THE GRASSLANDS OF NORTH AMERICA

by

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Preface

The material in this thesis was gathered from many books, pamphlets and government bulletins. No great new truths or principles are offered in this thesis. It is strictly on account of the great grasslands of the North American continent, their formation, the ecological relations of the plants found there, and their economic value.

There are many books and articles dealing with various phases of the prairies in this country. Few or none, however, deal with the subject in the light of proper utilization. Cheap feed, as furnished by the grass areas, is the foundation of the stock industry. Therefore an attempt has been made to cover the grass areas mainly from the stockman's point of view.

This study was carried on in the school of Forestry and the Department of Botany, under the direct supervision of William E. Lawrence, professor of plant ecology.

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Origin of the Prairies

During the Cretaceous period the Gulf of Mexico is commonly believed to have extended inland as far as Texas, Colorado and Kansas. This period marked the beginning of the flowering plant stage with its bees and butterflies. The country then was low and swampy with a humid climate. There were no mountain ranges on the west side of the continent; that part was submerged. Gradually the eastern and western shores slipped under the oceans and the waters of the Gulf of Mexico spread up through the center of the continent until they joined the waters of the Arctic. (8)

The most accepted theory is that gradually, toward the close of the Cretaceous period, the land mass was raised and the water drained back into the Gulf of Mexico. At this stage the Rocky Mountains were in the form of a delta, low and swampy. Erosion wore down these raised lands and filled the lower areas until the prairie region became a low swamp, capable of supporting hydrophytic plant life.

Once more the central part of the continent became land, but the Gulf of Mexico remained much larger than it is at present. There were coral reefs in Georgia, and a temperate forest covered Alaska and Greenland. Asia,

Alaska and Greenland were connected and both animal and plant life passed freely between them. This was the Tertiary period in the earth's history. (12)

The Eocene epoch presented a new picture. The mammals supplanted the giant reptiles. Grasses were beginning to appear; the vegetation was modern in character and the forest trees of today were well represented. (8)

During the Oligocene epoch the Rocky Mountains began rising, and as they rose the sediment washed down into the swamps and bogs of the low inland area until they were filled. Slowly the Rocky Mountains were pushed higher and higher until they began to cut off the moisture-bearing winds from the ocean. The western slopes of the long range of mountains received the moisture that previously had been spent on the Great Basin. With a decreased rainfall the trees could not exist. The grasses which had been growing in the shade of the trees were liberated and they soon took over the entire semi-arid valley. (12)

This marks the beginning of the prairies as they are today; long, endless stretches of grass bounded only by the horizon. This immense grass area covers approximately one-third of the continent of North America, and reaches from Canada to Central America, the main body lying in the United States.

Map of the Grass Areas of North America

This map is a composite representation of the grass areas of the North American continent. An effort has been made to locate as accurately as possible each area large enough to be of economic value. No one map was found which showed the grass areas of the continent in their entirety. There are several maps in existence which locate the areas for the different nations on the continent, but no two maps showed the boundaries alike. Therefore some of the better and seemingly more accurate maps were used, supplemented by general reading, to make this particular map.

The areas in Mexico and Central America were located mainly from vegetation maps taken from Clements' Plant Indicators (14), and the Naturalists Guide of the Americas (15). The eastern boundary of the prairies in the United States was taken from the Atlas of American Agriculture (56), supplemented by general reading. The western boundary was taken from both the Atlas of American Agriculture (56) and Plant Indicators by Clements (14), and supplemented by general reading from several United States Department of Agriculture bulletins. The Canadian boundary was taken mainly from general reading and the Naturalists Guide to the Americas (15).

Boundaries of the Prairies

In determining the boundaries of the North American prairies the vegetation maps of several U.S.D.A. bulletins and text books were used. The two most helpful publications were "Atlas of American Agriculture," U.S.D.A. Advance Sheets 6, 1924 (56), and "Plant Ecology," Weaver and Clements (68).

The prairies of North America are bounded in the main by a line which begins just below Lake Manitoba and Lake Winnipeg in Canada and extends to the Saskatchewan river, thence over into Alberta just south of Edmonton, and follows the boundary between British Columbia and Alberta down to the international boundary at about the 114th meridian. From here it roughly follows the east part of the Lewis Range of mountains through the west half of Montana; leads around the east side of the Big Horn mountains in Wyoming; skirts the foothills of the Rocky Mountains down through the center of Colorado and New Mexico, and follows the highlands through Mexico on into Central America to the Panama Canal. The east and west boundaries in Mexico and Central America thin out and disappear in the lower elevations toward the coasts.

The eastern boundary is less distinct. It follows along the coast of the Gulf of Mexico into Texas and swings

northward through the center of the state; cuts through the eastern corner of Oklahoma, the northwest corner of Missouri; swings eastward and takes in the whole of Illinois to Lake Michigan; swings westward along the eastern boundary of Iowa, diagonally across the state of Minnesota and then along the eastern edge of North Dakota to the international boundary. From just west of the Lake of the Woods the boundary runs across the southern part of Manitoba and back to Lake Manitoba and Lake Winnipeg in Canada.

In Canada the prairie continues in three belts running in a northwesterly direction from the international boundary beginning just west of the Lake of the Woods on the eastern edge and in the foot hills of the Rocky Mountains on the west, and running to the North Saskatchewan river on the north. The ground rises gradually from an elevation of about 750 feet in the Red River valley to about 4,500 feet in the foot hills of the Rocky Mountains. (15)

The prairies should not be confused with the plains east of the Mississippi which are strictly man made. This area was covered with trees until the pioneers began their migration westward. They believed that if a soil could not support trees it could not be expected to raise a crop of wheat, so immense areas of land were cleared of timber to make room for grain. (30)

Why the Prairies are Grassy

It is generally believed that the following climatic theory best accounts for the grass covered prairies of North America. The prevailing winds of North America originate in the Pacific ocean and with their load of moisture sweep eastward until they contact the west slopes of the Cascade and Sierra ranges. In order to pass these mountains the winds must rise, and as they gain elevation they come in contact with the cool upper strata of air. The power of air to hold moisture depends upon the temperature of the air, the warmer the air the greater the absorbing powers (65), consequently when the rising winds become cooler their carrying capacity decreases and the higher they must rise the cooler they become until their load of moisture is deposited on the west slopes of these mountains. (40)

The cool winds top the crest of the Cascades and Sierras and race down the other side. As they lose elevation they become warmer, and as they become warm their moisture holding capacity increases materially. They sweep across the great basin between the Cascade-Sierras and the Rocky Mountains hot and dry. They absorb such moisture as is available and leave behind the parched states of Arizona, Nevada, New Mexico and parts of Colorado.

Again the winds rise as they strike the slopes of the mighty Rockies, and in rising cool and deposit their moisture on the west slopes. Pouring down the other side, they lose elevation, become warmer and increase in moisture holding capacity. Like a huge dry sponge these winds sweep over the already parched land. There are no land masses to "squeeze out" this moisture. The famed "furnace" winds of the middle west have a clean sweep to the highlands east of the Mississippi River. Here they are once more forced to rise and automatically release their moisture. (40)

Cowles (18) states that in one sense it would seem that the presence of prairies may be due in part to factors operating at the present time and in part to the influence of cumulative soil factors operating through past centuries; that the evolution of a prairie soil through the influence of prairie vegetation favors the persistence of the prairie and that the evolution of a forest soil through the influence of forest vegetation favors the persistence of a forest.

It is usually conceded, however, that trees cannot grow on the prairies because of insufficient moisture and high evaporation. In the summer they are subjected to long hot dry spells, and in the winter the winds are cold and desiccating. There is seldom any snow to act as a protect-

ing blanket and the rainfall usually is scant, and in the early spring, with a frozen ground and high transpiration the tree finds little encouragement for development.

The grasses, because of their ability to become dormant during the two critical periods of a hot dry summer and a cold dry winter, are better suited to the prairies. During the long dry summers the aerial portions of the grass die down and only the roots remain alive. With the fall rains growth is resumed until another critical period is reached, usually in the winter. Again growth is resumed with the early spring rains and continued until conditions are unsuited for further development.

The Units of Prairie Vegetation

At first sight the prairies of North America seem to be a complex, intricate, and apparently endless variable cover of grassland. Careful study, however, will reveal that the cover consists of a strikingly few distinct groups. Further study will reveal that each group is characterized by only one or a few really important grasses.

According to Clements (68) vegetation responds by its distribution into groups, each of which is in close equilibrium with its particular climatic complex. Vegetational forms, because of these variations, have been grouped into the following classification.

1. Formation
2. Association
3. Associes
4. Consociation
5. Consocies
6. Society
7. Socies
8. Family
9. Colony

The Formation. The plant formation is the major unit of vegetation. It is a fully developed or climax community of a natural area in which the essential climatic relations are similar or identical. It is essentially a product of the climate and is controlled by it. (68)

The character of the climax of the formation is revealed by the dominants or controlling species of which it consists. All these belong to the same vegetation-form,

which represents the highest possible type under the prevailing climate. In grasslands, the climax dominants are grasses or sedges; in forests, they are trees; and in chaparral, shrubs. (68)

In delimiting climates and climaxes, the plant is the ultimate criterion, and climatic measurements must be interpreted in terms of plant growth.

The Association. Climax formations consist of two or more subdivisions known as associations. These are climax communities associated regionally to constitute the formation. For example the true prairie in the best watered area, mixed prairie in the region of intermediate rainfall, the short grass plains in drier areas, and desert plains in the very arid southwest are each an association. Each is a climax community in its particular area and is a unit of the major formation. The association is similar throughout its extent in physiognomy or outward appearance, in its ecological structure, and in general floristic composition.

The Associes. The associes is the developmental equivalent of the association. This name is used where the community is not permanent, but is replaced by another in the process of development or succession. An example of an associes is a community of cattails, bulrushes, and reeds in a swamp. This is only a temporary stage of development,

because as the pond shallows they will be replaced by other kinds of plants.

The Consociation. Every association consists of several dominants, each of which constitutes a consociation. The true prairie (Stipa-Sporobolus) association comprises the following dominants: needle grasses (Stipa spartea and S. comata), dropseed (Sporobolus asper), June grass (Koeleria cristata), wheat grass (Agropyron smithii), and little bluestem (Andropogon scoparius). Any of these may dominate an area more or less exclusively or at least to such an extent that it is more important than any of the others. Thus, within the true prairie association there occur wheat grass, needle grass, etc. consociations.

The separation of the dominants into consociations may be caused by several minor factors some of which may favor one dominant more than the others. Sometimes an area is successfully held against all invasions of other plants though the area is suited for all of them.

The Consocies. The consocies is a consociation in a developmental stage. The reed swamp may be used as an example. In a reed swamp Typha, Phragmites and Scirpus may be intermixed, but as a rule each occurs as a consocies in definite areas, the bulrush usually in the deepest water and the reeds in the shallowest. Sand-binding grasses on

dunes which are being forested furnish examples of associes with their consocies.

The society. A society is a community characterized by one or more subdominates. A subdominate is a species which is dominant over a portion of an area already marked by the dominance of consociations and associations. Thus the society is a localized or recurrent dominance within a general dominance. In grassland societies are usually conspicuous for only a short time during an especially good growing season.

Societies may not be confined to a single consociation, but may occur over wide stretches wherever development or physical factors warrant. An example of a society are the Poaceae, Erigeron and Amorpha which spring up at certain periods of the year, but soon die down and leave the permanent grasses in control.

The socies. A socies is a temporary subdominate. Ruderal weeds usually form socies. In other words a socies is a society in the formation.

The Family. A community made up of individuals belonging to the same species is termed a family. The family is usually in a small unit and is especially typical of early stages of development, it is rarely found in stabalized vegetation. A community of ragweeds, sunflowers and stinging nettles is an example of a family.

The Colony. Two or more species growing together during an early stage of development is said to be a colony. If two or more invaders populate a bare area the community is a colony; if only one, it is a family. A clean field of corn represents a family, a weedy corn field represents a colony. Both family and colony are developmental and no corresponding climax units occur.

Types of Grasslands in the United States

Grass is the climax formation on the savannahs and pampas of South America, on the veld in Africa, on the steppes of Russia, Siberia, China and Manchuria, on the semi-deserts of Australia and New Zealand, and on the great plains and prairies of North America.

Shantz and Zon recognize seven distinct types of grasslands in the United States. (56)

1. Tall grass, or prairie grasslands.
2. Bunch grass, or Pacific grasslands.
3. Short grass, or plains grasslands.
4. Mesquite grass, or desert grasslands.
5. Mesquite and desert grass, or desert savanna.
6. Marsh grass, or marsh grassland.
7. Alpine meadow, or Alpine grasslands.

Tall grass, or prairie grasslands. Tall grass is characteristic of the prairie region of the Mississippi valley, and small isolated areas in some of the eastern states, and along the Gulf of Mexico. A large variety of non-grass plants grow along with this cover of tall grass, making a never-to-be-forgotten picture in the early spring.

The 20-40 inches of rainfall for this region comes mostly during the growing season, and penetrates the deep rich soil from about two feet in the drier sections to

ground water in the more favorable areas. Except for the eastern edge the subsoil of this area is permanently moist. Late in the summer the moisture supply fails and the area becomes dry and parched. It is at this stage that fire is so often set to the dry grass, and the flames lick the ground bare until they are stopped by the low and more moist areas. These swampy areas support a heavy cover of sedges which provide an effective fire break. These periodic fires help to explain the absence of trees on the prairies today. Each year these fires run through the tall grass destroying any tree seedlings which might have become established, and pushing the forest edge back with each succeeding season. Most of this area is now under cultivation.

The corn belt, perhaps the richest farm land in the United States, lies within this region, covering the states of Illinois, Iowa, eastern Nebraska, Kansas, Missouri, and the Dakotas.

In Texas and southern Oklahoma cotton thrives on these prairie soils.

The tall grass vegetation is divided into three subdivisions.

1. Bluestem sod grass (Andropogon spp.)
2. Bluestem bunch-grass (Andropogon spp.)

3. Needle grass (Stipa spp.) and slender wheat grass (Agropyron spp.)

The bluestem sod grass is the most extensive and covers the biggest part of Illinois, Iowa, eastern Kansas, also parts of Missouri, Oklahoma, Texas, western Minnesota, eastern North Dakota, South Dakota and Nebraska. The dominate grasses are bluestem (Andropogon furcatus), bunch grass (Andropogon scoparius) and Indian grass (Sorghastrum nutans) and several other species of less importance.

Bluestem sod grass gives way to the bluestem bunch grass towards the west. In central Kansas and Oklahoma these two types are found mixed forming a transition zone or line of demarcation between the tall grass type and the short grass type from Nebraska to Texas. In this area the annual rainfall is from 20 to 30 inches which penetrates from 2 to 4 feet into the soil. Below this the subsoil is permanently dry. (56)

North of the bunch grass a sod forming needle grass takes over the area. The rainfall here is even less than in the bunch grass, averaging from 18 to 30 inches annually, but the evaporation is less and the moisture penetrates deeper into the soil. This region lies in Nebraska, the Dakotas and Minnesota, and is the greatest spring wheat region in the United States.

East of this area the land is low and swampy and covered with sedges, rushes and coarse grasses. This is the sedge prairie and consists primarily of (Calamagrostis canadensis), reed canary grass (Phalaris arundinacea), slough grass (Spart michauxiana), sedges, rushes and semi-aquatic herbs.

At the western edge of the bluestem bunch grass area and out into the short grass region in South Dakota, Nebraska, Colorado, Kansas, and Texas large sand hills occur. These are covered with either bunch grass or sand sage (Artemisia filifolia) and sand grass (Calamovilla longifolia). The moisture supply here is less than on the bunch grass area, but the cover is more open and the soil loose and friable.

Areas similar to these are found in Texas, Oklahoma and New Mexico, but they are covered mainly with bunch grass and shin oak (Quercus havardii) which seldom get over three feet high and form a transition between the bunch grass and the southern shrub type.

The coastal prairies on the Gulf of Mexico consist primarily of water grass (Paspalum sp.), switch grass (Panicum virgatum), broom sedge (Andropogon glomeratus), (A. saccharoides), and bluestem (A. furcatus). These species are able to persist in a wet, boggy soil. Cotton and rice do well on this land, and it is used to some extent for grazing. (86)

Bunch grass, or Pacific grasslands. The bunch grass type covers chiefly the western states--California, Oregon, Washington, Idaho, Montana and Nevada. Extensive areas are found in California, Oregon and Washington especially in the Palouse regions where it seems to thrive best.

The bunch grass association is found throughout the northern Great Basin just below the pine belt on the timbered slopes. The moisture in this region ranges from 10 to 25 inches with only parts of this falling during the growing season. This explains the bunched characteristic of the grass. With a higher percentage of moisture they would form a turf. (66)

This association also occurs in Arizona, New Mexico, Colorado and Utah, but only becomes economically important in Oregon, Washington and California where it furnishes valuable forage. Even in these states it is being rapidly killed out by overgrazing and careless range management.

The bunch grass association may be separated into three subdivisions or consociations. (66)

1. Wheat grass--sod forming
2. Wheat grass--bunch forming
3. Stipa-Poa--bunch forming

In eastern Oregon and Washington where the rainfall averages from 15 to 25 inches annually the wheat grasses are

ble to form a sod, composed mainly of wheat grasses (Agropyron spicatum), little bunch grass (Festuca idahoensis), blue grass (Poa sandbergii), and balsam root (Balsamorrhiza sagittata).

In the western part of this area the rain averages about 15 to 20 inches and the grasses assume a bunch formation. The cover consists of wheat grass (Agropyron spicatum) and blue grass (Poa sandbergii), which forms a transition zone between the wheat grass sod formation and the sagebrush desert. (56)

When the Americans settled into the great central valleys of California they found scattered stands of oaks with the area between occupied by weedy vegetation consisting mainly of bromus (Bromus rubens, B. hordeaceus, B. tectorum), filaree (Erodium circutarium), wild oats (Avena fatua and A. barbata), fox tail (Hordeum murinium), bur clover (Medicago hispida) and many others of lesser economic value. The Spanish had already greatly reduced the once fine cover of Stipa-Poa bunch grass by overgrazing.

California poa (Poa scabrella) and California needle grass (Stipa pulchra) apparently had made up the biggest part of the original grass cover. These grasses, due to overgrazing, gave way to the wild oats and bur clover, these in turn to filaree and fox tail, and finally to red brome (Bromus rubens). At present this grassland is charac-

terized by weedy annuals which for forage are a poor substitute for the former cover. (56)

Short grass, or plains grasslands. The short grass region lies between the 100th meridian on the east and the foot of the Rocky Mountains on the west. Moisture is the limiting factor in this area, the annual rainfall averaging between 12 to 22 inches. This causes the grass to be low and shallow rooted. The growing season is about 90 days, and there is no storage of moisture in the soil to prolong the growing season. The growing season for the main species varies from 100 days for the grama grass in the north to 40 days for the buffalo grass further south.

The short grass association is subdivided into approximately six consociations as follows:

1. Grama grass (Bouteloua gracilis)
2. Galleta grass (Hilaria jamesii)
3. Grama grass (Bouteloua gracilis) and buffalo grass (Bulbilis dactyloides)
4. Giro grass (Aristida longiseta)
5. Western wheat grasses (Agropyron spp.)
6. Grama grass (Bouteloua sp.) and western needle grasses (Stipa spp.)

A line running from the foothills of the mountains in Colorado north to the boundary between North Dakota and Montana separates the grama grass (Bouteloua spp.) on the

west from the other associations on the east. Included in the grama grass area are the high valleys in Colorado, New Mexico, Arizona and isolated spots in Utah.

The grama grass type (Bouteloua spp.) is a very important range section. Here the season is cool, short and the evaporation is low, compared to the other sections, and the relative rainfall comparatively low.

Extensive areas in northern New Mexico, Arizona and Utah are dominated by a practically pure sod of Galleta grass. This type, however, is very unstable, changing back and forth with the sagebrush in that area with the periodic changes of the wet cycle. In the wet years the Galleta grass (Hilaria jamesii) predominate, while in the dry years the sage brush is in the majority. This is also very valuable grazing land.

In western Nebraska, Kansas, Oklahoma, east Colorado, New Mexico and the Pan Handle of Texas the grama-buffalo grass is the characteristic cover, which is dominated equally by grama grass (Bouteloua gracilis) and buffalo grass (Bulbilis dactyloides). There are many other species in this association, but they are of small consequence. Further east, however, where the rainfall is greater, and penetrates deeper into the soil wire grass (Aristida longiseta) and psoralea (Psoralea tenuiflora) become abundant.

A belt of mixed grass lies between the grama-buffalo grass of the plains and the bunch grass of the prairies in Nebraska, Kansas and Texas. Like the Gallota grass this type changes its composition with the ebb and flow of the wet and dry seasons.

The western wheat grass (Agropyron smithii) is widely distributed over the heavy gumbo soils of South Dakota, Nebraska and Colorado. It produces an even heavy sod, containing a minimum of grass-like plants, and is very valuable for forage. It consists mainly of grama and buffalo grass with a scattered growth of western wheat grass (Agropyron smithii).

Grama grass (Boutelona gracilis) and western needle grass (Stipa somata) form an intermediate type between the grama of the plains and the needle grass of the prairies. Plants of both the tall grass and short grass regions are found here. Also the purple cone flower (Echinacea angustifolia) and June grass (Koeleria cristata) grow abundantly in this area.

Mesquite grass, or desert grasslands. The mesquite grass type occurs in Texas, New Mexico, Arizona and extends southward far into Mexico. This type is characterized by a growth similar to the short grass of the plains, except that growth begins with the summer rains in July and August. (56)

The growing season is short because of the low rainfall of from 12 to 18 inches, high evaporation and very high temperatures. After a short, rapid growing season the grass cures on the ground, making ideal winter forage.

Desert shrubs such as mesquite (Prosopis juliflora), creosote bush (Covillea mexicana), yucca (Yucca elata), cats claw (Acacia greggii) and Emory oak (Quercus emoryi) add to the very nutritious forage already there.

The mesquite grass type may be subdivided into three parts: (56)

1. Black grama (Bouteloua eriopoda)
2. Crowfoot grama (Bouteloua rothrockii)
3. Curly mesquite (Hilaria belangeri)

Black grama (Bouteloua eriopoda) is the dominate group, but it seldom occurs in a solid stand. It covers most of the sandy slopes and the foothills in New Mexico, Texas and Arizona aided by scattered growths of yucca (Yucca elata), mesquite (Prosopis juliflora), creosote bush (Colvillea mexicana) and cats claw (Acacia greggii).

Crowfoot grama (Bouteloua rothrockii) associated with species of (Bouteloua) and (Aristida) abound in the southeastern part of Arizona. Usually the area is free of shrubs, except along the borders where cats claw (Acacia greggii) and mesquite (Prosopis juliflora) come in from the adjacent deserts. The crowfoot grama association makes

excellent forage and is used extensively by the stockmen of that region, especially for winter feed.

In Texas and southeastern Arizona curly mesquite (Hilaria belangeri) forms fine grazing areas at the higher elevations. This type very closely resembles the buffalo grass of the plains, except that it is usually associated with scattered groups of mesquite (Prosopis juliflora), oak (Quercus emoryi) and other types of woody shrub.

Mesquite and desert grass, or desert savanna. This mixed type of short grass and shrubs occurs in Texas south of the Red River and south of the plains border to the southwest portion of the high plains. The rainfall in this region is heavy and comes during the growing season but the high evaporation and high temperatures cause extreme drought conditions. The precipitation ranges between 20 and 30 inches but due to the desert-like conditions of high evaporation the plants cannot take full advantage of it.

This area may be divided roughly into two divisions: (56)

1. The thorn-bush and mesquite grass association.
2. The mesquite and mesquite-grass association.

The mesquite and mesquite grass association is most characteristic of Texas. This is a distinctive park-like area due to the scattered mesquite trees and groups of prickly pears throughout the grass cover which consists

mainly of curly mesquite (Hilaria belangeri), buffalo grass (Bulbilis dactyloides) and species of Aristata and Boutelous.

This type forms a band running from the Gulf of Mexico on the south to the Red River on the north and is approximately 150 miles wide. The entire area is admirably suited for grazing.

Marsh grass, or marsh grassland. This type may be grouped into salt marshes and fresh water marshes. They are found in the central valleys of California, along the Gulf of Mexico, along the eastern seaboard and in the Everglades of Florida. Salt marshes are commonly found along the coast, but in Oregon and California inland marshes have developed into alkali marshes or areas. This makes it practically impossible to make a sharp distinction between fresh marshes and salt marshes. The fresh marshes are characterized by Indian rice (Zizania aquatica) and (Z. palustris), cat-tail (Typha latifolia) and tule (Scirpus validus) and in Florida by saw grass (Cladium jamaicense). On the other hand salt marshes are characterized by marsh grass (Spartina alternifolia) and (S. patens) while the alkali areas are marked by salt grass (Distichlis spicata).

Alpine meadow, or Alpine grassland. The total area occupied by this type is comparatively small and is confined mostly to Colorado, the northern Rockies and the Cascade-Sierras and usually found above timber line. The type

consists mainly of rock sedge (Carex rupestris), alpine nigger wool (Carex elynoides), alpine fescue (Festuca brachyphylla) and a great variety of alpine plants. Some of the broad leaved species found there are the gentians, primroses, saxifrages, forget-me-nots, painted cups, buck wheats, lupines, polygonums, erigerous, etc. These alpine meadows with their rich erotic flora make excellent summer range for sheep where the forage is fresh and green while the valleys below lie parched and brown.

Important Grazing Regions

Not all grass areas are suitable for stock grazing. The roaming buffalo and other grazing animals were fitted to follow the grass wherever they chose, but man and his herds cannot do this. He has to be more exacting for a multiple of economic reasons. He must have water and forage for a large number of stock in a restricted area. He must have an outlet to a market, and he must keep his stock where he can take care of them.

According to Will C. Barnes (4), the following are some of the regions better situated for stock ranching:

1. The Red Desert Region.
2. The West Desert Region.
3. The Owyhee and Adjoining (desert) Ranges.
4. The Nevada Desert Ranges.
5. The Jornada Range Region.
6. Open Range Lands in New Mexico.

The Red Desert region. This region is approximately 85 by 130 miles in extent, or contains approximately 7,000,000 acres, and lies above the 6,000 feet elevation in the Rocky Mountains in the southern part of Wyoming. (4) (64)

The vegetation consists mainly of sage (Artemisia tridentata), bud sage (A. spinescens), salt sage

(A. nutalli), shadscale (A. confertifolia), and winter fat (Eurotia lanata). Along the water courses are found some of the willows (Salix spp.), rabbit bush (Chrysothamnus sp.), mountain mahogany (Cercocarpus sp.), and Greasewood (Sarcobatus sp.). Also scattered through these are found western wheat grasses (Agropyron spp.), salt grass (Distichlis spicata) and other less important forage plants. (64)

After the stock come down from the cool mountain ranges they are placed on the Red Desert range for the winter, and held there until time to go back to the mountains in the spring. The carrying capacity of this range is about 250,000 head of sheep and by spring the forage has been completely exhausted. Formerly this was a very valuable winter range with a carrying capacity of more than twice that of the present. (64)

The Red Desert region, unlike the national forest ranges, has had no regulation, the rule being "first come first served". Competition has been so keen and so thoughtless that today the sheep leave the range in a lean and gaunt condition. (4)

The West Desert region. This is a region of scant rainfall and has few springs or streams of running water. The snowfall is heavy and lies on the ground for several

months. The melting snow is caught in both natural and artificial reservoirs where it is held for the dry season. (58) (74)

The West Desert at one time was one of the finest sheep ranges in the grazing region, but today its forage value is far below its former carrying capacity. According to Will C. Barnes in "The Story of the Range," it has a total of 16,000,000 acres, approximately 10,000,000 of which lie in Utah and 6,000,000 acres in Nevada. Like the Red Desert, the deterioration of this wonderful range is due to mismanagement by the competing stockmen, especially by the alien sheepmen who take their sheep on to a range and graze every available sprig of forage with no thought of the future or of other stockmen. Because of this treatment the forage has suffered severely. Two of the most valuable forage species, winter fat (Eurotia lanata) and bud sage (Artemisia spinescens) have been practically destroyed. The wheat grasses (Agropyron spp.), balsam root (Balsamorhiza sp.), lupines (Lupinus sp.), sunflowers (Helianthus spp.), mustards (Cruciferaceae spp.), Indian paintbrush (Castilleja sp.), wild carrot (Daucus sp.), buckwheat (Polygonaceae sp.) and numerous other palatable forage plants have become rare under these conditions. This once very valuable range today is a liability rather than an asset. (4) (60)

The Owyhee and adjoining desert ranges. This region is a demi-desert country lying in the southwestern corner of Idaho and the southeastern corner of Oregon in the counties of Malheur in Oregon and Owyhee in Idaho. In Idaho the range is bounded on the east by the Snake and Bruneau rivers and in Oregon by the crest of the western watershed of the Owyhee and Crooked Rivers. Adjacent to this range are large areas of similar range except for a lower carrying capacity. These with the Owyhee range make the largest solid block of range area still in the hands of the Federal Government. It contains about 28,000,000 acres of fine range land. The elevation lies between four and five thousand feet with the highest part lying in the Steins mountains of Oregon. The region is well covered with running streams, but these are usually in deep cuts which make it impractical for the stock to get to the water. Underground water can only be reached by deep wells which are very costly. (67).

Because of the inadequate watering facilities this range has not depreciated as much as some of the others. The rainfall is very scant, averaging between 8 and 10 inches, with about 2 inches coming during the growing season. This has served to discourage dry farmers and homesteaders. As a whole the lack of moisture, and the extremely rough topography has been the salvation of this winter range. The nearby mountains with their fine summer ranges make

this area an ideal winter range for sheep. Approximately 500,000 sheep use this range every winter and some stay on for the spring feed when the rains are late. (67)

Idaho fescue (Festuca idahoensis) is the predominating forage plant with considerable wheat grasses (Agropyron spp.), balsam root (Balsamorhiza sp.), sunflowers (Helianthus spp.), wild carrot (Daucus sp.), buckwheat (Polygonaceae sp.), and other good sheep forage. Bitter brush (Purshia tridentata), salt sage (Artemisia nutalli), greasewood (Sarcobatus vermiculatus), shadescale (Artemisia confertifolia), and bud sage (Artemisia spinescens) form the bulk of the browse. With management this area would be the finest range in the country. (4) (66)

The Nevada Desert Ranges. This region ties into the large unappropriated areas of Nevada. By far the largest part of Nevada is government land. Out of a total of 70,000,000 acres approximately 52,000,000 acres still belong to the federal government. (65) Because of climate, soil and other conditions it is very likely to remain range land for a long time. There are a few streams flowing out of the mountains, but they are soon lost in the sandy wastes of this semi-desert country. The few clumps of trees and springs quite early passed into private hands. (75)

Water limits the carrying capacity of this range which is much lower than the Owyhee country. The rainfall is less than 10 inches most of which comes during the dormant season in the form of snow. Water is obtainable by means of expensive wells, but resident stockmen cannot afford to put much money in these because of the many bands of roving sheep owned by aliens. These men have no regard for the other stockmen, their one consuming desire being to beat the other fellow to the grass. They have no home base in which a large sum of money is invested. While the resident stockmen are in the mountains with their sheep, these roving bands of sheep come in and take the feed being saved, and use up the stored water taken from the wells. Generally it amounts to the resident stockmen putting in an expensive well for the exclusive use of alien sheepmen. The result is that nobody does anything and everybody tries to get all he can while he can. (4) (75)

The important forage plants of this area are: shadscale (Artemisia confortifolia), the dominant plant in both Utah and Nevada, winter fat (Eurotia lanata), bud sage (Artemisia spinescens), hop sage (Grayia spinosa), the salt grasses (Distichlis spp.), and several of the gramas (Boutelous spp.), fox tail (Hordeum sp.), and squirrel tail (Hordeum sp.). These are all found around an elevation of 5,000 feet or more. (4) (45)

Open Range Lands in New Mexico. There are several ranges in New Mexico generally classed under the heading of "Open Range Lands." A large range of about 1,800 square miles lies along the Rio Grande, in northern New Mexico and southern Colorado at an elevation of about 6,000 feet. The range is well watered with an average rainfall of from 15 to 20 inches, most of which comes during the growing season. (38)

At one time this was one of the best ranges in the southwest. It was well watered, had fine forage, and was protected from the cold winter winds. These, however, proved to be the downfall of the range. Stockmen tried to get something for nothing, and the roving bands of sheep caused its ruination. (5)

The cover is similar to that of the Red Desert region of Wyoming. Sages (Artemisia spp.), winter fat (Eurotia lanata) and shadescale (Artemisia confertifolia) are the main feeds. In addition there are some wheat grasses (Agropyron spp.), grama grasses (Bouteloua spp.), salt grass (Distichlis sp.) and sacaton (Sporobolus sp.). (45)

The Jornada Range in the Rio Grande Valley. The Jornada range of southern New Mexico is especially useful for cattle. It is one of the most arid regions in the southwest with an average rainfall of 8.6 inches, most of which comes during the growing season. (38)

This semi-desert area lies at an elevation of between 4,000 and 5,000 feet. The early Spaniards called this region the "journey of death" because they lost so many head of stock in crossing this desolate stretch. This range has been used for several experiments in range problems by the forest service in an effort to help the stock raising industry in the southwest. (36)

Approximately 80 per cent of the forage on this area consists of perennial grasses. The most important of these are black grama (Bouteloua eriopoda), red three awned or needle grass (Aristida longiseta), tobosa (Hilaria mutica), dropseed (Sporobolus cryptandrus), burro-grass (Scleropogon brevifolius), muhlenbergia (Muhlenbergia gracillima), and salt grass (Sporobolus airoides). Also various brush species are found here such as mesquite (Prosopis glandulosa), black brush (Flourensia cernua), creosote bush (Covillea glutinosa), shadscale (Artemisia confertifolia) and sage brush (Artemisia filifolia). During the rainy season there is a fair covering also of annuals, but they furnish very little feed. (36)(38)(48)

Grasslands within the Arctic Circle

The grasslands of the Arctic are generally referred to as the tundra. This tundra is found mainly on the north coast of Canada and consists primarily of mosses, sedges and grasses. The dominant plants in these low grassy swamps are, besides mosses, Carex raiflora, C. rigida, C. reducta, C. stans, and a large number of weeds. (33)

In some places the coastal plain in northern Canada is a little higher in elevation and a little dryer, then the vegetation is dense and very uniform. It produces a mucky soil rich in humus, brown in color, and fertile by decaying plants. The plants found on these higher lands are Lloydia serotina, Salix pulchra, S. rotundifolia, Betula glandulosa, Oxyria digyna, Silene acaulis, Papaver nudicauli, Potentilla emarginata, Lupinus nootkatensis, Phaca frigida, Oxytropis nigrescens, Cassiope tetragona, Primula borealis, Pedecularis arctica, Lagostis glauca and Petasites frigada. The absence of Carex is noticeable in these areas.

The permanently frozen ground in the Arctic varies from within six inches of the surface to within several feet, depending on the type of soil and vegetation covering. Sandy soils thaw out deeper than do the heavier clay soils. A sandy soil under a heavy ground cover thaws out deeper than a bare sandy soil.

The tundra is free of snow about three months out of a year. During this short growing season a plant must produce seed for future plants. If the freezing weather comes before this process is completed, the plant lies dormant until the next season and continues from the stage left off. In this manner it may take two or more seasons for a plant to produce seeds.

Because of this short growing season no trees or shrubs grow in the homeland of the Eskimo. The tallest tree is the shrub-like Arctic willow. On some of the tallus slopes heavily manured by birds are found heavy mats of grasses, the dominating species of which are Poa pratense and Alopecurus alpinus. (33)

Grasses of Central America

Central America is taken to include Panama, the Canal Zone, Costa Rica, Nicaragua, Salvador, Honduras, Guatemala and British Honduras. This entire region lies in the tropical zone, and has a typical tropical climate. The Rocky Mountains of the United States continue down through Mexico and form a high central backbone through Central America. The highest peaks in these highlands average about 3,500 meters with the slopes reaching down to the oceans on each side. (32)

The flora of these highlands is high temperate, but with very little Alpine flora. The Pacific coast region is much drier than that of the Atlantic. The Pacific coast has well marked dry seasons, and extensive grassland areas called "savannas". These savannas are the continuation of the prairies of Mexico. The Atlantic coast is just the opposite with its humid climate and extensive rain forests.

With but few exceptions the grasses found in these central American savannas are the same as found on the prairies of our own country, and likewise on the plains of Mexico. The tribes to which most of the more important grasses belong are: Festuceae, Aveneae, Agrostideae, Choridieae, Hordeae, Tregeae, Oryzeae, Phalarideae, Streptochaeta, Bambriseae, Zizanieae. (32)

Grasses of Mexico

The grasslands of Mexico are very similar to those of the southwestern part of the United States. The grama grass formation of New Mexico is the northern terminus of the grass formation of Mexico. The northern part of Mexico is similar to the state of New Mexico in its arid climate and sparse vegetation.

In Mexico the grama grasses form an imperfect sod in the highlands, and thin out until they disappear completely in the tropical situations. The important species found here are: Bouteloua gracilis, B. chonchosioides, B. filiformis, B. radicose, B. hirsuta, and one or two others of lesser value. (32)

Economics of the Range

The range area is that portion of the United States which lies west of the one-hundredth meridian. Cattle and sheep are produced here largely by the utilization of the native grasses and forage growing on large areas of land which cannot at this time be economically cultivated. The area of this range land is approximately 800,000,000 acres, most of which is of low carrying capacity. (3)

The western states, being mainly range, or grazing states, depend to a considerable extent upon the stock industry. It is significant that approximately 40 per cent of the nation's meat is supplied from this area. (45)

In the past the stockmen have been perhaps the most independent type of producer in the United States, and generally he has managed his business alone. Marked changes, however, in the livestock industry have occurred since 1920. During this period the industry has not only had to recover from the abnormal conditions caused by the war, but it has been effected materially by the changed economic and financial conditions, and from changed agricultural practices.

In 1920 the situation confronting livestock producers may be briefly described as follows: Numbers of all live-

stock, except sheep, were near the peak, and the potential output of meat was excessive for domestic consumption; the war-time export outlet for chilled or frozen beef was cut off and the export outlet for cured pork products and lard promised to be curtailed; marked readjustments in numbers to post-war conditions were necessary. (62)

A study of the accompanying table and figure 1 shows the remarkably close correlation of cattle, sheep and population until 1885. After this date the livestock curves are characterized by considerable irregularity. The sheep curve diverged from the population curve in 1885, while the beef cattle curve continued up until 1895. The relative positions of the curves at present show a decreasing number of animals per capita.

A brief survey of the sheep industry will give a graphic picture of what has happened in general to the stock industry since 1920. In 1923 there were 36,695,000 head of sheep in the United States, which was increased to 53,321,000 in 1932. Slightly more than 72 per cent of this increase took place in the thirteen western grazing states, including Texas and South Dakota. The total inspected slaughters of sheep and lambs during 1932 amounted to 18,714,000 head. This exceeded the marketing of 1922-23 by about 64 per cent. This increase was absorbed by the

domestic markets, exportation of mutton and lamb are practically negligible. In 1922 the sheepmen furnished the American consumer five pounds of lamb and mutton per capita. This per capita supply was increased to 7.1 pounds in 1931, an increase of 42 per cent over 1922. Consumer demand, however, was greatly curtailed as a result of the lowered purchasing power of the consumer, and the increased production was moved into consumption only by a reduction in prices. The average price of sheep and lambs slaughtered in 1932 was $6.38 per 100 pounds. This is $7.57 less or 54 per cent less than the average price received in 1929.

The demand for wool in 1931-32 likewise fell off as a result of the depression and consumption was reduced materially. This decreased consumption and increased production caused wool prices to drop to a very low level.

Sheep production in the past tended to move in cycles. These cycles were somewhat irregular both in spread between the high and low points and in the duration. Major depressions in this industry have usually been followed by an important shift in the geographical distribution of sheep and changes in the character of the industry. During low prices the necessity of reducing operating costs has caused sheepmen to move to cheaper lands. This accounts for the major changes in the geographical distribution of the sheep industry in the last 100 years. (62)

A shift to the public domain with the proper management and control is the only thing left for the stockmen to do, other than to improve their production methods. With a decreased income it is very difficult for a radical change to be made in this respect.

Year	Population	Beef Cattle	Sheep	Year	Population	Beef Cattle	Sheep
		(All figures given in thousands)					
1850	23,192	14,400	29,100	1897		38,700	41,300
				1898		38,000	42,600
1860	31,443	18,900	27,600	1899		37,100	44,600
1867		12,600	38,100	1900	75,995	37,500	48,100
1868		13,600	37,600				
1869		14,800	36,200	1901		37,000	50,400
1870	38,558	20,000	39,000	1902		36,400	51,900
				1903		35,600	53,000
1871		21,000	38,900	1904		33,800	42,500
1872		21,100	38,600	1905		33,300	36,800
1873		20,900	40,100	1906		34,800	41,000
1874		20,500	41,100	1907		37,900	42,700
1875		20,400	40,800	1908		35,900	43,500
1876		20,800	43,300	1909		34,400	44,300
1877		22,200	43,000	1910	91,972	32,000	44,800
1878		23,800	42,800				
1879		26,400	45,800	1911		30,500	45,700
1880	50,156	25,900	48,500	1912		28,300	44,600
				1913		27,400	43,700
1881		24,900	51,200	1914		27,200	42,200
1882		27,600	52,300	1915		28,300	42,200
1883		33,400	56,600	1916		30,900	41,100
1884		34,100	57,500	1917		32,600	40,200
1885		34,400	56,500	1918		35,100	40,900
1886		35,700	53,600	1919		36,200	41,100
1887		37,900	49,100	1920	105,711	35,778	39,475
1888		38,300	47,200				
1889		38,300	45,700	1921		34,424	37,495
1890	62,948	39,800	47,000	1922		34,206	36,369
				1923		31,777	37,266
1891		40,900	46,400	1924		30,395	38,344
1892		42,000	48,400	1925		28,789	39,643
1893		40,500	51,300	1926		26,815	41,217
1894		43,700	49,300				
1895		41,700	46,700	1930	122,775		
1896		39,700	42,600				

Extimated population and total number of beef cattle and sheep in the United States, 1850-1926 (47)

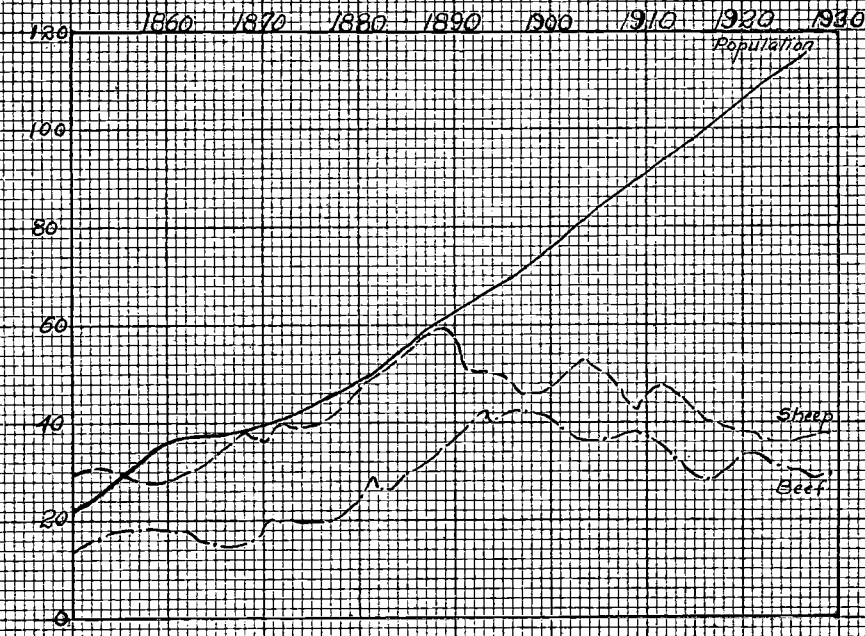

Fig. 1--Trend of population and beef cattle and sheep production in United States, 1850-1926 (47)

The Public Domain

The public domain is described as that land in the United States which is unsuited for permanent residence. This area is larger than the state of Texas, covering one-tenth of the area of the nation, or 300,000 square miles. (70) 12

The public domain has always been a great grazing common, free to all comers. It is unlawful to fence any of the land, and there have never been any regulations for its use. Today overgrazing has greatly reduced the carrying capacity, and erosion has increased the destruction of the forage cover. The damage is severe and it may never be wholly repaired, but with the proper management it can be improved, and its economic value better utilized.

The people of the United States are directly concerned with the proper use of this natural resource. About 50 per cent of the sheep and 16 per cent of the cattle of the nation are raised on the public domain. Stockmen have competed for the forage on these lands ever since the industry moved to the western states. The very nature of the existing conditions have caused these free grazing lands to be reduced to an almost depleted state. The Government has continuously ignored the possibilities that

lic in this 300,000 square miles of potential store house of forage for grazing animals. (70)

During Theodore Roosevelt's administration, a quarter of a century ago, a Public Lands Commission was appointed. This committee reported (70)[12] that "the general lack of control in the use of public grazing lands has resulted, naturally and inevitably, in overgrazing and the ruin of millions of acres of otherwise valuable grazing territory. Lands useful for grazing are losing their only capacity for productiveness, as, of course, they must when no legal control is exercised. Prompt and effective action must be taken if the value of very much of the remaining public domain is not totally to be lost." This report was made over two decades ago and to date nothing has been done to prevent the total destruction of the value of this area as range land.

Today the stockmen are facing the most critical period ever experienced by the stock industry. Their overhead can only be reduced by either moving to cheaper land or by changing the methods of production. The industry cannot move to cheaper lands. Only the methods of production can be improved upon. It is for this reason that most stockmen believe that the key to the situation lies in the vast public domain. It is believed that with proper management this area can be reestablished, and made as

valuable to the stock industry as are the mountain ranges of today under the administration of the forest service.

With the stockmen in this frame of mind a bill introduced into the House of Representatives January 5, 1934 by Representative Taylor of Colorado asking for government control of the public domain was very timely. The main purposes of this bill are to stop injury to the public grazing lands by preventing overgrazing and soil deterioration, to provide for the orderly use, improvement, and development of the public domain, and to stabilize the livestock industry dependent upon the public range. (59) "

Conditions are right for this bill to pass and the public domain be put under management. The Department of Interior will, in all probability, pattern to a large extent upon the forest service rules and regulations governing the high mountain ranges.

The public domain has been overgrazed by the competing stockman until today its economic value is very low. Most of the valuable forage plants have been destroyed, and erosion has washed away the rich humus from the ranges. The once grass-covered areas have retrogressed to a stand of unpalatable annuals and short-lived perennials. Forage of this type is practically useless to the stockmen.

There are two methods whereby these lands can be brought back to a reasonably high state of production. One

plan is to artificially reseed the areas, and the other is to protect the land from grazing until the better forage plants become reestablished. This is the better method. Artificial reseeding on such large areas would be impractical and the cost would be prohibitive.

The following discussion of the laws underlying the occupation of lands by vegetation is based on Sampson's bulletin "Plant Succession in Relation to Range Management". (51)

From its earliest stages of development to the highest type of plant life which the habitat is capable of supporting, a somewhat regular replacement of one type of plant by another is found. Probably the best explanation for this is the addition of humus to the soil by the plants as they die and decompose and thus prepare the way for a higher form of plant life. Accordingly, quite different plant types are recognized on soils in different stages of formation.

Beginning with the bare rock, the first vegetation consists of such uneconomic forms of plant life as algae and crustaceous lichens. These forms mark the pioneer stage of development. There is no humus at this stage, the conditions are very similar to a desert. Gradually these

plants decompose and build up a thin layer of humus. Only areas which have been badly burned over or eroded would be of this type. Generally the public lands would not be at this low stage of productivity.

After the pioneer stage of plant development has built up a sufficient layer of humus the first-weed stage appears. This stage is characterized by a semidecomposed soil, poor in organic matter and relatively low in moisture content. There is a distinct predominance of shallow-rooted, early maturing annuals. These spread and increase in density until the area is completely covered during the maximum growing period. As soon, however, as the growing season is over or the plants are killed by a frost, the ground surface is exposed, or practically so. Usually at this stage it will be found that a few aggressive short-lived perennial grasses and weeds have invaded the habitat. This stage furnishes a small amount of inferior forage if utilized at the proper time.

The second-weed stage is characterized by a fairly well decomposed soil, moderately impregnated with organic matter and retains a moderate amount of moisture throughout the growing season. This condition permits the establishment of a stand of perennial herbs of varying density, the woody, unpalatable species often predominating. Turf-

forming and bunch grasses begin to appear, and the interlacing roots and rhizomes bind the soil firmly. The grasses are not sufficiently abundant at this stage to form a sod.

By the time the second-weed stage has had its growth and has thus prepared the way for the next set of plants, the soil is sufficiently decomposed and contains sufficient organic matter and soil moisture to make possible the climax grass cover.

This is the process by which the public lands first became covered with a stand of valuable forage. Through overgrazing the cover was caused to retrogress in the same manner, beginning with the climax stage and going backwards into the second-weed stage, and finally into the first-weed stage. It is not likely that very many areas will have retrogressed to the pioneer stage of algae and crustaceous lichens. For the most part the ranges will be either in the first or second-weed stage. The problem will be to bring these areas back to the climax stage.

Careful grouping of the vegetation up and down the scale of development reveals four major stages of vegetation. These stages embrace all the lands which receive their moisture directly from precipitation, but do not include marsh lands and other similar areas. The plant stages from the

climax down to the most transitory cover are as follows:

1. The wheat-grass association (Subclimax or climax stage).
2. The porcupine-grass-yellow-brush association (mixed grass and weed stage).
3. The foxglove-sweet-sage-yarrow association (second or late weed stage).
4. The ruderal-early-weed association (first or early weed stage). (51) (10)

The grazing of live stock may, under certain conditions, either retard or promote the development of a plant cover and cause either retrogression or progressive succession. (51) (10)

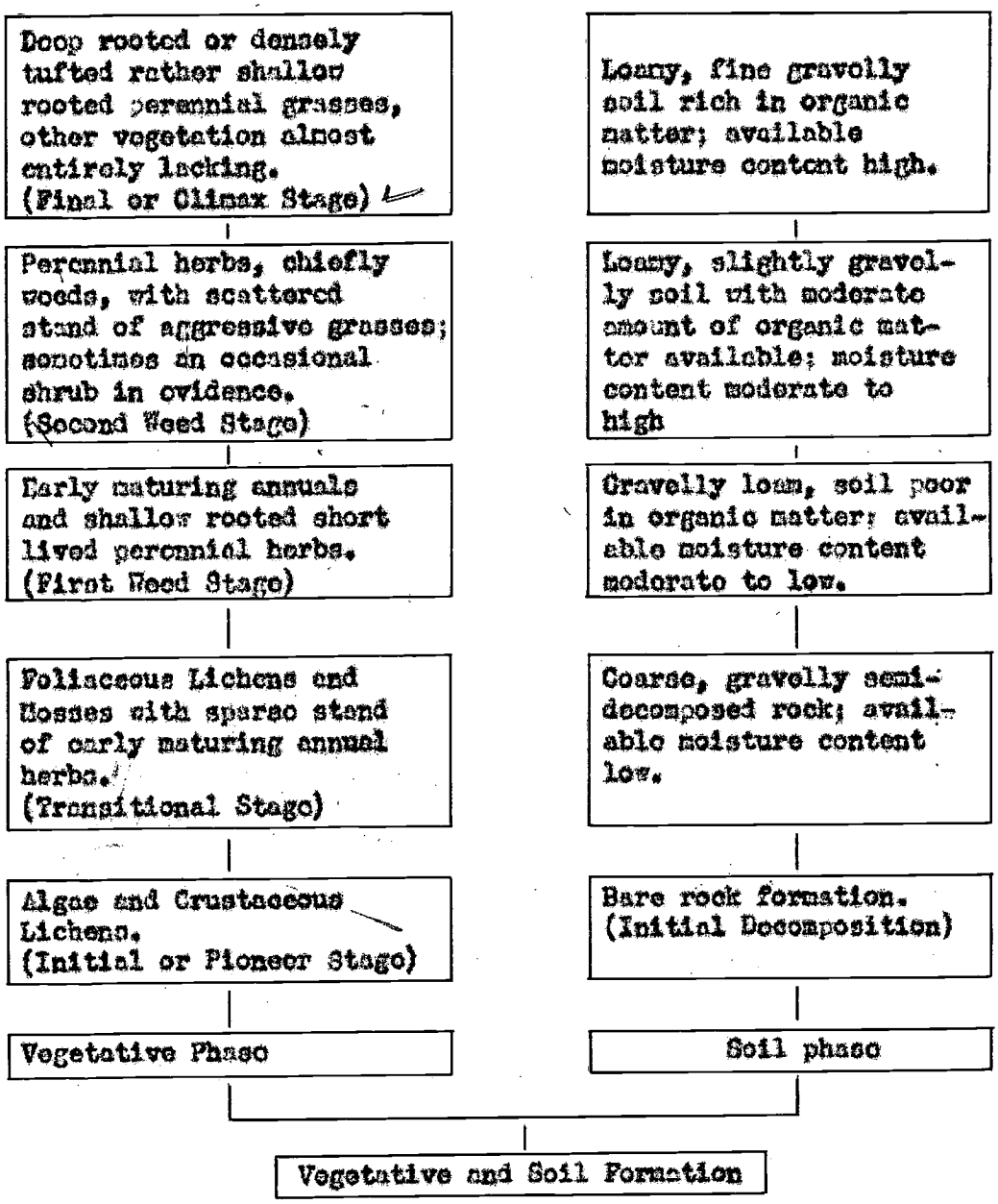

Fig. 2.—Plant succession or the development of vegetation where grass constitutes the climax or subclimax type. After Sampson (51)

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