1919

Soils of Nebraska as Road Materials-Naming, Routing, Marking of Nebraska Highways

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SOILS OF NEBRASKA AS ROAD MATERIALS

—and—

NAMING, ROUTING, MARKING OF NEBRASKA HIGHWAYS

REPORT OF

NEBRASKA STATE HIGHWAY ADVISORY BOARD

1919

Prepared by
STATE HIGHWAY ADVISORY BOARD
OF NEBRASKA

January 3, 1919.

Keith Neville,

Governor of Nebraska.

Sir:

I have the honor herewith to submit the report of the State Highway Advisory Board:

The present Board was appointed March 22, 1918, under Section 2,936, Revised Statutes of Nebraska, and is required to pass upon the naming, routing, and marking of highways, and co-operates with the State Conservation and Soil Survey of the Unitercity of Nebraska in testing road materials.

The personnel of the State Highway Advisory Board is:

G. E. CONDRA, Chairman, Lincoln.
GEORGE F. WOLZ, Fremont.
J. H. RIFFE, Hastings.
GEORGE JOHNSON, State Engineer, Secretary.

The Advisory Board presents a brief report on its work relating to naming, routing, and marking, and a more extended report on the Soils of Nebraska As Road Materials. The report on road materials was prepared by Dr. Condra, Director of the State Conservation and Soil Survey. I find it to be original and the first report of its kind ever published in any state, and as a large part of our roads for a number of years will be constructed with earth surface, and as this report deals directly with this class of materials, I am including same in my report As the Statutes require that the State Highway Advisory Board make a report, but do not specify the number of copies, I am, therefore, ordering the same number of copies printed as is specified by law for the Engineer's report.

Respectfully submitted,
GEORGE JOHNSON, State Engineer.

REPORT OF THE STATE HIGHWAY ADVISORY BOARD OF NEBRASKA

The Statutes of the state outline the work of the Advisory Board and require an annual report to the Governor. The Board passes upon the naming, routing, and marking of state highways and is connected with the work of testing road materials.

Appointment of Board—The Board serves as an adjunct to the State Board of Irrigation, Highways, and Drainage, and its members are appointed by said Board. The present members of the Board are George F. Wolz, J. H. Riffe, George E. Johnson and G. E. Condra.

Organization of Work—Immediately upon their appointment, the members of the Board met with the State Engineer and selected the following officers: G. E. Condra, Chairman, and George E. Johnson, secretary. The work was divided into two divisions—the routing and marking, and the survey and testing of road materials. Mr. George F Wolz took charge of the routing and marking in the North Platte area and Mr. J. H. Riffe in the South Platte area. Dr. Condra assumed the duties of the survey and testing of road materials, the field work to be correlated with the activities of the office of the State Engineer and the State Conservation and Soil Survey.

Meetings of Commission—A number of meetings of the Commission have been held in the office of the State Engineer and at other places for the purpose of passing upon applications presented by road associations, and to iron out problems relating to highways.

Field Work—Though no fund has been available for field work, it has been possible, through co-operation with state departments, to inspect a considerable mileage of the state highways during the last biennium. This field examination, or inspection of the various routes, has been found very useful as a basis in passing upon road projects. The detailed mapping that has been done in a number of counties through the co-operative work of state and federal departments, and the accessibility of maps made by these surveys, have made it not necessary to go over all highways proposed by road associations.

Form of Organization—The Board determined a method of procedure to be followed by road associations in formulating and presenting their applications for the approval of the Board. The procedure is as follows:

1. The formation of a road association, including the election of officers.

2. The preparation of a preliminary map and log of proposed road.

3. The filing of the application with the Secretary of the Board, this application to include the road name and a description of markers to be used.

4. Upon receipt by the Board an application is considered in executive session and a favorable or unfavorable report is forwarded to the road officers. No marking is permitted prior to the approval of the name and routing. A detailed log and map showing the routing is required from the association following the approval.

Meeting Road Officers—Most applications for the approval of roads are filed with the Secretary. In some cases, however, the representatives of an association appear to present applications. In case there is a dispute regarding the routing or about any other matter relating to the road, both sides of the question are heard.

A few large meetings have been held in which delegates were present from a number of points along the proposed routes and full discus-

sions of the naming, routing, and marking followed. In every case where there were differences of opinion, the Board has been able to bring the contending parties to a harmonious decision.

The open meetings have been most helpful in getting the county commissioners to agree upon the general improvement of a highway prior to its approval. This has had a tendency to hasten the development of a number of roads in the state.

Road Names—An attempt has been made to select only those names which have significance in the economic and welfare development of the state. The purpose has been to select Nebraska names for Nebraska roads, but this could not be done with the intra-state highways, such as the Lincoln Highway, Omaha-Lincoln-Denver Highway, Meridian Highway, and George Washington Route.

Road associations usually propose two or more names for the consideration of the Board and give reasons for their selection.

Names or routes are selected to represent some topographic feature, a person, a historic event, an industrial feature, an agricultural product, or some geographic condition. It is not always easy to select a name that will mean the most for the state as a whole, and we freely confess that the names approved to date are not what they should be to represent Nebraska.

Routing—The principal purpose in routing roads is to conserve the interests of the largest number and to guard against the selfishness of those who would profit at the expense of the public. A considerable amount of difficulty has been experienced by the Board in its attempt to route the highways that they may best serve the state.

The purposes for roads differ. Some roads are for local use and others are more for through-travel. The local-use roads are allowed to pass through small towns which they serve, whereas the through-roads, joining the larger places and carrying travel longer distances, are routed with less regard for the desires and wishes of the people in the smaller places. They are made as straight as possible with few turns and few railroad crossings. The purposes are to shorten distances, save time, and eliminate danger.

Markers—Most of the approved roads of the state have been marked by colors placed upon fences and telephone poles. Some of them have been designated by permanent markers.

There are several purposes in marking roads. One of the first of these is to guide travelers along the highway and prevent their getting off the right road. Among the other purposes are to direct travel at turns, indicate danger points, point out historic places and county lines, and to give the distances between and to nearby towns.

There has been a great deal of promiscuous marking of highways in Nebraska resulting in more or less confusion. The Advisory Board has tried to correct the conditions so far as possible, but has not had funds with which to carry on the systematic marking of roads. To date, practically all marking has been done by road associations and at their expense. It would seem that in the future the state should control the manufacture and placing of markers, or it should at least have full control of the selection and placing of markers.

The color schemes used in designating highways have not proved entirely satisfactory. Some citizens advocate the Wisconsin plan in which the various highways are given numbers placed upon structures along the roads. The whole subject of marking in Nebraska is being studied with a view of making definite recommendations to the authorities in charge and for the purpose of serving in standardization.

Survey of Road Materials—The State Conservation and Soil Survey, as a statutory duty, surveys the stone, sand, and soil road materials of Nebraska, and publishes bulletins thereon. The present trend of road development calls for an extension of this work and a more detailed survey of the road materials available along each highway. The department should be supplied with sufficient funds to enable it to complete the survey of road materials as soon as possible consistent with good work; and the materials, or representative samples, collected during the field work of this survey should be analyzed and tested in the laboratories of the department and the results made available for the state engineering department and for road builders generally.

APPROVED ROADS

The Board has passed upon a large number of applications, some of which have been completed and others of which remain incomplete because of the failure of the associations to file the necessary maps and reports. Some of the roads approved to date are as follows:

Lincoln Highway—This highway was well named. The road is national, extending between Atlantic City, New Jersey, and San Francisco, California. It crosses Nebraska between Omaha and the Wyoming line west of Bushnell, Kimball County. It follows closely the main line of the Union Pacific Railroad and touches a number of cities and towns. At first the road was marked by a color scheme placed principally upon telephone poles, but it is now designated by permanent markers. The colors are red, white and blue. The letter is L.

A few cut-offs have been proposed for this road, but the travel continues to follow the main line. The Bee Line road extends from Fremont to Blair and eastward into Iowa.

Omaha-Lincoln-Denver Highway—Named from the three cities included in the name. The routing follows closely the main line of the Burlington between Omaha, Lincoln, and Culbertson, from which the route turns northwest past Imperial and westward through Holyoke and Sterling to the South Platte Valley, which it follows a considerable part of the distance to Denver. The colors are black and white. The letters are O-L-D. The designation is by temporary and permanent markers.

Cornhusker Route—This bears the Nebraska name, which stands for the chief agricultural product of the state. The road is intra-state, leading from Marysville, Kansas, to Sioux City, Iowa, passing through such towns as Wymore, Beatrice, Lincoln, Wahoo, Fremont, Oakland, and Walthill. The colors are scarlet and cream. Letters are C. H. The road is well marked.

Meridian Highway—Crosses Nebraska between Thayer and Cedar counties and through such cities as Hebron, Geneva, York, Osceola, Columbus, Platte Center, Madison, Pierce, and Wausa; colors, band of white.

George Washington Highway—This national route extends between Savannah, Georgia, and Portland, Oregon, by way of Kansas City. It enters Nebraska south of Falls City and passes through such cities as Falls City, Auburn, Nebraska City, Plattsmouth, Omaha, Blair, Tekamah, Oakland, and Walthill. It is closely followed between Omaha and the Kansas line by the King of Trails marked by a yellow band and the letters K. T. The colors of the George Washington Highway are red and blue. The letter is W.

Omaha-Topeka Highway—Routing between Omaha and Topeka by way of Louisville, Weeping Water, Tecumseh, and Pawnee. Colors are bands—black, white, black.

Seward-York-Aurora Route—This highway extends from Lincoln to Grand Island by way of Seward, York, and Aurora. Colors, green and yllow, representing alfalfa and corn. Letters, S. Y. A.

Highland Cut-Off—An upland road between Valley and Central City. It detours from the Lincoln Highway. Colors, bands, yellow, white, and yellow.

Black Hills Trail—So named because route follows quite closely an old trail to the Black Hills. Terminals, Omaha and Black Hills. Leaves Lincoln Highway at Fremont; follows Elkhorn River to Norfolk; passes through Pierce, Creighton, Niobrara, Lynch, Butte. Color: White. Letters: B. H. T.

Loup River Black Hills Trail—Extends from Columbus and along Loup to Burwell, thence along the Calamus about thirty miles and northward through Long Pine and Springview to South Dakota and the Black Hills.A branch runs westward from Long Pine through Valentine, Chadron, and to the Black Hills. Part of this is known as the blue pole road, which also goes eastward through O'Neill, Neligh, and Norfolk. Colors, of main line, bands of black, yellow, and black.

Potash Highway—This proposed development between Alliance and Grand Island was named on account of the potash production in the vicinities of Hoffland, Antiocn, and Lakeside. The road has been improved to Lakeside and may be extended through following closely the Billings branch of the Burlington. The road has been routed and marked to Lakeside.

Sidney-Bridgeport-Alliance-Chadron Highway—This connects with the Lincoln Highway at Sidney and extends across western Nebraska to the Black Hills. There are three separate divisions to the road, that is, those between Sidney and Bridgeport, Bridgeport and Alliance, and Alliance and Crawford. Each division is marked.

Alliance-Hay Springs Highway—This follows the Alliance-Chadron road for about 15 miles, from which it turns northeastward to Hay Springs. The route is marked.

Alliance-Crawford Highway—This main road between Alliance and Chadron, connects also between Crawford and Chadron and is well marked.

Alliance-Oshkosh Highway—This extends across the tableland southeast of Alliance and thence through the sandhills to the North Platte Valley and Oshkosh. The road is fairly well marked.

Kimball-Scottsbluff Highway—Route between the two cities and fairly well marked.

North Platte Highway—This road is to leave the Lincoln Highway west of the city of North Platte and follows into and through the North Platte Valley touching such places as Lewellen, Oshkosh, Broadwater, Bayard, Scottsbluff, Mitchell, and Morrill. At present, most of the travel enters the valley from Ogalalla, Big Springs, Chappell, Sidney, Kimball. The North Platte Route has been called the irrigation way.

THE SOIL ROAD MATERIALS OF NEBRASKA

By G. E. CONDRA,

Director of the Nebraska Conservation and Soil Survey, Chairman of the State Advisory Highway Board.

Soils are the state's most important road materials. Though there are many soils in Nebraska, a satisfactory method of handling them in road work has not been fully determined.

This bulletin is a preliminary report based on the work of the State Conservation and Soil Survey* and the Advisory State Highway Board It may be of some use to persons building and maintaining earth roads awaiting a more complete report. The purpose of the paper is to outline the soil provinces of Nebraska and to discuss the physical properties of soils most used in road building. The term "soil," as here used, denotes both soil and subsoil.

The state owns the highways and the soil materials beneath them. These materials when properly combined are better suited for roads than is generally supposed. Due regard should be had, however, for the climatic conditions affecting roads. For example, some earth roads should not be graded; some should be graded to a crown, the form of which is determined by soil type, rainfall and drainage, and others require the mixing of materials to produce a stable surface. The methods of construction and maintenance are largely determined by the demands placed upon a road, and by the nature of the soils with which and upon which the road is built.

The Soil Survey—The soil survey has two leading purposes—one to give a general description of the soils of the state, and the other to make known the details of the various soil types relating to agriculture and state development. The first line of survey has covered fifty-two central and western counties. A report on this, the Reconnoissance Survey of Western Nebraska, was published by the U. S. Bureau of Soils, Washington, D. C., and distributed generally in Nebraska.

The detailed soil survey investigates the origin, topography, drainage, mechanical analysis, and agricultural value of soils. Twenty-four counties have been covered in this way. They are Richardson, Nemaha, Cass, Otoe, Gage, Saunders, Douglas, Washington, Dodge, Thurston, Wayne, Seward, Polk, Fillmore, Phelps, Hall, Chase, Dawes, Sheridan, Morrill, Box Butte, Scotts Bluff, Kimball, and Cheyenne. Reports have

*The writer is indebted to several persons who rendered valuable assistance in the preparation of this bulletin. Among them are George Johnson, State Engineer; F. A. Hayes, H. C. Mortlock, B. W. Tillman and A. H. Meyers, of the U. S. Bureau of Soils, and L. A. Wolfanger, V. H. Seabury, Frances J. Daly and Esther S. Anderson, of the State Conservation and Soil Survey.

been published on these except Sheridan, Morrill, Cheyenne, Chase and Phelps which are to be off the press within a few months. Less detailed reports, not so useful in road work, were made a few years ago on Sarpy, Stanton, Lancaster, Kearney and North Platte areas.

The soil survey is now progressing at the rate of three to five counties a year. The work is done by the State Conservation and Soil Survey of the State University in co-operation with the U. S. Bureau of Soils, Washington.

Use of Soil Reports—Reports of the soil survey are free upon request from the U. S. Bureau of Soils, Washington, as long as they last. Congressmen are sometimes able to secure copies from other sources after those of the Bureau of Soils are exhausted.

Soil survey reports are useful in several ways, as in agriculture, schools, the realty business, and for road purposes. The maps show drainage-ways, soils, houses, roads, and towns and are therefore a guide to travel. Knowing the nature of soils whether rough, smooth, sandy, and knowing how the types are affected by conditions of weather, one is better prepared to start upon a journey.

One of the main uses of the soil survey should be in connection with the construction and maintenance of dirt roads. Persons using the reports and maps for this purpose should read the descriptions of the subsoils especially.

PHYSICAL PROPERTIES OF SOIL

The properties of soils used as road materials have not been fully determined. They may be agreed upon and standardized before long. Among the properties considered in this report are color, structure, texture, voids, drainage, absorption, packing, drying, stability and wear.

Color has no particular importance in this connection except for use in identifying soils. The dark soils are usually high in organic matter content, yet they may be colored in part by a low oxide of iron. The yellowish and brownish soils and subsoils are stained with varying quantities of iron. The grayish soils may contain calcareous matter or light colored sand or both.

Structure relates mainly to the layers or zones in a soil section. Most soil sections show three divisions—the upper layer or soil proper; a middle layer (sometimes a hardpan), and a lower zone. (See Figure 1). These vary greatly in thickness and texture. The upper soil layer (1) is usually darkened more or less by organic matter. The middle zone or upper part of the subsoil (2) is more compact, made so mainly by the deposition of clay particles, calcium carbonate, and the compounds of iron and other materials derived from the upper soil. The lower subsoil in much of the state (3) is comparatively uniform and thick. It ranges

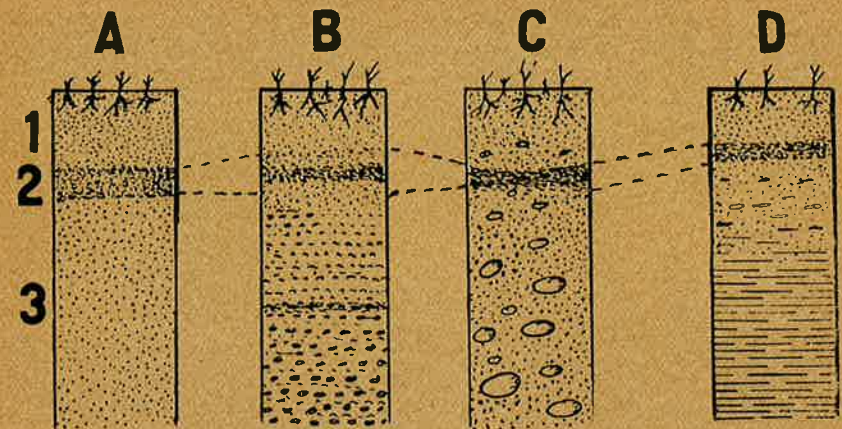

Figure 1. Showing Soil Sections. See Description.

from massive silts (soils on loess, A) to thick bends of sand (most alluvial soils, B). The subsoil developed upon the drift or glacial deposits lacks uniformity (C). It is an irregular mass of clay, silt, sand, pebbles, and boulders.

The sections of residual soils on such formations as the Pierre Shale and the Brule Clay show marked differences between the surface and the lower parts. They change within a short distance from the soil proper to the unmodified shale or bedrock. (D.)

The soil section showing the depth and condition of the subsoil should be investigated before road work is started. This can be done by sounding with augers. The information gained is necessary in determining the road plans and specifications.

Texture is an important property of soil used in earth roads. It relates to the size and grading of soil particles. As a rule the upper soil is not so fine textured and compact as the upper part of the subsoil.

There is a scale of textures ranging between clay and coarse sand. It is (1) clay, (2) silty clay loam, (3) clay loam, (4) sandy clay, (5) silt loam, (6) loam, (7) fine sandy loam, (8) sandy loam, (9) very fine sand, (10) fine sand, (11) sand and (12) coarse sand. These, except number 1, are mixtures of different grades of sand with silt and clay, and are determined accurately by mechanical analyses in the laboratory. At least four texture names should be well understood by road builders. They are clay, silt, sand and loam.

Clay is very fine grained. It is plastic and sticky when wet. The particles range between .0001 and .005 millimeter in diameter. When magnified 1000 diameters the finest clay particles appear the size of a small dot and the largest the size of a pea. There is no grit in most clays. No soil in Nebraska is composed wholly of clay.

Silt is a large content of most agricultural soils in Nebraska. It is often confused with clay because of its relatively fine uniform texture. Silt is coarser and more friable than clay. Its grains run between .005 to .05 millimeters in diameter or between clay and the finest grade of sand. There are several silty soils depending upon the percent of silt and the admixture of clay and sands. The principal thing in our well known loess is silt, not clay.

Sand of four grades is recognized in soil classification. The diameter of the particles, expressed in millimeters, is the basis of classification and the grades are: (1) .05 to .1, very fine sand, (2) .1 to .25, fine sand, (3) .23 to 0.5, medium sand. Sometimes the grade, fine gravel, is used for particles having diameters between 1 and 2 millimeters. The presence of sand in a sample is readily determined by the gritty feel, and in most cases by sight alone.

Loam contains silt and clay and more or less sand. The silt and sand tend to overcome the plasticity of the clay, making the type loamy or friable and loose. Loam is graded, i. e., composed of particles ranging between fine and coarse. A typical loam has a little less than 20% clay and less than 50% silt. An excess of clay, silt, fine sand, sand or gravel would distinguish the soil type as a clay loam, silt loam, fine sandy loam, sandy loam or gravelly loam. Probably the most perfect soil for road building in most places is a gravelly sandy loam.

Voids—Soil is far from being solid. It is composed of grains of various forms and sizes separated by spaces. The proportion of these spaces to a given volume of soil is called the "voids," which is the percentage of pore space.

The spaces are very small in fine textured soils and larger in the coarse textured types. The percentage of voids is greatest in fine textured soils and least in graded loamy soils.

It is not practical in most road work to determine voids. The desired results are secured by mixing materials ranging between fine and coarse. The heavy soils are as a rule well graded and low in voids.

Drainage relates to surface drainage, percolation and seepage. The fine soils drain rapidly on the surface and the open textured sandy types drain mostly by percolation.

Drainage is the principal problem, as a rule, in road construction and maintenance. This is particularly true where rainfall is heavy and the soil is fine. Under these conditions the purpose should be to build and maintain a road surface that will shed water, and to remove from the gutters and road bed all water which would soften the grade by seepage. (Figure 2.)

Figure 2. A Bad Road Resulting From Poor Cross Drainage. Photo by A. S. Merrick.

The soil texture and the amount of rainfall should largely determine the kind of road work used to facilitate drainage. A knowledge of these conditions will serve to distinguish between soils and roads which should be crowned and those which should not be graded.

Absorption—Soils differ greatly in their ability to absorb and hold water. The fine soils and graded types absorb water slowly. The clays and silts, being high in voids, hold much water if saturated. The capacity of fine soils is greater than that of sandy soils. Sandy soils absorb water readily and lose it mostly through percolation. The fine grained soils hold a large amount of capillary water and little gravity water. The sandy soils carry less capillary water and more gravity water.

Most soils should be graded to a well defined crown to promote runoff. The sandy soils should be crowned less because they need water and would in some cases be improved by a lack of surface drainage. Organic matter, loose dirt, and weeds are a detriment on most well improved road beds in the humid areas because they retard surface drainage and promote absorption.

Packing—Soils pack differently under traffic, dragging and drying. The sandy types remain loose under most conditions, and the fine textured types become heavy and compact. The graded soil is ideal for packing.

Most soils contract when drying and expand when receiving moisture or freezing (if saturated). This is particularly true with the clayey and silty types. One of the chief purposes in road maintenance should be to develop a compact wearing surface. This can be done chiefly by dragging at the right times.

Drying is caused by drainage and evaporation, but at different rates and with different results in the various kinds of soil and roads. The drying periods of soils and hence the "drag periods" of roads are closely related. A road crossing two or more soils dries by stretches and it is not possible to drag these stretches at the same time with the best results. This presents a problem of considerable magnitude where a road crosses a number of soils having wide range in texture. The only way to correct this condition is to build a uniform road surface by mixing the materials.

Several things determine the rate of drying. The rate is greatest in warm weather and on dry windy days. Other things being equal, hilly land dries faster than flat land.

Fine-textured soils dry slowly when poorly drained. The clays form hard cakes, granules and clods. The light soils are mobile. They dry rapidly by aeration and percolation. The heavy soils, drying, make hard roads and the lighter soils make sandy roads.

Stability relates to the ability a soil has to stand against such natural forces as creeping, caving, washing, and blowing. It is the property which resists the action of gravity, rains, wind, freezing and thawing.

A soil containing much clay will creep and slide in fills and cuts. It gullies on slopes. The silts stand well in cuts and fills and are not so much affected by rain and wind. The well graded loamy soils are quite stable. The sandy soils are subject to wind erosion, making their management very difficult in road work unless materials are available for protecting the surface or for mixing with the sandy soil.

Wear—Dirt roads are not suitable for heavy travel under all conditions. Rain makes the clayey and silty soils muddy, and ruts are formed where the surface breaks through. If not dragged in time, the wearing surface becomes rough with clods and finally knotted and pitted. A surface in this form is said to be "pitted." This condition can be corrected by planing. The silt roads develop dust when dry and the sandy roads show areas of loose sand. The effects of wear on soil types and the relation of dirt roads to wet and dry weather are particularly noticeable where a highway crosses several kinds of soil.

In maintaining a road bed, the texture of soils is a controlling factor to consider. The fine to medium soils should be dragged soon after rains. Holes should be filled with materials of the right texture. Very sandy roads may be damaged by grading because they need moisture. To maintain a good road surface on different soils and under the weather conditions is to solve a big problem.

Figure 3. A Physical Map Showing the Topographic and Soil Regions of Nebraska. Numbers 1 to 14 represent divisions of the High Plains Region.

Soil Regions of the State—Nebraska is large and diverse. The area is 77,510 square miles. The altitude ranges between about 840 feet in the southeastern corner of Richardson County and 5,300 in the northwestern corner of Kimball County. The annual rainfall decreases from 33 inches in the southeast to about 16 inches in the northwest. Surface features vary from smooth plains to mountainous areas. There are more than eighty kinds of soil traversed by 80,000 miles of wagon roads, a mileage equal to three and a third times the distance around the earth.

On a basis of soil and topography, the state has three well defined regions or provinces known as the Loess, Sandhill and High Plains. They have been described in various reports and are generally recognized by citizens of the state. (See Figure 3.)

Figure 4. Vertical Section olf Deep Subsoil, Loess Above and Drift Below.

THE LOESS REGION

This province is so named on account of the prevalent deposits of loess. The region occupies about 42,000 square miles or most of the southeast half of the state. It has eight distinct kinds of land or subdivisions,—the loess plains, wind formed areas, loess hills, drift hills, bluff areas, canyon areas, terraces, and flood plains or bottom lands proper.

Loess in General—Most Nebraskans know loess. It is well shown in many railroad cuts and in excavations as at Omaha, Plattsmouth and Nebraska City (Figure 4). The deposits, differing somewhat in origin, occur throughout the uplands of the Loess Region, except on the drift hills. There are at least three kinds of loess having importance in road work. They are similar and known as the plains, terrace and bluff loesses.

The loess is generally, but erroneously known as "yellow clay." Technically, it is mostly silt, containing some clay and fine sand. It is therefore a silt loam. The most distinguishing features are the buff color, massive appearance, fine and even texture, and the ability to stand nearly vertically in bluffs and other exposures. Three features of structure may be observed in the faces of bluffs, viz.—vertical cracks, separating the loess into columns; root casts, and small calcareous and iron oxide concretions.

Loess Plains—These are the nearly level uplands of the Loess Region (Figure 5). The area is about 14,100 square miles. The largest and

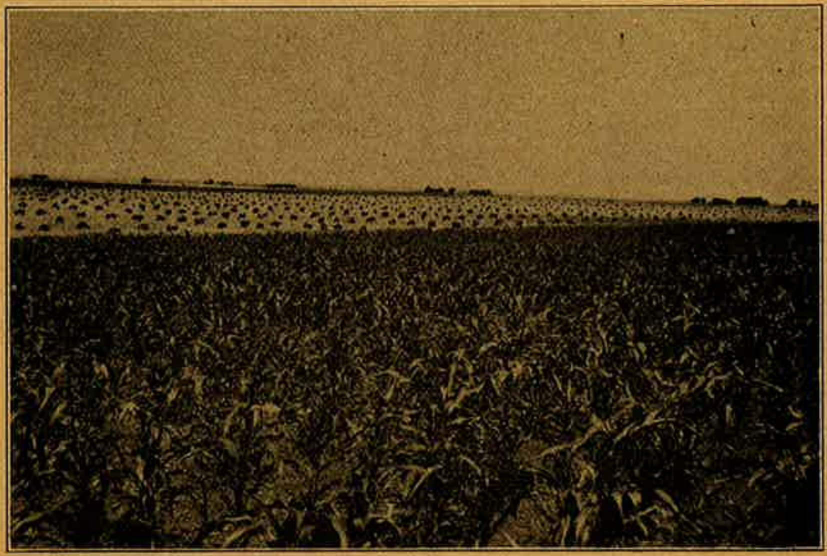

Figure 5. View Across the Loess Plains of Fillmore County.

most typical plain is between Dundy and Butler counties. Its general boundaries are the Platte, Republican and Big Blue valleys. Some of the typical locations on this plain are David City, York, Fairmont, Hastings, Minden, and Holdrege. The surface of this plain is quite even, but modified to some extent by small drainage-ways, shallow basins and low knolls. The borders are roughened at places by ravines, bluffs, canyons and sandy areas.

There are several loess plains in Nebraska. Small upland "flats" of this kind occur in most counties of the Loess Region. Formerly all of these flats were connected making a continuous plain over most if not all of the region. The orignal surface was eroded by streams, making valleys which separated the plain into many remnants or parts all lying in the same general slope and having similar surfaces.

Some of the loess plains are located as follows: On the divide north of Ogallala; south of the Platte Valley at Sutherland; in southwestern Lincoln County; the southeastern part of Chase; northeastern Dundy; southern Frontier; southwestern and southeastern Custer; part of the upland between Broken Bow and Sargent; northern Buffalo; small areas north of Ravenna; six miles south of North Loup; much of the upland between St. Paul and Boelus; west of Wolbach; southwest of Spalding; and the nearly flat uplands of Boone, Madison, Wayne, Cuming, Dodge, Douglas, Washington and other northeastern counties. Several small plains of this kind occur east of the Big Blue, as in eastern Seward, northern Gage, southern Lancaster, central Cass and eastern Johnson counties.

All the above plains are capped with loess from 25 to about 75 feet thick. The loess rests upon glacial deposits in the eastern counties and upon sand farther west. Locally it lies upon bedrock.

Loess Plain Roads—The loess plains are well served with roads, practically all section lines being open (Figure 6). There are nearly two miles of road per section, which is greater than in other parts of the state. There are many miles of graded road and relatively few culverts and bridges. The only drawback of any consequence in road building is the small, undrained basins. Sand for surfacing is exposed in a number of the small valleys. Probably there is no richer agricultural area in any country in which the country roads are kept in as good condition with so little work. Among the best-known roads crossing one or more loess plains are the Omaha-Lincoln-Denver (O. L. D.) Route, Cornhusker Route, Meridian Route, Seward-York-Aurora Route, Highland Route and the Capital Way.

Soils of the Loess Plains—Five principal soils occur on the loess plains, viz. Marshall silt loam, Grundy silt loam, Holdrege silt loam, Colby silt loam and Scott silt loam. Other types occur on the eroded borders of the plains and in the valleys. The surface soils and the upper parts of the subsoil of the plains proper differ considerably from east to west,

but the texture of the lower subsoil remains remarkably uniform. There is a slight change in the size of grain, becoming a little coarser westward. As a whole the loess plains have unusually large areas of uniform road materials.

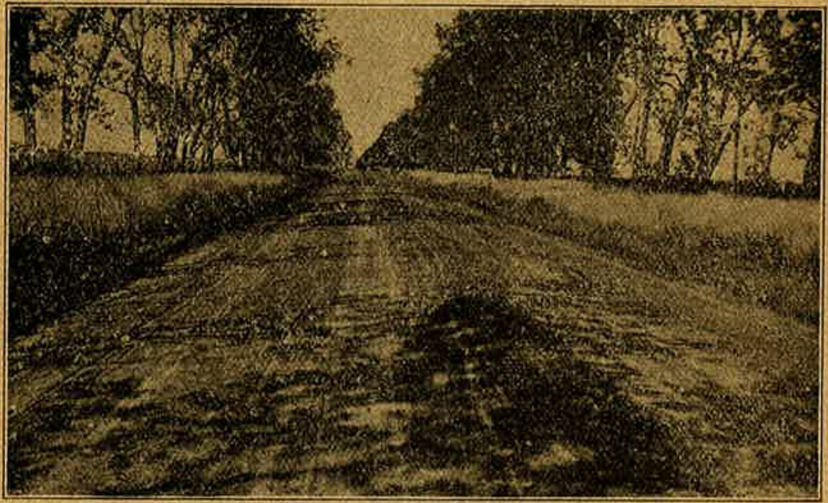

Figure 6. Loess Plains Road, the O. L. D. Highway.

The Grundy silt loam is the typical soil on the loess plains of the southern and southeastern counties. It was classed in our earlier reports as the flat phase of the Marshall silt loam. Persons wishing a description of the Grundy, as it is typically developed in Nebraska, should secure and read the soil survey of Fillmore County, pages 15 to 19. In Fillmore County the upper soil is dark brown, about 12 inches thick, and a heavy silt loam modified by organic matter. This layer passes into a darker heavy clay horizon mottled dark brown and yellowish. This zone is compact, hard and tough, but crumbles to granules when drying. It is very plastic and nearly impervious when wet. Farmers call it the "hard pan" layer. If near the surface, it is called "gumbo."

At a depth of two or three feet, the subsoil of the Grundy silt loam changes becoming yellowish gray to pale yellow and more friable, grading into the undisturbed loess which is usually very thick and more or less calcareous.

Mechanical Analyses of Grundy Silt Loam, Fillmore County.

Description	Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Very fine Sand	Silt	Clay
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Soil, 0 to 12 inches	0.0	0.2	0.1	0.8	15.8	65.4	17.6
Subsoil, 12 to 36 inches..	.0	.0	.0	.8	17.0	51.2	30.8

Small areas on the loess plains in the northeastern counties, in which there is a deep dark brown subsoil not underlain by a well defined hard pan layer, are classed as Marshall silt loam. These can be determined by sounding as is done on the soil survey.

Road Maintenance on the Grundy—The tough layer in the upper subsoil is a factor in road work on this soil type. The depth and thickness of this layer and the rest of the soil section should be determined before a road project is started. This will serve to show what materials are to be encountered in grading. It has been found that the best results are secured where materials from the heavy layer are placed in the lower part of the roadbed and covered by the upper soil.

The drag period of the Grundy silt loam is short. A good, hard road is made where the surface is properly crowned and dragged and lateral drainage is provided. A much better surface, one easier to maintain, is secured by surfacing with sand, if a supply can be had within hauling distance.

The Holdrege Silt Loam resembles the Marshall in its upper layer, but differs in the subsoil. The surface soil is about 15 inches deep, dark, friable, and of a silt loam texture which grades between 15 and 18 inches to a granular silty clay loam. Below this the subsoil becomes dark brown and granular to a depth of 28 inches. This layer is underlain by a friable, mellow silt loam of light gray color.

The Holdrege silt loam is not so sticky as the Grundy when wet. It blows very little. Road building is comparatively easy and the improved roads are smooth and fast.

Colby silt loam occurs typically on the western loess plains. Its surface is hilly to nearly level. The color is lighter than Holdrege, Grundy and Marshall soils due to the lower content of organic matter and the presence of more calcareous material.

The surface soil is light brown, grading quickly into gray, light gray or a white floury subsoil. The soil is calcareous throughout the section.

The Colby silt loam is modified by small areas of very fine sandy loam. Many roads are fairly good without grading. A good road is secured on the silt loam with relatively little work.

Basin Soils—The Scott silt loam is the leading soil in the basins or depressions of the loess plains. It was formed in intermittent lakes, the sediment having been washed from the border areas. The type is poorly drained. In fact it is not drained.

The surface of the Scott silt loam, sometimes called a basin phase of the Wabash, consists of 6 to 15 inches of dark brown to dark gray silt loam containing a considerable amount of organic matter. It becomes

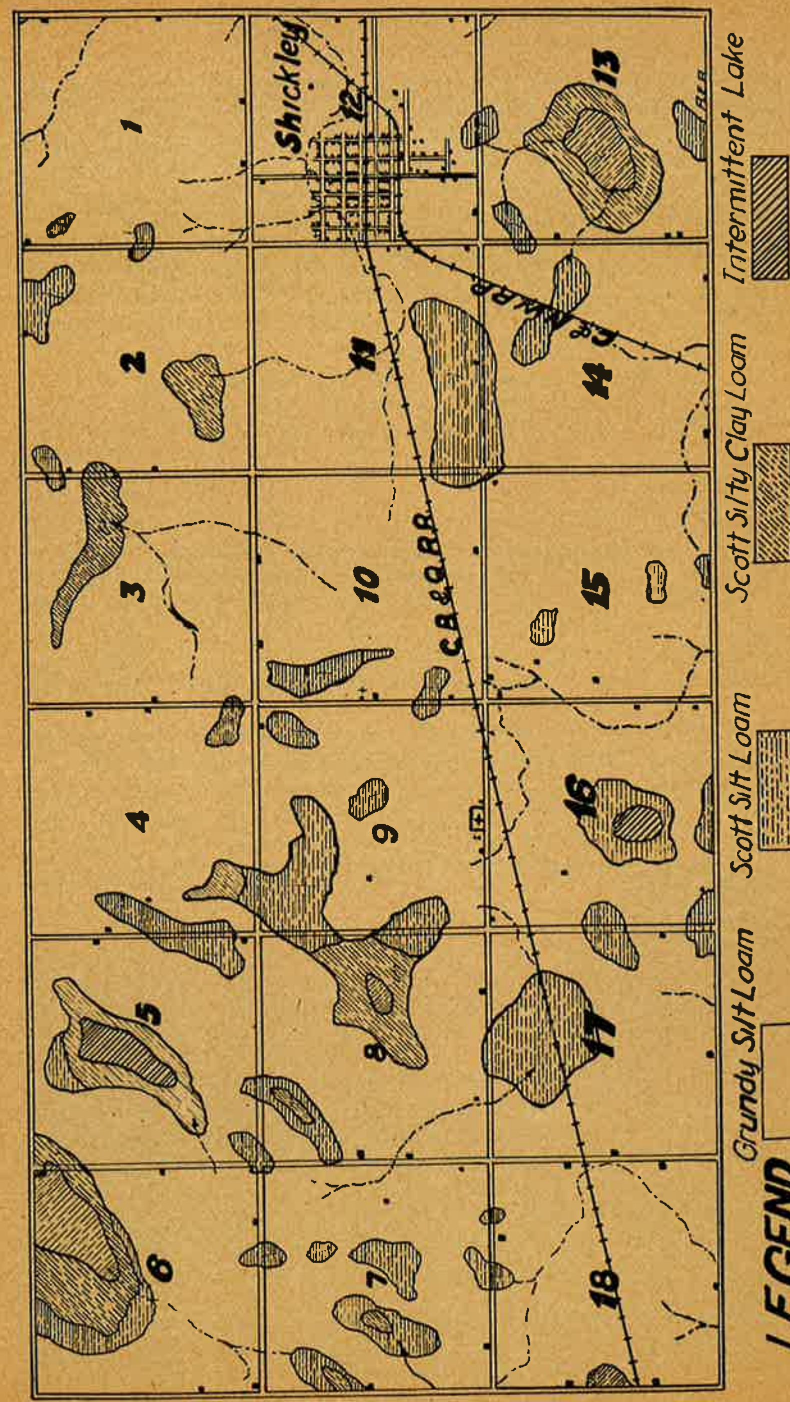

Figure 7. Showing Soil Types Near Shickley.

grayish and quite friable when drying. The distinctive feature of the Scott silt loam is a layer of ashen gray, pulverulent silty loam, 2 to 10 inches thick in the upper part of the subsoil. Below this is a dark or nearly black, plastic silty clay, mottled with brown. This material is tough and compact. Below 30 inches, the subsoil changes gradually to the condition of undisturbed loess.

Some of the best defined areas of basin soil are in York and Fillmore counties (Figure 7). Less extensive ones occur throughout the loess plains and on most alluvial terraces. The Scott silt loam grades into silty clay loam and clay.

Mechanical Analyses of Scott Silt Loam, Fillmore County

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil, 0 to 6 inches	0.0	0.1	0.1	0.6	12.6	71.2	15.2
Subsoil, 6 to 20 inches	.2	.8	.3	.5	16.0	73.4	8.6
Lower subsoil 20 to 36 in	.1	.2	.1	.4	9.5	58.0	31.6

Mechanical Analyses of Scott Silt Loam, Gage County

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Subsoil	.4	1.0	0.6	1.6	10.4	68.8	17.1
Lower subsoil	.1	.2	.2	1.9	7.1	57.0	33.2
Soil	0.1	1.0	0.6	1.6	9.2	72.3	15.1

Road Maintenance on Basin Soils—The Scott silty clay loam and the clay are heavy. They become very plastic and sticky when wet, and tough, hard and compact when dry. They are difficult to handle both in farming and in road work. Flooding and seepage make roads soft. This can be overcome by grading above the level of standing water. Roads are improved by the incorporation of coarser soils and sand. The drag period is short.

Wind-Formed Areas—There are a number of areas along the western border of the Loess Region, and a few patches on the loess plains and their borders, in which the surface has been eroded and formed into choppy hills resembling dunes. They total about 900 square miles.

In a general way, the larger wind-formed areas make up a border land between the loess and sandhill regions. Their soils vary much in texture, but are composed mostly of sand and silt making sandy roads. The largest areas of these soils are located as follows: North and northeast of Minden; east of Hildreth; north of Grand Island; in western Boone County; eastern Wheeler County; northwest of Greeley; northeastern Lincoln County; on the upland south of North Platte; 10 miles southwest of Maywood, and the east border of the sandhills in Dundy County.

The soils of the wind-formed areas have been grouped with the Richfield, Valentine and Colby series. The practice now is to place those in which some of the qualities of the loess show, as in the northern part of

Phelps County, with the Colby very fine sandy loam and fine sandy loam. The soils along the borders of the sandhills are in most places classed with the Valentine.

Loess Hills—These hills occupy an area of about 11,900 square miles principally in the northeastern counties of the state. A narrow belt extends southward just west of the bluff belt of the Missouri. Loess hills were eroded from the original loess plain and are characterized by a loess cap which forms their remarkably smooth surfaces. In most of the hills, the loess is underlain by sand, and glacial drift. These materials outcrop at widely separated places and are encountered in wells and some wagon and railroad cuts. The drift rests upon bedrock which is exposed in some valleys. The principal soil of the loess hills is the Marshall silt loam.

Marshall Silt Loam—There are several kinds of soil in the loess hill areas, but the Marshall silt loam has the largest distribution. It is a typical silt loam. The upper soil is dark brown to nearly black and 10 to 15 inches thick. It contains considerable organic matter.

There is no well defined clay pan in the subsoil. The upper part of the subsoil is slightly heavier than the surface layer. It grades into typical loess.

The Marshall silt loam is comparatively mellow. It absorbs moisture quite readily and does not wash much. It works up well in roads.

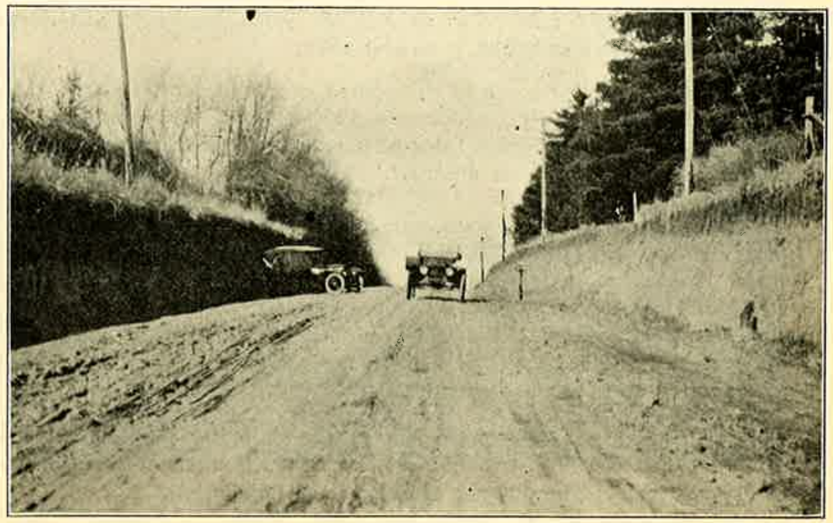

Figure 8. A Loess Hill Cut, Otoe County. Photo by A. S. Merrick.

Loess Hill Roads—No part of Nebraska has developed more rapidly and successfully in road work. Hills have been cut (Figure 8) and fills made along hundreds of miles of highways, as in Custer, Sherman, Boone, Cedar, Thurston, Washington, Douglas, Sarpy, Cass, Otoe, Nemaha and other counties. The per township mileage is nearly as large as on the loess plains, but there are many more fills, cuts, culverts and bridges. Roads generally are kept in good condition by grading and systematic dragging. Sand exposed in some hill sides and a few valleys has been used for surfacing at places.

The roads on loess hills are characterized by their smooth surfaces, made so by dragging and wear. They carry heavy loads of farm products and are easy on autos and drivers. Some of the best stretches of good roads in the loess hill areas are on bench and flood plain lands. This is particularly true along the valleys of the Loup System.

The Lincoln Highway crosses the loess hills between Omaha and the Platte. The George Washington Route, closely following the Omaha-Kansas City Highway, is principally on the loess hills between the Kansas line and Omaha. The Cornhusker Route crosses the loess hills in the northeastern counties.

Drift Hills—Quite well defined drift hills occur in the southeastern counties. They occupy an area of about 6,700 square miles. The hills were eroded from the drift (glacial deposits). Erosion removed nearly all of the loess cap at most places and dissected the glacial drift to the form of hills.

Drift hills average smaller and less smooth than loess hills. They are easily recognized by the form and by the presence of gravel, pebbles and boulders which may be exposed in the soils (Figure 9) and uncovered in such places as banks, cuts, and wells.

Drift hills occupy much of the upland in Saunders, Cass, Otoe, Lancaster, Nemaha, Richardson, Johnson, Pawnee and Gage counties. The land is unlike the bordering loess hills and loess plains. The soils are different and the roads are different.

Drift Hill Soils—These were derived from two well defined drift sheets known as the "Nebraskan" and "Kansan", and from a sand plain between them. The range in texture is considerable. There are small areas of sandy and gravelly soils, and larger areas of silt loam. In some places, extensive weathering of the drift has produced a uniform soil resembling the Marshall silt loam. This is particularly true where loess has been incorporated with the drift.

Two soils, a silt loam and a loam, occur generally on the drift hills. The first has received two names—the Carrington silt loam and the Shelby silt loam. The other is known as the Shelby loam.

The Shelby silt loam is a dark soil in its upper part, but changes be-

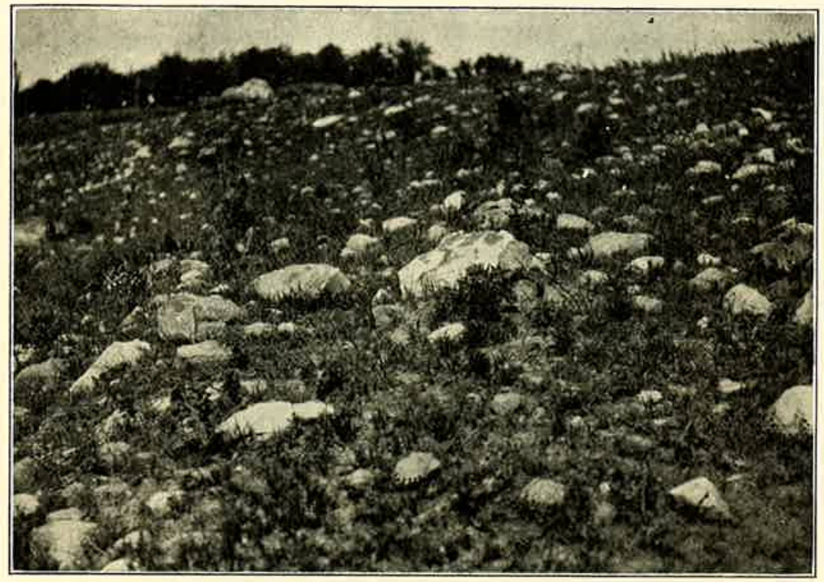

Figure 9. View Showing a Bowlder Area in Nemaha County. There Are Few Square Miles Like This in Nebraska.

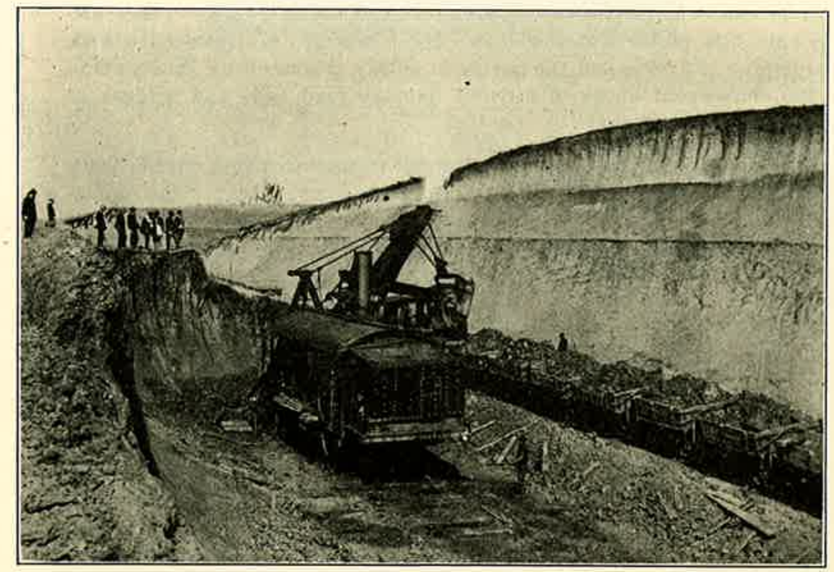

Figure 10. Railroad Cut in Drift Hills. It Is Being Widened Because of Caving. A Loess Cut Would Stand Much Better. Observe That Some of the Bowlders Are Inked in.

low this finely weathered zone, which carries considerable humus, to a slightly compact upper division of the subsoil and then to the drift containing clay, silt, sand concretions and boulders. This type has more clay and sand and less silt than the Marshall. It becomes quite sticky when wet and drying, forms hard clods which break into dust and some sand. The road surface becomes knotted and dippy. This condition can be remedied by dragging after rains and by shaving or planing when a road is extremely dry and rough.

A soil, known as the Shelby loam, occurs on many knolls, sharp crests and steep hill sides of the drift hills. The type represents an eroded phase of the silt loam. It contains less organic matter, due to erosion, and shows stony materials. This type is difficult to handle in road work because of its uneven texture and the presence of boulders.

Hill sides in which sand is exposed form a sandy loam soil of limited extent. This type and a fine sandy loam developed on outcrops of the Dakota sandstone make bad places in roads crossing them. Such patches of road can be improved by surfacing with silt or clay.

Mechanical Analyses of Shelby Loam

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	1.0	3.9	5.8	11.6	7.6	47.8	21.4
Subsoil	.8	3.9	4.7	9.5	7.7	38.4	34.9

Drift Hill Roads—Road development has been rapid and nearly universal in the drift hill areas. Most section lines are open. There are many cuts, fills, culverts and bridges. Some difficulty is experienced with the slumping of grades and the caving of cuts. (Figure 10). Heavy rains and the consequent floods of streams damage road beds and bridges of small valleys (Figure 11).

Grading and dragging are more difficult in this area than on the loess hills and loess plains. Boulders interfere to some extent. The prevalent soil becomes very sticky when wet and hard when dry. It ruts and pits, but is corrected by dragging and planing making very hard road bed with a little rougher wearing surface than that developed upon the soils of the loess areas.

Bluff Lands—In a general way, all rough lands bordering valleys and formed from mantle rock materials are called bluffs. Bluffs proper, are the steep valley-sides produced by rivers cutting against the upland. They are common along the Missouri, Platte and Republican. The bluff areas grade into hills without a distinct line of division, (Figure 12), and have an approximate area in the Loess Region of about 1,000 square miles.

Some of the river bluffs of Nebraska are quite high, especially those of the Missouri. From the top downward, they contain loess, drift and bedrock. The mantle rock materials dislodge from the steep slopes mak-

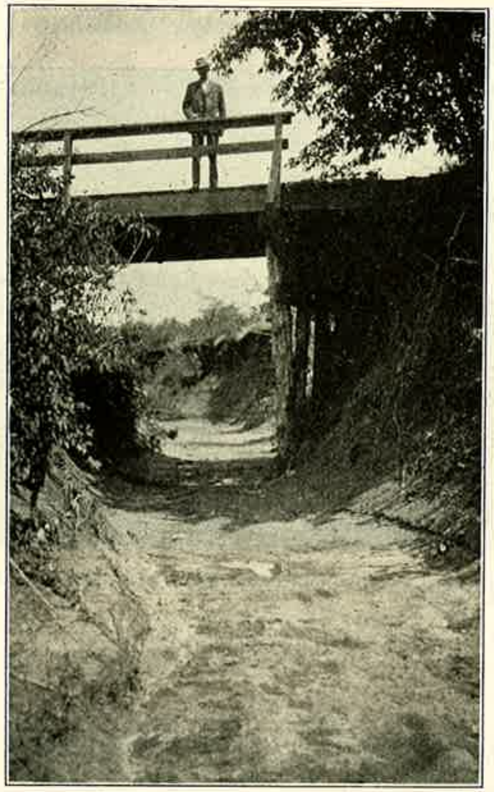

Figure 11. View Showing How the Drift Hill Areas Erode and Damage Bridges

Figure 12. View of Grass-Covered Bluff Land. Roads Follow the Foot of Bluffs.

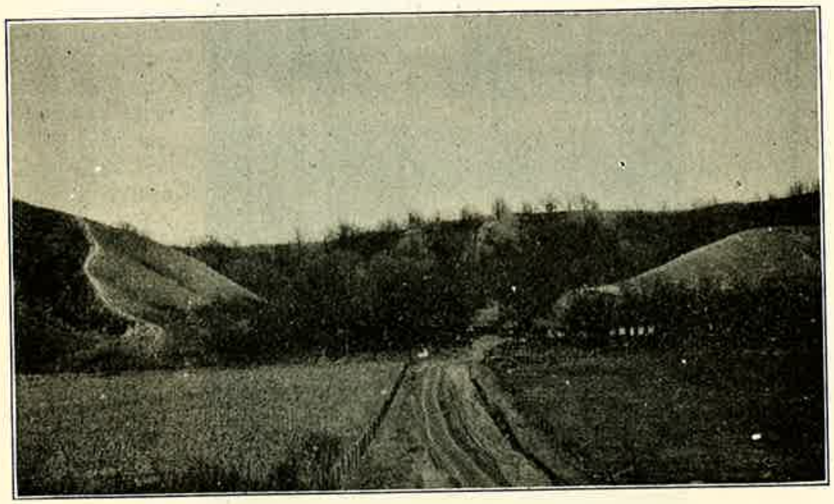

Figure 13. A Bluffland Road, Leading Out From and Across An Alluvial Fan Bordering the Flood Plain.

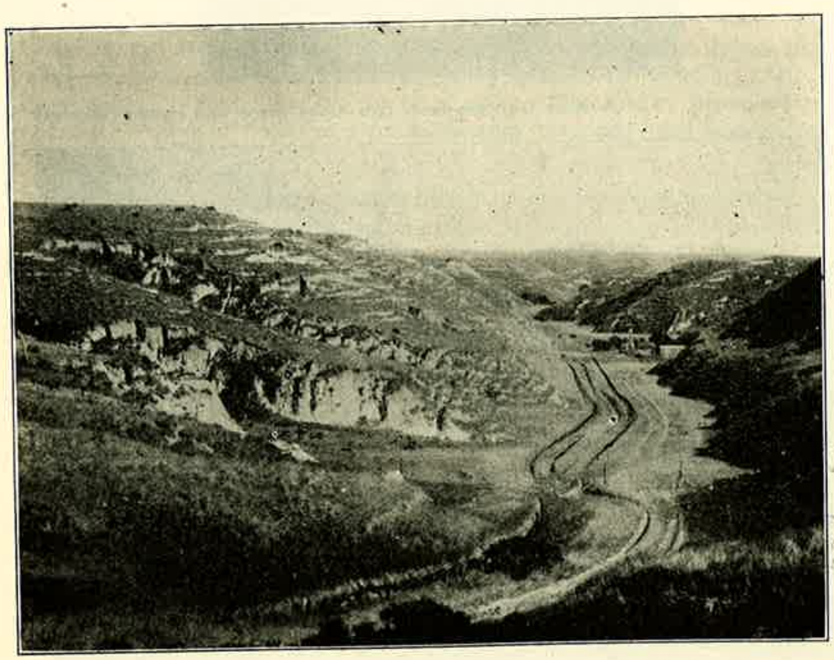

Figure 14. A Canyon Road. Small Land Slides Show on the Slopes.

ing land slides below and vertical walls above. The bluff land belts are cut by many deep ravines and small valleys and further modified by numerous ridges and spurs. As a whole the topography is very rough. The principal soil is the Knox silt loam.

There are many places on the valley sides of the Loess Region in which bedrock materials such as limestone, chalk rock, sandstone and shale, are exposed. These weather down forming different types of land and soil, as along the Republican, Big Blue, and Nemaha valleys.

Knox Silt Loam resembles the Marshall silt loam in its lower parts, but has less humus in the upper layer. It has a thin surface soil, but becomes fertile when humus is added.

A noticeable feature of the Knox is its ability to stand in nearly vertical cuts and grades. It is mellow and can be plowed at any depth in the subsoil.

Bluff Roads—The chief drawback to these roads is the roughness of the country and the consequent steep grades or profiles. Most highways follow ridges and ravines (Figure 13) in order to reach the lines of easiest travel. Many expensive cuts and fills are required. The loess stands well in excavations and fills, but erodes badly at places after heavy rains. Though the roads become somewhat slippery, they do not become very muddy. They dry rapidly as a rule.

There are many fine views along the bluff roads, overlooking the Missouri, Platte and Republican. These attract auto parties.

Canyon Areas—About 1,500 square miles of the western parts of the Loess Region is roughened by deep, steep sided, valleys called canyons. In places the canyons are so numerous as to separate the upland plain into many small, block-like flats, making road building nearly impossible. Such areas occur in parts of Lincoln, Hayes, Frontier, Hitchcock, Gosper, Dawson and Custer counties. Small slips or land slides are common in canyons having sides not so steep, (Figure 14) and in places the flat divides have been eroded away leaving areas of bold hills separated by V-shaped canyons.

The soils of canyon areas are now classed as the rough phase of the Colby series. The color is light gray. There is less humus than in other soils derived from loess and the texture ranges between silt and fine sand. Coarser materials occur on most of the floors or bottoms of the canyons. These were washed from sand layers under the loess.

Bench Land or Terraces—Most large valleys in the Loess Region have flats or plains above their first bottoms. These elevated flats, known as terraces, are thought to be remnants of old flood plains. They occupy about 2,150 square miles of the Loess Region.

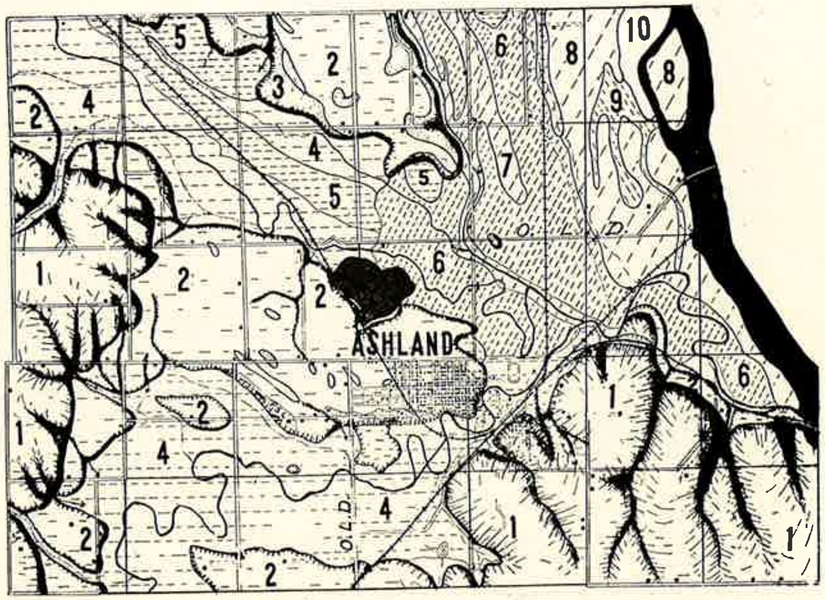

Figure 15. Showing Land Forms and Soils in the Vicinity of Ashland.

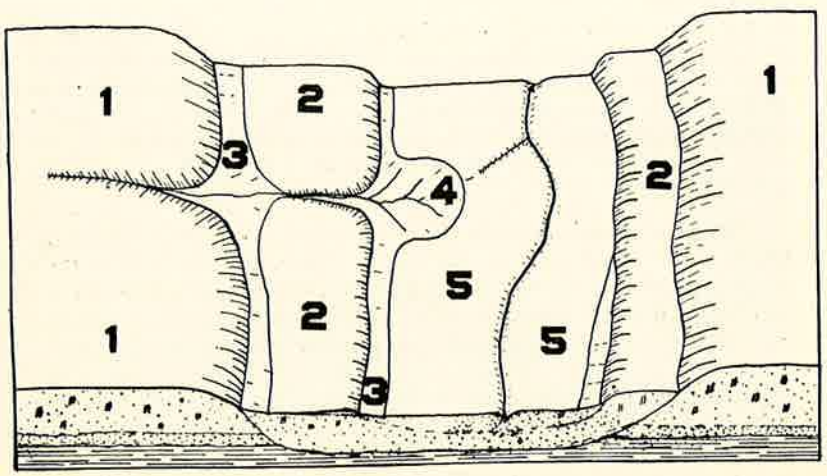

Figure 16. Generalized Cross Section of a Valley, hSowing Land Forms.

Some of the best defined terraces are at Blair, Omaha, Nemaha City, Ashland (Figure 15) Wahoo, Lincoln, Lyons, Fullerton, St. Paul, north of Fremont, Schuyler and Columbus and at Oxford, McCook and Culbertson. They occur in two or three levels at most of these places. The terraces of figure 15, are represented by (2). The city of Ashland is on a terrace having two distinct levels, known as second and third bottoms. Small depressions are shown by enclosed lines and the areas of sandy soil at the edges of terraces are represented by dotted line. See the position shown by (3).

Most terraces are capped with a silt loam covering thick beds of sand. The prevalent soil on terraces in the Loess Region is the Waukesha silt loam.

The Waukesha Silt Loam is a dark brown heavy silt loam, 12 to 15 inches deep and high in organic matter. It has a smooth velvety feel. The subsoil is a yellowish silty clay which at about 20 inches becomes very compact and grades into a yellow color. The subsoil becomes loess-like below 30 or 40 inches.

The Waukesha occupies most of the bench areas in the central and eastern counties, but is modified by small patches of Scott silt loam and by low knolls having soils of coarse texture. Small knoll-like elevations are lighter, ranging between very fine sand and sandy loams. The poorly drained or basin-like areas have comparatively heavy soils, the Scott silt loam and the Scott silty clay loams.

Sand is exposed along the edges of some terraces. This sand mixes with the silt from above or washes out upon the valley floor making fine sandy loams.

Mechanical Analyses of Waukesha Silt Loam, Saunders County

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	0.0	0.2	0.2	1.1	17.3	61.7	19.5
Subsoil	.1	.1	.1	2.0	18.7	63.2	15.8

Mechanical Analyses of Waukesha Silt Loam, Nemaha County

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	0.0	0.0	0.0	0.9	7.4	73.0	18.7
Subsoil	0.0	0.2	0.2	0.4	6.4	72.8	19.9

Mechanical Analyses of Waukesha Silt Loam, Seward County

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	0.0	0.3	0.3	0.9	14.6	56.0	28.2
Subsoil	0.6	0.7	0.3	0.8	11.7	61.9	23.9

Terrace Roads—The relation of terraces to wagon roads and railroaus is generally understood. They afford good roadways quite well drained and above floods. The silt loam soil grades easily. The basins present a difficult problem. Roads built across them are usually bad unless elevated above the standing water and unless other materials are used in mixing and surfacing. Some supervisors grade across the edges of the benches, paying no attention to the kinds of materials encountered, leaving a road bed of sand which becomes gutted by wind and water, making it nearly impassable and expensive to repair.

Bottom Land—The bottom lands are well defined in all river valleys and in most creek valleys of the Loess Region. The total area of bottom land in the region including flood plains, alluvial fans, colluvial slopes, and the poorly defined, low benches, (Figure 16) is about 3,750 square miles.

Figure 16 is a generalized drawing in which Arabic numerals are used to designate land forms. They show as follows: 1, uplands; 2, terraces; 3, colluvial slopes; 4, alluvial fan; 5, flood plain.

The bottom or alluvial lands have a close relation to roads and should be better understood with respect to their drainage and soils. Bottom lands are known as "made land" built by streams. They are composed of clay, silt, sand and coarser materials more or less stratified. Considerable organic matter is present in the upper soil and as seams in the deeper parts of a section or an exposure.

Flood plains or lowest surfaces of valleys were built mainly of materials deposited by flood waters, hence the name. They are quite smooth, except where roughened by water erosion or by wind erosion and deposition. They are very poorly drained, even marshy, at places. High waters and marsh areas are drawbacks to road building in ways known to all. Drainage and stream correction are therefore of importance in road work as well as in agriculture.

Alluvial Fans are formed at the mouths of steep tributary valleys bordering flood plains. The small, swift streams of these valleys carry much sediment, but drop it upon reaching the flat land. The sediment deposited in this way causes the water to spread and distribute other sediments in a fan-shaped form. There are thousands of small alluvial fans in the Loess Region, and other parts of the state. They usually lie above the flood heights of trunk streams and are fairly well drained.

Colluvial Slopes occur on the edges of flood plains and extend on to the foot of valley sides. They are built mostly of fine materials washed from the slopes. The colluvial forms are made smooth by the action of sheet water. They differ greatly in size and somewhat in the texture of their soils, but are best defined where there are few ravines and where for a long time the trunk stream has not eroded against the slope and removed the local deposits. Some colluvial slopes are terrace-like. They lie above flood level and are fairly well drained. They afford favorable locations for roads. The soils are of comparatively fine texture, dark

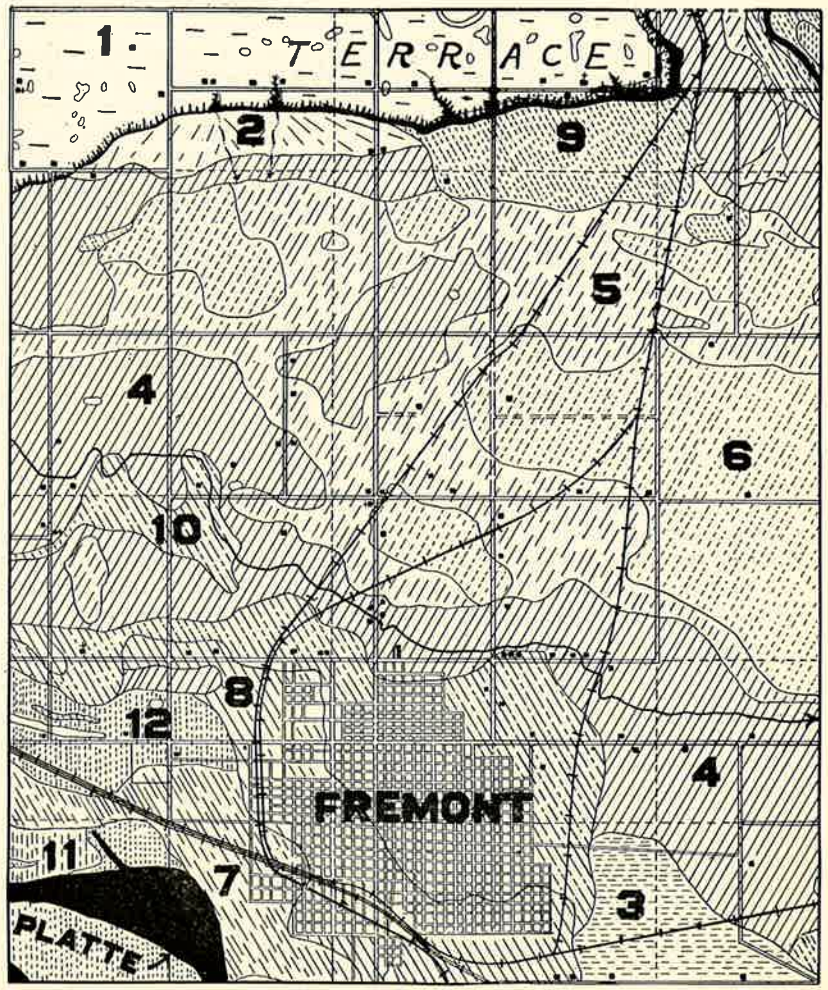

Figure 17. Showing Soil Types in the Vicinity of Fremont.

brown to black and deep. The prevailing soil type, as mapped in Dodge and Hall counties, is called the Judson silt loam.

Alluvial Soil Sections—Taken as a whole the bottom land soils of the Loess Region present four types of structure, as follows:

1. Comparatively uniform, dark colored, fine textured soils having a depth of 2 feet or more in the surface layer and upper part of the subsoil and grading below to slightly coarser materials of considerable thickness. The soil series best representing this structure are the Wabash and Lamoure.

2. Comparatively uniform brownish to dark surface soils ranging between clay and loam in texture and grading at a comparatively shallow depth to layers of sand. The Sarpy series is representative of this structure.

3. Soils sandy throughout the section, but containing some organic matter in a thin surface layer.

4. Sand deposited along trunk streams and in sand draws. It is fine to coarse and suitable for surfacing. Coarse river wash is the best example of this structure.

Alluvial Soils—A number of alluvial soils have been mapped in the Loess Region. Among them are those of the Wabash, Cass, Sarpy, Lamoure and Judson series (Figures 15 and 17). Descriptions of the types of these series have been made in various soil reports as in Washington, Nemaha, Richardson, Douglas, Dodgs, Hall and Phelps counties.

In figure 15, Arabic numerals are used to show topographic divisions and soil types, as follows: 1, hilly upland in which the Marshall silt loam and the Shelby silt loam prevail; 2, bench or terrace land modified by small basins and fringed by sandy soils, shown by 3; 4, Wabash silt loam; 5, Wabash clay; 6, Cass silt loan; 7, Cass very fine sandy loam; 8, Cass fine sandy loam; 9, Sarpy fine sand; 10, River wash.

In figure 17, showing the Fremont area, 1 represents terrace modified by depressions and sandy borders; 2, Judson silt loam; 3, Lamoure silt loam; 4, Wabash silt loam; 5, Wabash silty clay; 6, Wabash clay; 7, Cass fine sandy loam; 8, Cass very fine sandy loam; 9, Cass loam; 10, Cass silt loam; 11, Sarpy very fine sand; 12, Sarpy fine sandy loam.

The Wabash silt loam, silt clay loam, and clay are common alluvial soil types in the eastern part of the Loess Region (Figures 15 and 17). They are close textured, dark colored and unusually deep. Among the flood plains showing principally the Wabash soils are those of the Big Nemaha, Little Nemaha, Weeping Water, Salt Creek, Maple Creek, and Logan Creek, and most of the Big Blue and its tributaries. There are considerable areas of Wabash soils in the Platte, Elkhorn and Missouri River valleys.

Mechanical Analyses of Wabash Silt Loam, Otoe County

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	0.1	0.2	0.3	0.5	3.1	77.6	18.1
Subsoil	.0	.2	.2	.5	1.7	67.5	29.9

The Cass Series is represented by five types (Figures 15 and 17) which are the clay, silty clay, silt loam, loam, very fine sandy loam and fine sandy loam, black in the surface layer, brownish to grayish in the upper subsoil and underlain by a thick layer of sand. So far as road materials are concerned the Cass soils are not very different from the Marshall except that they are thinner and grade sooner into sand.

Mechanical Analyses of Cass Silt Loam, Gage County

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	0.0	0.2	0.2	0.4	11.2	67.3	20.9
Subsoil	.0	.1	.2	2.3	17.2	66.6	13.4

Mechanical Analyses of Cass Loam, Saunders County

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	0.0	0.4	0.8	7.7	33.0	44.4	13.9
Subsoil	.0	.2	.4	5.6	54.8	31.9	7.1

The Sarpy series of soils, shown by the surveys, is fairly distinct from the Cass group so far as the agriculture is concerned, but not so distinct as road materials. (Figures 15 and 17).

Mechanical Analyses of Sarpy Very Fine Sandy Loam, Nemaha County

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	0.0	0.2	0.2	20.6	52.4	20.1	6.8
Subsoil	.0	.1	.2	40.3	44.0	12.7	2.8

Mechanical Analyses of Sarpy Silt Loam, Nemaha County

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	0.0	0.0	0.0	0.9	10.5	73.4	15.0
Subsoil	.0	.1	.1	6.9	56.5	29.5	6.4

Mechanical Analyses of Sarpy Clay, Nemaha County

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	0.0	0.0	0.0	2.1	5.2	37.1	55.4
Subsoil	.0	.1	.0	11.9	52.8	28.2	6.6

The Lamoure Silt Loam, silty clay and clay have been mapped along the Platte in Dodge (Figure 17), Polk, Hall and Phelps counties. They are typically shown in Dodge County. The types resemble those of the Wabash series, but are less perfectly drained. They have a calcareous subsoil, which is lighter in color than that of the Wabash series. The Lamoure soils contain alkali and saline areas.

Mechanical Analyses of Lamoure Silty Clay, Dodge County

Description	Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Very fine Sand	Silt	Clay
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Soil	0.4	1.6	2.2	8.9	11.7	44.9	29.8
Subsoil	.6	2.6	3.4	18.2	7.2	27.2	40.7

Mechanical Analyses of Lamoure Clay, Dodge County

Description	Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Very fine Sand	Silt	Clay
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Soil	0.1	0.7	1.1	8.0	7.5	47.9	34.7
Subsoil	.9	1.4	1.0	3.9	4.8	41.5	46.5

The Judson Silt Loam occurs as small areas principally on colluvial slopes at the foot of uplands and terraces in various parts of Dodge (Figure 17), Hall, Polk and Phelps counties and is not subject to flooding. It is of dark brown color, contains considerable humus, and is deep.

There are a number of other alluvial soils in the principal valleys of the Loess Region. As a rule they become more sandy and carry less humus as one goes westward.

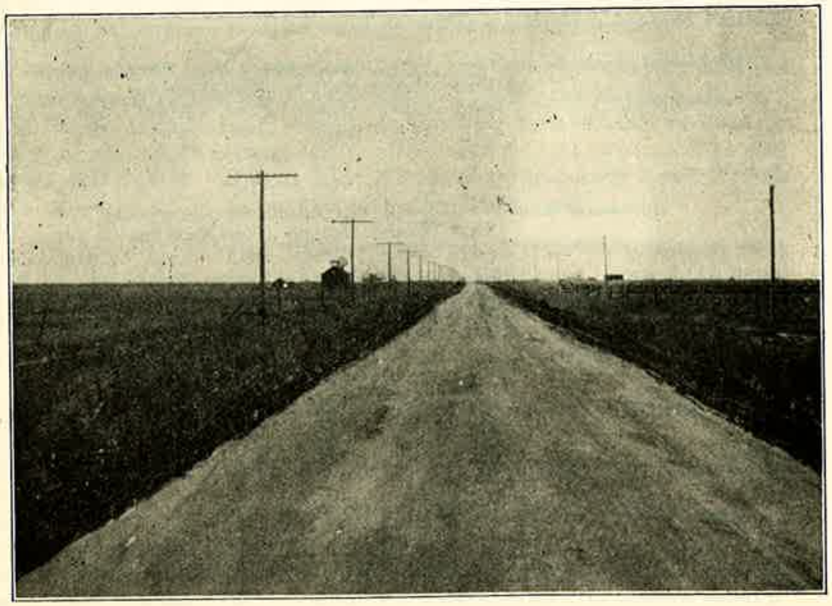

Figure 18. Improved Lincoln Highway Near Grand Island.

Bottom Land Roads—Persons making roads with alluvial materials should do sounding to determine the soil section and textures. The results are unsatisfactory where this is not done and the materials are not mixed in right proportion or the road bed is not surfaced. A patchy condition of road is produced which erodes and wears unevenly. There are, as a rule, sufficient materials along bottom land roads for the selection of textures suitable for the production of relatively good road beds. In some places surfacing material can be secured from the gutters. This, as along the Platte, may be medium to coarse gravel. Small clay areas or silty clay areas may be the source of fine material used to combine with the sand. Much of the soil along the Platte in the extreme western part of the region is well graded and suitable for road work. It is the gravelly sandy loam. There are many miles of alluvial road in the Loess Region. The best-known road is the Lincoln Highway which follows the Platte Valley from Waterloo to Big Springs (Figure 18). Most of this road is in quite good condition except the sandy stretches and the poorly drained places.

THE SANDHILL REGION

This is the most distinct soil region in Nebraska. The topography, drainage, soils and roads are very unlike those of the loess region to the east and the high plains on the west.

The main body of the sandhills, in the north-central and central-western parts of the state, is known as the sandhill region. There are several outlying areas and patches of hills, making in all about 20,000 square miles of hills, basins, valleys, marshes and lakes. (Figure 19).

Land Forms—The classification depends upon the basis used, whether for origin, topography or utilization. Much of the surface of the sandhill country was formed or shaped by wind. The land is nearly all grassed over, making the state's largest prairie area. It is used mostly for grazing (hills) and for hay production (valleys). Some of the valley soil is farmed.

The hills vary greatly in form and size. They are grouped together in most places forming east-west ridges. Some of the hill slopes have been eroded forming pits, called blowouts. The small, irregular depressions between the hills are the basins. The large, well drained lowlands grading upward into the hills and having more or less open courses for considerable distances are called dry valleys. The low-lying, comparatively flat wet land, is known as hay land, wet meadows, or wet valleys. It is modified by many marshes and lakes.

The soils of the sandhill areas are quite sandy as a rule. They correlate very closely with the land forms and are herein described as dunesand, dry valley soils, and wet valley soils.

Dunesand is the typical soil on the sandhills. It occupies about two-

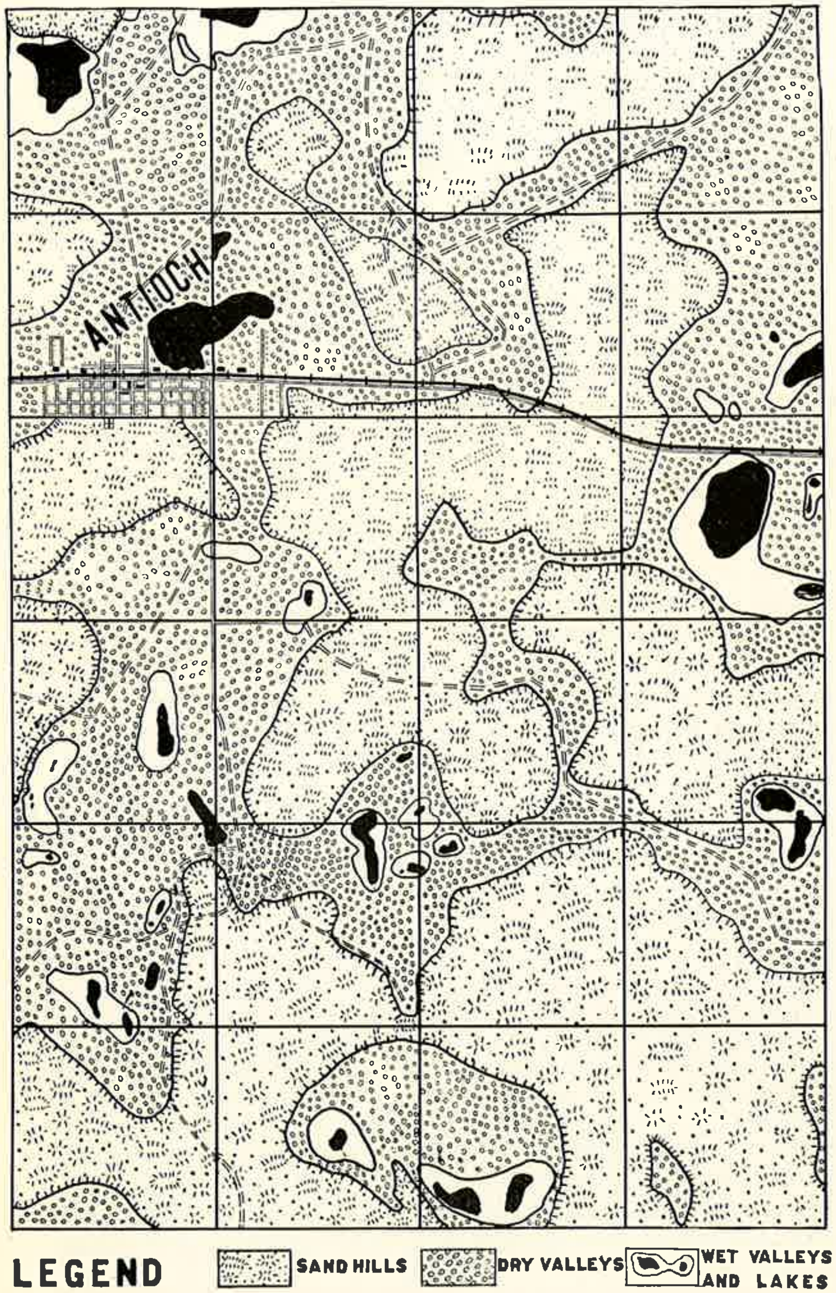

Figure 19.

thirds of the area of the sandhill region. Dunesand is characterized by its mobility, low humus content, and uniform fine sandy texture. There is little difference between the surface soil and subsoil. Both are light gray in color and of loose structure. They contain a very low percentage of silt and clay.

The State Survey classifies the hills under two divisions; namely, first grade and second grade, depending upon the continuity of the grass cover and the amount of blow ground.

The mechanical analysis of dunesand is as follows: Fine gravel, 0%; coarse sand, 0.7%; medium sand, 7.7%; fine sand, 73.7%; very fine sand, 15.2%; silt, 0.7%; clay, 1.9%.

Dry Valley Soils occur on the small basins and dry valleys. They are more stable than dunesand. According to the state and federal surveys, there are four soil types: namely, very fine and sandy loam, fine sandy loam, loamy sand, and sand. These have been described as belonging to the Valentine series. The very fine sandy loam and the fine sandy loam are quite stable, having fairly well defined surface soils. They do not blow badly and are farmed at a number of places. The lighter soils blow some where exposed.

The dry valleys are known as hard lands in contrast to the sandhills proper.

The mechanical analyses of dry valley soils run about as follows:

Valentine Fine Sandy Loam

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	0.0	4.9	11.8	36.5	24.9	13.9	7.7
Subsoil	.0	2.4	5.7	29.6	29.5	17.7	15.1

Valentine Loamy Sand

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	0.2	3.8	11.1	48.3	30.8	9.0	6.7

Wet Valley Soils are on the poorly drained valleys. The largest distribution is in Cherry County, northeastern Morrill, northern Garden, southern Sheridan, and southern Rock counties. Two wet valley soils, the fine sandy loam and the loamy fine sand, have been mapped and classed with the Gannett series. They are composed principally of the finer grades of sand, but contain small amounts of clay and some humus. Small areas of the Gannett soils contain alkali.

The wet land grades into marsh areas, which occur on the seepage sides of lakes. Some of the valleys are nearly wholly occupied by marsh lands which contain a great deal of organic matter. The vegetation of the marshes is unlike that of the wet meadows and very different from the covering on the hills.

Sandhill Roads—Most sandhill roads are trails following valleys and crossing the hills at their lowest and narrowest points (Figure 20). Seepage areas of valleys are avoided, especially when there is most water. Hill and dry valley roads are in best condition after rains. Blow ground is avoided where it is possible to do so.

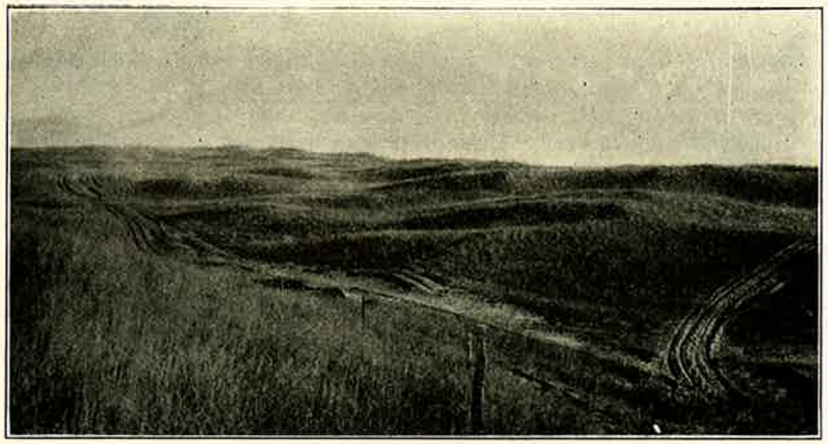

Figure 20. Unimproved Sandhill Roads.

The typical sandhill road follows a crooked course. It might be termed a "snake" road or a "kinky" road. Few roads follow section lines. There are many gates and few culverts and bridges.

Considerable advance has been made the past few years in improving sandhill roads. It has been learned that grading is not feasible, except in a few places where a permanent surface can be made.

Most difficulty is experienced with the loose sand which drifts where it is exposed to the action of the wind. Dry valley and wet valley roads remain in fair condition as a rule without much work.

The roads crossing the loose sands are surfaced with manure, hay, (Figure 21), alkali mud, cinders, or magnesia rock (Figure 22). Very good results have been secured by the use of cinders and magnesia, but the other materials, though more accessible, are only temporary. The cinders are hauled from towns and from the potash plants and the rock is brought from the nearest outcrops. Unfortunately there are few rock exposures in the sandhills.

Figure 21. Hay on a Sandhill Road, Garden County.

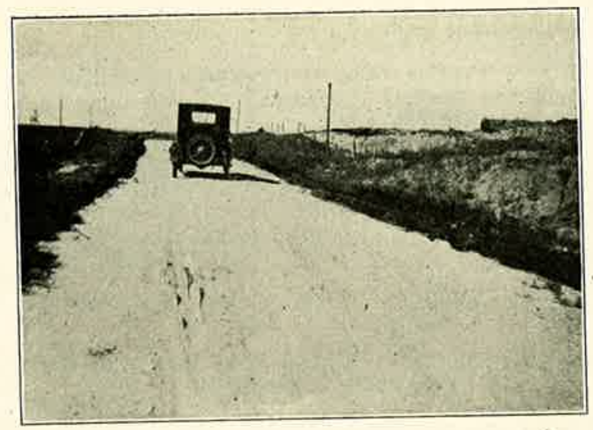

Figure 22. A Sandhill Road Southeast of Alliance, Surfaced With Magnesia Rock.

The runway gates (Figure 23) have come into general use along the principal trails in the vicinity of Hoffland, Antioch, and Lakeside.

THE HIGH PLAINS REGION

This, the most diverse region of Nebraska, occupies a little more than 15,000 square miles of high table lands, rough broken areas, and valleys (Figure 3). It has three names—the Table Land Region, Western Region and the High Plains. The most distinctive feature is the high plains, hence the name now used.

The largest natural subdivisions of the High Plains Region are Perkins Plain, 1,650 square miles; Cheyenne Table, 3,275; Pumpkin Creek Valley, 375; Wild Cat Range, 215; North Platte Valley, 930; Box Butte Table, 2,010; Niobrara Valley, 240 (western part); Dawes Table, 1,368; Pine Ridge, 500; Hat Creek Basin, 390; White River Basin, 800; Springview Table; Ainsworth Table, 305, and Holt Plain, 925. (See Figure 3). These divisions are described in some of the survey reports and in the Geography of Nebraska. The following pages discuss briefly the land forms, soils and roads of each subdivision.

Perkins Table—The subdivision, Perkins Table, (See 1 on figure 3), lies in Perkins, Chase, and Keith counties and northeastern Colorado, but has its most typical development in the northeastern part of Perkins County. It is bordered on the north by South Platte Valley, on the east and south by sandhills and loess areas. The surface varies from nearly level to rough and is modified by a few sandhills.

The soils of Perkins Table are residual and aeolian. They were developed upon the Ogallala Formation. Three leading series are represented, namely, the Rosebud, Dunlap and Valentine. The Rosebud types are grayish to brown, deep to shallow. and underlain by sand or bedrock. Four types are represented, the silt loam, fine sandy loam, sandy loam, and loam. The Dunlap soil (called Dawes) has a heavy upper subsoil. It is best developed in the vicinity of LaMar. The Valentine soils represented by five types are lighter than those of the Rosebud and Dunlap. They show less difference between the soil and subsoil and have a tendency to blow.

Roads on Perkins Table are good to bad. The hard land roads, except on the Dunlap silt loam, remain in fair condition without working. They are quite easily graded and maintained. The Dunlap silt loam becomes rutted and rough when wet, but makes a good road when properly graded and especially so if surfaced with gravel.

The Omaha-Lincoln-Denver Highway (O. L. D.) traverses Perkins Plain between Imperial and Holyoke, Colorado. There is a noticeable difference in the condition of this highway in Nebraska and Colorado and not to the credit of our state.

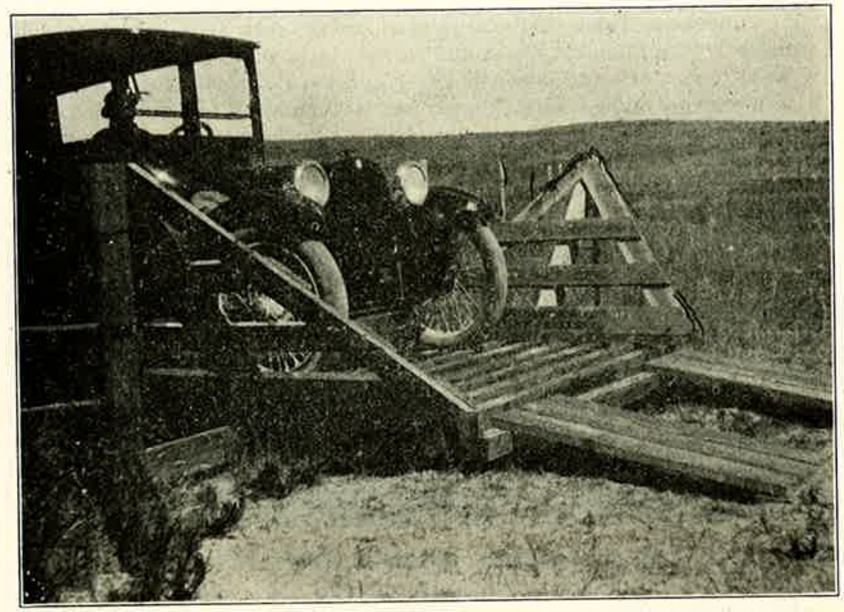

Figure 23. The Runway Gate.

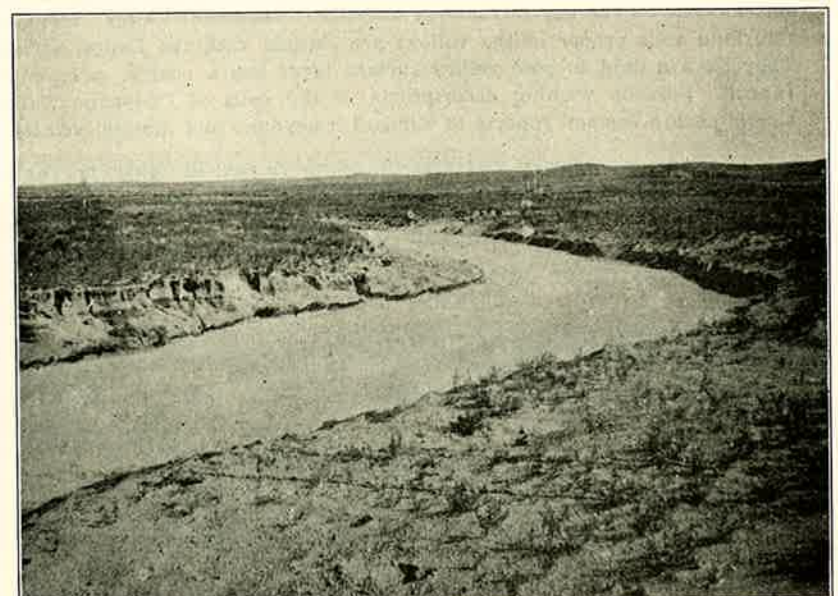

Figure 24. The Sanddraw Which Is a Feature Along the South Platte and the Lodgepole. It Presents Problems in Road Work, But Supplies Good Sand and Gravel.

Cheyenne Table—This large area (See Figure 3) is bordered on the north by the Pumpkin Creek and North Platte valleys and extends southward to and beyond Lodgepole Creek and the Colorado line. The surface is a smooth table land at places, but is undulating to rolling and rough in much of the area. The eastern part, a spur between the Platte valleys, is capped with loess. The rest of the area, except on the valley floors, has residual soils developed upon the Ogallala Formation.

The leading soil series on the table land is the Rosebud, represented by five types ranging between the Rosebud silt loam and the Rosebud gravelly sandy loam. The Kimball county survey classes these with the Sidney series, a name which has been discontinued.

The Rosebud soils are comparatively deep to shallow, depending upon the geographic position whether on slopes or smooth land. The nearly level lands of the table are modified by basins, lined with a heavy soil known as the Scott silt loam. These areas make bad roads if not improved. Unimproved new road on the table are rough, due to black root, called "nigger's wool." Grading and a small amount of dragging keep roads on the Dawes soils in good condition without surfacing.

Some of the steep slopes of Cheyenne Table have stony outcrops which interfere with grading. The slopes, notably those along the Lodgepole, have coarse soils classed with the Cheyenne series. Similar materials occur in many sand draws (Figure 24). Finer textured soils of the Tripp series occur on the low terraces, principally in Lodgepole Valley. The bottom land soils proper of the valleys are classed with the Laurel series. They have a light to pale yellow surface layer and a coarse, calcareous subsoil. Persons wishing descriptions of the soils of Cheyenne Table should secure the soil reports of Kimball, Cheyenne and Morrill counties.

The Lincoln Highway traverses the southern part of Cheyenne Table, passing across the upland between Big Springs and a point just east of Chappell (Figure 25), and following the Lodgepole Valley to and beyond the Wyoming line. The road is well improved much of the distance by using Cheyenne soils for surfacing. Cheyenne Table is crossed by several highways as between Kimball and Scottsbluff, Sidney and Bridgeport, (Figure 26), and Chappell to Oshkosh.

Pumpkin Creek Valley lies between Cheyenne Table and Wild Cat Range and is tributary to the North Platte Valley (See division 3 of figure 3). It is bordered by escarpment-like walls throughout most of its course, (Figure 27), but is more open near the Wyoming line and at the point of junction with the Platte.

Long slopes are a feature of Pumpkin Creek Valley. These slopes are of two kinds,—those formed by the weathering and erosion of the Brule clay and those formed from colluvial materials. The Brule clay slopes are rounded, and billowy. They are eroded in the form of small badlands at a few places. The colluvial slopes, occurring south of the

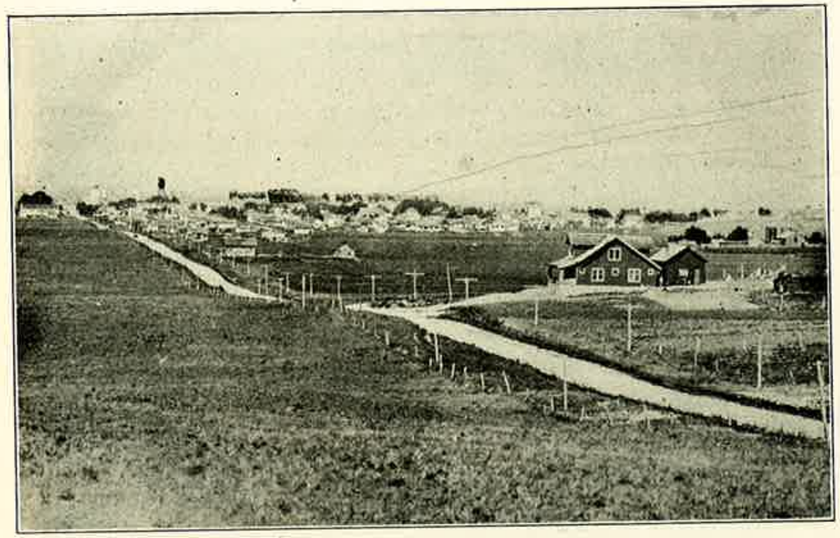

Figure 25. Lincoln Highway Entering Lodgepole Valley, Chappel Showing in the Distance.

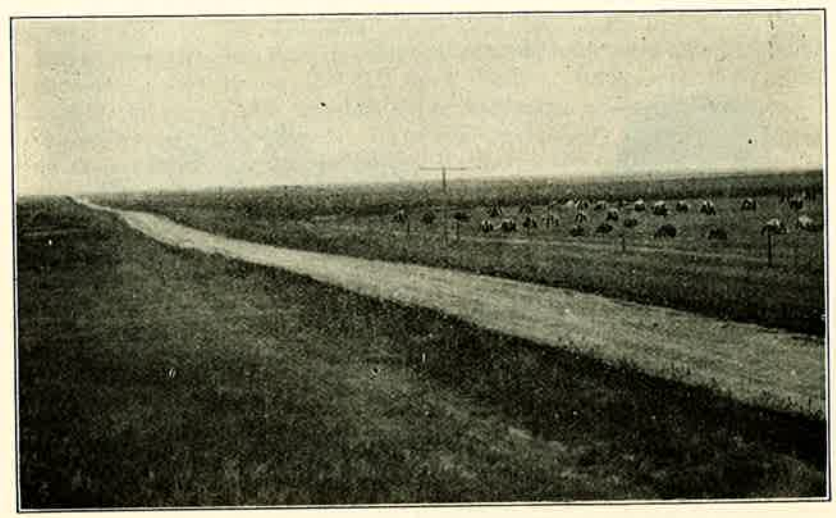

Figure 26. Road on Dalton Table, Cheyenne County.

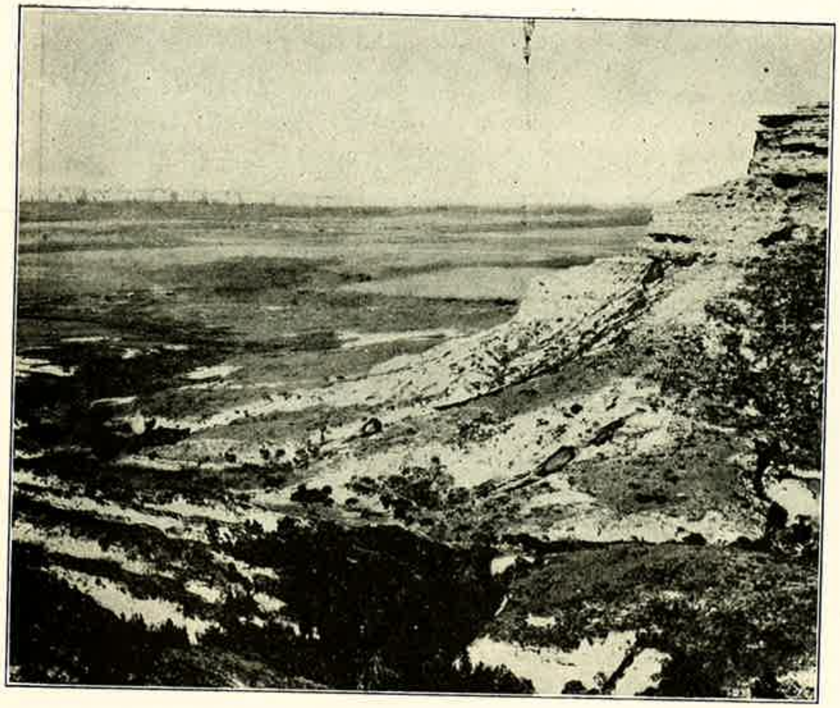

Figure 27. View into Pumpkin Creek Valley From the South.

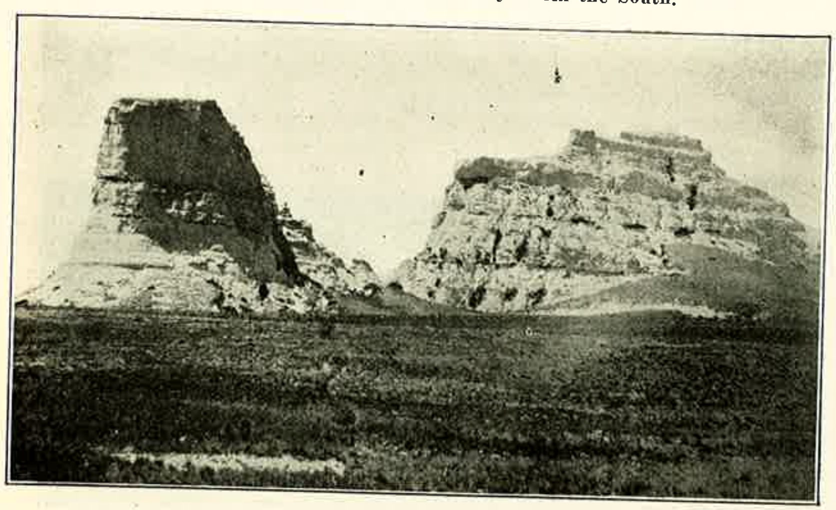

Figure 28. Court House and Jail Rock. The Long Slopes Are Occupied by Epping Silt Loam.

creek and in the eastern part of the valley are comparatively smooth and terrace-like in form. The bottom lands of the valley consist of the flood planes bordering Pumpkin Creek and its tributaries and of low terraces.

There are a number of soils in Pumpkin Creek Valley. Those with large distribution are classed with the Epping, Bridgeport, Tripp, and Laurel series. The Epping silt loam was developed upon the Brule clay. It grades within a short distance from the yellowish brown surface soil to the undisturbed Brule clay. The soils on the colluvial slope are classed with the Bridgeport series represented principally by fine sandy loam and very fine sandy loam, but are modified by small areas having a fine sand texture. These soils drain well and are easily worked, but are subject to blowing where light textured. The roads require surfacing where the soil blows.

The Tripp soils occur on the benches, and range between the very fine sandy loam and fine sand. The drainage is good and most of the soil is suitable for road work except that of light texture which is subject to blowing. The Laurel soils occur on the first bottom of the trunk and tributary streams.

The soils of Pumpkin Creek Valley are described in the reports of Scotts Bluff and Morrill counties and in the Reconnoissance Soil Survey of Western Nebraska.

Pumpkin Creek Valley is not well served with roads. The valley is crossed by the Kimball-Scottsbluff road, and the Bridgeport-Sidney road. These are improved at places.

Wild Cat Range—The mountainous area between Pumpkin Creek Valley and the North Platte has received the name, Wild Cat Range (Division 4 of Figure 3). The area begins near the eastern end of 66 Mountain in Wyoming and extends eastward and southeastward about 50 miles, ending in Court House and Jail Rock south of Bridgeport. The range rises from 400 to 700 feet above the bordering valleys in most of its course, but lowers eastward. Three prominent spurs of the range extend northward and northeastward toward the Platte ending in Scottsbluff Mountain, Castle Rock and Chimney Rock. A prominent spur extending southward ends in Hog Back Mountain and Wild Cat Mountain. Among the prominent features of Wild Cat Range are Signal Butte, elevation 4,583 feet; Bald Peak, 4,420 feet; Scottsbluff Mountain, 4,462 feet; Hog Back Mountain, 5,038 feet; and Court House Rock, 4,100 feet (Figure 28). The range is scenic.

Much of Wild Cat Range is rough broken land thinly covered with grass, shrubs and pines. The less abrupt parts of the area are occupied by the Rosebud stony fine sand and the more gradual slopes by the Rosebud loamy fine sand (Figure 29).

Road building is difficult in Wild Cat Range. The roads follow canyons and across the lowest gaps or divides. The grades are steep, re-

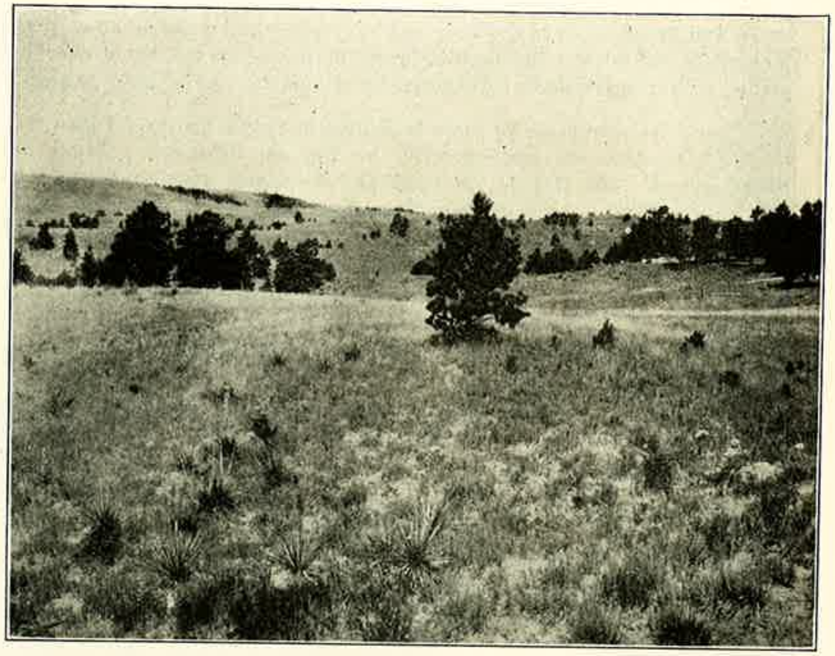

Figure 29. Upper Part of Wild Cat Range Showing Rosebud Loamy Fine Sand.

quiring extensive cuts and fills. Materials are available, however, for good roads.

North Platte Valley—The North Platte Valley is the state's most important irrigation area (Division 5 as shown by Figure 3). The extensive and diversified agriculture requires good roads and an outlet to other parts of the state.

The North Platte Valley is wide in Scottsbluff and the western part of Morrill County, below which it narrows considerably to the point of junction with the South Platte. The upper parts of the valley sides are formed principally of steep, smooth slopes and stony land. Sandhills hug the northside between Oshkosh and North Platte. The rough stony land on the south side gives way below Lewellan to loess bluffs. One feature of the valley is the large terrace on the north side between the Wyoming line and northwest of Bridgeport. A long, gradual bench-like colluvial slope forms the south side of the most of the valley in Scotts Bluff County. The flood plain proper has a considerable area of silt loam to sandy and gravelly soils, part of which is poorly drained.

There are several soils in the North Platte Valley, varying from silt loam to nearly barren slopes of the rough broken land (Figure 30). The

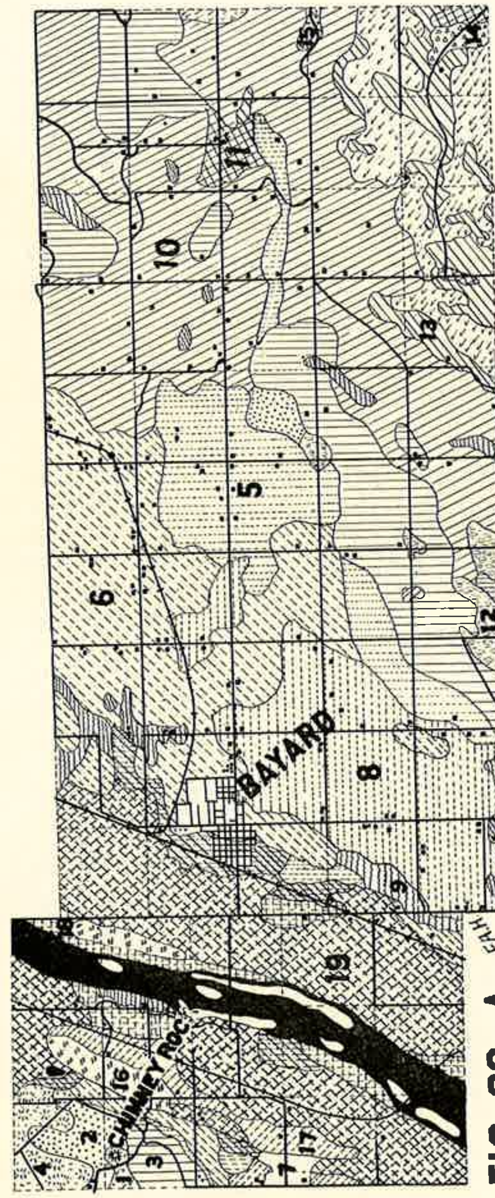

FIG. 30. A

FIG. 30. B

Figures 30-A and 30-B.

soils with largest distribution are classed with the Epping, Mitchell, Tripp, Laurel and Minatare series, which are described in the soil reports of Scotts Bluff and Morrill counties.

Figure 30, part A, shows a strip of soils extending from Chimney Rock northward across the valley a distance of 13 miles. These soils are on steep slopes, the flood plain, bench land and slope land as shown by Figure 30, part b. The soil types of Figure 30, part a, are as follows: 1, rough broken land; 2, Bridgeport loamy fine sand; 3, Bridgeport loamy very fine sand; 4, dunesand; 5, Tripp loamy very fine sand; 6, Tripp very fine sandy loam; 7, Tripp loamy fine sand; 8, Tripp loam; 9, tripp gravelly sandy loam; 10, Bridgeport very fine sandy loam; 11, Rosebud very fine sandy loam; 12, poorly drained areas on bench land; 13, Rosebud very fine sandy loam (shallow phase); 14, Rosebud loam; 15, dry stream bed, a gravelly sandy loam; 16, Laurel loam; 17, Minatare loam; 18, Laurel very fine sandy loam; 19, Minatare silt loam; 20, river wash, not shown by Arabic numerals, but represented by clear areas in Platte River.

The Epping Silt Loam was developed upon the Brule Clay which outcrops in the valley sides forming the long, smooth slopes at the foot of the rough lands. A few areas, as at the foot of Scotts Bluff, have been eroded as small bad lands. The upper soil of the Epping silt loam is light yellowish brown and 5 to 8 inches deep. The subsoil is lighter in color and may not show change in color and texture to a depth of 3 feet or more. The subsoil passes into the compact Brule clay. The Epping silt loam and the underlying Brule are easily worked, but they can be improved as road materials by the addition of sand. There are extensive areas of the Brule clay and its silt loam soil at various places in Scotts Bluff and Morrill counties.

Mechanical Analyses of Epping Silt Loam

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	0.0	0.4	0.7	4.9	34.8	51.9	7.0
Subsoil	.1	1.1	1.2	4.4	34.3	50.8	8.1

The Mitchell Soils consist of light brown or buff colored silt loam and very fine sandy loam covering the terrace-like colluvial slopes as in Mitchell and Gering valleys. They were derived principally from the Brule clay and have been modified by wind and sheet water. The soils are deep, quite compact, friable and easy to work. They contain considerable organic matter in the surface soil and are of light buff color in the lower part. The Mitchell soils are slippery, but not sticky when wet. They are suitable for road grading, but can be improved by mixing with coarse materials.

Mechanical Analyses of Mitchell Silt Loam

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	0.0	0.4	0.4	2.2	18.2	67.1	11.8
Subsoil	.0	.2	.2	2.0	24.9	54.6	18.2

Mechanical Analyses of Mitchell Very Fine Sandy Loam

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	0.1	0.4	2.2	21.5	40.8	26.5	8.5
Subsoil	.0	.5	2.4	21.4	29.2	33.3	13.5

The Tripp Soils occur on the terraces as north of Scottsbluff and Bayard (Figure 30, A) and at Lisco and Broadwater. The range of texture is from loam to gravelly loam. The color of the soil is light brown to yellowish. Six types of soil belonging to this series were mapped in the valley. The gravelly, sandy loam, loamy sand, loamy fine sand, fine sandy loam, very fine sandy loam and loam. The gravelly sandy loam occurs along the edges of the benches. It is coarse, loose and drouthy, but well suited for road work in surfacing most other soil types in the valley. The finer Tripp soils support a considerable part of the irrigation. They are suitable for road building when graded and particularly so when surfaced.

Mechanical Analyses of Tripp Very Fine Sandy Loam

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	2.0	3.5	3.0	8.6	40.3	33.8	8.5
Subsoil	2.8	4.4	4.2	10.9	43.8	27.4	6.7

Mechanical Analyses of Tripp Loam

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	1.2	2.9	4.6	22.3	24.2	23.2	21.4
Subsoil	.0	6	2.2	15.6	26.2	27.2	28.3

The Laurel Soils, represented by the very fine sandy loam and the fine sandy loam, occupy parts of the flood plain and portions of the very low benches. They are quite high in organic matter, of light brown color and underlain by sandy to gravelly subsoil. Though on low ground, the soils drain quite well. The fine sandy loam forms a belt north of the river from Mitchell to the Morrill County line. Both types occur at a number of places in the valley.

The Minatare Series is represented by one type, the silt loam which occurs on the lowest-lying, poorly drained first bottom land (Figure 30,A). The color of the surface soil is gray to grayish brown. The subsoil is a light colored heavy clay. Both soil and subsoil are highly calcareous, and in some places badly alkalied. The most extensive area of the Minatare silt loam extends from along the north side of the river from a point 5 miles northwest of Minatare eastward and southeastward to northwest of Bridgeport. South of the river is an area extending eastward from McGrew into Morrill county.

Large areas of the Minatare silt loam show seepage coming from irrigation on the bench lands, Mechanical Analyses of Minatare Silt Loam

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	0.0	0.2	0.2	1.4	41.4	51.0	5.7
Subsoil	.0	.1	.1	.7	16.5	46.1	36.4

Roads of North Platte Valley—Extensive road improvement is needed in this part of the state. There are enough soil and rock materials for use if properly combined. Advance has been made in road building particularly in the vicinities of Morrill, Scottsbluff, Gering, Bayard, Bridgeport and Broadwater. Many miles of road have been graded to the standard widths and some have been surfaced with gravel hauled from the edges of the bench land and from the sand bars of the river. The beet sugar company assisted with this work.

The North Platte valley was followed in part by the Oregon Trail Roads then sought hard ground and were shifted when the paths became deep as is shown by figure 39. The valley is now connected with the Lincoln Highway by roads leading from Scottsbluff and Gering to Kimball, from Bridgeport to Sidney, from Oshkosh to Chappell and Lewellen to Ogallala. A North Platte Highway should be built up the valley from North Platte.

Box Butte Table—This division lies between the North Platte and the Niobrara (See No. 6 of Figure 3). It is bordered on the east by the sandhill region and is modified at places by small areas of sandhills. The Table is described in the soil survey of Box Butte County. The surface of Box Butte Table ranges from nearly flat (Figure 31) to undulating, rolling and rough. Near the Platte and Niobrara, the surface is roughened by numerous ravines and canyons.

The soils of Box Butte Table are classed with the Rosebud, Dunlap, Yale, Tripp, Laurel and Valentine series. The Rosebud and Dunlap soils are similar to those of Cheyenne Table.

The Rosebud types are scattered generally, but the Dunlap silt loam occurs principally to the west and southwest of Hemingford. It has a brown to dark brown surface soil 6 to 12 inches deep, underlain by a dark brown compact heavy silt loam which passes gradually through a grayish brown heavy silt loam into a light, floury, calcareous silt loam. The type occupies flat areas.

High terraces in the vicinity of Alliance are capped with the Yale silt loam and very fine sandy loam which carry considerable clay. The low terrace of Snake Creek Valley are covered with the Tripp very fine sandy loam.

The Valentine loamy fine sand occurs in the southern and eastern parts of Box Butte County. The principal soils on the bottom land of Snake Creek are the Laurel silt loam and fine sandy loam. They are poorly drained and contain alkali spots.

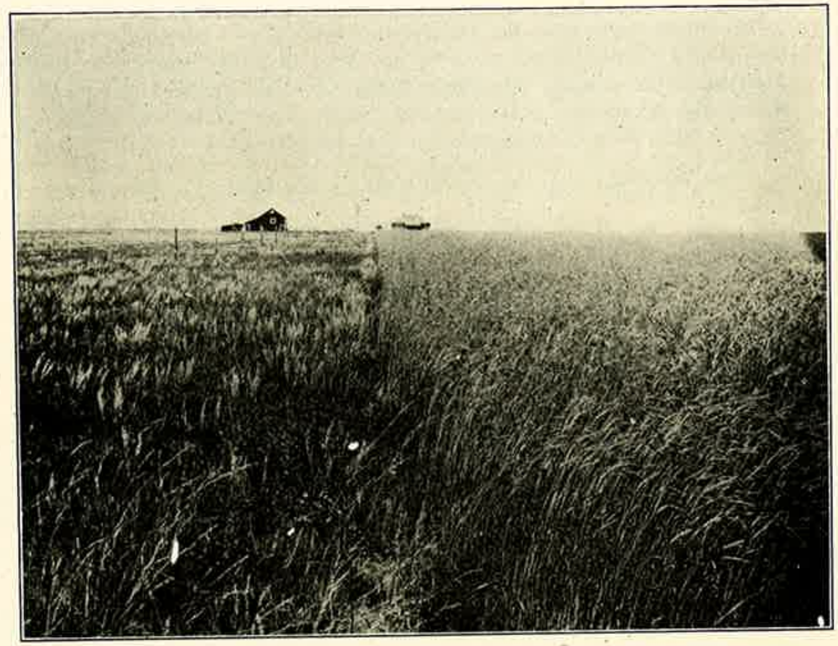

Figure 31. A Typical View On Box Butte Table, Near Hemingford.

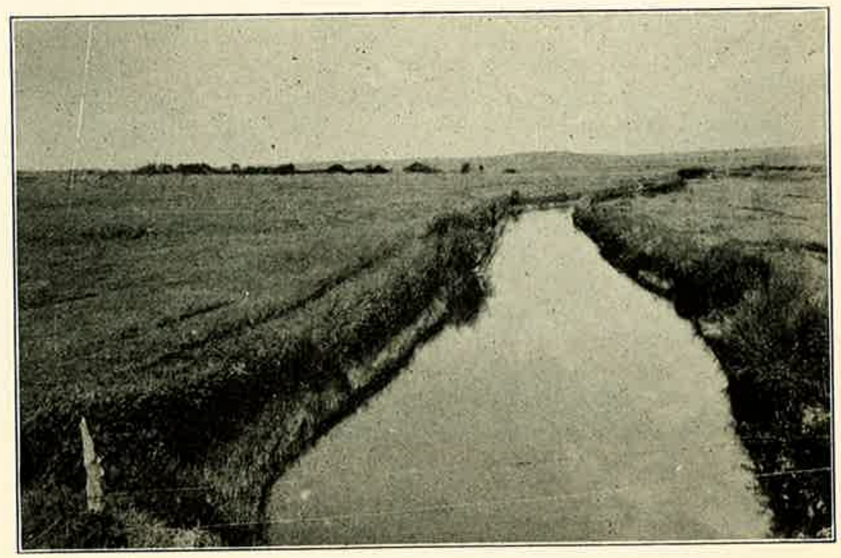

Figure 32. The Open Course of Niobrara Valley Between Box Butte and Dawes County.

Generally speaking, the soils of Box Butte Table are quite well suited for use in roads. Most of them are firm and fine enough to prevent blowing. The Dunlap silt loam makes the best roads. The Valentine loamy fine sand and the dunesands blow quite badly and require surfacing. Magnesia is accessible for this purpose.

The following analyses are of soils on Box Butte Table:

Rosebud Fine Sandy Loam

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	0.2	0.4	1.2	65.6	15.8	13.0	3.7
Subsoil	.6	.4	1.0	72.4	12.6	8.9	3.9

Rosebud Very Fine Sandy Loam

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	0.2	2.4	4.4	41.2	22.2	24.6	5.0
Subsoil	0.1	2.6	4.9	47.4	19.4	15.5	9.9
Lower Subsoil	.4	3.4	5.2	52.3	17.0	10.8	10.0

Dunlap Silt Loam

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	0.0	0.8	1.4	15.0	37.3	34.0	11.0
Subsoil	.1	.4	1.2	12.4	30.0	32.0	23.6

Yale Silt Loam

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	0.1	1.4	2.0	12.6	37.2	32.9	13.3
Subsoil	.0	.6	.6	4.6	37.0	40.4	16.7

Roads have been improved from Alliance to the leading towns to the north, east and south. The Community Club of the city has led in this work.

Box Butte Table is cut off from most other parts of the state by sandhills, hence there is a strong demand for good roads leading out. The Potash Highway has been improved to Antioch. When completed, it will lead through the sandhills past Hyannis and Seneca to Broken Bow and Grand Island.

Niobrara Valley—This valley has three distinct courses or divisions in Nebraska. Two of them separate parts of the High Plains, and the third division is in the northern part of the sandhills. The western course of the valley lies between Box Butte and Dawes tables (See 7 of Figure 3). It is narrow and bordered by rough lands near the Wyoming line, but widens considerably across Sioux, Dawes (Figure 32), and Box Butte counties where there are bold, rounded grass covered slopes and some broken land in which stone is exposed. The soil of largest distribution on the valley sides is the shallow phase of the Rosebud very fine sandy loam underlain with sand and stone. The valley floor is divided between low benches and the flood plain proper. The benches are occupied principally by the Tripp sandy loam and some fine sandy loam. The first bottom soils are the Laurel fine sandy loam and very fine sandy loam. This part of the Niobrara is crossed by roads leading between Crawford and Alliance, Chadron and Alliance and Hay Springs and Alliance.

Mechanical Analyses of Tripp Very Fine Sandy Loam

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	0.0	2.2	3.1	21.3	43.0	22.4	7.6
Subsoil	.1	2.8	4.4	28.2	34.7	12.0	17.5
Lower Subsoil	.1	5.3	8.1	42.2	29.0	5.7	9.0

The sandhill course of the Niobrara Valley is narrow and deep and closely bordered by sandhills and stony land (Figure 33). The lower course lying between Keya Paha and Boyd counties on the north and Brown, Rock, and Holt counties on the south is somewhat wider. The slopes are more gradual and occupied in most of their parts by the Pierre shale which forms a very heavy soil similar to that of the northern parts of Hat Creek and White River basins, but occurring under a heavier rainfall. The unimproved roads on this clay soil become nearly impassable during rainy weather.

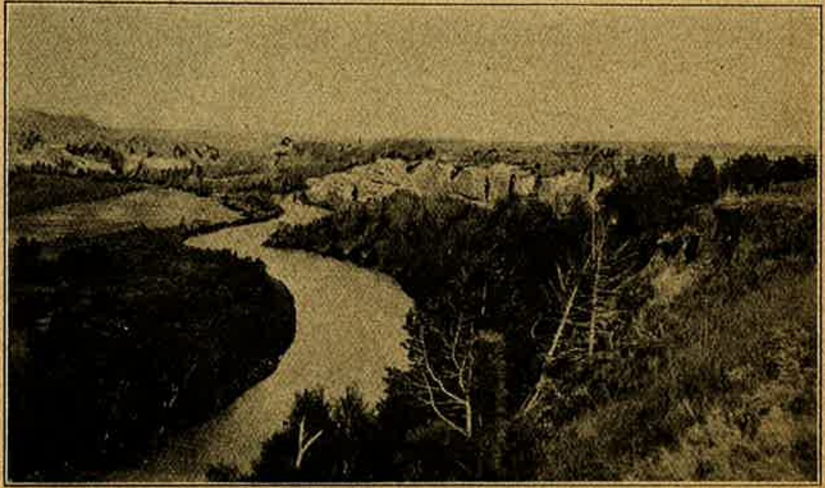

Figure 33. The Beautiful Course of the Niobrara East of Valentine.

The Pierre clay soils extend into Ponca Creek Valley as far as the town of Butte. They occupy much of the northern part of Knox County. **See Figure 3, on which the Pierre in the vicinity of the Niobrara is shown by broken lines.**

Dawes Table—The area known as the Dawes Table extends through Sioux, Dawes and Sheridan counties (See 8 of Figure 3). It is between the Niobrara and Pine Ridge, but is not closely set off from the latter. The surface grades from a typical table in Dawes County to a rolling surface in Sheridan County (Figure 34). Some parts are badly dissected.

The soils of Dawes Table are classed with the Rosebud and Dunlap series and resemble those which have been described in connection with Box Butte and Cheyenne tables. The Rosebud very fine sandy loam is a shallow phase of the type. It occupies much of the rolling land. The Dunlap silt loam is on the flat table.

Figure 34. The Undulating Table.

Roads on Dawes Table remain in fair condition without much work. The soils are suitable for grading and mixing. Roads follow section lines except on the rough land.

Pine Ridge—The name Pine Ridge has been given to a mountainous country of irregular form, which lies in general between the Niobrara, Hat Creek, and White River valleys (See 9 of Figure 3 also Figures 35 and 36). The area was eroded out of the High Plains. The north face of Pine Ridge is very steep at most places. It contains deep canyons, prominent cliffs, and long steep slopes. There are two escarpments or cliff elements in this face of the ridge, one of them lying just below the table land itself, and the other coming down to the borders of Hat Creek and White River basins. There are a number of park land areas between these rougher parts of Pine Ridge.

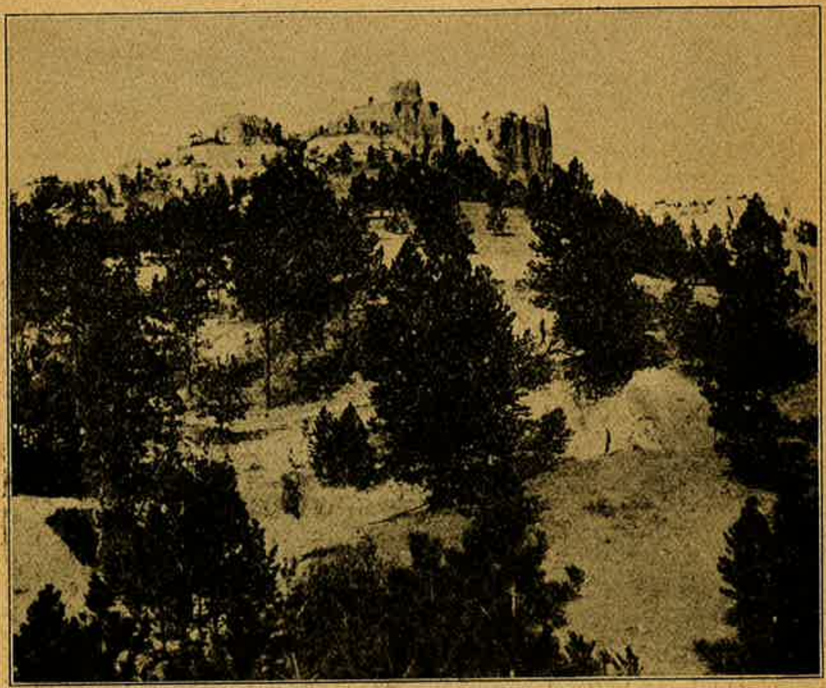

Figure 35. A Pine Ridge View Along Sowbelly Canyon, Sioux County.

Much of the Pine Ridge country is covered with scattered stands of pine trees. The steeper slopes are bare and the more gradual ones are grassed over. Parts of the park land are farmed. Soils range between stony land and the Rosebud very sandy loam. Road building is difficult. The highways follow the canyons in crossing the ridge (Figure 36). Road work requires extensive cutting and filling. There are materials present, however, for road beds and surfacing.

Hat Creek Basin occupies the extreme northwestern part of the state and extends into South Dakota (See 10 of Figure 3). The basin slants away from Pine Ridge. The southern part of the basin is composed of long rounded slopes and of low butte-like forms developed upon the Brule clay. The soil of this division has been classed under two series, the Dawes and the Epping. It is known as yellow gumbo, but is less heavy than the name would indicate. The soil ranges between silt loam and a fine sandy loam.

The northern part of Hat Creek Basin is formed of billowy hills developed upon the Pierre shale. The soils range between clay and a clay loam. They are dark gray to brownish and quite thin at most places, become very sticky and muddy when wet, and hard when dry.

There are few roads in Hat Creek Basin. Highways lead along Monroe, Sow Belly and Hat Creek canyons to the uplands and Harrison and other points on the south and northward across the gumbo lands to Ardmore, South Dakota.

White River Basin is bordered on the south and west by the steep slopes of Pine Ridge (See 11 of Figure 3). Numerous small valleys open to the basin from Pine Ridge. The lower slopes of the ridge, which form

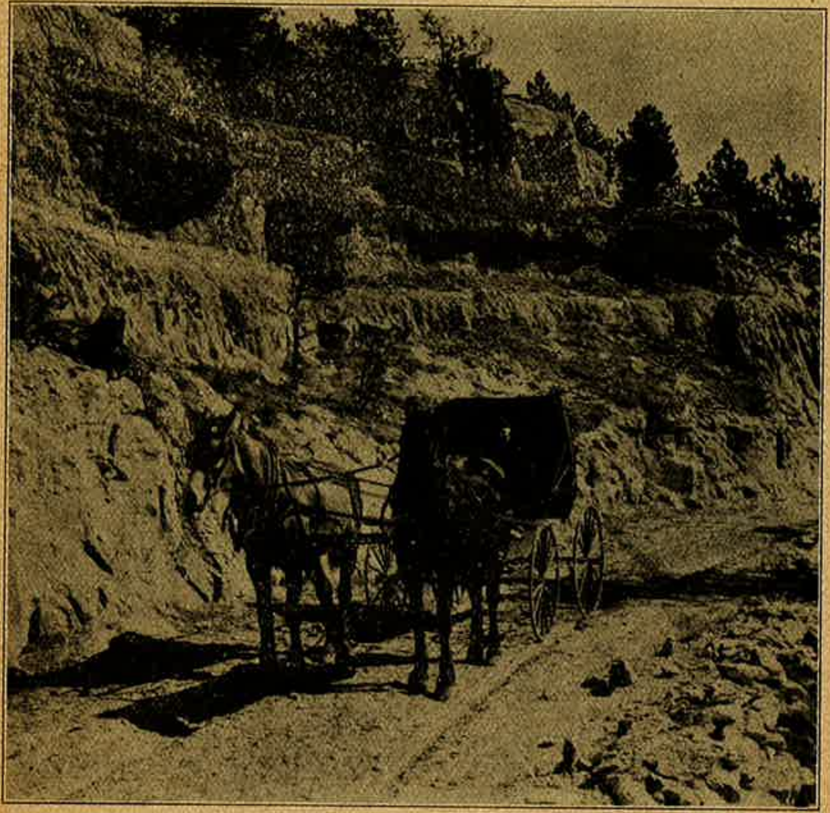

Figure 36. A Pine Ridge Road, Hat Creek Canyon, Sioux County.

the southern and western borders of the basins, are long and billowy. They are largely formed upon Brule clay and part of the soil is classed as Epping silt loam. The more gradual slopes have a deep, silt loam soil with a heavy middle layer. This type is called the Dawes silt loam (Figure 37). The two soils just named form a belt which reaches northward to White River in most of Dawes County and follows northward around the edge of Pine Ridge on the west. These soils become slippery, but

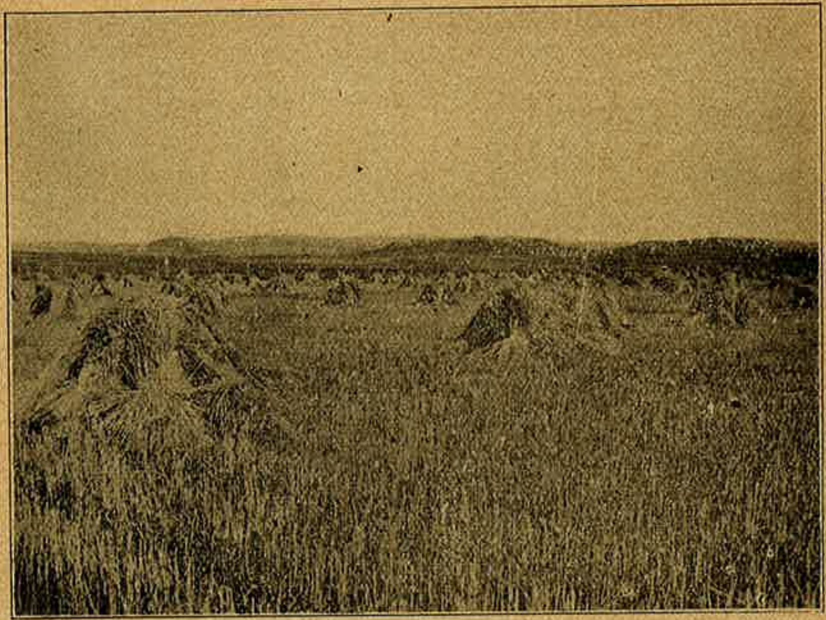

Figure 37. Typical Agricultural View Across the Dawes Silt Loam.

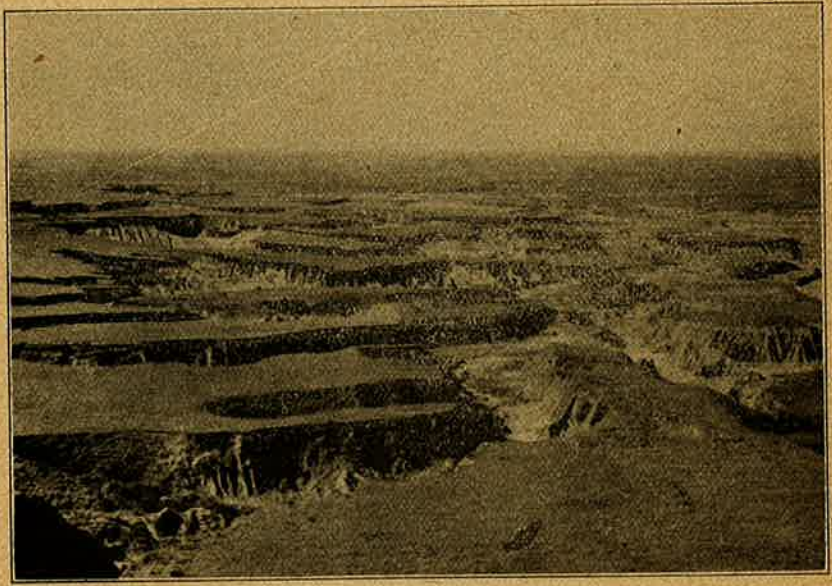

Figure 38. A Small Badland Area, Dawes County.

not very muddy when wet. They are easily graded to make a good road especially when surfaced with coarse materials. A few patches of badlands interfere with roads on the Epping silt loam (Figure 38).

The northern part of White River Basin is the well-known dark gumbo land developed upon the Pierre shale. The wet soil is heavy, very sticky, muddy and nearly impassable. If graded, it makes a good hard road, though quite rough when dry. The mileage of roads in this part of the basin is low.

The valleys of White River Basin have narrow strips of flood plain and bench lands. The bench land soils range between silt loam and fine sandy loam, and serve quite well as road materials. There are several good roads in White River Basin as between Chadron and Crawford, and leading southward from Chadron and Crawford to Dawes Table.

Springview Table—This table occurs in Keya Paha County, but extends a short distance into Cherry and Boyd counties (See 12 of Figure 3). It is spotted, the surface being divided between hard smooth lands, rough broken land, loose sandy soil, and small dunesand areas. Much of the hard land contains gravel at or near the surface. Its roads remain in fair condition without work, but can be improved by grading and surfacing with materials at hand. The sandy areas make bad roads.

Ainsworth Table—This small table is in northern Brown County, nearly surrounded by sandhills (See 13 of Figure 3). The surface is smooth to rough and divided between hard land and small areas of dunesand and Valentine soils. The soil with the largest distribution is the Rosebud fine sandy loam. A small area of silty clay occurs east of Bassett.

Ainsworth Table has a small road mileage, yet some roads are well improved including surfacing. Sand for surfacing outcrops in the vicinity of Long Pine and other places. Hard roads are naturally good and fast.

Holt Plain—Here, in the northern part of Holt County, is the easternmost area of the High Plains Region (See 14 of Figure 3). Holt Plain is quite smooth on the upland proper, but is rough near Brush, Eagle, and Bird creeks. Much of the plain is hard land, but parts are sandy.

The soils with largest distribution are known as O'Neill loam, O'Neill gravelly loam and Valentine sand. A sandy soil, which blows, occurs in the north, northeastern and southern parts of the plain.

The O'Neill loam is a dark gray to brown loam about 10 inches deep, underlain by 10 to 15 inches of light yellowish brown clay loam, below which is a thick bed of sand and gravel The gravelly loam type has a thin surface soil and coarse subsoil. Both types make natural roads. The gravel is a good surfacing material.

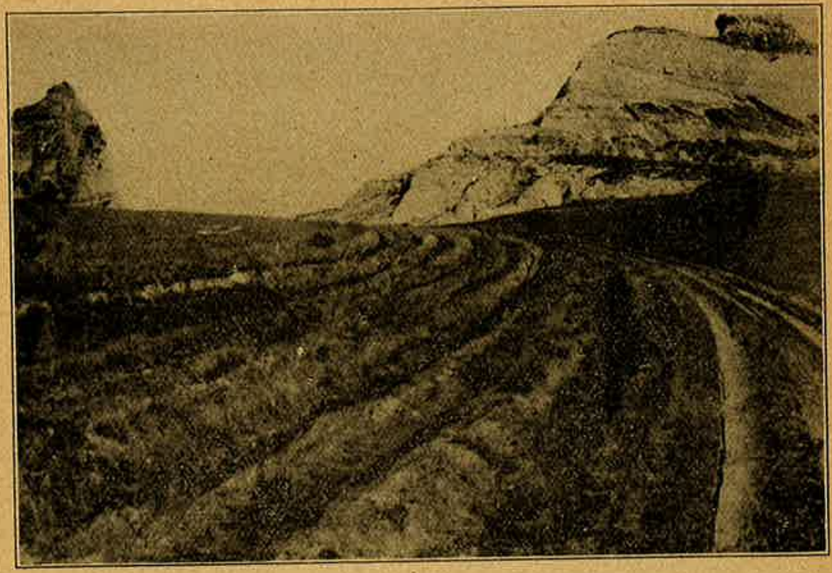

Figure 39. A Remnant of the Oregon Trail, Showing How It Was Shifted On Hard Ground as the Paths Became Deep.

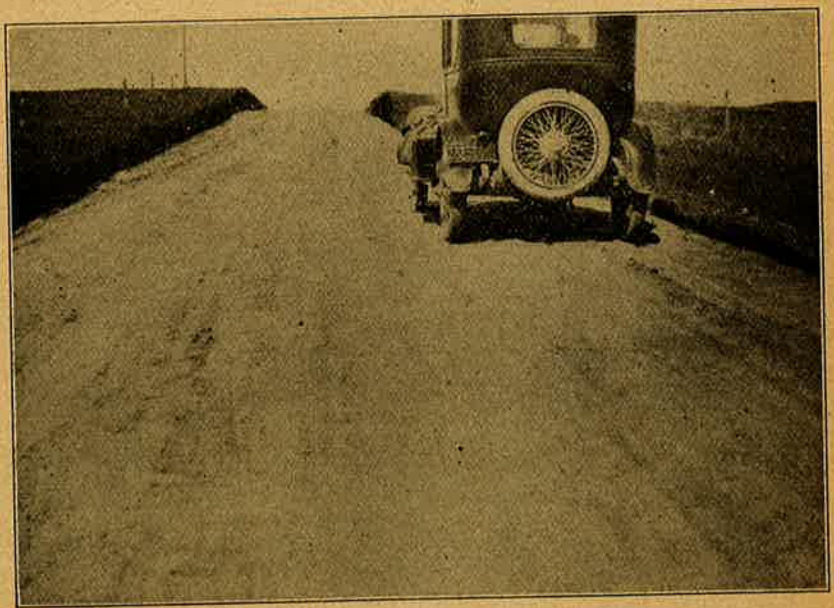

Figure 40. A Stretch of Gravelly Sandy Loam Road, Deuell County.

Mechanical Analyses of O'Neill Loam

Description	Fine Gravel Pct.	Coarse Sand Pct.	Medium Sand Pct.	Fine Sand Pct.	Very fine Sand Pct.	Silt Pct.	Clay Pct.
Soil	.2.4	8.7	8.2	17.1	16.5	29.7	17.[illegible]
Subsoil	1.9	6.8	8.7	16.7	7.2	32.5	25.9
Lower Subsoil	9.7	18.2	16.7	37.5	6.1	4.8	6.5

BUILDING AND MAINTAINING DIRT ROADS

This subject cannot be discussed in full in this connection. Only a brief review of the factors involved in dirt road work will be attempted. Among the subjects to be outlined are surveys, grading, dragging, and road patrol.

Road Surveys—The first thing to do preparatory to the work of construction is to make a road survey. This is a detailed survey including the running of leve's to determine grades, and the preparation of plans and probable costs. Another line of field investigation has importance. It relates to the soil sections, soil types, and such investigations as are necessary to determine the best combinations of soil materials in making a road bed. This requires sounding, collecting samples, and the mechanical analysis of samples. Soundings are made with augers. Samples are collected from each part of the soil section. They are studied by the parties conducting the surveys and by those doing the construction work, but are analyzed to better advantage by the State Conservation and Soil Survey in co-operation with the office of the State Engineer.

In the early history of the state, before the land was fenced and farmed, it was not necessary to survey and build roads. Travel followed the easiest routes and water (Figure 39). The tendency now is to build and maintain permanent roads (Figure 40).

Grading—The term "grade" has two meanings in road work. Among engineers, it means the bringing of a road to grade. This involves cutting and filling. A general usage of the term refers to the making of a road bed, i. e. the placing of road materials. The form thus constructed is generally known as the grade.

Grading is done with scrapers and teams and with tractors pulling elevator graders or blade graders (Figures 41 and 42). The materials are moved from the sides of the roads to the middle, leaving gutters and lifting the bed to a crown. The standard crown in Nebraska is 24 feet wide, with an elevation of 6 inches. The gutter slopes are three to one on the inside and one and a half on the outside. Evidently this should be modified in places to suit the soil conditions. In placing the soil materials in a grade, due consideration should be given to the texture of the soils as shown by the section. This means that an attempt should be made to segregate the upper, middle and lower parts of the soil section and to place them in that position in the road which will produce the best re-

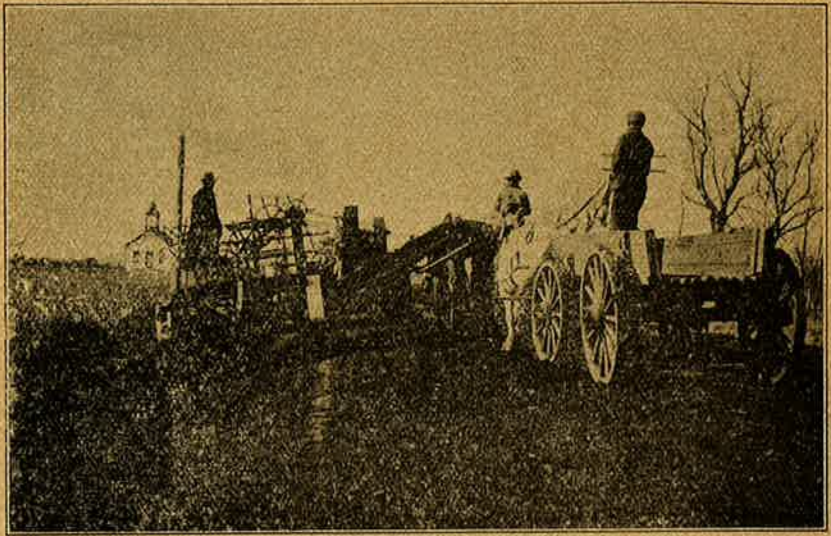

Figure 41. The Elevator Grader.

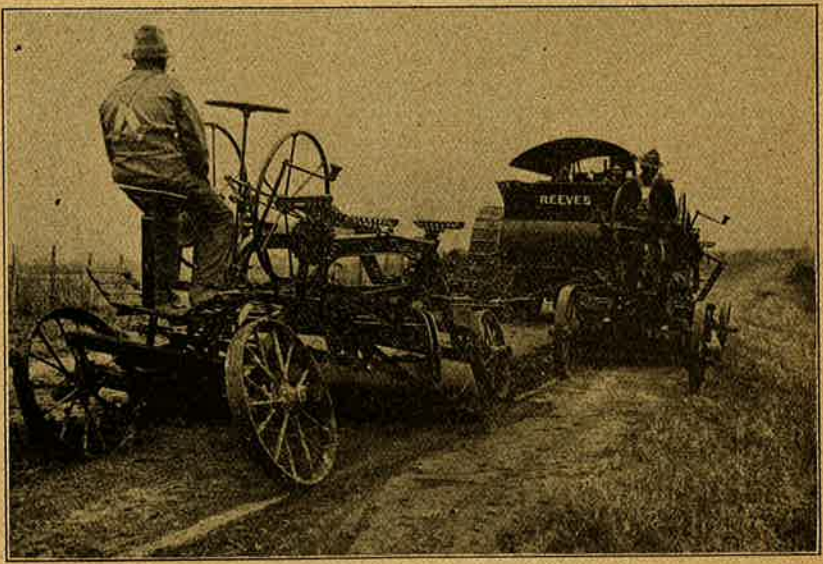

Figure 42. The Blade Grader.

sults. This can be done when an elevator grader is used. The clay pan can be deposited in or near the base of the road and the surface part of the soil can be used to cover or cap the road, or what is better, the sand in the deeper part of the section can be placed on top for surfacing. Though this procedure cannot be followed at all places, it is feasible and possible on certain stretches of alluvial land. The only choice on most roads is in selecting and segregating the soil textures occurring in the different parts of the section encountered in making the gutter.

There are many hill sides in the drift hill area of the state where seepage shows up. Such places can be controlled by cross draining with tile. Low places on flat lands can be corrected by the use of permanent culverts.

The road crown should be changed with the drainage condition. It should flatten on hills and the gutters should be made shallow to correspond. Otherwise, if the same form of crown and shoulder and depth of gutter are carried across the hill the grade is made steeper and erosion is promoted.

Flat land roads crossing alkali soils should be well crowned and guttered to improve the surface drainage which assists in removing alkali from the soil and the road.

It is evident that many miles of Nebraska roads have been graded without enough regard for the soils and drainage. Some roads are left very uneven, a condition which should not be permitted if the traveling public is to be considered. It is particularly necessary to properly place materials in a road bed. If the soil section does not have suitable materials they should be hauled if they are within hauling distance.

The well graded road bed is suitable for the sub-grade of the more permanent road surfaced with concrete, brick, etc. The surveys made for dirt roads will be of use in the permanent roads of the future.

Surfacing—A large mileage of Nebraska roads has been built of soil without mixing. The wearing surface was formed from whatever happened to fall upon the top part of the road bed. This practice and condition can be improved to some extent by segregating the materials brought from the gutters, but the only feasible way to produce more permanent roads to carry travel efficiently all the year, is to make a surface with materials suited for the purpose.

Some roads are clayey. They need sand and gravel and it requires only a small amount to improve the wearing surface, yet it may need a cover 4 to 6 inches deep to produce the best results. The gravel can be hauled in wagons or in dump carts, deposited along the middle of the road, spread with a blade grader when the clay is wet, and disked in. The gravel is taken up by the clay and the road soon reaches a condition in which it is easily maintained and will carry travel under a wide range of weather condition.

Some roads are on silt loam soils. They are in good condition much of the year where the rainfall is light, but become heavy and muddy where the rainfall is heavier, and such roads should be surfaced. They require less sand and gravel than clay roads. The difficulty in much of the state, where roads extend across silt loam soils, is the absence of gravel. About the only supply is in ravines and along the streams. This can be hauled at comparatively small expense.

Sandy roads need both clay and gravel. Ordinarily it is best to cover them with a layer of clay and cap this with gravel if the materials are available. Gravel will improve a sandy soil making it less subject to blowing, but the combination lacks the binding quality produced by clay.

Alkali soils are difficult to handle. Most of them contain fine sandy loam and clay. They need gravel, which if not thoroughly incorporated with the soil, makes a very hard, rough surface. It has been found best in some places to spread a thin layer of sand and gravel when the road is muddy and to harrow or disk this, and to repeat the application when the soil is in a condition suitable for the work.

Dragging—This is an important process in road work. The purpose is to make a road smooth, and compact. Few road subjects have received as much consideration as dragging, yet the work of dragging has not been perfected. Several conditions can be improved. First, the roads can be built to permit dragging over greater distances by a given person or power. As it is, a road crossing stretches of clay, silt and sandy soils is not ready for dragging in all parts at the same time because they dry unequally, making dragged periods of different lengths. The most difficulty is experienced with clay roads which have a short drag period. If the work is not done within a period of about four hours as a rule, when the surface is just right, the best results are not secured. The silt loams and sand loams have longer drag periods and are therefore easier to manage.

The labor and power in road dragging have not been solved satisfactorily. The farmer is often busy with his farm work when dragging should be done and cannot afford to quit for the price received for the road work. Evidently it will not be easy to perfect a system of dragging in which farmers are not engaged. Sometimes a road has been badly cut up by heavy cars or trucks and this condition cannot be corrected by using the ordinary road drag. It can be handled best by using a blade grader or a maintainer pulled by a tractor.

It is safe to conclude that the problem of road dragging cannot be solved satisfactorily until the roads have been made more uniform by surfacing and until the dragged periods are better understood on the various types of roads not surfaced. It will be necessary also to further systematize the work of dragging. Some of the bad effects, such as leaving loose materials in the middle of a road or the building of ridges at the borders of the crown should be prevented.

Planing—This has been called shaving. It has to do with reducing the hard rough places on a dry road.

Clayey and silty roads become knotted and pitted under travel and particularly so by autos. This rough condition of a road bed makes travel disagreeable and unsafe. The road can be made smooth by the use of a planer or a maintainer (Figure 43). The maintainer is suitable also for grading, and for removing snow.

Removing Snow—Nebraska has not done much in the way of removing snow from roads. Kansas, on the contrary, has this work well organized. It is particularly noticeable that the roads of that state are in good condition when the snows are deep and melting. One is able to travel over a dry road bed bordered by deep snow. The snow is removed from the road bed by a simple A-shaped drag drawn by horses, or by a grader, or a maintainer. It is pushed into the gutters where it melts in due time without weakening the road bed. The expense is light compared with the benefits and the removal of snow in this way seems to be a necessary process in making dirt roads more permanent.

Road Patrol—A road is in some respects like a house. It must be looked after to prevent deterioration. So far as Nebraska roads are concerned, there has been too much building in proportion to the maintenance. The old adage, "A stitch in time saves nine," should be applied to roads.

If a road should be built, it should be maintained in good condition

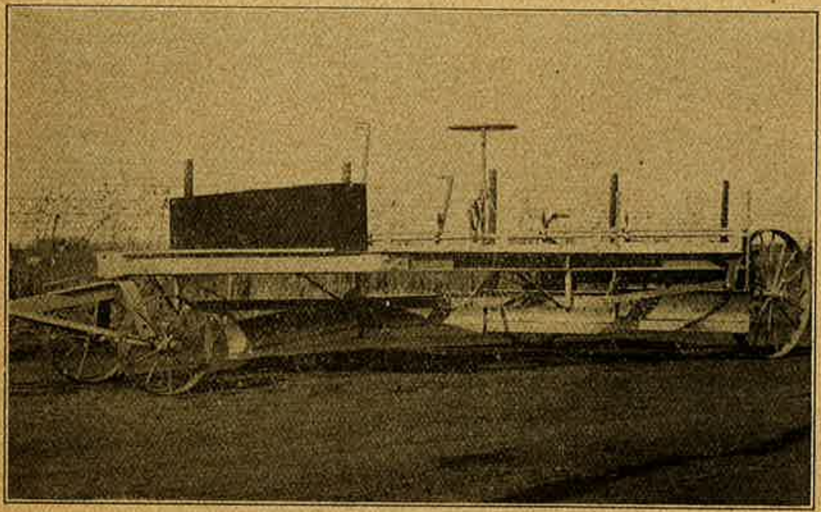

Figure 43. The Highway Maintainer Has Blades Which Can Be Adjusted to the Form of the Road in Grading, Dragging and Removing Snow.

to serve the traveling public. This means patrol, which should cover the following:

(1) The repair of ruts, holes, and small sandy spots.
(2) Inspection and supervision of dragging.
(3) Inspection of grades and bridges.
(4) The prevention of damage to wet roads by heavy trucks and autos. This will require legislation.
(5) Placing danger signs at caved banks, damaged grades, and damaged bridges
(6) The inspection and prevention of flood damage to road grades and bridges.