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University of Nebraska-Lincoln

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UNIVERSITY OF NEBRASKA
CONSERVATION AND SURVEY DIVISION

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Land and Water Conservation Problems of the Missouri River Basin*

By G. E. Condra

The University of Nebraska

President A. J. Weaver: Ladies and gentlemen, the next speaker is Dr. G. E. Condra, Dean and State Geologist of the University of Nebraska. He is a state and national leader in survey and conservation. He is to talk without manuscript. You will be pleased with his address.

Dr. Condra: Mr. President and members of the Mississippi Valley Association, let me thank you for the opportunity to speak here today. This is my second or third appearance with your Association. I will try to meet the expectations of President Weaver.

Introduction: My subject relates to the background of the comprehensive development of the land and water resources of the Missouri River Basin. You know that the development of these resources has a close supplemental relation to the development of the river for navigation and other purposes.

My subject is to be discussed from the conservation angle in which beneficial use and development in harmony with public welfare are involved. These purposes of conservation require a factual basis.

You are conversant with the physical features, climate, and resources of the Missouri River Basin. You know that soil and water are the really dominant resources here because they are basic to the agricultural, industrial and social development of the region.

The basin has an area of about 530,000 square miles. It is very diverse as to its geology, topography, mineral resources, climate, soils, water resources, wildlife, agricultural enterprises, and cultural features. It varies from low-lying plains to tablelands and rugged mountain. It has intermittent to permanent rivers and lakes, extensive native grassland, forest areas and wide range in

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* This paper was given at the Mississippi Valley Association, in St. Louis, 1936. Requests for copies of it have been received from various sources, hence its publication at this time. With slight modification, it is taken from the stenographic report of the Association, which was organized in 1919 to further the industrial, commercial and agricultural interests of the Mid-Continent region.

productivity of the farm lands. Specifically the land-water problems of the basin relate to precipitation, soils, soil moisture, groundwater, surface water, irrigation, drainage, hydro-power, flood control, navigation, domestic water supply, water pollution and better land use. Several federal and state agencies are engaged in the study of these problems. Their big job is to further fact finding relating to the resource inventory of the region, and the development of these resources.

Climatic Influence: Climate is the dominant factor in the development of the region's agricultural resources. The amount, frequency, and distribution of the rainfall have importance in the replenishment of soil moisture, ground water, and surface water generally. The annual rainfall is variable and probably cyclic, consequently, these phases of it and the recurrence of drouth are environmental factors in parts of the basin.

The Rainfall Asset: The amount of precipitation received in the different belts of the basin is a main factor in land and water use, but this alone does not determine the land use capabilities. When the precipitation occurs, and how it is disposed of, as by evaporation, surface runoff, or by soil infiltration and plant use, are also factors in the agricultural development. The soils vary greatly in their capacity to absorb and hold water, some of them being essentially drouthy, and others quite drouth resistant. The sandy soils sub-drain much of the precipitation water beyond the reach of plant roots; the heavy clayey types cause relatively high surface runoff; and the deep, medium textured soils absorb and hold much water making it available for plant growth. Consequently, the effects of rainfall and the duty of soil water are variable in the basin, depending upon topography, soil texture and crop requirements. The big agricultural problem in most of the basin is the conservation of soil water.

Surface Waters: These are sheet water, streams, marshes, lakes, and artificial lakes. They are formed from rainfall, surface runoff, and groundwater, or by diversion and ponding, and are reduced by evaporation, transpiration, percolation, and water withdrawal for use.

The streams of the basin vary considerably in quality of water and uniformity of flow, due mainly to the geologic, soil, and climatic conditions. Those fed only by surface runoff vary most in

discharge, whereas those fed from groundwater are more uniform in flow.

The streams are used for many purposes, as for stock water, irrigation, hydro-power, urban water supply, and recreation, and at places for sewage disposal. Most of them afford habitat relations for fish, birds and other wildlife. Some are being developed for fish culture and the Missouri is being developed for navigation. Several of the streams present flood control problems of considerable magnitude.

Most of the natural lakes and marshes of the basin occur in the Sandhill Region of Nebraska and in the glacial areas of Montana, North Dakota, South Dakota and northwestern Iowa. Many of them are shallow and become dry during periods of drouth. The ephemeral lakes on the upland plains and table lands have little economic importance. They disappear mainly by evaporation and percolation, but their beds supply some grazing and at places wild hay. The more permanent lakes of the region afford fishing, hunting, some stock water, and recreation. The marshes are suitable for wildlife such as muskrats, which have importance as fur-bearers.

The surface waters present problems of lake level control, drainage control, flood control, reservoir storage, irrigation, hydro-power development, pollution abatement, and navigation on the Missouri.

Groundwater: This form of water fills the porous mantlerock and bedrock up to the water table. Recharge lifts the water table, and evaporation, transpiration, springs, pumpage and drainage lower it.

Groundwater is the source of springs, well water, considerable stream flow, and subirrigation. Much of it is medium hard and of good quality. In some of the deeper formations, however, it is quite heavily mineralized with iron, lime, salt, sulphur, etc., and is used in places for sanitation purposes.

Most of the pump irrigation water, rural water supply, and municipal water supply of the region is from ground water. The survey, production, and conservation of ground water are factors of growing importance in the basin; however, there are areas where the supply is exhausted during drouths, causing failure of springs and wells.

Water Table Decline: Much is being said about declining water table in this region and that its depth is lowering markedly at places. In some places, however, such reports are based on observations made after heavy pumpage and mean local "draw down" and not decline of the water table generally; nor should it be said that the water table is declining in areas where there is practically no groundwater, hence no water table, as in some of the shaly land areas.

A period of high rainfall lifts the water table and drouth lowers it considerably in some areas. The water table level fluctuates only a few feet during the year in certain large ground water areas of the region, as in the Sandhill Region of Nebraska.

Land Use: All land of the basin has some agricultural importance. There are large areas of highly productive land and areas too rough or too sandy for cultivation. Some land is defective, due to lack of water supply, the presence of alkali, frequent flooding, or other unfavorable conditions. The main types of land in the basin requiring amendment or adjustment in their agricultural use are:

1. Badlands with practically no soil—in North Dakota, South Dakota, Nebraska and Wyoming
2. Rough stony lands with little or no soil—in all states of the basin
3. Tablelands with sandy soil and low capacity to hold moisture—in Kansas, Colorado, Wyoming, Nebraska, South Dakota, North Dakota and Montana
4. Shaly lands—in all states of the basin, but with largest areas in Montana, the Dakotas, Wyoming and Nebraska
5. Blufflands and canyon areas—along the Missouri and its principal tributaries
6. Low-lying bottomlands subject to flooding—in all states
7. Severely eroded hilly farm lands in the humid belt—in Missouri, Iowa, northeastern Kansas, eastern Nebraska and southeastern South Dakota

The severely eroded *badlands* are nearly barren of vegetation. They release much sediment to the rivers. Just how to reclaim them for agricultural use is a problem.

The *rough stony lands* occur principally in the mountains, at the borders of tablelands, and locally along the Missouri and its largest tributaries. They are too rough, and at places too stony

for cultivation, and are best suited to grazing and forestation. Their overgrazing is not good practice because it accelerates erosion and the consequent silting of streams and lowlands.

The *sandy table land* soils are drouthy except during the years of maximum rainfall with favorable distribution. When the soil of this type of land becomes dry and incoherent and is not protected by plant cover, it is subject to wind erosion producing the well known dust storms. However, the land recovers rapidly with increased rainfall. Some of this land is becoming idle, presenting problems of ownership, management and use. No doubt a considerable part of it should be seeded permanently to native grass and used for grazing.

The large areas of *shaly land* in some of the states are defective for cultivation, and have been badly managed. They have little or no well water. Too much of this land has been plowed and large areas of it are being returned to native grass. Land of this kind grows grass well and is suited to grazing, but its overgrazing is objectionable.

The shaly lands present problems in resettlement, involving the location of ranch buildings where drinking water can be found. Generally they are managed to best advantage by fencing them as large pastures, impounding stock water from the surface runoff, and by conservative grazing.

Blufflands and *canyon areas* occur principally in the borders of the upland plains and tablelands. Much of the area of these lands located along the Missouri and other valleys is grass-covered, forested, or farmed. Generally, however, the land is too rough for farming and should be kept in grass or forest cover for use in grazing and as park and recreational areas.

Sandy bottomlands are formed from sand and gravel wash. As a rule, they are subject to flooding. They have little agricultural value due to frequent flooding, erosion, and sedimentation. Soil erosion and the consequent overloading of rivers with sediment and the sanding of the bottomlands have become big problems in the control and development of the Missouri River. Undoubtedly you are interested in the reclamation of the thousands of acres of river wash along the Missouri.

Smooth, sandy flood plains have wide occurrence in the basin. They are natural grass lands and should be conserved for grazing, wild hay production, and forest growth. They are better

suited for these purposes than for cultivation. The shallow water table is their controlling factor. However, the use and management of the sandy and sanded bottom lands involves flood control, as in the Republican and other valleys.

Conservation of Farm Lands: The up-and-down hill plowing in the humid areas of Missouri, Iowa, Kansas, Nebraska and other states of the basin has developed sheet erosion and gullying. Some of the best lands here have been depleted. Do you know what can be done to reclaim this land? Are you in favor of soil erosion control? Do you realize that these, our best lands, must be better managed, i.e. conserved?

Grassland Resources: When white men reached the Missouri River basin they found the plant life, animal life, and the Indian in natural relationship, closely correlated with the environmental conditions. The native grasses, shrubs, trees and animals were long-time indices of natural land and water use and of climatic influence, but, until recently, we have failed to recognize the fact that the native plants and animals constitute important resources and have a basic role in land-use.

It has taken severe drouth to prove the value of native grassland with shallow water table and demonstrate the fact that such land affords grazing and wild hay every year whether wet or dry. The prejudice against native prairie as expressed by the terms "raw' or "unimproved" is not well founded, because in places such prairie land may not be improved by destroying its sod and placing it under cultivation, and because it is possible in other ways to develop native grasslands to an increased beneficial use.

Fortunately large tracts of the original grassland, as in the Sandhill Region of Nebraska, remain in the natural state. The grasses protect the soil from wind erosion and support successful cattle raising. And it is certain that much of our shaly land and certain other areas of the basin should be regrassed and used for grazing and wild hay production.

Place for Trees: Trees, like the native grasses, have importance in the use of land. For very obvious reasons, we should grow more shrubs and trees on our farms, ranches, rural school grounds, and recreational areas. This will require an agricultural forestry program for the conservation of timber and other resources, mostly on federally-owned land where forests occur naturally.

However, state and federal foresters now realize that there is a phase of forestry related to the conservation of water, land, wildlife and livestock and to those intangible social benefits relating to human comfort and the increased happiness of living.

The agricultural or farm forestry of the basin must cover a wide area having variations in climate, topography, groundwater, soil, population, and types of agriculture. Therefore, it is necessary that a sound program be provided not only for different types of planting, but also for different methods of application.

Much has been learned through the Biological and Forest surveys regarding the kinds of trees and shrubs that will grow and survive under the various conditions of the basin. This means that in the future only those species that are adapted to the climate, water, and soil conditions should be planted here.

The objectives of an agricultural forestry program for the basin should be to maintain and improve agriculture and living conditions, by:

1. Conserving the soil and improving moisture relations
2. Protecting farm crops, gardens, etc., from high winds
3. Protecting people and livestock from climatic extremes and improving living conditions in general
4. Improving wildlife habitat
5. Producing wood products, primarily fuel, fence posts and rough lumber
6. Protecting the natural and planted forests for the most beneficial use that can be made of them.

Wildlife Conservation: The main wildlife resources of the basin are fish, song birds, game birds, and the game and fur-bearing animals. In addition to the classes of life just named, there are many kinds of microflora and fauna that are feed for the higher animals, and which, in this respect, constitute the biological background of the economically important wildlife. In other words, they are feed for fish, birds, and mammals, a knowledge of which is important in wildlife management.

Not many years ago, the waters, prairies and forests of the basin were thickly populated with wildlife and, as noted before, the plant life, animal life and the Indian were closely correlated. However, all of this has been changed. We killed most of the original stock, destroyed the natural living conditions for fish, birds, mammals and other forms, and are now trying to "con-

serve" the remaining wildlife for fishing and hunting, knowing as we must that the only way to do this is by making it possible for such life to live and reproduce.

The destruction of brush land and forests, the burning and overgrazing of prairie, the draining of marshes and lakes, the straightening of streams, and the pollution of streams and lakes have destroyed the habitat relations of wild flowers, wild fruits, native song birds, game birds, fish, fur-bearers and other forms, and has changed the migration ways of the native fauna. Consequently, the first thing to do now, if we really are to conserve wildlife, is to restore its suitable habitats. This means, for example, that for their survival, there must be permanent waters suitable for fish; brush land for quail; trees and shrubs for song birds; prairie and natural feed for grouse and prairie chickens; water and feed for ducks, coots and shore birds; refuge areas for the breeding and migrant wildlife, and the close regulation of fishing, trapping and hunting.

Cooperating with the federal departments, state surveys are being made of the wildlife. The results of these surveys and researches are expected to serve in the formulation of programs for wildlife conservation. Are you for such program where it is possible?

Conservation Specialized: Enough has been said to show that conservation activity has become specialized under well defined subdivisions, but there remains unity of purpose and need for the coordination and cooperation of all conservation agencies along lines leading to the desired objectives. And now is the time for your group and other similar groups to join in a program for factual conservation effectively coordinated and efficiently administered.

Irrigation Reclamation: Irrigation has become an important factor in the agricultural developing of subhumid and semiarid lands of the basin, limited only by the availability of water, suitability of soils, and good management. Since the amount of land suitable for irrigation far exceeds the required amount of water available for reclamation, it has become necessary to use water where it can have the most effective beneficial use. It is also necessary to integrate irrigation with the other methods of water and land use, and make every safeguard against failure.

People of the basin are now irrigation minded, due to the effects of drouth, the manifest success of irrigation and the availability of federal funds for the construction of self-liquidating projects. More consideration than in the past is given to the availability and dependability of water supplies, the suitability of the soils, and the economic factors involved in successful irrigation farming.

At the start, practically all irrigation of the basin was with water diverted from streams during the irrigation season, but because the flow of the streams was low when water was most needed, it became necessary to conserve the non-irrigation season flow and the flood flow of the streams in order to obtain dependable water supplies. This led to the construction of large regulating reservoirs at several places in the basin. The outlay in the basin for large irrigation projects coordinated with power developments, has been many millions of dollars, resulting in extensive reclamation.

Pump Irrigation from goundwater and from streams is being expanded generally in the region. It is based on a careful consideration of the dependability and quality of water, suitability of the soils, cost of installation and maintenance, and the economic benefit that accrues from such development.

The natural *subirrigation areas* of the lowlying sandy lands of the principal valleys of the region represent a total area greater than that under the other forms of irrigation. At places the groundwater table can be held at the optimum depth for the production of native grass, forest, and certain cultivated crops. This is done by the spread of flood waters to recharge of the groundwater and by drainage control to hold the water table at the desired depth. Do you realize that there are large areas of subirrigated sandy land in the basin that produce more beneficially than they would under cultivation?

Water Pollution: The streams of the basin are being polluted with erosion sediments, garbage, industrial wastes and sewage, making them unsightly and filthy. Pollution of the lakes makes them unsafe for bathing and in some cases too foul for wildlife, bathing and even for boating.

Shallow groundwaters absorb the products of decaying organic materials, making them unfit for drinking purposes, but as a rule the deeper waters filtered through sand and gravel are quite free from pollution. Many of our rural wells are unsanitary and un-

safe sources of drinking water. This condition should be corrected.

Pollution is becoming a menace in the basin and should be regulated and controlled. Generally speaking, it is not good policy to permit untreated sewage to be run into the creeks and rivers.

Water Treatment: Polluted waters are not safe for potable use without treatment and water having physical defects should be corrected by treatment suited to the needs. Finally, water softeners are used to correct the hard waters, and certain materials are used to remove excess iron or manganese. In most states all public drinking water supplies are tested at regular intervals and certified as to their potability.

Water Survey: Geological and Water surveys have been active in the basin the past few years in the study of the water-bearing formations, to determine the source, depth, quality, and the direction and rate of movement of the groundwater. In most states the groundwater survey is carried on through cooperation with the U. S. Geological Survey. The surveys perform an advisory service in locating well water supplies.

Conservation of Artesian Water: There are thousands of flowing (artesian) wells in the Missouri River Basin, their depths ranging between 50 and 2,000 feet or more. Many of them supply good potable water and others yield saline or heavily mineralized water.

At places the artesian water is the only dependable source of the rural and urban water supplies. Unfortunately, however, many of the flowing wells in North Dakota, South Dakota, northwestern Iowa and Nebraska have been allowed to flow unrestricted, resulting in water wastage and the reduction of artesian pressure. And at places, the groundwater, the surface waters, and the soils are being polluted by oil and salt coming from wells.

The wastage of artesian water has continued too long, with unfavorable results. North Dakota has a law for the control of artesian wells and the Nebraska Legislature passed a joint resolution directing the State Geological Survey to protect the artesian water of the state. Do you favor the control of water wastage?

Flood Control: Every large stream of the basin has reached the flood stage in some part of its course. However, the 1935 flood in the Republican is outstanding because of its magnitude, dam-

age to property, and the loss of human life. Just how the floods of the Republican and some other rivers of the basin should be controlled has not been determined. Reservoirs are advocated for such control but this would require the reservoirs to be empty when the water would be needed for irrigation and other purposes. Consequently, it may be advisable to compromise here by planning control measures that will not conflict so strongly with beneficial water use.

Some hold that the cost of complete flood control on the Republican and some other rivers would be prohibitive, therefore not feasible, and that the land use in these valleys could be adjusted by placing the farm homes and towns on the terraces or valley-sides and by using much of the floodable land for grazing, native hay production, forestation, and some farming. However, flood control here is largely a problem for recommendation by engineers of the War Department who are making field surveys of several valleys and rivers of the basin to determine how to control floods. Others are engaged in making a setup for irrigation. The findings of these groups will serve in deciding what should be done to regulate the floods and the water-land use.

A close study should be made of every large tributary of the Missouri having flood frequency. This study should cover the conditions that cause floods, i.e. the climatic features, the geological features and the topographic features. It should include stream gaging records, and in so far as is possible, evaluate the soil infiltration and soil runoff relationships.

Navigation: As you know, the Missouri River is being made navigable as far north as Sioux City. The river control structures are expected to hold the river to a definite course. This, if accomplished, will prevent the destruction of agricultural land along the river. The Fort Peck reservoir in Montana is to be a factor in the regulation of river flow. It will be a factor in flood control. However, much study should be made of the environment features of the basin before irrigation, flood control, power development, and navigation can be successfully integrated along the Missouri. You are for such study, I believe.

Inter-state Relations: Some of the tributaries of the Missouri are inter-state streams. Also, some of the groundwater, as in the flood plains of the Republican and Platte valleys, and some arte-

sian waters, move independently of state lines, being recharged in one or more states and released for use in others. Consequently, the use and conservation of both the surface water and the groundwater have some inter-state relations which are not adequately covered by compacts between the states concerned. Fortunately, no troublesome international relations are involved in the allocation of the waters of the basin. What is your stand on water survey, streams gaging, pollution abatement, and water control? Are you for them?

Conservation of Service: As you know, certain federal and state agencies or departments have been engaged in the study of the various land and water resources of the Missouri River Basin for a number of years. The Mississippi River Commission, War Department, Reclamation Service, Agricultural Experiment Stations, and the Geological, Soil, Water, Biological and other surveys are engaged in surveys and researches that are basically important. Then too, during the depression and period of drouth, new federal agencies were set up to perform temporary services in survey, agriculture, conservation and relief. Some are serving efficiently and apparently most of them expect to be placed on permanent status.

Although an attempt is being made to coordinate the work of the new agencies with the older federal and state activities, this is not being fully accomplished very effectively, nor is it feasible to do so in all cases because of the different objectives. However, some claim that a better plan in the establishment of new agencies would have been to affiliate them with departments that were performing the services that were to be expanded, and that this would have required less man power, would have developed closer cooperation between state and federal agencies, and given more efficient service.

It is clear now that only those public activities that operate free from poltical clearance remain in good standing with the public generally, and it seems that it may become necessary eventually to make some retrenchment in the new activities and adjustment in the older activities. This, if done, will call for an evaluation of all agencies concerned and the discontinuance of those that are no longer needed, or have no definite field, or cannot show good reason for their continuance.

The purpose of the statement preceding is to call your atten-

tion to the fact that in a program for the development of the land and water resources of the basin the principles of conservation should be applied to public service generally as well as to the natural resources. In other words, the activities relating to conservation should be closely standardized. This means, in effect, the conservation of conservation.

Conservation Traverses: Friends, if there were time for it, I would now describe certain east-west traverses across the Missouri River Basin in order to show what is being accomplished in land and water conservation. One of these traverses would be from near Denver eastward to above St. Louis. Another would extend from northern Colorado and southern Wyoming into Iowa, and the third would be from the Rockies in Montana eastward past Fort Peck reservoir into North Dakota.

Let me select the second traverse, which extends through the Platte Basin and ends in the humid farming area. It is a journey along a great transportation route from mountain forests and snow fields, past large reservoirs, irrigation canals, irrigated lands, and hydro-plants, to the land where "the tall corn grows."

For many years the Platte Basin was occupied only by wildlife and Indians. Then came the trappers, fur traders and the Oregon and Mormon trailers, who crossed the so-called "American Desert." Years later the landscape changed, due to the use and conservation of water and soil.

Our journey starts on the Continental Divide in northern Colorado, where there are wide expanses of forested mountains and scattered snow fields. Cool trout streams emerge from the melting snow and forest. The clear streams hurry down the forested slopes and through the native grassland parks forming the head waters of the Platte.

We reach the North Platte River at Saratoga, Wyoming, where there are two routes—one eastward over the high Medicine Bow Range to Laramie and the other down the Platte by the Seminoe, Pathfinder, and Alcova reservoirs to Casper. Below Saratoga where the native vegetation is scant and there is some cultivation, the river becomes turbid.

The high dams and large resorvoirs just named were built at places where the Platte is in deep gorges. The combined storage capacity of the reservoirs is about 2,500,000 acre feet, and the conserved flood water is used for irrigation in Wyoming and Nebraska.

In the mountains west of Guernsey, Wyoming are a high dam, a storage reservoir, and a large hydro project. The energy generated from the river at Guernsey and at a station near Lingle, is used to light and power the North Platte Valley in eastern Wyoming and western Nebraska.

East of the Lingle project large dams divert water from the river through long canals to reservoirs and thousands of acres of land grown to alfalfa, sugar beets, wheat, beans, and other crops. Some of the gravity irrigation water becomes groundwater from which the return flow is appropriated for irrigation farther down-valley. Also, some of the groundwater is used for pump irrigation or for rural, municipal and industrial supplies.

The North Platte Valley is broad in eastern Wyoming and western Nebraska where it has become a great agricultural and industrial area, with six large beet sugar factories, good highways, railroads, modern schools, and growing cities. We see here the benefits that accrue by harnessing waters that formerly flowed to non-use. Eastward from this great irrigation area, the Valley narrows between steep slopes. Here the Kingsley dam is building to store the flood and non-irrigation season flow of the river. The dam is to be two miles long, 160 feet high, will cost about $10,000,000, and the reservoir back of it will store, 2,000,000 acre feet of water. This dam and reservoir are units of the Central Nebraska Irrigation and Power Project which is to cost about $35,000,000. The project is to have several hundred miles of canals and laterals, three power plants, about 1200 miles of high tension distribution lines, and is planned to add about 200,000 acres of land to the irrigation area between North Platte and Grand Island.

About three miles east of the Kingsley dam is the diversion dam of the Sutherland Project which has been developed for power and irrigation at a cost of about $11,000,000. Its reservoirs have a combined storage capacity of about 170,000 acre feet; the generating capacity of the power plant located south of North Platte is 18,000 KW; and the area to be irrigated by the project is about 100,000 acres.

Detour in the Sandhills: We journey northward from Oshkosh, Nebraska for a circuit in the great Sandhill Region which is a natural grassland well suited to cattle raising. The hills afford pasturage; the basins and flats produce hay for winter feed; and

the shallow groundwater supplies abundant well water, and the flow of streams.

The minor uses of the sandhill area are for forest reserves, federal game preserves, wildlife sanctuaries for ducks, grouse and prairie chickens, and state recreational areas. Aside from cattle raising, the main use of the sandhills is for groundwater storage from which live streams of uniform flow issue and are developed outside the region for irrigation, power, recreation and wildlife.

The main conservation problems in the Sandhill Region involve the maintenance of uniform grass cover on the hills, the maintenance of the most favorable depth of water table in the hay flats, the preservation of lake level, and the conservation of wildlife. Ranch management has assumed a high degree of adjustment and standardization in these areas and only high grade animals are raised.

Sandhill Water Storage: Nature gave Nebraska, in the sandhills, the most ideal water storage area in the Great Plains Region. The amount of comparatively shallow groundwater here is more than 500,000,000 acre-feet, equal to about 500 times the capacity of the Pathfinder Reservoir. This water is an important resource. It is recharged by rainfall and released all year at a notably uniform rate to streams which reach the Missouri.

The area of the part of the Sandhill Region lying between the Platte and Niobrara valleys is about 19,332 square miles or 12,372,480 acres on which the annual rainfall is about 21,600,000 acre feet, most of which enters the ground. In about 80 percent of the region groundwater is released by underdrainage to streams at the rate of 20 to 25 percent of the volume of the rainfall, in the approximate amount of about 4,000,000 acre feet per year.

The annual contribution of sandhill groundwater to the Platte Valley is about 2,500,000 acre feet per year or more than twice the capacity of the Pathfinder Reservoir, and the outflow to the Niobrara is very large. The sandhill water is a big factor in the irrigation and power development of Nebraska.

We return to the Platte Valley and journey eastward, down the Lincoln Highway, through a district irrigated from reservoir water and through an area irrigated from many wells which tap a groundwater supply in the valley having a volume of more than 20,000,000 acre feet.

Next, we detour to the two large irrigation projects, built on

the Middle and North Loup branches of the Platte at a cost of $2,745,000. They use water coming largely from the Sandhill Region.

Near Columbus is the Loup River Public Power Project, a self-liquidating project, which diverts from the Loup River and returns water to the Platte below Columbus. It cost about $12,000,000 for the diversion works, canals, reservoirs, power plants, spillways and more than 1,000 miles of transmission lines. Its two power plants have a combined generating capacity of about 47,700 KW or an annual production of about 182,000,000 KW hours.

Transmission Lines and Rural Electrification: The large power projects of the Platte basin are tied together by 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 other projects and serves the rural electrification districts, institutions and municipalities in a wide area.

Resume: The large reservoirs in the Platte basin, not including the South Platte, have a combined storage capacity of more than 6,000,000 acre feet. The new project in Wyoming and Nebraska will add many thousands of acres to the irrigation area of the basin. The new irrigation, power and rural electrification projects in the Platte basin and adjacent areas of Nebraska will cost about $84,000,000. The combined capacity of the hydro-powers of the Platte Basin in Nebraska and Wyoming is to be about 500,000,000 KW hours of firm power annually.

Are the developments along the Platte encouraging to you? And do you favor such development elsewhere in the Missouri Basin where they are economically feasible? (Applause)

In the Humid Belt: Our traverse continues into the humid belt of Nebraska, Iowa and beyond where soil erosion has scarred and impoverished this wonderful agricultural area. Fortunately, however, erosion control practices are now employed generally in this area and with beneficial results. These lands of the humid belt between Nebraska and St. Louis must be conserved. (Applause)

Fortunately, the surveys and the agricultural experiment stations, agricultural extension, and Soil Conservation agencies are active in the humid area and in most other parts of the Missouri River Basin. They afford dependable factual, education, and action bases for the development and conservation of the agricul-

tural enterprise. And enough is known about the water resources of the basin to serve in their initial planning of comprehensive development. Cooperating with the public agencies are the farmer groups, industrial groups, and other semi-public organizations of many kinds including the Missouri Valley Association.

Conclusions from Traverse:

1. The natural forest at the headwaters of the Platte is being protected against fire and other hazards because it has economic value and favorable relations to runoff, erosion prevention and the rate of siltation in reservoirs and irrigation canals.
2. Overgrazing of the natural grasslands in the subhumid areas of the basin is hazardous to the best land and water use because it accelerates soil erosion and siltation and retards land use capability.
3. Large areas of former dry lands of the Platte Basin are now under successful irrigation.
4. The Platte Basin and adjacent areas are now lighted and powered by the energy harnessed from the Platte and its tributaries.
5. The irrigation canals, reservoirs, and forests have importance in wildlife production and for recreational purposes.
6. The marked industrial development of the Platte Basin relates back to the harnessing of the water resources, and to right land use. It is an example of what can be accomlished in a diverse region by the multiple use of water and the right use of land.
7. A coordinated development of the resources is being accomplished in the Platte River Basin.
8. The development of the Platte Basin has correlative value in the development of the transport, trade, and cutural activities of our country generally.
9. The humid land areas of southeastern South Dakota, eastern Nebraska, eastern Kansas, western Iowa and northern Missouri are being conserved for long-time beneficial use, and in fact, all of the traverse area is going forward in every essential way.
10. The development of the hinterland of the Missouri is a necessary part of the comprehensive development of the basin.

Now, Mr. Chairman, ladies and gentlemen, let me say in closing that your close attention and friendly attitude held throughout the time assigned for my discussion is highly appreciated. You have led me enthusiastically most of the time. Really, you pepped me up and it is plainly evident that you are for the best development that can be made in the basin, including flood control and navigation on the main channel of the river. (Applause)

PRESIDENT WEAVER: Dr. Condra, you have delivered well. Your speech was followed closely and appreciatively by all present. It has broadened our view of water and land conservation. We are glad that you handled the subject exactly as you did. (Applause)