigation in the State.

FEDERAL APPROPRIATIONS

The total allotments covering both loans and grants made by the Federal Government for the 4 public power and irrigation districts in the State are $50,267,000. A substantial part of the total allotment is to be used for the irrigation phases of these developments. In addition to these irrigation projects $12,814,000 has been allotted to the Loup River Public Power District, and $10,791,500 to 28 Rural Electrification Districts.

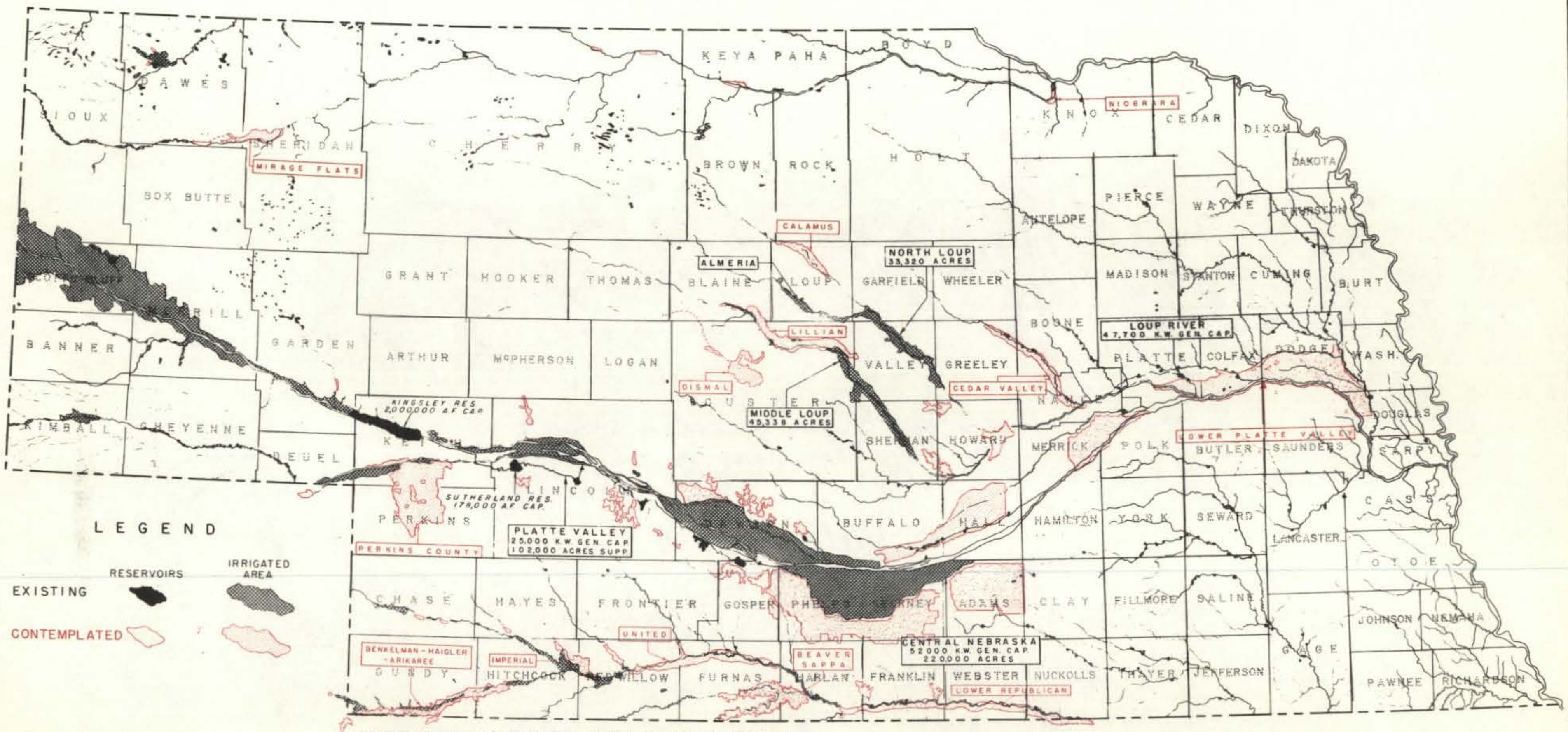
IRRIGATED ACREAGE

The acreage of irrigated land for each county in Nebraska as indicated by the county assessor's records is shown in the following summary:

LAND IRRIGATED
Acres

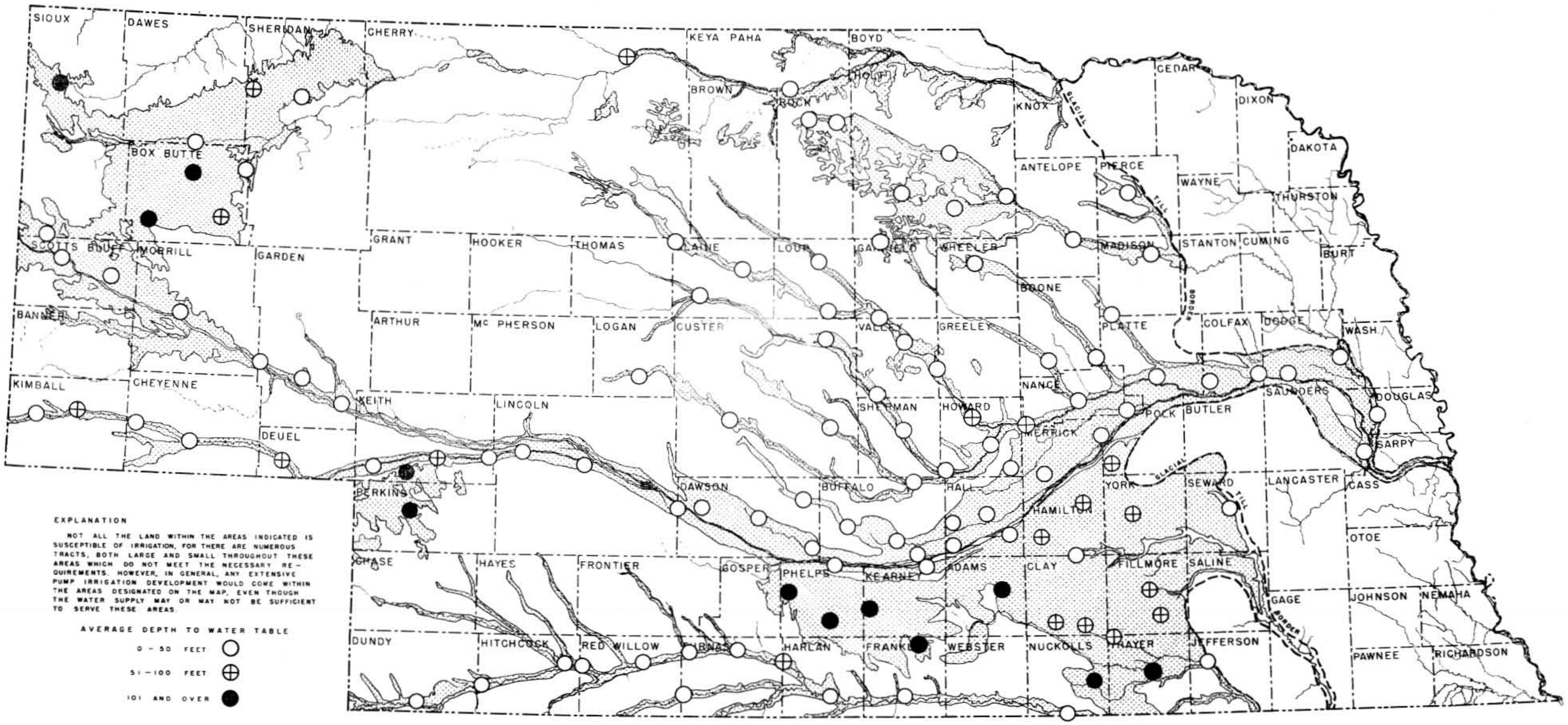
County	Pump 1937	Total Pump and Ditch 1940
Adams	274	450
Antelope	22	389
Arthur	0	10
Banner	78	1,365
Blaine	140	220
Boone	515	1,273
Box Butte	0	3,960
Boyd	11	65
Brown	310	572
Buffalo	22,350	34,081
Burt	0	60
Butler	143	759
Cass	120	190
Cedar	0	20
Chase	1	2,257
Cherry	1	2,662
Cheyenne	321	4,248
Clay	44	327
Colfax	110	2,462
Cuming	380	783
Custer	354	4,711
Dakota	0	130
Dawes	32	11,118
Dawson	14,201	89,400
Deuel	2,087	6,860
Dixon	19	64
Dodge	624	1,352
Douglas	1,205	1,235
Dundy	75	4,020
Fillmore	22	365
Franklin	387	1,250
Frontier	0	353
Furnas	379	1,018
Gage	139	200
Garden	408	24,080
Garfield	189	2,790
Gosper	285	1,283
Greeley	131	1,650
Hall	9,702	15,278
Hamilton	1,430	1,974
Harlan	569	1,577
Hayes	360	1,349
Hitchcock	319	10,980
Holt	112	160
Howard	492	550
Jefferson	124	220
Johnson	1	41
Kearney	1,365	9,892
Keith	2,160	25,060
Keya Paha	0	65
Kimball	403	7,674
Knox	77	220
Lancaster	85	110

EXISTING AND CONTEMPLATED IRRIGATION
NEBRASKA
1940



SOURCE—BUREAU OF IRRIGATION, WATER POWER AND DRAINAGE

MAP SHOWING
GENERALIZED AREAS OF FLAT TOPOGRAPHY WITH ARABLE SOILS IN NEBRASKA



SOURCE OF DATA: CONSERVATION AND SURVEY DIVISION
UNIVERSITY OF NEBRASKA

NEBRASKA STATE PLANNING BOARD

Lincoln	1,901	47,260
Logan	22	22
Loup	211	5,115
Madison	403	1,366
Merrick	1,448	4,717
Morrill	229	84,500
Nance	67	473
Nuckolls	147	400
Otoe	0	5
Perkins	148	480
Phelps	1,342	8,200
Pierce	651	656
Platte	223	1,335
Polk	30	428
Red Willow	1,462	5,150
Richardson	0	35
Rock	95	280
Saline	158	309
Sarpy	105	200
Saunders	20	410
Scotts Bluff	647	201,000
Seward	115	536
Sheridan	121	1,000
Sherman	40	3,830
Sioux	78	28,383
Stanton	190	1,417
Thayer	228	340
Thomas	40	44
Thurston	1	34
Valley	225	12,281
Washington	0	120
Wayne	0	50
Webster	75	710
Wheeler	0	46
York	81	656
Total	73,059	693,970

The foregoing table shows that irrigation is practiced in 88 of the 93 counties in Nebraska. Scotts Bluff County has the largest irrigated acreage with 29 per cent of the total irrigated land in the State. The total area of the State now capable of being served by present irrigation facilities is 40 per cent of the total area susceptible to reclamation, and 4 per cent of the total cultivated land in the State. However, less than 2 per cent of Nebraska is now being irrigated. These comparisons show that there is a relatively small portion of the State under irrigation, and that the existing possibilities for expansion are promising.

Of the 17 states in which irrigation is practiced, California has the greatest irrigated area with over 4,000,000 acres. Colorado ranks second with 3,300,000 acres. Nebraska holds eighth place with less than a million acres. It is not generally realized that the irrigation development in the United States is rather small. For example, the total irrigated area in the 17 states is approximately 18,500,000 acres, which is about 5 per cent of the 400,000,000 acres cultivated in the United States.

BENEFITS OF IRRIGATION

The benefits derived from irrigation are not confined to the irrigated areas alone, but are extended to every part of the State. To those living outside the irrigated territory come benefits in the way of greater wealth for our State. During drought years, feed and general farm commodities are shipped from the irrigated areas to needy portions of the State.

A comparison of differences in crop production on irrigated and unirrigated land further emphasizes the advantages to be enjoyed by the induction of successful irrigation practices. The amount of increase in crop yields is dependent upon a number of factors among which are the physical features of the soil and the amount and distribution of moisture. Therefore, no reliable figure can be given with reference to the increase that would be applicable under all conditions and in all localities. The most valuable data available are the records maintained at the State experiment stations where research has been conducted to determine the increase in crop yields for irrigated land over that on dry land under similar conditions.

Records show that the application of supplemental water when needed results in the difference between 100 and 300 bushels of potatoes per acre; between 2 and 4.5 tons of alfalfa per acre, and between no sugar beets and 15 tons of sugar beets per acre. The above statistics indicate the advantages that can be expected when supplemental water is available and is applied at the proper time. The records used in this study were obtained over a period covering 10 to 12 years, and therefore, represent an average of conditions for the period of the experiment.

The benefits of irrigation resulting in the increased production capacity of the land are reflected in other ways. With reference to population statistics, Scotts Bluff County is a good example, since it has the largest irrigated acreage of any county in the State. The assurance of crop yields every year is very necessary, and one of the inducements for the location of manufacturing plants used in processing agricultural products.

Throughout 50 years of irrigation experience Nebraskans have become increasingly irrigation-conscious. This is attested by the magnitude of present irrigation undertakings which will result in facilities for the conservation and utilization of our 2 greatest natural resources, water and soil. The Keystone Reservoir with 2,000,000 acre-feet of storage, the Sutherland Reservoir with a capacity of 178,000 acre-feet, and the projects on the North, Middle, and Loup rivers together with existing projects will be capable of transforming hazardous agricultural areas into productive fertile valleys adequately served with electricity, and the associated conveniences of the urban centers. Irrigation plans will be continued until all available irrigable land within the limits of feasibility is developed to the maximum expansion.

Thus, it is possible for a State of great agricultural risks to become a land of reasonable security in the future. To achieve agricultural stability in an unstable climatic environment is the challenging task to state and local community planning. If the change is to occur, the State and minor civil divisions of the region no less than the Federal Government must energetically attack the problem. Federal progress along some lines will be conditioned in large measure by the extent to which complementary action is effected by the State and its subdivisions. The success or failure of an active long-term program of readjustment and development for Nebraska will depend very largely upon local attitudes, policies, and action.

The recent droughts are only temporary setbacks and if proper adjustments and full utilization of the water resources are made, a much safer and more prosperous future lies ahead for Nebraska.

PUMP IRRIGATION

Soon after irrigation from surface supplies was begun in the valley of the Platte, farmers began to use windmills as a means of raising water from wells. The records show that many windmills were in use for irrigation purposes prior to the year 1900. It is probable that at least 5 irrigation wells were in operation in the Platte River Valley prior to the year 1912. Since that date, the number of wells has increased steadily.

The progress of irrigation in Nebraska has been erratic largely because of the variation in precipitation. The occurrence of a number of wet years occasioned abandonment of ditches and wells, whereas, a few dry years would find all types of irrigation systems being revived again. The total annual precipitation is not always a yardstick by which to estimate the amount of supplemental water necessary. The corn crop of Nebraska is dependent upon ample rainfall in July and August, the season when drought often occurs.

A preliminary study of pump-irrigation costs was made in Nebraska by a representative of the United States Department of Agriculture in 1913. This report shows that at that time there was a great variation in the methods of well construction and pump design.

Because of a decided lack of good well-drilling equipment, there was a tendency to use wells of large diameter dug by hand. For the most part, the depth was limited to 25 or 30 feet due to the type of equipment used and the existence of a common belief that large-diameter shallow wells produced better yields than small-diameter deep ones. This misunderstanding was costly to many early pump irrigators.

As well machinery developed, and the process of digging irrigation wells was better understood, holes of small diameter and greater depth came into common use.

Early casings were often made of wood; however, in some cases, a rough wall of stone was laid up. Later the perforated galvanized casing came into very common use and there was developed precast concrete casings of various diameters and designs. Metal and concrete casings were commonly sunk by removing the material from the interior with a sand bucket and applying pressure to force the tube downward. No attempt was made to place screened gravel around the outside of the casing. Later development consisted of pouring screened gravel around the casing and allowing it to settle with the casing. One of the later developments consisted in putting down a large-size blank casing to the required depth. The perforated casing was placed inside and centered. Screened gravel was poured between the 2 and the blank casing removed. This produced the so-called "gravel packed" well which has proven so successful in many areas where it has been impossible to get good results with old-time methods.

Many of the early wells consisted of large-diameter pits dug to a point near the water surface. Below this a small-diameter casing penetrated the water-bearing strata. In this pit was placed a horizontal centrifugal pump which, because of its simplicity and low first cost, has always been popular in irrigation practice. This particular type of pump, however, is ordinarily installed near the water surface in order that a short suction line can be used to facilitate priming and increase the efficiency. Rotary pumps were used at an early date and were also placed in pits in order that they might operate near the water table. The water lift, which consisted of a series of buckets mounted on an endless chain, made an early appearance in the valley. Later came the vertical centrifugal pump which at that time required a casing 36 inches or more in diameter. A later design could be lowered into a 24-inch hole. The deep-well turbine developed about 1901, also made an early appearance in the Platte Valley and now promises to be one of the most popular of all irrigation pumps.

As is generally the case in all newly irrigated regions, water-handling methods were crude and little attempt was made at land leveling, construction of borders, or use of corrugations. For the most part, the entire discharge of the pump was conducted in one ditch to some row crop where the flow was directed to a few rows and largely left to take care of itself.

PRESENT DEVELOPMENT

There is indeed room for a great deal of standardization both in the methods of well construction and general design of the irrigation plant. At the present time, there are in operation in the State many heavy duty well-drilling rigs manned by capable operators who understand well-drilling and development practices. There has been a tendency of late years to standardize on the use of the 18 or 24-inch diameter wood, metal, or concrete casings put down by the gravel-pack method.

Within the last year or two, well drillers from California have introduced the so-called "stove pipe" casing into western Nebraska for deep wells. This casing, made of red steel, is forced downward with large hydraulic jacks as sand and gravel is removed from the interior with a sand bucket. As the casing is lowered, a careful log is kept of the position and extent of all water-bearing material. When drilling is completed, a perforation device is lowered inside the casing and perforations are cut opposite strata of favorable water-bearing gravel.

Well development by surging and proper pumping methods is better understood now than in former years. Under old methods of development, the pump was started and often discharged great quantities of sand which damaged impeller, bearings, and volute cases to say nothing of the cave-ins which generally occurred lowering the ground around the casing for several feet. At present, if it is necessary to remove fine materials from the water-bearing gravel, it is done by lowering the surge block into the casing and oscillating it up and down beneath the water surface with the well rig. Water is alternately drawn in and driven out through the perforations. This process brings in some sand which can be removed with a bucket and when the pump is installed, it is started slowly and brought up to speed through several hours time.

Much has been learned about the character and extent of water-bearing gravels in all parts of the State. Tests have established the fact that a considerable depth of water-bearing material is important if wells of high yield are to be obtained. The yield of a well is measured by what is known as "specific capacity". The water surface within a well lowers preceptibly as the pumping proceeds. This lowering of the water surface is known as "draw-down". The specific capacity is the number of gallons yielded per minute per foot of draw-down of the water surface. In other words, it is the discharge in gallons per minute per foot of draw-down.

Tests made by the Department of Agricultural Engineering, University of Nebraska in 1931, brought to light many important facts regarding the yield of wells. That the depth of gravel strata is important is exemplified in the following data:

	Well Number 8	Well Number 13
Diameter of casing	24 inches	24 inches inside
Depth of well	54 feet	90 feet
Depth of water	36.33 feet	66.58 feet
Discharge per foot of draw-down	32 gal. per minute	66.5 gal. per minute

The test of the above wells showed that well Number 8 had a draw-down such that when pumping 690 gallons per minute, the total lift was 41 feet, while well Number 13 was capable of discharging about 1,200 with a total lift of 42 feet. The great superiority of well Number 13 is immediately apparent.

In the old days, many wells were located by guess, although in some cases the so-called "water witch" was brought into play definitely to decide the matter. Now the drilling of test wells of small diameter to sample the character and extent of the water-bearing strata has become a matter of regular routine with all reputable well men.

MATCHING PUMP TO WELL

When the driller has completed a well, and turned it over to the landowner, the next job is that of purchasing a pump. Tests made in the valley of the Platte in 1931 showed that wells of identical diameter of casing and depth of water-bearing material may have widely varying specific capacities (yield in gallons per minute per foot of draw-down). It is not possible for a manufacturer to sell the landowner a pump exactly fitted to any particular well until a pump test has been run to determine just what type of bowl assembly and impeller is needed to develop the best possible efficiency. Pumps are sold without this information every day but the farmer may contribute hundreds of gallons of engine fuel or pay for many kilowatts of electricity which go for no purpose except to pay for a job of mismatching pump to well. Good well drillers are rapidly preparing themselves to render a well-testing service. Some pump manufacturers practically insist on a well test before a pump will be sold for any job and farmers are rapidly learning that high efficiency pays good dividends when an outfit is operated through a long pumping season, or when the total lift is considerable.

Careful matching is particularly important where direct-connected electrical outfits are used. Most of the motors which the farmer will purchase are of the constant-speed type which means that the pump will operate at a given discharge and head. It may be that the well is capable of producing only 800 gallons per minute, in which case there would be serious consequences if the pump were so operated that the discharge was 1,000 gallons per minute. Some wells have characteristics which make it more economical to pump them at less than their maximum capacity, hence the importance of correctly fitting the pump to the job.

Most pump manufacturers have conducted exhaustive tests on their equipment, and are prepared to furnish the purchaser an outfit which will develop high efficiency if information regarding the yield of the well can be furnished. The day of blind well-drilling and pump fitting is rapidly drawing to a close and so much the better for the future of pump irrigation in Nebraska.

TYPES OF PUMPS USED

For pumping from sand pits, streams, and shallow wells the horizontal centrifugal pump has many advantages. It is comparatively cheap in first cost, light in weight, has few moving parts and is now so well-designed that high efficiencies are developed. It may be had in sizes which will deliver from 50 to 5,000 gallons per minute against heads of from 0 to 200 or more feet. In ordinary installations, the pump proper is set upon the lake or stream bank with the suction line in the water and the discharge line extending to the point of delivery. The one common mistake made in installations of this type is the use of too small a discharge pipe giving rise to excessive friction head which greatly reduces the discharge or requires excessive power.

The vertical centrifugal pump is similar to the horizontal except that the volute case and impeller are placed beneath the water surface and are carried on a heavy metal frame, or on the discharge pipe. The shaft leads from the impeller to the surface where it may be driven by a belt or directly connected to a power unit. This type of equipment is particularly well adapted to wells in which there is considerable fluctuation of the water table, but where the total head does not exceed 50 feet. A casing at least 24 inches in diameter is necessary to accommodate the large sized volute.

A third type of pump which is becoming increasingly popular, because of its rugged construction, long life, wide adaptability, and relatively high efficiency, is the turbine. It works on the same principle as the types just described except that it is smaller in diameter and may be designed to operate with any lift from 50 to 800 feet. The shaft comes to the ground surface to permit a drive. It runs down inside of the discharge pipe to the impellers mounted in the bowls and placed near the bottom of the well. Each impeller with its volute case of bowl assembly is known as a stage end and in ordinary irrigation practice from 2 to 6 stages are necessary to raise water efficiently, depending on the lift.

Pumps of this type are designed to meet almost any condition of lift and quantity of water desired. The propeller and mixed-flow pumps are somewhat similar in design to the turbine and have wide usage in irrigation practice for certain conditions of lift and discharge.

In the early days the common type of drive was the flat belt which resulted in efficiency losses of from 10 to 15 per cent. When high lifts and more continuous operation are contemplated, consideration may well be given to the multiple "V" belt drive which is proving popular due to its long life and high efficiency. When an internal combustion motor is used for power the modern bevel-gear drive may be substituted for the belt and a direct-connected arrangement employed with little loss of power.

POWER OF PUMPING

The farm tractor is yet by far the most popular type of power used for pumping in Nebraska. The farmer has the tractor, so why not use it? In many cases, this is good logic.

When the power required is too great or when the outfit must be operated continuously through the summer and fall months, then an engine power unit or an electric motor may prove more profitable. The light, high-speed Diesels are gaining in popularity because of their cheapness of operation. The first cost is high, however, and to be profitable a long-running season is necessary, during which a large acreage of ground can be covered. The operating cost may be only one-fourth that of an ordinary gasoline engine.

With the ever-increasing expansion of electric power lines, there is sure to be added interest in electric motors as a means of driving pumps. The same drives as mentioned for engines may be used for them but the direct-connected arrangement is more popular. When directly connected, the pump must run at uniform speed and, therefore, is limited by its design to some specific head and delivery. Greatly added running costs may result if a careful job of matching pump, motor, and well is not done.

In several communities, specially designed power lines are being carried into rural districts with the expectation that farmers will see fit to use the new form energy for pumping. In many instances, the pumps now owned by the farmers are of the old, slow-speed type and have been operated by tractors. With engine power it was possible to drive the outfit at any desired speed by changing the throttle. If the delivery was such that the well was pumped out the speed could always be reduced. When the change to electricity is made, care must be used to get well engineered drives if the venture is to be attended with much success.

It would seem only logical that a pump test should be run on the well to determine its yield and the most economical pumping rate. If electrical power is available, a motor may be used to determine horsepower requirements and efficiencies of the pump at various speeds. When the most efficient operating conditions are discovered then a drive may be designed which will give best results. A motor which is too big for the job at hand may prove expensive and one which is too small will overload and heat dangerously in the summer.

PUMPING COSTS

Under given conditions of lift and discharge, it is possible to estimate the cost of pumping quite closely. There are, however, many conditions which enter into and vary the situation when dealing with plants which have already been installed. Fixed costs are arrived at by figuring interest on the investment plus depreciation on the equipment to which is added taxes. Figures on operating costs are made up of such items as fuel, lubricating oils, repairs, cost of electricity, attendance, et cetera. Thus, on a plant recently examined, the costs were arrived at as follows:

Well.	$ 500.00
Pump	450.00
Power Unit.	700.00
Total Cost	$1,650.00
Interest on $1,650.00 at 5%. . .	$ 82.50
Depreciation on well at 3% . . .	15.00
Depreciation on pump at 8% . . .	36.00
Depreciation on engine at 12%. .	84.00
Total Fixed Cost Per Year	$217.50

If 100 acres are irrigated, it is apparent that the fixed cost per acre will be $2.17 regardless of how much the plant is operated. The necessity of watering a fairly large acreage with expensive pumping plants is at once recognized.

Operating costs may vary a great deal, depending upon many factors. Low plant efficiencies mean high operating costs, and these low efficiencies may be due to a great many things which only careful examination or actual test will discover.

Assuming a belt and pump efficiency of 60 per cent and an engine burning tractor fuel at 10 cents per gallon, the fuel cost only for lifting enough water to cover an acre one foot deep through various heads would be about as follows:

Foot of lift	Cost per acre-foot
10	$ .26
20	.52
30	.78
40	1.04
50	1.30
60	1.56
80	2.08
100	2.60

Low engine and pump efficiencies may produce fuel costs several times as great as those above indicated. Successful pump irrigation under any condition requires a well-engineered plant. Under actual conditions, surveys seem to indicate that a figure of 10 cents per acre-foot per foot of lift for a total cost of pumping is perhaps a good average when all things are taken into consideration.

Figures on highly efficient Diesel or electrically operated plants show total costs as low as 3 cents to 3 1/2 cents per acre-foot per foot of lift.

DISTRIBUTION OF PUMP-IRRIGATION WELLS

Practically all irrigation wells in Nebraska are west of a line passing north and south along the eastern edge of Hamilton County. This line marks the western border of the till sheet or the point at which the glaciers which invaded eastern Nebraska extended. West of this line, beds of Pleistocene gravels and sands underlie the mantle materials. These Pleistocene deposits are, for the most part water-bearing, and, where they can be encountered at relatively shallow depths, provide excellent supplies for irrigation pumping. Up to the present, pump-irrigation developments have taken place largely along streams because of the lower lift and less expense encountered in applying water. If a series of dry years should follow, extensive developments can be looked for in the high plains south of the Platte River where lifts may exceed 100 feet.

The actual number of irrigation wells now in existence and the acreage irrigated is not definitely known. Some indication can be obtained, however, from the summary given under Irrigated Acreage in the Irrigation and Reclamation section; this summary shows the counties in which pumps are found and the corresponding irrigated acreage.

The Assessor's Report for 1937 indicates that pump irrigation was practiced in 77 counties, and that the area so irrigated was 73,069 acres of which 86.3 per cent or 63,059 acres were located in 17 counties, each of which has more than 500 acres under pump irrigation.

The number of counties having over 1,000 acres each under pump irrigation was 12 and these 12 counties contained 60,653 acres or 83 per cent of the State total pump-irrigated acreage.

Only 6 counties in the State had over 1,500 acres each under pump irrigation but these 6 counties account for 52,401 or 71.7 per cent of the total pump-irrigated acreage in the State.

Three counties; Buffalo, Dawson, and Hall, are shown to contain 46,253 acres under pump irrigation which is 63.3 per cent of the State total.

No reliable data are available as to the potential capacity of irrigation pumps now existing in the State but it is thought to average about 750 gallons per minute, and that the average period of operation varies from 200 to 400 hours per year. The average area irrigated by each pump probably varies from 50 to 60 acres, and the average amount of water pumped is probably about 1 acre-foot or less per acre irrigated.

PROBABLE BENEFITS FROM IRRIGATION

With the exception of material gathered at the North Platte and Mitchell Experiment stations, little actual experimental data exist as to the increased yields to be expected from application of irrigation water. These data obtained under certain soil and climatic conditions could not be expected to apply universally over the State of Nebraska but will serve to give some indication as to the increases to be expected.

In the irrigation of corn at the North Platte Experiment Station in the years from 1925 to 1934 inclusive, the application of 13.74 inches of water produced an average yield of 55.82 bushels as contrasted to 18.54 dry land or an increase of 37.27 bushels per acre. This represents an increased yield of 2.58 bushels per inch of water applied.

In the years from 1927 to 1935 inclusive, silage corn was irrigated with an average application of 13.18 inches of water. This produced an average yield of 10.56 tons of fodder per acre or 1,171 pounds of silage per inch of irrigation water added. As no records of dry land silage yields are available, no comparison between irrigated and dry land yields is possible. The highest single yield of corn silage obtained under irrigation up to the present is 20.3 tons per acre.

In the 11 years, 1925 to 1935 inclusive, an average of 25.38 inches of irrigation water has been applied to potatoes per year. This has increased the yield from 99.5 bushels per acre on dry land to 333.3 bushels for irrigated land or an increase of 233.8 bushels per acre. In other words, each inch of water added has produced 10.74 bushels of potatoes.

The greatest use of irrigation water for alfalfa at the North Platte Station has been for the purpose of restoring water to the subsoil preparatory to reseeding of the crop on land which has recently been in alfalfa, and from which the subsoil moisture has been removed by its deep-root system. In the 10 years, 1926 to 1935 inclusive, an average application of 18.15 inches of water per year has produced 4.62 tons of alfalfa per acre as contrasted with 1.95 tons under dry land conditions or an increase of 2.67 tons per acre. In other words, each inch of water added has produced 435 pounds of alfalfa.

PROPOSED PUMP-IRRIGATION PROJECTS

Five new public pump-irrigation projects have been approved by the Department of Roads and Irrigation, and four of these applications have been filed with the Public Works Administration in Washington, D. C. These irrigation districts were organized in Hall, Dawson, Merrick, Box Butte, and Clay counties. The estimated cost and number of acres for each project are as follows:

Name of District	Estimated Cost	Acreage
Hall County Public Pump-Irrigation District	$ 364,230	30,000
Dawson County Public Pump-Irrigation District	358,600	24,000
Merrick County Public Pump-Irrigation District	275,455	16,000
Panhandle Public Pump-Irrigation District	440,500	10,000
Harvard Public Power and Irrigation District	608,000	20,000
Total	$2,046,785	100,000

WATER POLLUTION

Pollution of streams, lakes, and ground water is rapidly becoming a menance in Nebraska. The water supply is polluted and contaminated by garbage, industrial refuse, offal, and seepage from ground water. Unsanitary disposal of foul materials which makes streams unrightly, filthy, and unsuited for bathing, boating, and wild life, is now prohibited by law. Shallow ground waters absorb the odors of decaying organic materials thus becoming not safely potable.

Sources of water supply of many municipalities are unfavorably located in relation to sewage disposal and sources of water pollution and contamination. Town and city garbage, industrial refuse, and sewage in streams are often responsible for unsanitary conditions.

SANITARY WELL WATER

Unfortunately the sources of most water supplies are poorly located with reference to sanitation because too little thought has been given in the past to the relation of sources of contamination and water supply. Most drinking water in the State is drawn from wells with an abundant ground-water supply.

Except in a few areas, the supply is sufficient. This does not mean that all town and farm water supplies are free from pollution and contamination.

Recent water surveys furnish valuable data concerning water-bearing formations, and the source, depth, quality, direction, and rate of the movement of ground water. These data afford scientific guidance in the location and development of sanitary rural and urban water supplies. The following rules relate to sanitary well water conservation in Nebraska:

1. Open or dug wells are not sanitary.

2. The well driller must know the structure of the land, the depth of the water table, and the direction of the ground-water movement in order to determine the sanitary location of a well.

3. Wells should be located where they will not catch the polluted and contaminated underflow from privy vaults, cess pools, leaky sewers, flooded streams and other sources. It is necessary that wells be located upgradient from sources of pollution and contamination.

4. When the farm home, town, or city is located in a broad valley, the well or wells should be placed up-valley and the sewage disposal down-valley from the home, town, or city.

5. Every municipality should protect its water-producing ground against pollution or relocate the water supply on clean, protected ground.

6. Wells should be graded up, and enclosed to prevent the entry of surface drainage and the trapping in them of frogs, mice, rats, and other animals.

7. In places where the ground water is separated by clay layers at first, second and third waters, the well should be sunk to the lower water-bearing sands. The upper water, which may be polluted, should be adequately cased off.

8. Spring water in general is not a sanitary source of drinking water because it is supplied from local drainage areas. These areas are apt to become contaminated because there is usually a shallow depth of earth through which the water filters from the surface to the aquifer.

The Well Drillers Association is one of the largest of its kind in the United States. Its members cooperate with the Geological and Water Surveys of the University of Nebraska and the State Department of Health in a program of well water improvement. The University of Nebraska offers short courses and extension service for the well drillers, who report the depths, types of wells, and other valuable data to the surveys on well logs.

WATER TREATMENT

Polluted and contaminated waters are unsafe for domestic use without adequate treatment consisting of sedimentation, aeration, flocculation, filtration, and disinfection. The sewage treatment varies with the type and subsequent use of the water. The usual chemicals used are alum, lime, soda, and chlorine. Finally, hard water should be softened by the application of small quantities of lime. Thus far no practical method has been devised to improve the potability of salt water.

Most of the well water in Nebraska is naturally safe for drinking purposes, therefore water treatment is less common in the State than in most other states. The careless disposal of sewage and industrial wastes is fast polluting the ground water, lakes, and streams, making water treatment increasingly necessary.

At present, the major streams of the State are rather seriously polluted. Ample legal authority exists to control stream pollution by requiring the installation of necessary treatment works. The State Department of Health gives advisory service to improve the operation and maintenance of existing treatment plants. The major problems consist of the difficulty of securing State and local appropriations large enough to provide an adequate staff to insure efficient and continuous operation of such plants.

Study should be given to sewage and industrial waste treatment plants now operating to devise a guidance program for local administration and technical supervision of such works. The major objective is to insure their continuous and satisfactory operation.

REGULATIONS RELATING TO WATER SANITATION

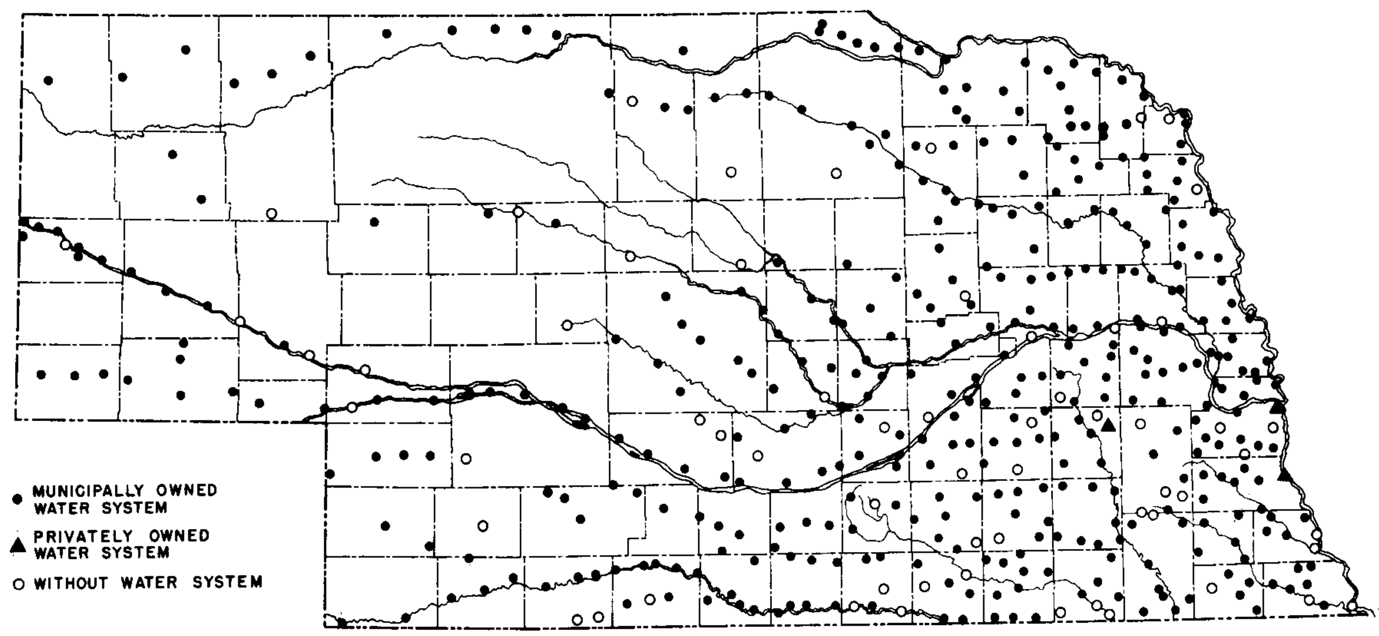
No municipality, district, corporation, company, institution, person or persons, shall install, change or make alterations in or additions to, or enter into contract for installing, changing, making alterations in or additions to any water works system to serve more than twenty-five persons, any sewerage system to serve more than twenty-five persons, or any swimming pool, public swimming or bathing place or places, until complete plans and specifications fully describing the proposed construction, alterations or additions have been submitted to, and received the written approval of the State Department of Health.

Plans and specifications for water works, sewerage systems and swimming pools must be submitted in triplicate. When approved, one of these is for filing as a permanent record with the Department, one is for the owner, and the other for the engineer submitting such plans and specifications. Thereafter such plans and specifications must be substantially adhered to, unless deviations are submitted to, and receive the written approval of the State Department of Health.

DOMESTIC UTILIZATION OF WATER
PLATTE RIVER BASIN
Estimated Population, 1938

	Water Supply System	Public Swimming Pools	Sewer System	Sewage Treatment Plants
Municipal population with access to service	219,521	159,283	201,175	122,362
Per cent of municipal population with access to service	95	69	87	53
Total municipal population of Basin				230,528

MUNICIPAL WATER SUPPLY SYSTEMS
NEBRASKA
1939



NO VILLAGES UNDER 200 POPULATION SHOWN

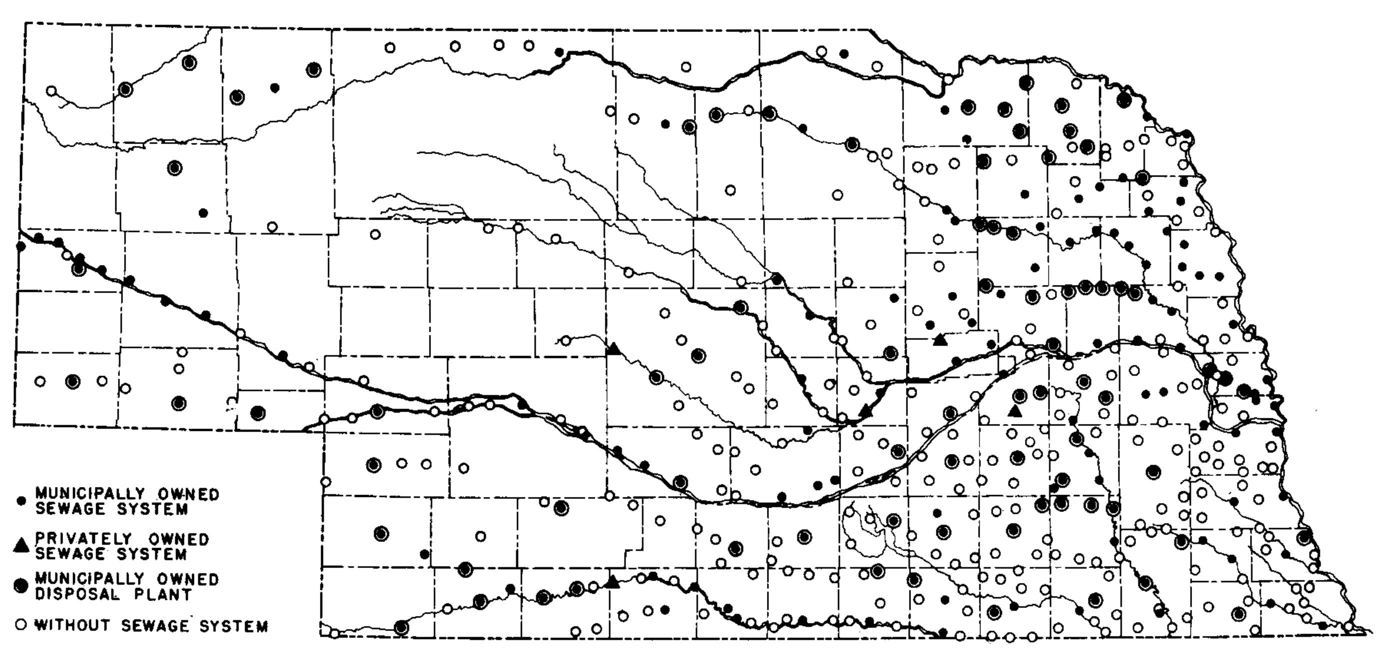
SOURCE—LEAGUE OF NEBRASKA MUNICIPALITIES

NEBRASKA STATE PLANNING BOARD

W.P.A. O.P. NO. 465-81-3-155

LXXVIII

MUNICIPAL SEWAGE SYSTEMS AND SEWAGE DISPOSAL PLANTS
NEBRASKA 1939



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NEBRASKA STATE PLANNING BOARD

W.P.A. O.P. NO. 465-81-3-155

DOMESTIC UTILIZATION OF WATER
LOUP RIVER BASIN
Estimated Population, 1938

	Water Supply System	Public Swimming Pools	Sewer System	Sewage Treatment Plants
Municipal population with access to service	39,522	13,648	29,309	11,781
Per cent of municipal population with access to service	88	31	66	26
Total municipal population of Basin				44,684

DOMESTIC UTILIZATION OF WATER
REPUBLICAN RIVER BASIN
Estimated Population, 1938

	Water Supply System	Public Swimming Pools	Sewer System	Sewage Treatment Plants
Municipal population with access to service	40,034	26,265	30,342	16,259
Per cent of municipal population with access to service	88	58	67	36
Total municipal population of Basin				45.444

DOMESTIC UTILIZATION OF WATER
ELKHORN RIVER BASIN
Estimated Population, 1938

	Water Supply System	Public Swimming Pools	Sewer System	Sewage Treatment Plants
Municipal population with access to service	56,422	24,311	51,268	18,564
Per cent of municipal population with access to service	95	41	86	31
Total municipal population of Basin				59,378

DOMESTIC UTILIZATION OF WATER
BLUE RIVER BASIN
Estimated Population, 1938

	Water Supply System	Public Swimming Pools	Sewer System	Sewage Treatment Plants
Municipal population with access to service	99,857	72,234	79,549	61,168
Per cent of municipal population with access to service	98	71	78	60
Total municipal population of Basin				102,290

DOMESTIC UTILIZATION OF WATER
NIOBRARA RIVER BASIN
Estimated Population, 1938

	Water Supply System	Public Swimming Pools	Sewer System	Sewage Treatment Plants
Municipal population with access to service	13,623	4,227	9,653	5,697
Per cent of municipal population with access to service	87	27	62	36
Total municipal population of Basin				15,694

DOMESTIC UTILIZATION OF WATER
MINOR MISSOURI RIVER BASIN ABOVE PLATTE
Estimated Population, 1938

	Water Supply System	Public Swimming Pools	Sewer System	Sewage Treatment Plants
Municipal population with access to service	253,580	231,595	247,306	6,399
Per cent of municipal population with access to service	99	91	97	3
Total municipal population of Basin				254,959

DOMESTIC UTILIZATION OF WATER
MINOR MISSOURI RIVER BASIN BELOW PLATTE
Estimated Population, 1938

	Water Supply System	Public Swimming Pools	Sewer System	Sewage Treatment Plants
Municipal population with access to service	37,467	14,542	28,013	2,958
Per cent of municipal population with access to service	90	35	67	7
Total municipal population of Basin				41,544

DOMESTIC UTILIZATION OF WATER
WHITE RIVER BASIN
Estimated Population, 1938

	Water Supply System	Public Swimming Pools	Sewer System	Sewage Treatment Plants
Municipal population with access to service	6,486	6,309	6,309	6,309
Per cent of municipal population with access to service	95	93	93	93
Total municipal population of Basin				6,808

ELECTRIC POWER

The development of the electric light and power industry in Nebraska began about 1882. Electric trolley cars were operated in Omaha for the first time in 1887 and in Lincoln about 1890. It was not until 1900 that electricity came into more general use in the State. Today nearly every town has either a power plant producing electricity or is connected to a high-voltage power line. Rural electrification is developing rapidly in Nebraska.

The following table shows the annual increase in the number of consumers of electricity during recent years:

NUMBER OF PRINCIPAL CUSTOMERS
USING ELECTRIC ENERGY
Nebraska, 1926-1937

Year	Commercial Service	Municipalities Railroads and Miscellaneous	Residential	Farms	Total
1926	33,202	392	172,892	2,500	208,986
1927	35,356	529	181,781	4,000	221,666
1928	36,491	474	186,144	6,260	229,369
1929	39,034	632	194,542	7,485	241,693
1930	38,869	617	199,332	8,960	247,778
1931	41,131	1,263	1[illegible],136	9,930	245,460
1932	42,054	528	183,777	9,660	236,019
1933	41,049	502	182,802	9,522	233,875
1934	41,297	636	186,360	9,544	237,837
1935	42,087	707	191,392	9,946	244,132
1936	43,102	1,056	193,137	10,899	248,194
1937	43,050	886	195,346	12,583	251,865

Source: Compiled by the Edison Electric Institute for the Nebraska State Planning Board

RURAL ELECTRIFICATION

For a number of years conditions were not favorable to the development of rural electrification in the State. The following are some of the factors which have helped to make rural electrification possible:

(1) Enabling legislation under which the farmers could organize.

(2) Supply of wholesale electric energy at low cost.

(3) Available money for financing at a low rate of interest.

In 1933 the Legislature passed Senate File 310 permitting the organization of public power districts. To date, 30 rural electrification districts have been organized under this law. Plate LXXXI shows the Nebraska Rural Electrification Districts that have been organized under Senate File 310.

HYDROELECTRIC POWER

Also organized by authority of Senate File 310, are the 3 large Public Works Administration projects. Of these 3 projects the Platte Valley Public Power and Irrigation District and the Loup River Public Power and Irrigation District are operating and the Central Nebraska Public Power and Irrigation District is under construction. When completed the last named will be the largest hydropower plant in Nebraska.

TRANSMISSION LINES AND RURAL ELECTRIFICATION

The large federal power projects are being tied together by 2,000 miles or more of high-voltage transmission lines in order to avoid standby costs and to increase the dependability of service. The hookup includes the Sutherland, Tri-County, Columbus, and the other projects which will serve the rural electrification districts, institutions, and municipalities of the State. The cost of this electric distribution system will be approximately $20,000,000.

In an effort to use the potential power in the streams of the State, there have been approximately 287 power sites developed in Nebraska, a number of which are operating at this time. There are 22 hydropower plants in the Big Blue River, the most completely developed river in the State. The largest hydroelectric power projects in the State are those near Kearney, Gothenburg, Valentine, Boelus, Fullerton, Sargent, Ericson, Barnston, and Superior in addition to the Public Power District plants recently completed or under construction. There are, in addition, potential power sites which could be developed when the demand for electric energy increases.

TYPE OF PRIME MOVER

Steam is the principal type of prime mover used in the generation of electric energy in Nebraska. In 1936, 80 per cent of the generating capacity of the State was steam, 15 per cent internal combustion, and 5 per cent hydro. In 1938, by including the Sutherland and Loup River projects, the rate of generating capacity by types was changed to 62 per cent steam, 13 per cent internal combustion, and 25 per cent hydro. The hydrogenerating capacity increased from 13,713 kilowatts in 1936 to 85,866 as shown in the report of the 1938 Electric Power Statistics by the Federal Power Commission. With the completion of the Tri-County project it will be increased further to 137,866 kilowatts, representing about 34 per cent of the total generating capacity of the State.

NEBRASKA RURAL ELECTRIFICATION DATA
November, 1940

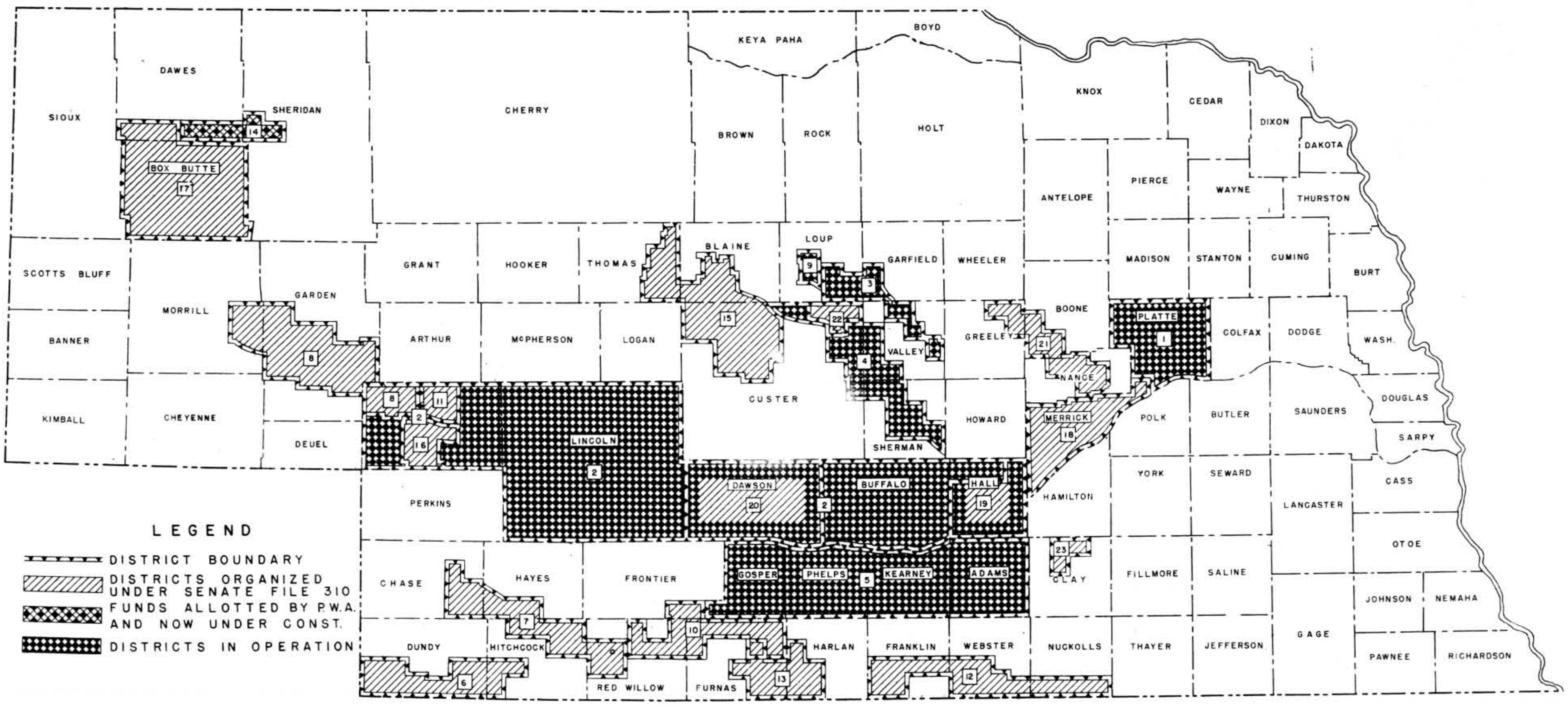
Rural Public Power Districts	(1) Total REA Allotments	Miles of Transmission Lines		Customers	
		Circuit (2)Auth.NSRC	Energized	Present	Ultimate
Boone-Nance	$231,000	234.40	114	117	447
Buffalo County	399,000	184.25	164	277	460
Burt County	522,000	648.85	513	781	1,026
Butler County	180,000	198.75	139	157	303
Cedar-Knox	373,000	493.68	347	582	749
Chimney Rock	275,250	341.95	245	530	667
Cuming County	680,300	687.10	583	895	1,061
Dawson County	427,000	270.60	289	441	636
Eastern Nebraska	1,746,000	2,459.40	1,500	2,700	4,322
Gering Valley	45,000	47.65	38	105	126
*Hall County	172,000	122.50	140	150	348
*Hamilton County	223,500	294.00	98	89	486
Howard County	425,000	602.05	330	318	1,135
Lancaster County	586,950	652.82	479	663	1,240
Loup River	540,000	692.25	493	581	1,359
Madison County	290,000	362.75	223	215	662
*Merrick County	125,000	112.00	106	130	267
Norris	357,000	594.85	400	536	569
Northeast Nebr.	306,000	376.00	220	365	659
Polk County	482,500	507.25	380	556	855
Roosevelt	227,000	228.50	195	535	550
Seward County	284,000	308.00	237	311	532
Southeastern Nebr.	441,500	436.75	465	765	1,100
Southern Nebr.	430,000	430.00	355	562	1,825
Stanton County	165,000	226.50	142	178	347
Thayer County	187,000	173.00	0	0	382
Wayne County	387,500	439.81	196	345	934
York County	283,000	256.80	178	222	608
Totals	(1)$10,791,500	12,382.46	8,560	13,156	23,655

(1) Includes $536,250 for wiring and irrigation equipment
(2) Nebraska State Railway Commission as of October 15, 1940
* Districts recently consolidated with Southern Nebraska R.P.P.D.

Compiled in the office of the Nebraska State Planning Board from data furnished by Power Districts

NEBRASKA PUBLIC POWER AND IRRIGATION DISTRICTS

DECEMBER, 1940



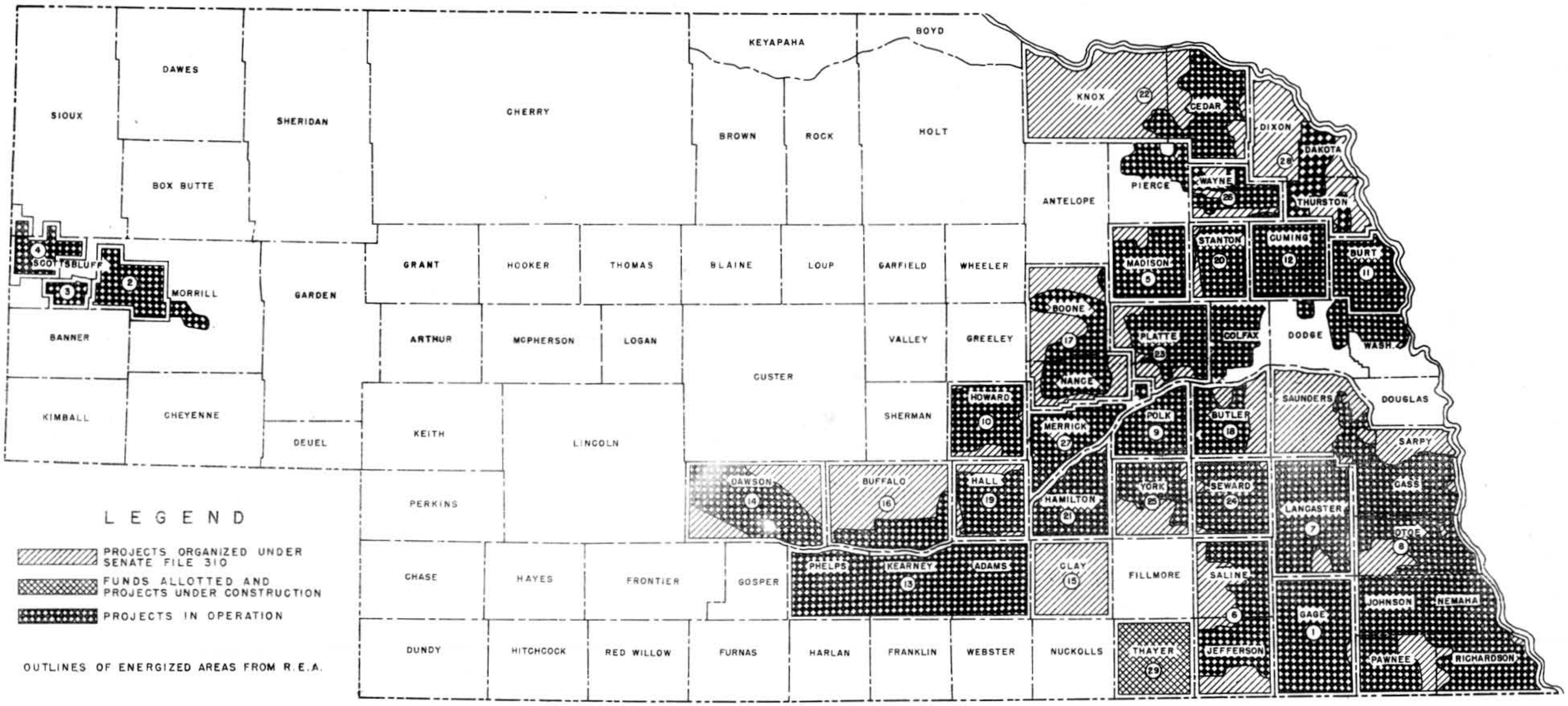
DISTRICTS

1 LOUP RIVER PUBLIC POWER DISTRICT
2 PLATTE VALLEY PUBLIC POWER & IRRIGATION DISTRICT
3 NORTH LOUP PUBLIC POWER & IRRIGATION DISTRICT
4 MIDDLE LOUP PUBLIC POWER & IRRIGATION DISTRICT
5 CENTRAL NEBRASKA PUBLIC POWER & IRRIGATION DIST.
6 BENKLEMAN-HAIGLER-ARIKAREE PUBLIC POWER & IRR. DIST.
7 IMPERIAL VALLEY PUBLIC POWER & IRRIGATION DISTRICT
8 BLUE CREEK PUBLIC POWER & IRRIGATION DISTRICT
9 ALMERIA PUBLIC POWER & IRRIGATION DISTRICT
10 UNITED PUBLIC POWER & IRRIGATION DISTRICT
11 WHITE TAIL PUBLIC POWER & IRRIGATION DIST.
12 REPUBLICAN RIVER PUBLIC POWER & IRR. DIST.
13 BEAVER-SAPPA PUBLIC POWER & IRR. DIST.
14 MIRAGE FLATS PUBLIC POWER & IRR. DIST.
15 DISMAL RIVER PUBLIC IRRIGATION DISTRICT
16 SOUTH PLATTE PUBLIC POWER & IRRIGATION DIST.
17 PANHANDLE PUBLIC PUMP IRRIGATION DISTRICT
18 MERRICK COUNTY PUBLIC PUMP IRRIGATION DIST.
19 HALL COUNTY PUBLIC PUMP IRRIGATION DISTRICT
20 DAWSON COUNTY PUBLIC PUMP IRRIGATION DIST.
21 CEDAR VALLEY PUBLIC POWER & IRRIGATION DIST.
22 SARGENT PUBLIC IRRIGATION DISTRICT
23 HARVARD PUBLIC POWER & IRRIGATION DISTRICT

NEBRASKA STATE PLANNING BOARD   W.P.A. O.P. NO. 465-81-3-155

NEBRASKA RURAL ELECTRIFICATION DISTRICTS

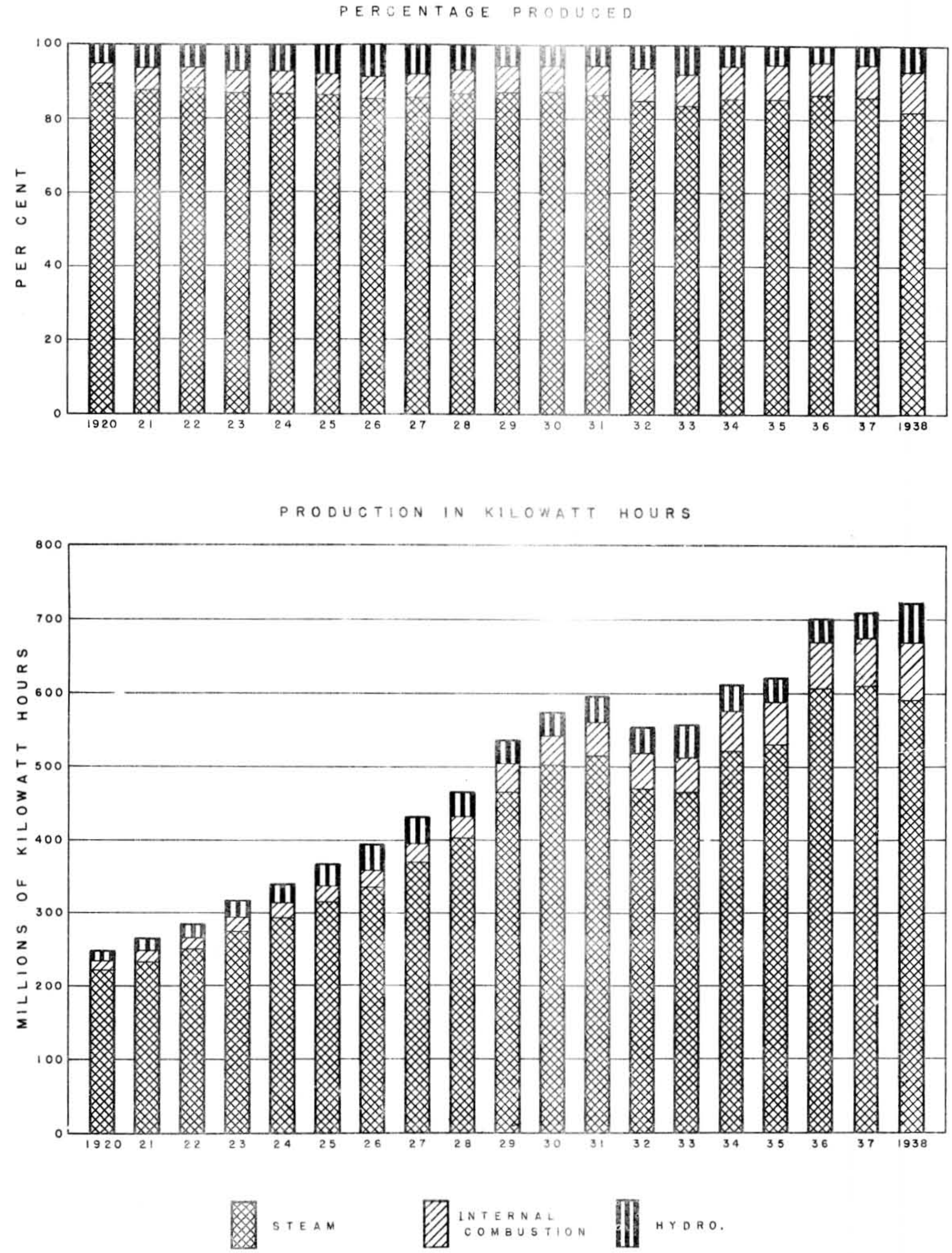
DECEMBER, 1940



DISTRICTS

1 SOUTHEASTERN NEBRASKA PUBLIC POWER DISTRICT
2 CHIMNEY ROCK PUBLIC POWER DISTRICT
3 GERING VALLEY RURAL PUBLIC POWER DISTRICT
4 ROOSEVELT RURAL PUBLIC POWER DISTRICT
5 MADISON COUNTY RURAL PUBLIC POWER DISTRICT
6 NORRIS RURAL PUBLIC POWER DISTRICT
7 LANCASTER COUNTY RURAL PUBLIC POWER DISTRICT
8 EASTERN NEBRASKA PUBLIC POWER DISTRICT
9 POLK COUNTY RURAL PUBLIC POWER DISTRICT
10 HOWARD COUNTY RURAL PUBLIC POWER DISTRICT
11 BURT COUNTY RURAL PUBLIC POWER DISTRICT
12 CUMING COUNTY RURAL PUBLIC POWER DISTRICT
13 SOUTHERN NEBRASKA RURAL PUBLIC POWER DISTRICT
14 DAWSON COUNTY PUBLIC POWER DISTRICT
15 CLAY COUNTY RURAL PUBLIC POWER DISTRICT
16 BUFFALO COUNTY PUBLIC POWER DISTRICT
17 BOONE—NANCE RURAL PUBLIC POWER DISTRICT
18 BUTLER COUNTY RURAL PUBLIC POWER DISTRICT
19 HALL COUNTY RURAL PUBLIC POWER DISTRICT
20 STANTON COUNTY RURAL PUBLIC POWER DISTRICT
21 HAMILTON COUNTY RURAL PUBLIC POWER DISTRICT
22 CEDAR—KNOX RURAL PUBLIC POWER DISTRICT
23 LOUP RIVER PUBLIC POWER DISTRICT
24 SEWARD COUNTY RURAL PUBLIC POWER DISTRICT
25 YORK COUNTY RURAL PUBLIC POWER DISTRICT
26 WAYNE COUNTY RURAL PUBLIC POWER DISTRICT
27 MERRICK COUNTY RURAL PUBLIC POWER DISTRICT
28 NORTHEAST NEBRASKA RURAL PUBLIC POWER DISTRICT
29 THAYER COUNTY RURAL PUBLIC POWER DISTRICT

TOTAL PRODUCTION OF ELECTRICITY FOR PUBLIC USE
BY TYPE OF PRIME MOVER
NEBRASKA
1920—1938

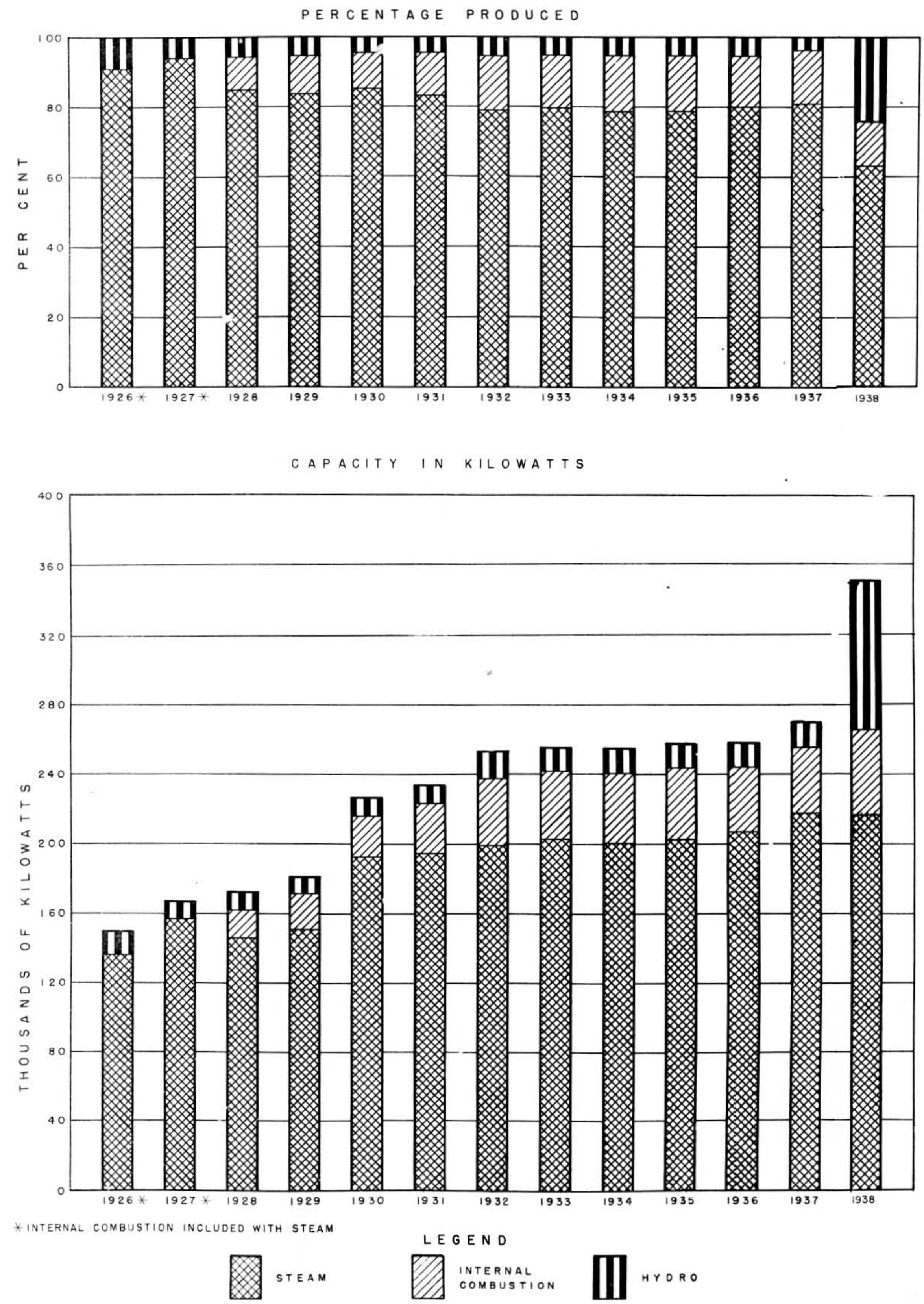


SOURCE—FEDERAL POWER COMMISSION

NEBRASKA STATE PLANNING BOARD

W.P.A. OP. NOS. 165-81-6999 AND 465-81-3-155

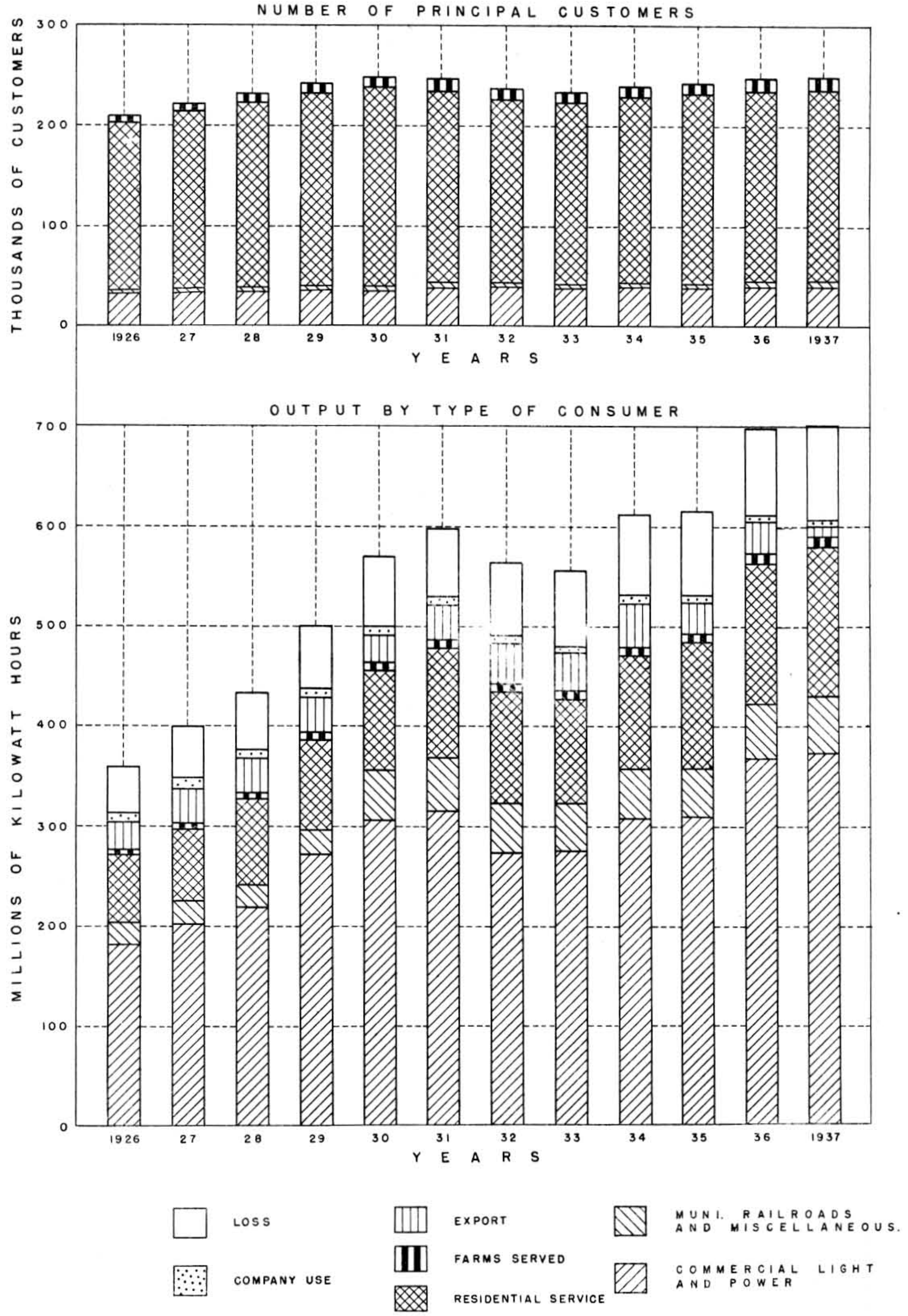
GENERATING CAPACITY IN KILOWATTS
BY TYPE OF PRIME MOVER
NEBRASKA
1926—1938



SOURCE—EDISON ELECTRIC INSTITUTE
FEDERAL POWER COMMISSION FOR 1937—1938

NEBRASKA STATE PLANNING BOARD W.P.A. O.P. NOS. 165-81-6999 AND 465-81-3-115

DISTRIBUTION OF ELECTRIC ENERGY IN NEBRASKA 1926 1937



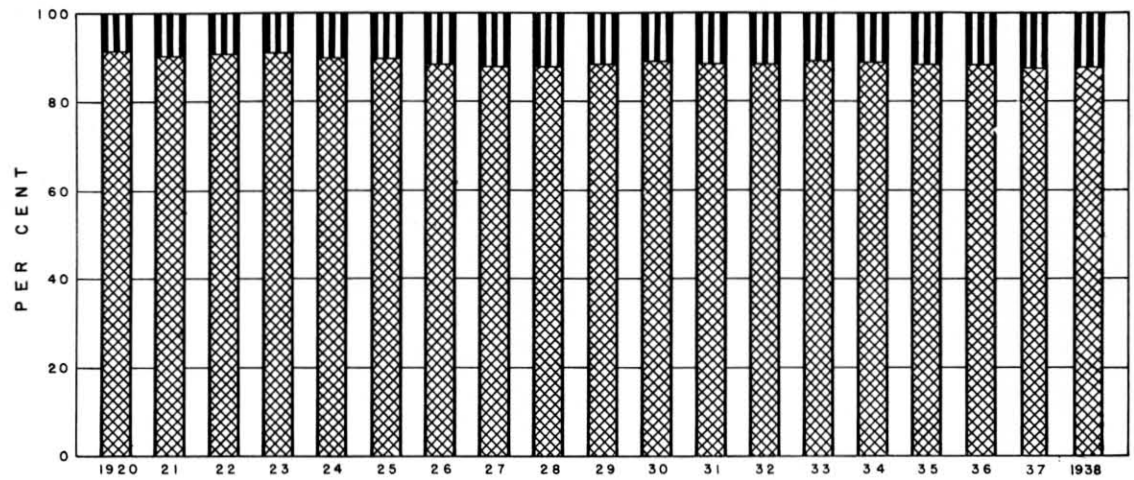
NEBRASKA STATE PLANNING BOARD

SOURCE—EDISON ELECTRIC INSTITUTE

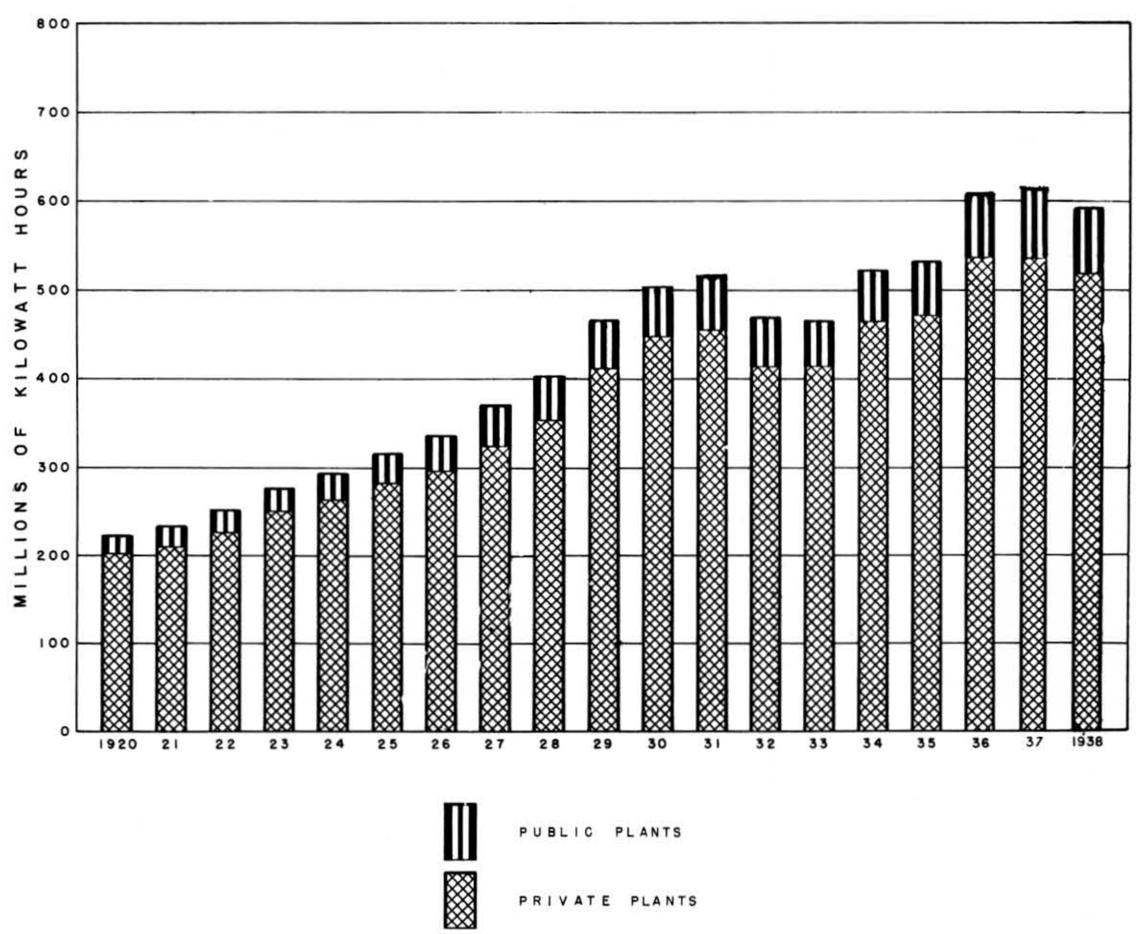
W. P. A. PROJECT O.P. NO. 165—81—6999

PRODUCTION OF ELECTRICITY FOR PUBLIC USE
BY TYPE OF OWNERSHIP
KWH GENERATED BY STEAM
NEBRASKA 1920—1938

PERCENTAGE PRODUCED



PRODUCTION IN KILOWATT HOURS

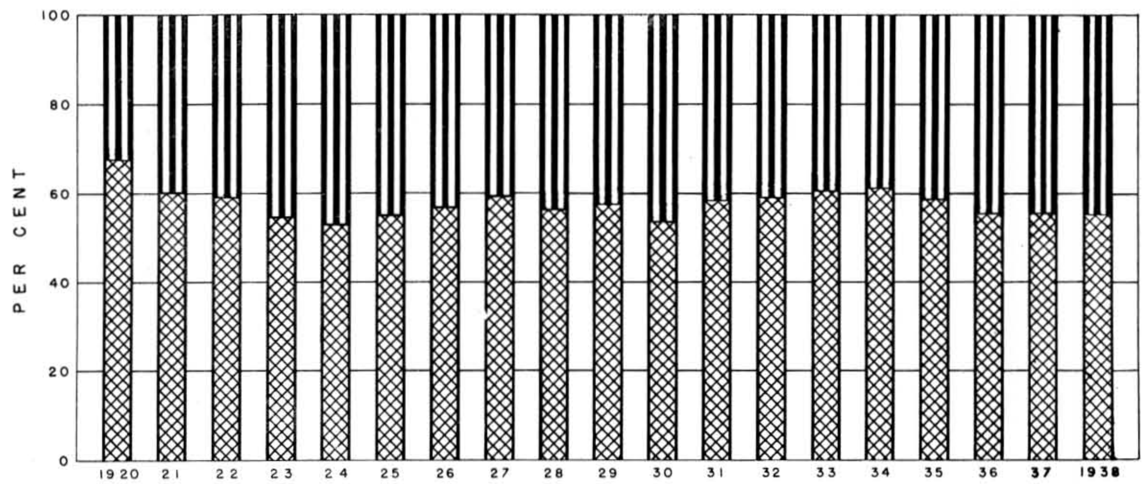


SOURCE—FEDERAL POWER COMMISSION

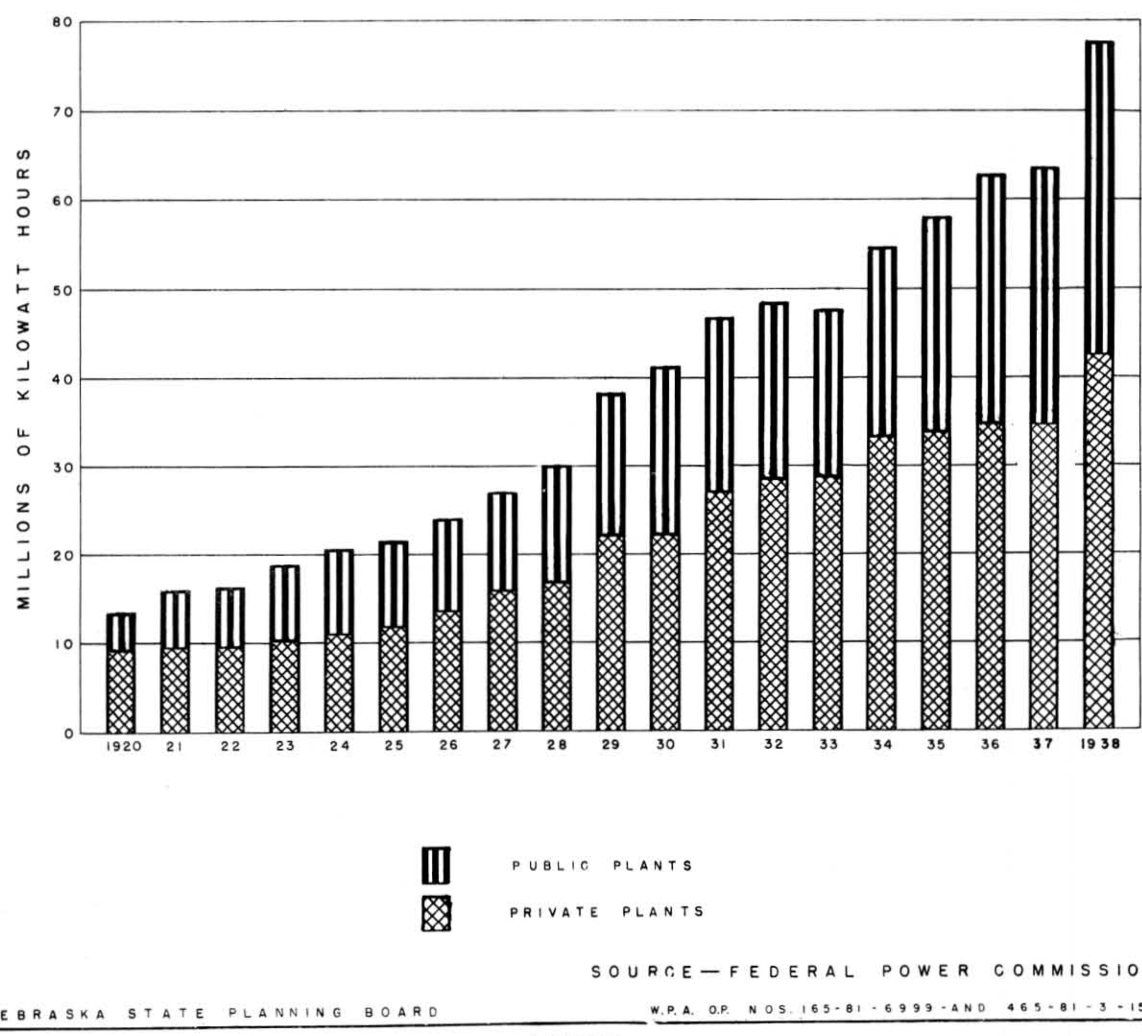
NEBRASKA STATE PLANNING BOARD W.P.A. O.P. NOS. 165-81-6999 AND 465-81-3-155

PRODUCTION OF ELECTRICITY
FOR PUBLIC USE
BY TYPE OF OWNERSHIP
KWH GENERATED BY INTERNAL COMBUSTION
NEBRASKA 1920—1938

PERCENTAGE PRODUCED



PRODUCTION IN KILOWATT HOURS



SOURCE—FEDERAL POWER COMMISSION

NEBRASKA STATE PLANNING BOARD

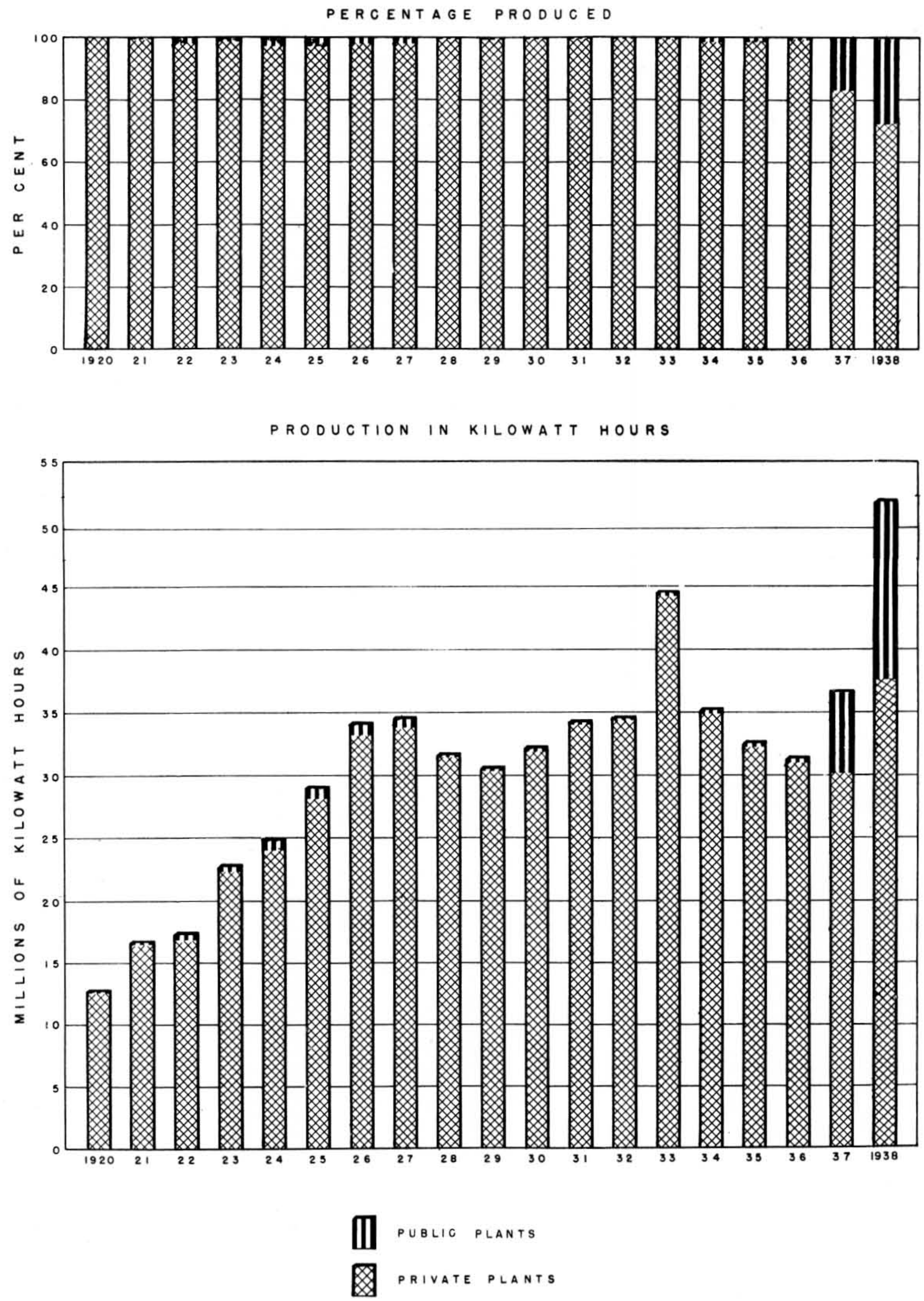
W.P.A. O.P. NOS. 165-81-6999-AND 465-81-3-155

PRODUCTION OF ELECTRICITY FOR PUBLIC USE

BY TYPE OF OWNERSHIP

K. W. H. GENERATED BY WATER POWER

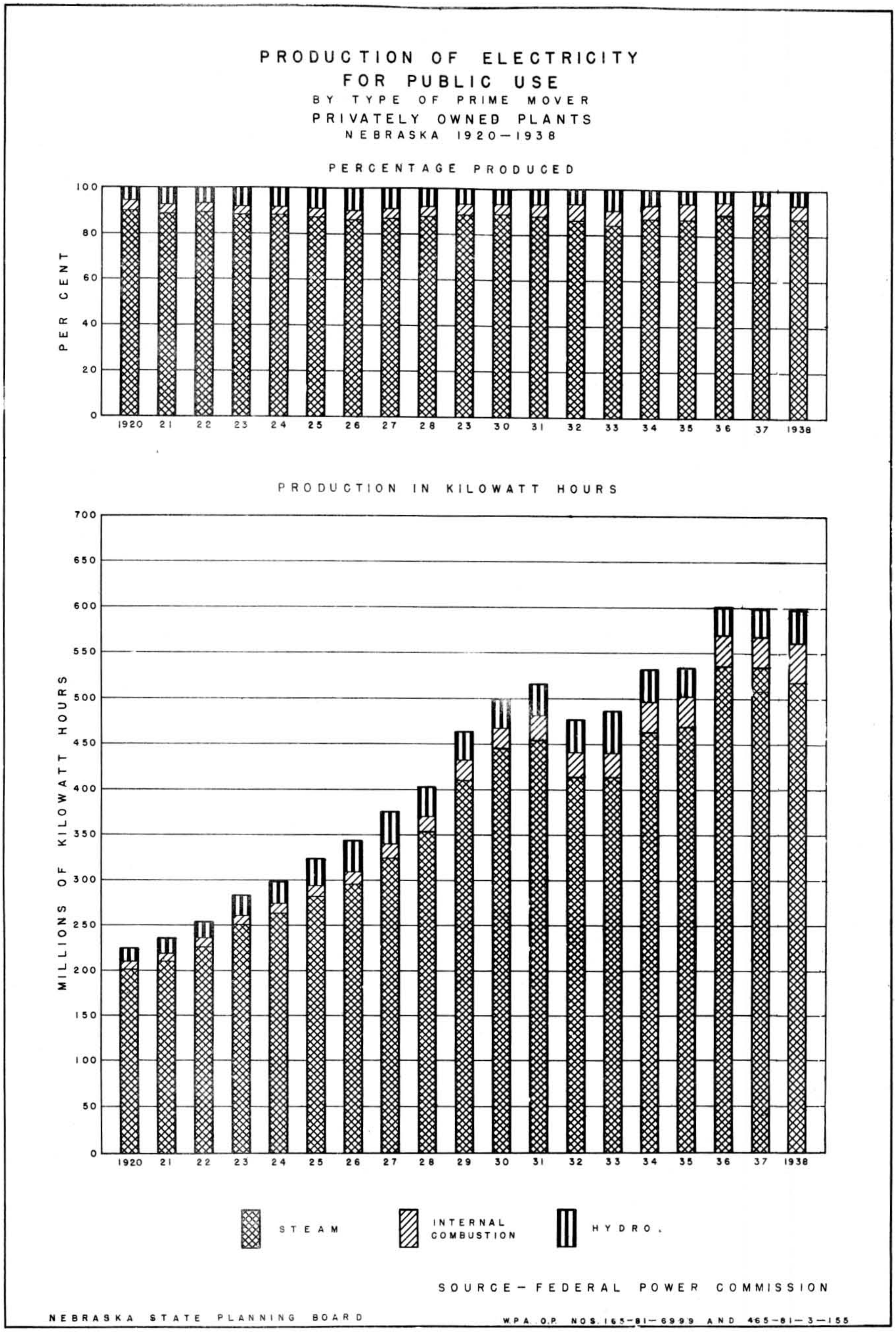
NEBRASKA 1920—1938



SOURCE—FEDERAL POWER COMMISSION

NEBRASKA STATE PLANNING BOARD

W.P.A. O.P. NOS. 165-81-6999 AND 465-81-3-155



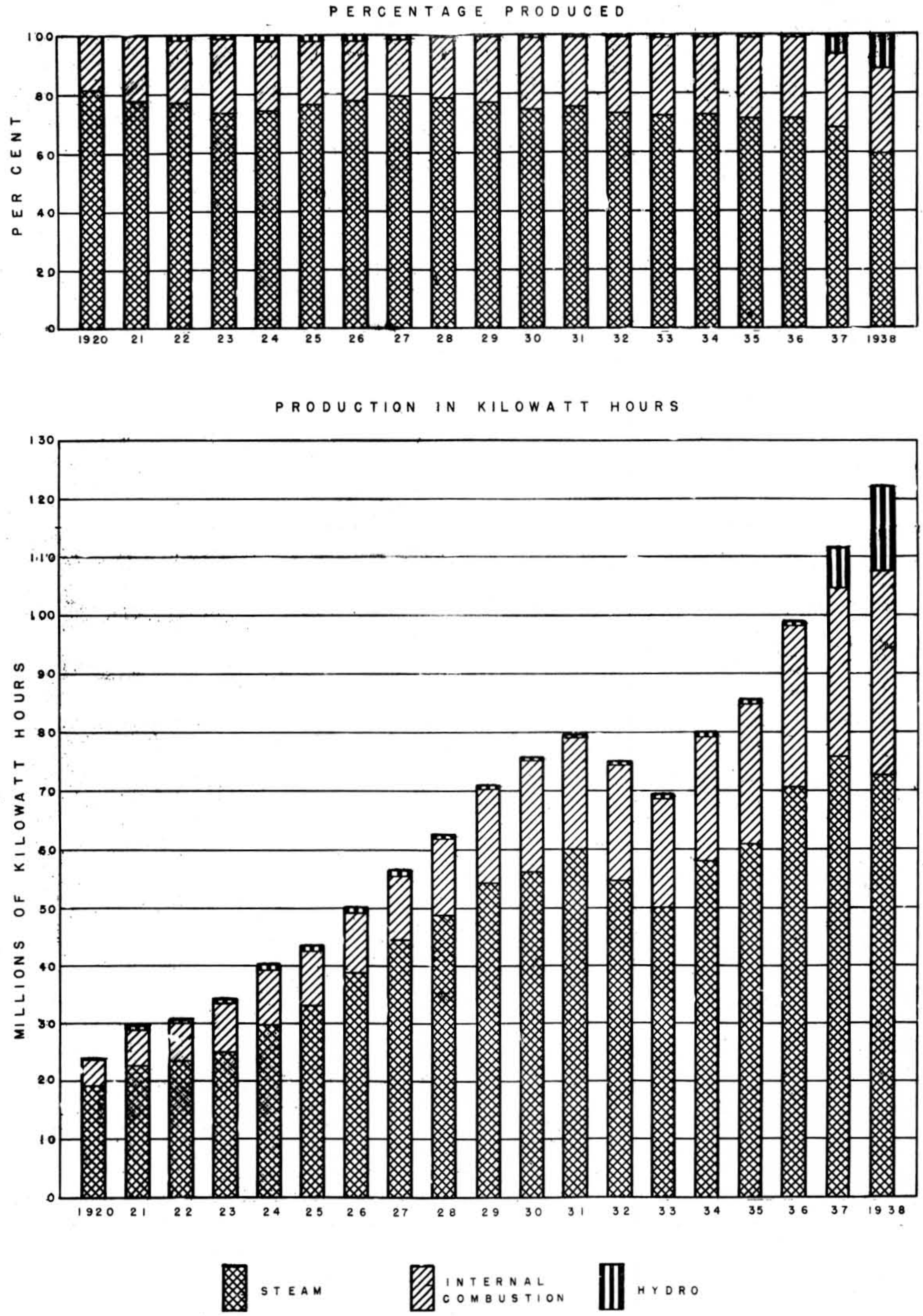
PRODUCTION OF ELECTRICITY
FOR PUBLIC USE
BY TYPE OF PRIME MOVER
PRIVATELY OWNED PLANTS
NEBRASKA 1920—1938
PERCENTAGE PRODUCED
PER CENT
100
80
60
40
20
0
1920 21 22 23 24 25 26 27 28 23 30 31 32 33 34 35 36 37 1938
PRODUCTION IN KILOWATT HOURS
MILLIONS OF KILOWATT HOURS
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
1920 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 1938
STEAM
INTERNAL COMBUSTION
HYDRO.
SOURCE — FEDERAL POWER COMMISSION
NEBRASKA STATE PLANNING BOARD
W.P.A. O.P. NOS. 165-81-6999 AND 465-81-3-155

PRODUCTION OF ELECTRICITY FOR PUBLIC USE

BY TYPE OF PRIME MOVER

PUBLICLY OWNED PLANTS

NEBRASKA 1920–1938

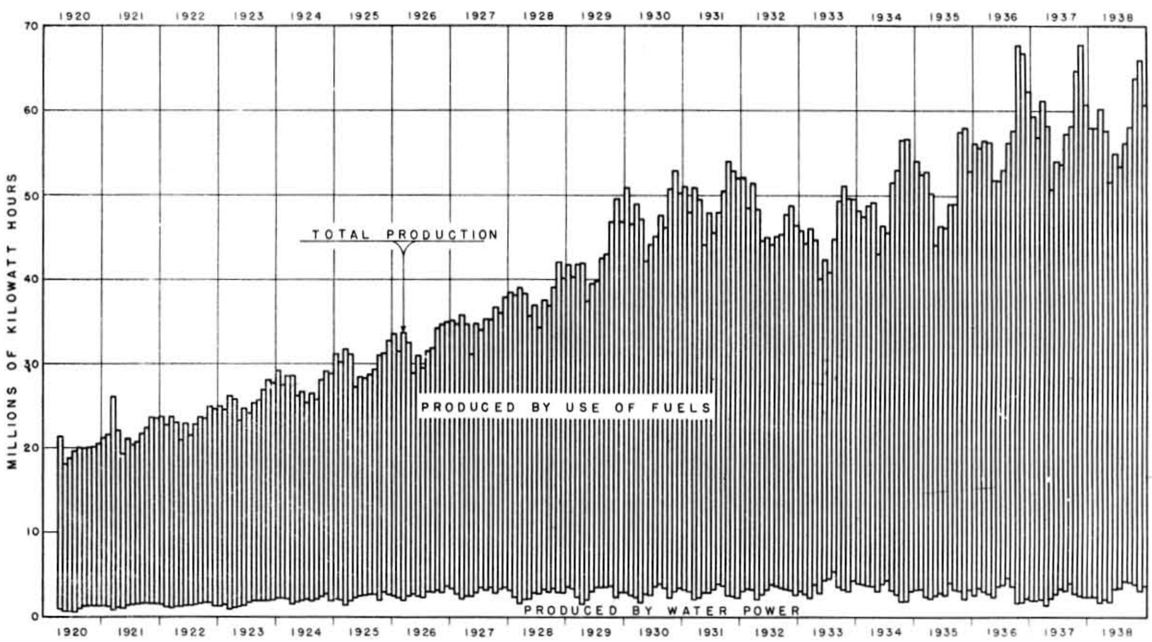


SOURCE FEDERAL POWER COMMISSION

NEBRASKA STATE PLANNING BOARD

W.P.A. O.P. NOS. 165-81-6999 AND 465-81-3-155

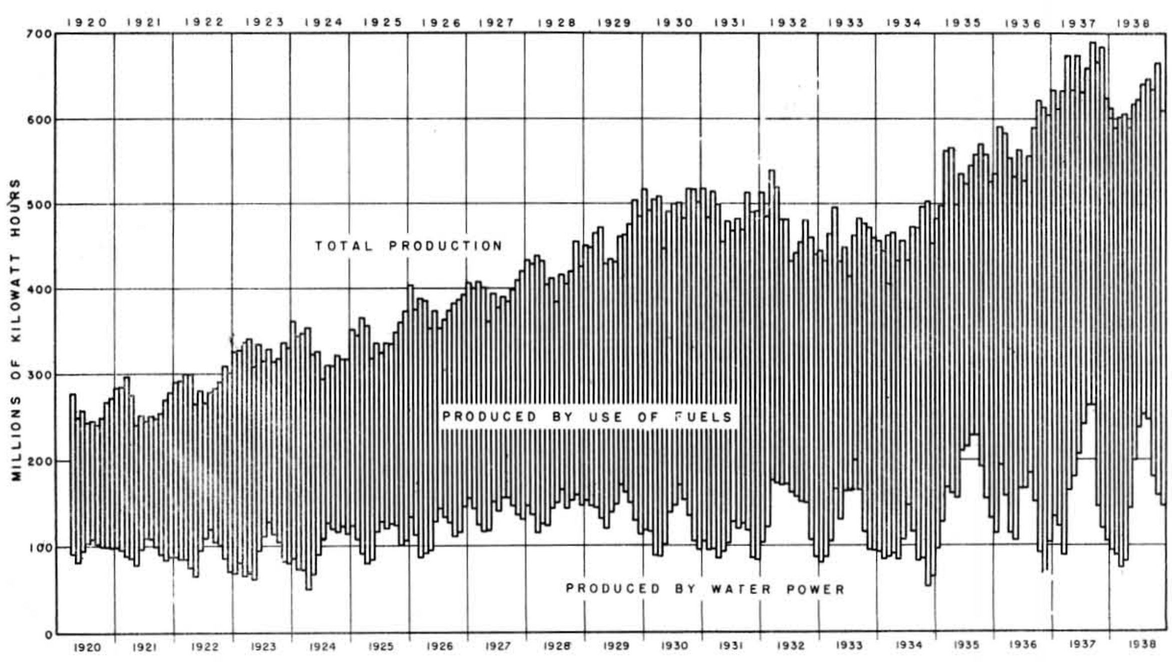
MONTHLY PRODUCTION OF ELECTRICITY
FOR PUBLIC USE
BY FUEL AND BY WATER POWER
FOR WATER YEARS 1920–1938
NEBRASKA



SOURCE–U.S. GEOLOGICAL SURVEY
AND FEDERAL POWER COMMISSION

NEBRASKA STATE PLANNING BOARD — W.P.A. O.P. NO. 465-81-3-155

MONTHLY PRODUCTION OF ELECTRICITY
FOR PUBLIC USE
BY FUEL AND BY WATER POWER
FOR WATER YEARS 1920–1938
WEST NORTH CENTRAL DIVISION

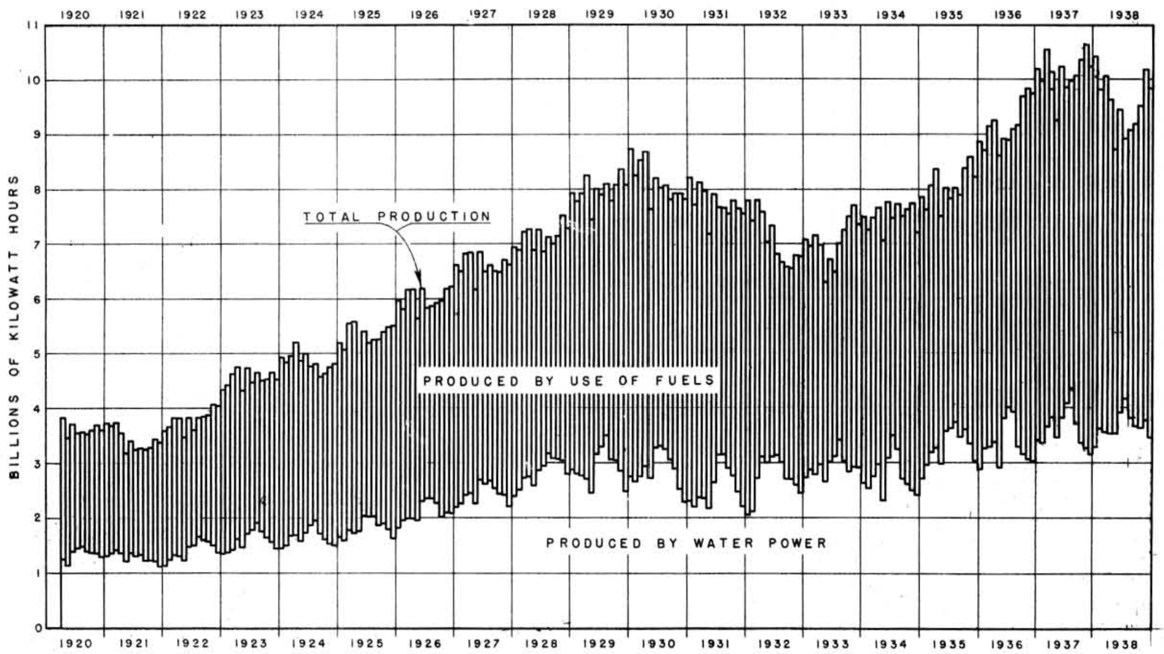


SOURCE–U.S. GEOLOGICAL SURVEY
AND FEDERAL POWER COMMISSION

WEST NORTH CENTRAL DIVISION
NORTH DAKOTA, SOUTH DAKOTA, NEBRASKA, KANSAS, MINNESOTA, IOWA, MISSOURI

NEBRASKA STATE PLANNING BOARD — W.P.A. O.P.–NO. 465-81-3-155.

MONTHLY PRODUCTION OF ELECTRICITY
FOR PUBLIC USE
BY FUEL AND BY WATER POWER
FOR WATER YEARS 1920 1938
UNITED STATES



SOURCE-U.S. GEOLOGICAL SURVEY
AND FEDERAL POWER COMMISSION