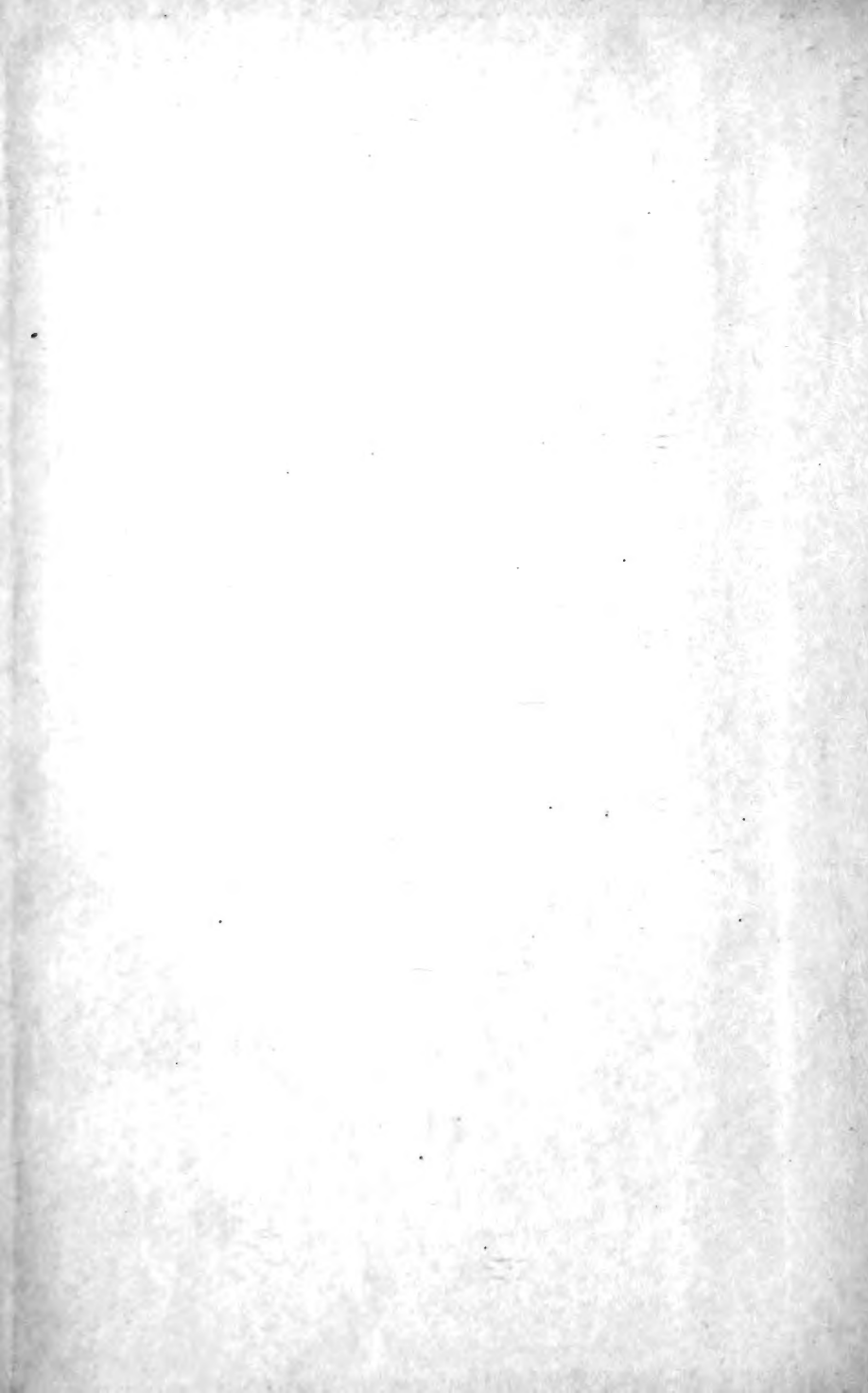


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10652

THE PHYTOGEOGRAPHY OF NEBRASKA

I
GENERAL SURVEY

BY

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AND

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SECOND EDITION

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PREFACE TO THE FIRST EDITION.

This work is the result of nearly five years of active study of the floral covering of Nebraska, carried on by the members of the Botanical Seminar in the Botanical Survey of the State. The study of the vegetation of Nebraska, begun when Dr. Bessey came to the University, in 1884, was carried on, chiefly from the floristic side, by members of the Seminar from 1886 to 1892, with zeal and effect. During that time Messrs. Smith, Webber, Williams, and Woods, together with one of the authors of the present work, devoted a large portion of their botanical energies to the determination of the flora of the State and of the distributional boundaries of species. When the Botanical Survey was organized in 1892, both of the authors became members, and from that time, assisted at times by Mr. Smith, Mr. Woods, Mr. Rydberg, Mr. Saunders, Mr. Shear, Mr. Bell, and Mr. Ernst Bessey, they have directed the work of the Survey with a view to the ultimate publication of a report, or a series of reports, in which the floral covering of the State should be treated from the phytogeographical standpoint, and a series of monographs dealing with it from a floristic standpoint. A beginning has been made in the latter direction by the publication of three parts of the Flora of Nebraska. The time seems ripe for putting forth the first installment in the former series. A great deal remains to be done in many directions, such as phenological observations in regions III and IV, for example, that will render a complete phytogeography of Nebraska impossible for many years to come. But the work of the Survey has progressed far enough to enable us to present the general portion of such a phytogeography in an adequate manner, and to deal with details in many of the more important subjects. It is believed that within the subjects treated in this first report on the phytogeography of

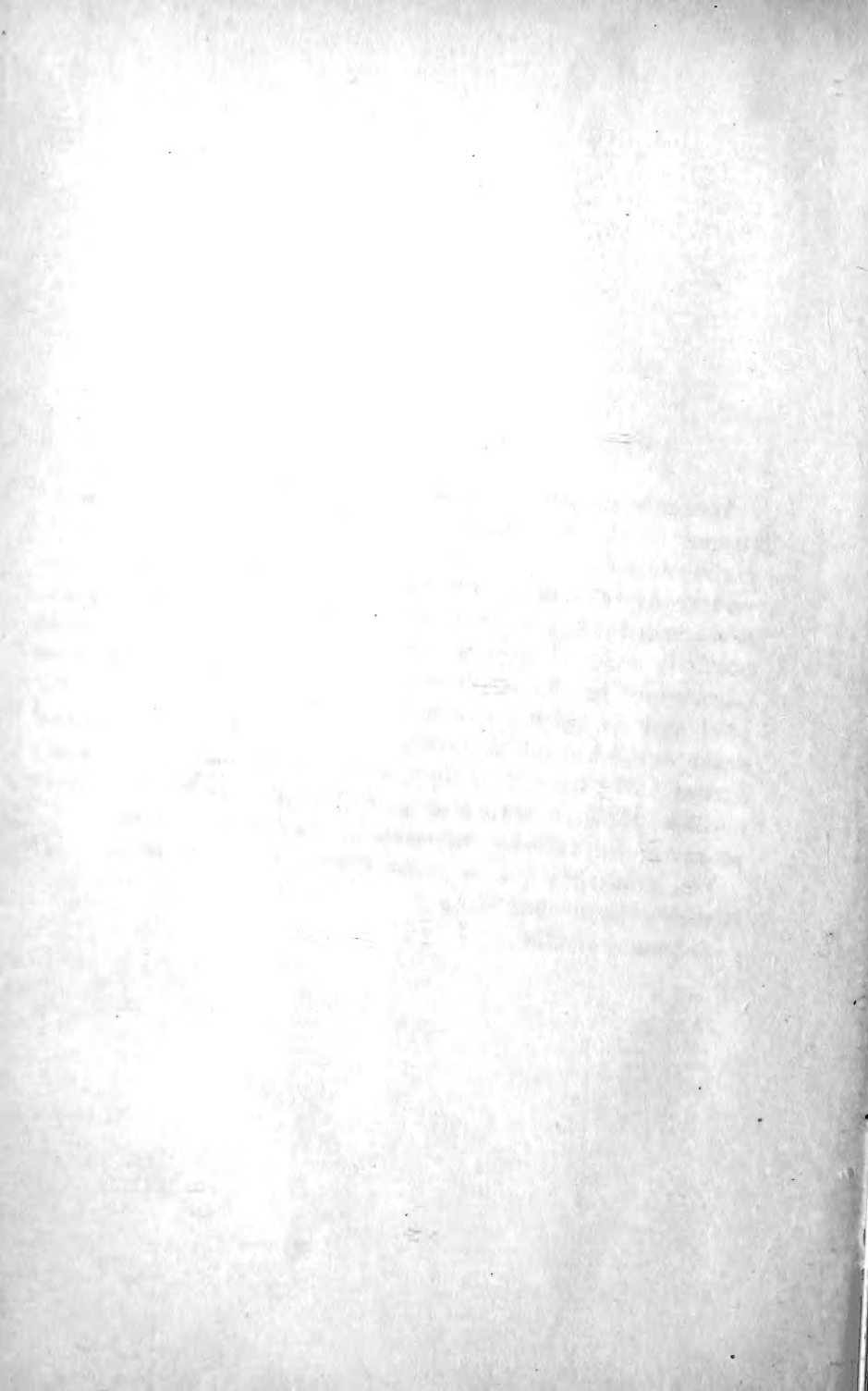
Nebraska our data are now sufficient to justify us in making known the results that have been accomplished.

It goes without saying that the writings of the German phytogeographers which have appeared in recent years have been a chief source of inspiration. In particular the admirable *Pflanzengeographie von Deutschland* of Dr. Oscar Drude has made light the darker places in our path by the copious illustrations and comparisons which it furnishes. It will readily be perceived that the writings of Dr. Drude, the chief of which we have enumerated in the list of works consulted, have been made use of in the methods employed. We have departed from his methods with reluctance, and only in cases where the peculiar circumstances of our region appeared to make it imperative. We are indebted to several members of the Botanical Seminar and to a number of collectors in various parts of the State for valuable assistance and information. To Mr. F. W. Taylor in particular we are indebted for the means of making many important expeditions to distant parts of the State. Prof. E. H. Barbour has contributed the sketch of the geology of the State and much information during the progress of our work. But above all we must acknowledge the invaluable counsel and assistance of Dr. Bessey, freely given at all times both in the preliminary work and in the preparation of this report. Without it, we should have been able to accomplish little.

It remains to be said that in the following pages we have made use of the metric system of measures, the centigrade thermometer, and the nomenclature of the "Rochester Rules." The nomenclature, therefore, is substantially that of the Check List prepared by the Botanical Club of the A. A. S. If any explanation were required, it would be enough to say that the whole flora of the State is covered by no other work in common use. Furthermore, on the principle that that is certain which may be rendered certain, we have omitted the author-citation. In taxonomic works the author-citation is imperative. But in a work of this kind there seems no occasion for it. As Mr. Lester F. Ward has

suggested, fixed and stable rules of nomenclature will obviate the apparatus criticus of parenthesis and double citation to which uncertain methods have brought us.

May 4, 1897.



PREFACE TO THE SECOND EDITION.

The greater portion of the first edition having been destroyed in the fire which consumed the building of Messrs. Jacob North & Co., the publishers, the Regents of the University authorized a new edition as a publication of the Botanical Survey. We have availed ourselves of the opportunity to make a thorough revision, made necessary in several particulars by the progress of the Geological Survey since 1897 and by further investigation of the vegetation of the State in the Botanical Survey, and to insert some additional matter. We have thus been able to make use of the many notable phytogeographical publications of the last three years and to profit by criticisms of the former edition.

The nomenclature is substantially that of Britton and Brown's *Illustrated Flora*.

February 1, 1900.



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INTRODUCTION.

The relation of phytogeography to biology.—Within a few years phytogeography has become a distinct department of botanical knowledge. The development of this branch of the science has been effected chiefly by the efforts of a few continental botanists. It is true that many earlier botanists contributed largely to this result, principally in the direction of geographical and distributional data. But their work was of necessity elementary in character, and the facts they worked out were miscellaneous and undigested. Geographical botany, as then understood, was concerned almost solely with the cataloguing of species and with distributional problems. The essential relation of habitat and organism was fully perceived more recently. The fuller perception of this relation and its consequences has established phytogeography as it is now understood.

Phytogeography must involve not only problems of distribution and of occurrence, but must be concerned with deeper problems of biological function. It is the investigation of these latter problems and their connection with the former and the accentuation of this phase of the subject that give phytogeography an important position as a department of the science, and contain the promise of its future ascendancy. In so far as it is an expression of the secondary branches of the science, phytogeography has in itself the realization of the establishment of a higher biological science.

In its more immediate aspects, phytogeography portrays the floral covering of a region, and in so doing sets forth the connection between geography and botany, which has given it form in the past. But ultimately it is concerned with the interrelations of the organic elements of this floral covering. It determines the place and the rôle of these elements, and seeks to discover the ultimate causes underlying

phytobiological activities. It deals with the aggregate of the causes and forces which the vegetation of a region expresses.

Conception and definition.—Phytogeography is the study of vegetation. It is a resultant of several conceptions, none of them singly sufficient, but in their united application setting before us the vegetation of the earth as vegetation, that is, the vegetative covering, or, as the Germans so happily put it, the *Vegetationsteppich*. These conceptions are four: the individual plant, the species, the habitat-group, and the formation. From and through these we come to the conception of vegetation. Historically the idea of species came first into prominence. Botanists were long engaged in the study of species as such, and until comparatively recent times the Linnaean division of Botany into "*dispositio et denominatio*" was substantially controlling. From species the standpoint shifted to individual plants as such, and the individual plant received the attention of the best workers almost exclusively. Both of these movements were necessary before the study of vegetation as such was possible. The conception of the vegetative covering must be reached through the conceptions of the species on the one hand and of the individual plant upon the other hand. Sound taxonomy is a prerequisite of floristic and distributional investigation, and hence of one aspect of Phytogeography. Morphology is the foundation of another side and Ecology of still another, and perhaps the most important. The first deals with species, the last two deal with individuals. By bringing all to bear, we may understand vegetation.

This definition is broader than that given to *Pflanzengeographie* by Drude in 1890 and goes beyond his more liberal views of 1895. But it appears to be substantially what his work in 1895 and the work of the contributors to Engler and Drude's *Vegetation der Erde* must lead to, and Warming's title, *Ecological Plant-geography*, suggests the same conclusion, namely, that Phytogeography is many-sided and rests upon Ecology on one side. Although Dr. Drude in a letter to the authors refers to the Phytogeography of

Nebraska as "*ihre floristische Studien*," and on the other hand Dr. Coulter in a letter refers to it as "your ecological studies," we may believe that neither Floristics nor Ecology is the proper or the future name of this department. Ecology, "that portion of botanical science which treats of the relations of the plant to the forces and beings of the world about it"* is in fact a phytogeographical application and development of physiology. Ecological Phytogeography is not all of Phytogeography, and we may be assured that the whole will in the end include its parts. The term Phytogeography may not prove to be the best. It may be, as the title *Die Vegetation der Erde* would indicate, that in the end we shall say merely Vegetation or some word of like import. But it does not seem wise in such a work as this to indulge in more neologies than are imperative, and in a public survey, where geographical limits are to be observed primarily, there is not a little appropriateness in the name Phytogeography.

As phytogeography rests, analytically, upon the individual plant, the species, the habitat-group, and the formation, the phytogeographer will do well to arrange his results in corresponding manner. To the individual plant would correspond the vegetation-form, a conception based upon morphology considered purely from a phytogeographical standpoint. The species, considered primarily with reference to numbers, would be represented by distribution or floristics. In sharp contrast with these are conceptions which have to do with the species considered associationally, i. e., in groups. The habitat-group, the ecological conception, results from combination of the two ideas. The species are here considered with respect to function and environment and with reference to their disposition into groups as a result. In the formation the idea of association is the primary one. The formation or the idea of vegetation, however, includes something of the three preceding conceptions, and is in consequence to be regarded as the summation of phytogeographical investigation. The difference is shown more clearly by

* Barnes, *Plant Life*, 307, 1898.

reference to the immediate foundation of each department of the subject. Floristics is primarily the consideration of the species numerically, the vegetation-form a study of the species morphologically, and ecology the study of species, as represented by individuals, physiologically, or, better, environmentally. The study of vegetation is the investigation of species associationally. All other aspects of the species, and, indeed, species themselves, are subordinated, if not lost sight of.

In consequence of the many-sidedness of the subject, the phytogeographer should not restrict himself to one standpoint. Now one must be taken, and one phase of the subject accentuated, and now another. But the factors in phytogeographical investigation may be grouped conveniently under two general heads: geographical or physical factors, including physiography, soil composition, geology, and meteorology, as they affect or determine the constitution of the vegetative covering; and biological factors, including morphology, physiology, and histology, as through the individual units they determine the composition and character of the whole. To these may be added taxonomy, the necessary forerunner of all investigation in which the species is an element, and phytopaleontology, to which we must look for explanation of the past of vegetation and the basis of its present constitution and distribution.

Terminology.—The recent development and expansion of phytogeography have rendered the older terminology inadequate. The new terminology which has sprung up has not attained sufficient currency or uniformity within itself to give it entire authority or to prevent more or less ambiguity from attaching to its terms. Even the latest writers on the subject feel obliged to define the terms which they apply to phenomena already well understood. Since the most recent literature upon this subject is in the German language, and since as yet comparatively few original contributions of importance have appeared in English, it is necessary either to translate or adapt the German terminology so far as

applicable to our conditions, or to attempt to formulate an independent English terminology. Neither plan is entirely feasible. We have been obliged to take a middle course, translating or adapting German terms when we might, and, where that was impossible or inexpedient, endeavoring to devise independent terms in English.

History of the investigation of the flora of Nebraska.—The region now comprised within Nebraska early received the attention of botanists. The Missouri river afforded a natural highway for exploring parties to the Rocky mountains and the country beyond. In consequence our territory received attention, incidentally at least, from the earliest explorers, and the beginning of the investigation of the vegetation of Nebraska may be referred definitely to the opening years of the present century. Naturally such attention was superficial and to a great extent entirely fortuitous, and its results were scattered and of little value. With the geological and military surveys of the vast region formerly included in the Territory of Nebraska, appeared some slight system in the matter of obtaining and collating botanical data, but as the present boundaries of the State are of comparatively recent date, no strictly systematic investigation of the flora of our state could be made. Rather more than a decade ago, Dr. Bessey, Professor of Botany in the University of Nebraska, undertook the scientific investigation of the botany of the State. Through his efforts and those of his pupils work upon the flora of the State proceeded with the strictest observance of systematic, scientific methods. So fruitful has this work been that in certain directions the botanical possibilities of the State have been all but exhausted, while in all lines a broad foundation for future research has been laid. Compared with such results, the scattering data acquired from earlier explorations and reconnaissances lose all but historic interest.

It may be seen from the foregoing that the botanical history of Nebraska falls into two parts, the first embracing the period of merely incidental or unsystematized exploration,

from 1803 to 1884, and the second embracing the time during which botanical work has been conducted in a systematic manner, from 1884 to the present. In view of their relative unimportance as factors in the advancement of the knowledge of the flora of the State, the early explorations will receive but brief treatment.

Lewis and Clark in their famous journey to the Pacific coast made use of the Missouri river for both the outward and the home journey. As they were not especially interested in the investigation of the plains country, they left the river at few points and then only for short incursions upon the prairies. The packets of specimens collected upon the outward journey in 1803 were lost in the mountains, and could be replaced only in part during the return trip in 1806. The plants of this collection were identified by Frederick Pursh. The only botanical record of them is to be found in Pursh's *Flora Americae Septentrionalis*, published in 1814, where the new species are described. Two years after the Lewis and Clark expedition, in 1808, Nuttall and Bradbury passed up the Missouri in company with a similar exploring party. They collected on the Nebraska side of the river at several points, notably at the mouth of the Platte, at old Council Bluffs, Blackbird, and in the lower valley of the L'Eau-qui-court. Their collections, which were of considerable extent, were published in part in Fraser's Catalogue, 1813, and in part in Nuttall's *Genera of North American Plants*, 1818. Charles Geyer, the botanist of the Nicollet expedition in 1838-1839, collected extensively along the bluffs and lowlands of the Missouri river. The list of plants collected by him, prepared by Dr. Torrey, and published in Nicollet's Report in 1843, was the first one at all comprehensive for any portion of the State. Fremont in 1842 traversed nearly the entire southern half of the State, making important collections in the valley of the Little Blue and of the Platte. The collections were identified by Torrey, and a complete list was published in Fremont's report in 1845. In 1844, Fremont also collected

along the Republican river in the western part of the State, but no botanical record of the collection remains, as it was wholly lost. In 1848 Stansbury passed through the State, following the route pursued by Fremont. His journal and list of species were embodied in Stansbury's report, published in 1855. The journal contained some information upon the flora of the plains, and the list added materially to the number of collected species. Warren, in an account of a military reconnaissance of the sand-hill region made in 1855, remarks briefly upon the botanical features of the territory traversed. The most important, botanically, of the early expeditions was that of Warren in 1856-1857. He passed westward through the State, exploring the Elkhorn and Loup valleys, and the western foot-hills. Returning, he traversed the entire valley of the Niobrara and explored a portion of the great bend of the Missouri. The list of determinations was made by Dr. Engelmann, and was published in Warren's report in 1858. Hayden, while engaged in the geological survey of Nebraska, made numerous observations of considerable botanical interest which appeared in the First Annual Report of the U. S. Geological Survey (1867).

Upon the opening of the University of Nebraska, in 1871, an opportunity was afforded for continuous investigation of the flora of the State. But the limited means of the University in the early years of its existence made it impossible at first to secure a specialist in botany, and the University was not fortunate in the person who first filled the old chair of natural history. Not only was no adequate work done upon the flora of Nebraska during his term, but what was done has required undoing. The pretentious catalogue, enumerating some 2,000 species, put forth by Professor Aughey in 1875, and his lists given in other writings, might lead one to suppose that the flora of the State was well known when he severed his connection with the University. The facts are otherwise. His collections contain not more than 200 species, and are confined to the southeastern portion of the State.

His catalogue and his lists, as has been shown elsewhere,* were based almost entirely upon conjecture as to the range of species, taken from data in the manuals, and they have proved entirely unreliable.

When in 1884 Dr. Bessey was elected to the newly created chair of botany in the University, accurate and sustained work upon the flora of the State was at last begun. In 1886 Dr. Bessey presented his first report to the State Board of Agriculture upon the Grasses and Forage Plants of the State. Since that report, his annual reports to the State Board of Agriculture and the State Horticultural Society have been largely concerned with the native plants of the State and their distribution. These reports are of the first importance for the phytogeography of the State. Two years after Dr. Bessey took charge of the botanical department of the University, the Botanical Seminar was organized, and under his direction began to investigate the flora. As a result of this work and of that done by Dr. Bessey as botanist to the Agricultural and Horticultural societies, Mr. Webber in 1890 put forth a catalogue enumerating 1,890 species, and indicating where they had been collected or observed by reliable collectors. This catalogue, like all subsequent catalogues issued by the University, was based upon actual herbarium specimens exclusively. The next year Mr. Webber published an appendix, giving the results of further collections made by himself and other members of the Seminar. A second edition of this, with a supplementary list by Dr. Bessey, was quickly issued, and these raised the total of reported species to 2,492. For the purpose of systematizing the work upon the flora of the State already in progress, and giving it continuity, the Botanical Survey of Nebraska was organized by the Seminar in 1892. The members of the Seminar have carried on the work of this survey almost entirely with their private means, but at times have been assisted somewhat by the State Board of Agriculture and the United States Department of Agriculture. The last report

* Bot. Surv. Neb., 3: 43, 1894

of the Survey states the flora of Nebraska at 3,192 species, a number which has since been considerably augmented by further collections.

The members of the Seminar, chiefly since the organization of the Survey, have personally visited substantially every portion of the State and have collected and made extensive notes in every locality of importance. In the wooded-bluff and meadow-land region Mr. Webber in 1889 collected along the bluffs of the Missouri from Rulo to Nebraska City. The greater part of the remainder as far as Omaha has been gone over between 1893 and 1896 by Messrs. Pound, Saunders, and Clements in a succession of trips, some of extended duration. The upper Missouri and the Ponca district were gone over by Dr. Clements in 1893.

The prairie region has been the scene of active work at all times, being in its length and breadth readily accessible from the University. The western portion of the region was gone over by Dr. Rydberg in 1891, and has been the scene of extensive and valuable labors by Dr. H. Hapeman, of Minden. Prof. G. D. Swezey has also contributed to our knowledge of this region.

A succession of extended expeditions has traversed every portion of the sand-hill region. Dr. Bessey in 1887 and Dr. Clements in 1893 went through the Niobrara district, which has also been made known by the extensive collections of Rev. J. M. Bates, of Long Pine. Mr. Webber in 1889, Messrs. Smith and Pound in 1892, and Dr. Rydberg in 1893 went over different portions of the Loup district, and Messrs. Woods and Saunders in 1893 traversed the whole of the Republican district, which has, in addition, been the field of an active collector, Mr. E. M. Hussong, of Franklin.

Different portions of the foot-hill region have been gone over by Dr. Bessey in 1889, Mr. Smith in 1889, Mr. Williams in 1891, Dr. Rydberg in 1891, Messrs. Smith and Pound in 1892, Mr. Woods in 1892, and Dr. Bessey and Dr. Clements in 1897.

A more detailed statement of the ground covered by the

various collectors who have visited different portions of the State will be found in the third report of the Survey.*

Bibliography.—The books consulted or made use of in the course of the work which do not relate specially to the flora of the State, chiefly books of a general character, are given in the first list. In the second list are enumerated all books or papers relating especially to the flora of the State.

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CHAPTER I.

PHYSIOGNOMY AND CLIMATOLOGY.

Physiography.—Nebraska occupies a central position in the Great Plains region of North America. Its boundaries are purely political except upon the east and northeast, where it is limited by the Missouri river. But the Niobrara river on the north, the Republican river on the south, and the foot-hills on the west coincide approximately with the political boundaries. The southern boundary of the State is formed by the parallel of 40 degrees of north latitude, and the northern boundary by the 43d parallel. On the west, the 104th meridian west of Greenwich is the boundary as far as the 41st parallel; south of this, a line drawn a few kilometers west of the 102d meridian separates Nebraska from Colorado. In general shape the state is a parallelogram, longest from east to west. Its extreme width approximates 335 kilometers, and its length 660 kilometers. In area it ranks among the large states of the Union, comprising 190,000 square kilometers. It is, therefore, much larger than all of the New England states combined, contains 38,500 square kilometers more of territory than England and Wales combined, and is considerably more than one-third as large as France or the German Empire.

GENERAL TOPOGRAPHY.—From its location in the center of the Great Plains it follows that the surface of the State is little diversified, consisting for the most part of rolling prairies, which in the west and northwest rise into elevated plateaux and foot-hills. The southeastern portion of the State lies about 275 meters above the level of the sea. Towards the west and the north the ascent is gradual, reaching an altitude of about 1,500 meters in the Hat Creek country and of over 1,600 meters in the western foot-hills. The lowest point in the State is Rulo, 240 meters above the

level of the sea, and the highest the Wild Cat mountains, 1,616 meters above the level of the sea. For the first 150 kilometers the ascent is at the rate of 1 meter per kilometer, for the second 150 kilometers at the rate of 1 1-3 meters per kilometer, for the third 150 kilometers 1 2-5 meters per kilometer, and for the fourth 150 kilometers there is an average rise of 2 meters to the kilometer. In the extreme western portion of the State the rate of ascent is approximately 3 meters to the kilometer. Along the eastern border of the State lies the valley of the Missouri, from 1 to 16 kilometers wide, bounded by rather steep and broken bluffs on the west. Directly beyond these lie the broad, rolling prairies which comprise the eastern half of the State. These prairies are characterized by long series of low, gently undulating hills, separated by broad, shallow depressions. West of the prairies are the sand-hills, marked by sharper, more broken hills and by deeper and more narrow valleys. These pass somewhat abruptly on the west into the elevated plateaux, which are characterized by numerous isolated buttes and by deep, precipitous ravines. To the northwestward lies the high table-land known as Pine Ridge, which surrounds the most unique region in the State, namely, the Bad Lands.

RIVER SYSTEMS.—The river systems of the State are five in number, dependent upon the Missouri river as their ultimate affluent. The three chief of these, the Platte, the Niobrara, and the Republican are parallel; the fourth, the White river, drains a submontane country and flows to the northeastward, where it joins the Cheyenne, a tributary of the Missouri. The fifth, the Blue, drains the prairie region south of the Platte, flowing south to the Kansas, which, having already received the Republican, empties into the Missouri. The general direction of the waters of the State is towards the east or the southeast. This is not only true of the main streams, but of their most important tributaries as well.

The Missouri river, which forms the northeastern and eastern boundary of the State, rises in the Rocky mountains

of Montana and pursues a generally southeastern and southern course until it empties into the Gulf of Mexico. Taken in its entirety, 5,200 kilometers, it is the longest river of the world, and its hydrographic basin ranks among the most extensive. In the upper portion of its course it exhibits all the characteristics of a mountain stream, and is especially noted for its cool, clear waters and numerous cataracts. By the time it has traversed the prairies of the Dakotas, it has become greatly modified. Although still retaining its swift, turbulent current, it has greatly increased in depth, and its waters have acquired a typically yellow color, due to the immense quantities of sand and silt carried along. Where it touches Nebraska, the Missouri flows through a broad, fertile valley, varying from 800 meters to 16 kilometers in width, and enclosed between an almost continuous chain of steep, wooded bluffs, pierced here and there by numerous ravines and occasional large tributaries. The Missouri river is notable for the extremely shifting character of its tortuous channel. It rarely flows midway between the bluffs, but sweeps alternately from one side of the valley to the other, leaving first a broad stretch of lowland on the Nebraska side and then cutting in beneath the overhanging bluffs. The latter are constantly undermined by the swift currents which abound in the river during the spring and autumn "rises." During these periods the river sweeps far under the overhanging ledges, and the first notice of its effect is the crash heard as a large strip of bluff falls into the river. In some places areas as great as 16 hectares have fallen into the river in a day or two, owing to the great undermining power of the current. On the other hand, the stream has been known to leave its former bed and cut an entirely new channel during a single night. The immediate vicinity of the river is remarkable for frequent lagoons and cut-offs, direct results of shiftings of the channel. The actual length of the Missouri river along approximately 480 kilometers of Nebraska territory is upwards of 660 kilometers. Its mean width is 800 meters, the maximum being

2,000 meters, the minimum 200 meters. While large tributaries are very numerous on the Iowa side, but few large streams flow into the Missouri from the Nebraska side, for the reason that the watershed is close behind the bluffs, and the waters of the interior are turned into the Elkhorn, the Platte, and the Blue. The Platte and the Niobrara excepted, but eight streams of more than 40 kilometers in length flow directly into the Missouri. The majority of these are about 50 kilometers long, but Ponca creek is 170 and the Little Nemaha 110 kilometers in length. The direction of these streams is either northeast or southeast, and instead of running into the interior, they take a parallel course for the most part beside the bluffs.

The Platte river is formed by the union of the North Platte, which rises in the North Park of Colorado, and the South Platte, whose source is in the South Park of Colorado. The North Platte, the main river, is the longer, being 1,600 kilometers from its source to its junction with the Missouri. The South Platte is 750 kilometers to its union with the North Platte. Throughout its course in the State, the Platte is a broad, shallow stream, lying between low, mostly treeless banks, and characterized by numerous, long, narrow sand-bars. Where it enters the State the North Platte is about 150 meters wide, the South Platte about 100 meters. At the point of junction of the two the river is about 300 meters wide. At its confluence with the Missouri, its extreme width is nearly 1,600 meters. The stream rarely flows in a definite channel, but on account of the extreme width of its bed commonly splits into several smaller streams, separated by narrow wooded islands or long strips of sand-bar. In the western part of the State, the North Platte flows through a deep, gorge-like valley, rarely more than a kilometer in width. In the central and eastern parts of the State, the bluffs are generally found at a considerable distance from the stream, and the immediate valley attains a width of from 3 to 16 kilometers. Below the junction of the two branches, the Platte receives no tributaries of

importance on the south, since the watersheds of the Blue and the Republican rivers follow it at a very short distance. Pumpkinseed creek is the only tributary of any importance which the North Platte receives in the foot-hill region. In the same region the Lodge Pole, a much more considerable stream, 175 kilometers in length, flows into the South Platte just before the latter enters the State. In the central and eastern parts of the State, the Platte receives on the north, Wood river, 150 kilometers long, the Loup, 570 kilometers long, Shell creek, 100 kilometers in length, and the Elkhorn river, 500 kilometers long. Of these, the Loup and the Elkhorn deserve special consideration.

The L o u p river is formed by the junction of the North, Middle, and South Loups. They rise in the heart of the sand-hill region and pursue parallel courses toward the southeast, uniting about 175 kilometers from the mouth of the main river. Near their source they are cold, swift streams, fed by springs, and flowing in a narrow, deep channel with a calcareous sandstone bed. In the upper part of their course they lie in deep gorges with abrupt banks. In the lower part the gorge widens into a narrow valley covered for the most part with meadow land. The Middle Loup receives on the west an important tributary, the Dismal, which heads in the peculiar lake region of Grant and Hooker counties. The North Loup receives the Calamus, a river 150 kilometers long, which drains a marshy region in the sand-hills of Brown county.

The E l k h o r n river rises in the sand-hills of central Rock county and pursues at first a general easterly and then southeasterly direction to its junction with the Platte. Compared with the Loup, the Elkhorn is a sluggish stream, pursuing a tortuous course, between low, denuded banks. It lies in a broad valley of no little fertility, marked in its upper portion by extensive hay fields.

Salt creek, the only important tributary of the Platte on the south, rises in the prairies of southern Lancaster county and pursues a northeast direction between the watershed

of the Blue on the one hand, and of the Missouri on the other. It is a deep, sluggish stream, flowing between low, wooded banks. Its waters are highly discolored by the large amount of silt which it carries, and saline on account of the numerous salt basins which it drains.

The Niobrara river rises in the high table-lands of eastern Wyoming and flows in a narrow gorge until it is joined by the Keya Paha, at which point the gorge broadens into a valley 800 to 1,200 meters wide. It is 560 kilometers in length. Its width where it enters the State is but a few meters, but near its mouth its extreme width is 150 meters. Its current is exceedingly rapid, the channel is shallow and sandy, and in the eastern portion the banks are low and wooded. The bluffs of the Niobrara are peculiarly steep, and are covered with a dense growth of shrubs and small trees, and in some places the valleys themselves are heavily wooded. The chief tributary on the north is the Keya Paha, which rises in South Dakota and is in all respects similar to the Niobrara. On the south the Niobrara has the most remarkable drainage system of any stream in the State. The extensive sand-hill region to the south constitutes a vast reservoir whose waters find their way into the Niobrara through numerous spring branches. These small streams have their sources in large springs in the sand-hills and flow through extremely narrow, precipitous canyons. Their waters are cold and limpid and are almost entirely destitute of vegetation. To the westward the river receives several large tributaries, which, rising in marshes or ponds in the sand-hills, flow in their upper course through broad, marshy valleys, bounded by high sand-hills, and in their lower course through precipitous canyons.

The Republican river rises in the sandy plains of eastern Colorado. Where it enters the State it is still a small stream, but after receiving the South Fork, and particularly the Frenchman, it assumes the proportions of a river. Its general direction through the State is easterly to eastern Nuckolls county, where it bends southward into

Kansas, at length uniting with the Kansas river. Its entire length is rather more than 600 kilometers. Its minimum width in the State is, perhaps, 15 meters, and its maximum about 200 meters. The bluffs rise at some distance from the river and are generally bare. At their base lie rather broad, treeless valleys. Along the banks there is commonly a fringe of willows. The Republican river is similar to the Niobrara in general character, but is broader, more shallow, and interrupted by frequent sand-bars. The chief tributaries on the north are the Frenchman, the Red Willow, and the Little Medicine, all streams of some size. On the south the principal tributaries are Beaver and Prairie Dog creeks.

The **B i g B l u e** river, which affords the chief drainage for the most fertile portion of the State, rises in the prairies of Hamilton county very close to the bluffs of the Platte. It pursues an eastern and then a southern direction through very broad, level valleys, which are for the most part heavily wooded in the vicinity of the stream. It is a deep, sluggish river with muddy bed and banks. Its length is 350 kilometers, its maximum width in the State somewhat less than 100 meters. Its most important tributary is the Little Blue river, which drains the western portion of the prairie region. The Little Blue is a much swifter stream, with clearer waters, flowing for the most part in a sandy channel. Along its course are found the densest woods of the State. Its length is about 275 kilometers; its average width in the State is 25 to 30 meters.

The **W h i t e** river rises on the northern slope of Pine Ridge. For the 80 kilometers of its course in Nebraska, it flows through a region broken up by canyons and receives innumerable small tributaries. Its approximate length to its junction with the Cheyenne is 400 kilometers. It is of little importance in Nebraska, but, together with another tributary of the Cheyenne, Hat creek, drains the most peculiar region of the State.

Hat creek rises in the central part of Sioux county and pursues a generally northward course to the State line

through a rugged, submontane region. It is formed by the union of numerous small streams draining the deep canyons which mark this region. It is chiefly important because it drains the Bad Lands.

LOST CREEKS.—The sand-hills, and even more the western foot-hills, are remarkable for streams rising in springs or ponds which flow for a varying distance through the porous, sandy soil, at last losing themselves completely. In some cases, after a short subterranean course, which may often be ascertained from surface conditions, they appear, again to be lost after pursuing a short course. Sometimes their lower course is marked by an extensive sand-draw, which marks the former channel of the stream. These sand-draws invariably present peculiar conditions, and have a vegetation of their own. The chief of these streams is Snake creek, which rises in southeastern Sioux county, and flows in a generally southeastern direction for more than 80 kilometers, at length losing itself in the sandy plains of northern Cheyenne county. Similar streams are Dry creek and Point of Rocks creek in Box Butte county, Willow creek in Cheyenne county, and Rush creek in Deuel county.

LAKES AND PONDS.—The chief lake regions are in northeastern Cherry county, at the head of Plum creek, and in Grant and Hooker counties at the head of the Dismal. Besides these there are numerous large ponds scattered here and there throughout the sand-hills, and occasionally in the foot-hill region. The lakes occupy valleys between ridges of steep sand-hills. The general shape, conforming to that of the valley, is oblong. Like the ponds in wet valleys throughout the sand-hill region, they invariably occupy the northeastern portion of the valley. They have no surface connection, although they lie close together and the passage from one valley to the other is usually easy. The valleys slope gradually to the very edge of the lake in many cases, and the waters are clear and shallow. The margin, which is destitute of woody vegetation, and the bed are sand. Sometimes at the upper, or western, end they are lost in marshes. Chief

among these is Dads Lake, a little more than 8 kilometers long and from 1,500 to 2,800 meters wide. It occupies a long valley, bounded by very high, steep hills, and has no outlet. Along the course of the Missouri there are numerous so-called lakes, often of some size, which have been formed invariably by the cutting off of a portion of the river's channel. They are in fact merely old river beds, or, at most, lagoons. The saline waters of the State are confined to two regions, the salt basins of Lancaster county and the alkaline ponds of the foot-hill region. These are entirely unlike both in their origin and in their general character. The salt basin system, which consists of numerous small basins, has arisen as a result of erosion by the waters of numerous salt springs. The chain of basins covers between 4,000 and 6,000 hectares, the largest individual basin comprising not much less than 500 hectares. These basins are always closely connected or flow directly into Salt creek, which ultimately receives the waters of the entire salt basin system. The alkaline ponds of the foot-hills have no outlet, and their alkaline properties are chiefly due to evaporation. They occur isolated and are of small size.

BUTTES.—The buttes are the only representatives of mountain formations found within the limits of the State. They occur rather widely distributed in the foot-hill and sand-hill regions but are most abundant in the former. They are bare, pyramidal or conical peaks, with flat tops, and sides so precipitous as to be almost inaccessible. Though never rising more than 200 or 300 meters above the surrounding country, their height above sea level is considerable. Thus Scott's Bluff is 1,421 meters and the Wild Cat mountains 1,550 meters high. Other conspicuous buttes are Chimney Rock, Court House Rock, and Pine Bluff, each over 1,200 meters high, Coliseum Rock and Squaw Butte in the Bad Lands region, each about 1,000 meters high, Keya Paha Buttes, Turtle Buttes, and Forked Hill in the Niobrara country, a little less than 1,000 meters high, and Lookout mountain in the Republican valley, about 800 meters high.

The Wild Cat plateau, 1,616 meters high, is probably the greatest elevation in the State.

SAND-HILLS.—The sand-hills occupy a broad belt in the central and west-central portions of the State. This belt in the central portion extends entirely across the State, and is broadest in the middle. Its boundary on the east is indefinite. It may be represented by an exceedingly irregular line which inclines to the east between river valleys and recedes correspondingly. On the west the line of demarcation is much more sharp, although areas of sand-hills occur in the foot-hill region. The area covered by this belt is approximately 75,000 square kilometers. The sand-hills are thought to owe their origin to winds, and it is certain that the hill contours are a direct result of the prevailing winds of the region. The blow-outs are a special instance of wind agency. These blow-outs, which are the distinguishing feature of the true sand-hills, are large crater-like pits blown or scooped out of the side or top of a hill.

CANYONS.—The gorges and gullies of the state fall into two divisions: the ravines which abound in the Missouri bluffs and the prairie region, and the canyons which are typical of the foot-hill region and of the river basins of the sand-hill region. Although canyons occur regularly along the Niobrara, the Republican, and the upper Platte, the great areas of canyons are in the Keya Paha country, the upper Republican district, in the central foot-hills, and in the Hat creek basin. The most extensive of these areas is the second. The most peculiar is the last.

BAD LANDS.—The Bad Lands occupy an extensive district in the Hat creek and White river basins. There are also stretches of Bad Lands in the foot-hill region south of the North Platte. The Bad Lands are caused by excessive and continuous erosion of the canyon sides and the buttes resulting therefrom. The result of this constant leveling is the formation of an extremely loose soil in which it is impossible for vegetation to secure a foothold, and the sculpturing out of numerous fantastic cliffs and buttes. The

comparatively slight precipitation and great summer heat, together with the instability of the soil, bring about an almost complete absence of vegetation.

Geology.—*The state of Nebraska, like similar regions in the Great Plains, is generally level, with a gradual rise in elevation from east to west. The configuration of the region is such that the diversity of the topographic features is greater than one at first realizes.

The topographical features of the State are due largely to the action of water, and, in a certain way, to the action of the wind, and in some cases to the combination of the two. The prairie, which may be ever so level, is often a great deal more rolling and broken as the river courses are approached, this being due entirely to the erosive action of water upon the surface. However, surface erosion is reduced to the minimum because of the sandy nature of the soil, which absorbs 90 per cent of storm water, leaving but 10 per cent to flow off and wash away the soil.

The Bad Lands are largely clays and marls, which absorb little or no storm water, and are subject to excessive erosion. As a result, we have castellated buttes, pinnacles, chimneys, and other characteristic forms of the Bad Lands. In the region of the sand-hills, the topography is, or rather was, shaped largely by the wind, although at the present time it is universally conceded that the sand-hills of Kansas and Nebraska are becoming more stable. Upon high table-lands, such as Pine Ridge, there are numerous rocky crags and pinnacles due largely to the constant action of wind and water combined.

The geology of the State, though extremely simple, is in a certain sense obscured by the overlying soils of unusual depth, thus concealing the terraines or rock-masses from view. An exposure of rock is a rare occurrence. However, these overlying soils which conceal the terraines below are just as much geological formations as the rocks themselves.

The important overlying deposits resolve themselves into

*By Prof. E. H. Barbour.

three distinct groups as follows: Drift, Loess and Plains marls, and Sand-hills. Across the eastern fourth of the State is found a deposit of glacial material consisting of gravels, clays, and stray boulders, overlaid in some cases by later deposits of loess. The extent of this loess is such that it covers one of the broadest areas of the State, extending through the southern half from east to west, but merging insensibly into soil and coarser material of the same appearance and texture, which we may call "western loess" of western Nebraska, commonly called "plains marls." As far as the casual observer is concerned, there is no difference between the eastern loess, which consists of 50-60 per cent of silt, and the western loess, which consists of 60-70 per cent of the next coarser material, very fine sand.

The next superficial formation is the sand-hill region, including in this term the sand-hills proper, and also the gravels carried during tertiary times from the Rocky mountain slope. In a certain sense, the tertiary gravels brought by water from the Rocky mountains may be considered as a continuation of the glacial gravels and sands carried from northern regions and deposited over the eastern portion of the State. The Bad Lands extend south from the northwest counties across the entire western end of the State, though in rather disconnected patches. The Bad Lands are poor in all superficial deposits.

Studying the geology of the State from the actual exposures of bed rock, all rocks of the southeastern counties, including most of Gage and a part of Lancaster, are carboniferous and universally characterized by the excessive number of foraminiferal shells, *Fusilina cylindrica*, which from their shape, size, and enormous number have given the carboniferous limestone of the State the common name of rice-stone.

Immediately following carboniferous times, there was a season during the whole of the Jura-trias, when Nebraska was above water, and so losing rather than receiving deposits. This accounts for the absence of Jura-trias in the State, and explains why the rock, which occurs after and upon the

carboniferous, is so much younger, cretaceous. The cretaceous extends from north to south in a nearly straight line along the first guide meridian west, that is, between 98 and 99, until Wheeler county is reached, whence it goes diagonally across the State to Keya Paha county.

In the western portion of the State, covering several counties along the North and South Platte rivers near their junction, is a large tract of cretaceous, probably Colorado, little studied as yet. There are also isolated patches in the Bad Lands, Sioux county (Fort Pierre), and some in the southern counties. The cretaceous is commonly divided into eastern, or Dakota, and western, or Colorado, cretaceous. In the cretaceous are represented the Dakota, the Benton, the Niobrara, and the Fort Pierre. The latter probably extends across the State, from the eastern one-third to the west, being exposed in but a few places.

Covering all the western two-thirds of the State occurs the tertiary, in which is represented as the lowest layer the Miocene of the Bad Lands. Above this, in isolated patches, occur the rather coarse sands and gravels of the Loup Fork, found far west and extending across the State from Sioux county to Frontier and Hitchcock counties.

Meteorology.—The western plains, of which Nebraska is a part, are characterized by hot summers and mild winters. Extremes of either heat or cold, though frequent, are usually local, and almost invariably transient. Over a region which possesses a surface so little diversified one would expect to find climatological conditions very equable. This is true for means covering large extents of territory only; neighboring localities often manifest very marked deviations. Such differences are easily traceable to local conditions, and have no important bearing. In general the mean annual temperature, which is greatest in the southeastern corner of the State, decreases regularly to the northward and the westward, i. e., with the latitude and the altitude respectively. In like manner, the rainfall, which is most abundant in the southern portion of region I, diminishes toward the north

and west, though with less regularity. Thus the mean temperature for region I is 10° , for region IV, 7° . The annual precipitation for region I is 830 mm., for region IV, 459 mm. While the difference between totals is not so great, the period of occurrence of temperature extremes and the temporal distribution of rainfall are so dissimilar for the two regions that, while the one is wooded and mesophytic, the other is a xerophytic, desert-like table-land.

Owing to the imperfection of the meteorological record the following data and tables apply only to the year 1896. The general data are quoted from the annual summary of the Climate and Crop Service for 1896 by G. A. Loveland. The temperature and precipitation tables have been compiled from the same work.

“The mean annual temperature for the State was 11 ; the° mean temperature for November, the coldest month, being -3.2° , and for July, the warmest month, 23.5° . The lowest monthly mean was -8.5° at Bassett in November, and the highest was 27° at Republican in July. The lowest temperature was -30° at Lodge Pole on the 27th of November, and the highest was 42.8° at Norman on the 26th of July. The average total precipitation over the State for the year was 655 mm., which is 66 mm. above the normal. The greatest total precipitation was 1,194 mm. at Sutton, and the least was 315 mm. at Fort Robinson. The greatest monthly amount over the State was 120 mm. for April, and the least was 4 mm. in February. The greatest monthly precipitation was 344 mm. at Rulo in May. The total average snowfall was 600 mm.; it was greatest in the northwestern section, where it was 910 mm., and least in the south, where it was 420 mm. The greatest amount of snow reported was 1,425 mm. at Lodge Pole and the least 15 mm. at Aurora. The average number of days on which the precipitation amounted to $\frac{1}{4}$ mm. or more was 61, the maximum number being 109 at Omaha. The average number of clear days was 167, of partly cloudy, 121, and of cloudy, 77. The average velocity of the wind over the State was 14 kilometers per hour, which is .8 kilometers

per hour above the normal. The maximum velocity was 128 kilometers per hour at Lincoln on May 12."

Separate tables are given for each of the phytogeographical regions of the state.

REGION I.

WOODED-BLUFF AND MEADOW-LAND REGION.

TEMPERATURE TABLE.

Station.	Elevation (meters).	Mean Temperature.				Annual mean.	Absolute Max.	Tem. Min.
		Winter.	Spring.	Summer.	Fall.			
Rulo.....	256	1.5	13.	....	11	12.5	40	-19
Salem.....	277	2.5	13.5	25.5	10	11.5	39	-17
Nemaha.....	274	-1.0	12.0	24.0	8	11.0	....	.....
Tecumseh.....	340	0	12.0	23.0	...	10.5	37	-20.5
Arnburn.....	326	1.0	12.0	24.0	9.5	12.0	40	-21
Turlington.....	370	-1.0	11.0	23.0	8.0	10.0	38	-25
Nebraska City.....	287	....	12.0	23.5	9.0	....	35.5	....
Weeping Water....	329	-1.5	10.5	21.5	6.0	8.5	36.5	-23.5
Ashland.....	335	.5	10.5	23.0	8.5	10.5	36.5	-21.5
Omaha.....	340	0	11.0	23.0	8.5	9.5	35.5	-22
Tekamah.....	326	-2.0	10.5	22.0	8.0	9.0	36.5	-23
Santee.....	377	-2.0	9.5	23.0	6.0	8.0	40.5	-25
Lynch.....	...	-2.5	9.0	22.0	5.0	8.0	38.0	-24
		2.5	11.2	23.0	8.1	9.2		

PRECIPITATION AND SKY TABLE.

Station.	Precipitation in Millimeters.					Condition of Sky,		No. of Days	
	Winter.	Spring.	Summer.	Fall.	Total.	Rainy.	Clear.	Pt. Cldy.	Cldy
Tecumseh.....	38	373	307	204	922	81	143	86	137
Arnburn.....	58	377	346	237	1018	84	112	154	100
Turlington.....	33	338	287	232	892	91	160	117	89
Weeping Water.....	35	395	315	224	969	96	124	193	49
Ashland.....	21	363	255	265	904	94	163	164	39
Omaha.....	29	377	248	243	897	109	117	115	134
Tekamah.....	26	398	340	249	1013	84	106	208	52
Santee.....	5	278	244	193	719	73	116	176	74
Lynch.....	5	234	297	139	675	72	167	94	105
	26	347	293	220	889	87	134	145	86

REGION II.
PRAIRIE REGION.

TEMPERATURE TABLE.

Station.	Elevation.	Mean Temperature.				Annual mean.	Absolute Max.	Tem. Min.
		Winter.	Spring.	Summer.	Fall.			
Hebron.....	344	1.0	11.0	22.5	8.5	11.0	38.0	-21.0
Beatrice.....	376	0.0	11.5	23.0	9.0	11.0	36.0	-20.5
Blue Hill.....	600	-0.5	9.5	24.0	9.0	10.5	39.5	-23.0
Crete.....	417	1.0	11.0	23.0	9.0	11.0	35.0	-21.0
Lincoln.....	360	1.0	11.0	23.0	9.0	11.5	36.5	-20.5
Aurora.....	546	0.5	9.5	23.5	8.0	10.5	38.0	-20.5
Lexington.....	727	1.5	9.0	21.0	7.5	9.5	37.0	-24.0
Grand Island.....	567	0.5	9.5	22.0	8.0	10.0	36.5	-22.0
Loup.....	630	1.0	10.5	22.0	7.0	10.0	38.0	-21.5
Norfolk.....	467	-2.0	9.0	21.0	6.5	9.0	34.0	-23.0
Creighton.....	484	-3.0	9.0	22.0	5.0	8.5	39.5	-26.0
		0.1	10.0	22.5	7.8	10.2		

PRECIPITATION AND SKY TABLE.

Station.	Precipitation in Millimeters.					Condition of Sky.		No. of Days.	
	Winter.	Spring.	Summer.	Fall.	Total.	Rainy.	Clear.	Pt.Cldy.	Cldy.
Hebron.....	19	264	343	205	831	66	...	...	...
Beatrice.....	32	342	530	149	1053	64	139	188	39
Blue Hill.....	12	399	374	185	971	59	134	152	80
Crete.....	31	371	389	233	1024	98	121	158	87
Lincoln.....	24	399	302	224	949	95	180	107	79
Aurora.....	9	409	257	190	865	75	130	96	140
Lexington.....	19	265	148	110	542	57	147	117	102
Grand Island...	12	460	223	168	863	81	132	123	111
Loup.....	6	304	411	136	857	61	194	125	47
Norfolk.....	11	247	299	182	739	..	...	...	...
	17	346	327	178	869	72	134	133	85

REGION III.

SAND-HILL REGION.

TEMPERATURE TABLE.

Station.	Elevation.	Mean Temperature.				Annual mean.	Absolute Max.	Tem. Min.
		Winter.	Spring.	Summer.	Fall.			
Benkelman.....	904	2.0	10.0	25.5	8.0	11.5	42.0	-22
Red Cloud.....	514	1.0	11.5	25.0	8.0	11.5	39.5	-22
Holdrege.....	708	0.5	11.0	23.5	8.5	11.0	33.0	-22
Imperial.....	1000	1.5	9.5	22.5	7.0	10.0	40.0	-27.5
North Platte.....	866	1.5	9.0	22.0	8.0	10.0	38.0	-25.5
Calloway.....	779	-0.1	7.0	22.0	7.5	9.0	38.0	-24.0
Whitman.....	1093	-2.5	4.5	20.0	3.0	6.0	36.5	-29.0
Oakdale.....	525	-2.0	8.5	21.5	6.0	8.0	37.0	-26.0
O'Neill.....	602	-2.0	8.0	20.5	5.0	7.5	35.5	-24.0
Kennedy.....	823	-1.0	7.5	22.0	5.0	8.0	39.5	-28.0
		-0.1	8.5	22.5	6.5	9.0		

PRECIPITATION AND SKY TABLE.

Station.	Precipitation in Millimeters.					Condition of Sky,		No. of Days.	
	Winter.	Spring.	Summer.	Fall.	Total.	Rainy.	Clear.	Pt.Cldy.	Cldy
Benkelman.....	12	169	109	39	329	44	169	147	50
Red Cloud.....	17	354	265	172	798	61	142	149	75
Holdrege.....	2	356	272	120	750	..	...	...	...
Imperial.....	26	166	230	65	487	..	...	...	...
North Platte...	14	144	167	88	413	70	126	201	39
Calloway.....	7	213	186	85	491	46	257	62	47
Whitman.....	13	125	184	72	404	56	96	223	47
Oakdale.....	6	265	295	170	736	81	110	179	77
O'Neill.....	12	249	257	165	683	63	194	61	111
Kennedy.....	14	152	226	130	522	48	272	63	31
	12	219	219	110	561	52	170	137	59

REGION IV.

FOOT-HILL REGION.

TEMPERATURE TABLE.

Station.	Elevation.	Mean Temperature.				Annual mean.	Absolute Max.	Tem. Min.
		Winter.	Spring.	Summer.	Fall.			
Lodge Pole.....	1195	...	7.5	21.5	7.0	...	36.5	-30
Kimball	1432	...	...	21.5	8.0	...	36.0	-28.0
Gering	1500	-0.1	7.5	22.0	6.5	9.0	41.0	-29.5
Hay Springs	1195	...	6.0	21.0	...	...	38.5	-28.0
Fort Robinson.....	1147	1.0	8.0	21.5	6.5	9.0	38.5	-27.0
		<u>0.5</u>	<u>7.2</u>	<u>21.5</u>	<u>7.0</u>	<u>9.0</u>		

PRECIPITATION AND SKY TABLE.

Station.	Precipitation in Millimeters.					Condition of Sky,		No. of Days.	
	Winter.	Spring.	Summer.	Fall.	Total.	Rainy.	Clear.	Pt.Cldy.	Cldy.
Lodge Pole.....	17	187	181	60	445	37	...	...	..
Kimball .....	..	...	153	54	...	..	...	...	..
Gering	19	114	166	42	341	62	236	57	73
Hay Springs....	..	190	189	99	...	..	...	...	..
Fort Robinson..	20	105	65	100	290	28	...	...	..
	<u>18</u>	<u>149</u>	<u>155</u>	<u>71</u>	<u>358</u>				

CHAPTER II.

STATISTICS AND REGIONAL LIMITATION.

Before proceeding to the detailed consideration of the floral covering of the State, it is necessary to devote some space to an exposition of the principles of phytogeographical statistics, since statistics will play an important part in every branch of the discussion.

Principles of phytogeographical statistics.—In order to be of value for phytogeography, statistics must be interpretations of the biological conditions manifested in different portions of the floral covering. To be this, they must be based, as regards geographical divisions, upon regions limited naturally, that is, limited by physiographic and climatic differences and not by political boundaries. And the plant-groups made use of must be biological, not taxonomic; that is, they must be based upon biological association rather than upon phylogenetic or taxonomic relationship. Distributional statistics depend on the one hand upon regional limitation and on the other hand upon biological limitation. They deal not only with the occurrence, importance, and character of plant-groups, but also with the manner of association and relative significance of the elements which compose such groups.

DISTRIBUTION.—Phytogeographical statistics are concerned largely with distribution. Distribution is a direct expression of the biological struggle between coordinate groups, whether species, elements, vegetation-forms, or formations. Under the term "distribution" two closely related ideas are included. On the one hand it refers to the active agencies in the shiftings of the various members of the floral covering. On the other hand it has reference to the floral covering in a state of equilibrium, or, in other words, the cessation of action on the part of distributing agencies upon a particular group. Distribution in the latter sense expresses the relation

between the situations of coordinate groups. The former might be termed "migration," and the term "distribution" might be reserved for the latter. The two ideas, however, are so inseparably connected that it is impossible to speak of one without involving the other except in treating of the actual changes in the distributional boundaries of particular groups, and of the primitive flora as a factor in present distribution. Disregarding the original flora, the factors in distribution are of two kinds: those resulting from the morphology of the plant members and those due to external physical agencies. These two, although often acting together, and then indeterminate, may generally be recognized as separate factors. The former are purely biological in nature and will be considered in another place. The latter are essentially phytogeographical and as such should receive attention at this point. Physiographical factors may be obstructive in nature, such as mountain ranges, deserts, and broad rivers at right angles to lines of stress; or conductive, such as prevailing winds, rivers in the line of stress, and floods. Obstructive factors give rise to what might be termed negative distribution, that is, the comparative absence of shiftings of distributional boundaries. Instances of this are to be found in valleys enclosed by mountain ranges, and in most desert or sand-hill regions. Conductive factors, on the other hand, give rise to what may be called positive distribution, characterized by constant shiftings of distributional boundaries, which is best exemplified in hydrographic basins. The Great Plains region, of which Nebraska is a part, lying as it does near the center of the hydrographic basin of the Missouri river, is in general characterized by positive distribution. Conductive factors cause lines of stress which are therefore especially characteristic of regions where positive distribution is to be found. Hence it may be stated that lines of stress are in general, if not always, coincident with the direction of river systems, whether large or small. This is especially noticeable in Nebraska. Along the Missouri the line of stress is northward-southward, and as a result of this

the northward stress of the Missouri is transferred to its three tributary systems and for them becomes a westward stress. Owing to the position of the State, the southward stress is but feeble. The vegetative covering of the foot-hills finds an insuperable barrier to the westward. The congested condition must then find relief to the east, and, following the line of least resistance, an eastward tendency is the result, which is transmitted by our three parallel river systems. For Nebraska, lines of stress are east and west. The only exception of importance is the Hat creek basin where the lines are north and south. Minor exceptions to this are found along the valleys of secondary streams throughout the State. But they are without significance in determining the general character of the vegetative covering.

PURPOSE OF STATISTICS.—Distributional statistics enable us to determine the lines of coincidence between subdivisions of the floral covering and physiographical areas; that is to say, they furnish a basis for regional limitation. Moreover, they make it possible to identify biological groups foreign to the physiographical region in which they are found. They are of first importance in determining comparatively the exact boundaries of a region, in that we decide through comparison of statistics whether the intrusion of plants of one region into another is regional extension or extra-regional migration. Another purpose is the investigation of the origin and expansion within our limits of groups of plants derived from other floras and the identification of the elements of the flora. A third object is the determination not only of the prevalence but also of the abundance and frequency of characteristic forms by reason of their superior qualities of adaptation to environmental conditions. Through statistics we endeavor to ascertain both the facts and the reasons. While distributional statistics play no part in the characterization of formations, they are important in the case of those formations extending over the entire territory, in which the prevailing genus or species in the one region gives way to a nearly related genus or species in another region without

changing the essential nature of the formation. Another sort of statistics, those of temporal distribution, are also of importance, and will be treated of elsewhere.

FLORAL ELEMENTS.—The term “floral element” has been used in a restricted sense to refer to groups of plants derived from circumjacent floras. To us it seems preferable to use the term to denote the various constituents of the flora with respect to geographical origin and derivation. A list of the species occurring in any region will disclose a number of species foreign to the general run of the vegetation. Thus, in a catalogue of the species of the prairie region in this state, we meet with *Cystopteris fragilis*, *Arisaema triphyllum*, and other shade-plants, *Cleome serrulata*, *Cycloloma atriplicifolium*, and other sand-hill species, *Chenopodium hybridum* and *Amaranthus albus*, and other invaders from distant parts of the world. All of these are of a different nature from the vegetation of the region as a whole and alien to its normal character. More careful investigation will reveal groups of such plants, of common origin, which are established or becoming established in situations foreign to the general physical character of the region, or are competing with the native vegetation on its own ground. It is often desirable to contrast these several groups with the aggregate of original or long-established occupants of the soil. Hence we shall speak of the latter also as an element of the flora. Floral elements are best classified with reference to the basis on which they are constituted, according to regional origin. We may first set off the *proper element*, that is, the endemic element; then the *derived elements*, that is, those derived by migration from other floras, which have become established; and finally the *adventitious element*, composed of species which have been introduced directly or indirectly by man, and hence have appeared for a much shorter period and are less a part of the flora. The proper element will in most cases be endemic as well. Yet it is conceivable that a species proper to a region may be derived by a total migration which left no stragglers, or by a migration so complete as to

give to the remnant the appearance of outposts of an advance. The derived elements may be classified according to the region or province to which they belong or whence they have proceeded. Thus, in the prairie province *Cycloloma atriplicifolium* belongs to the proper element. Where it invades the Mississippi basin region, it may be referred to in the flora of the Alleghany province as of the prairie element, but in the wooded-bluff and meadow-land region in this state we should call it rather a part of the sand-hill element. So, the *Artemisias*, the Greasewood, and the like, in the prairie province are Great basin elements. But where any of them get into the sand-hill or prairie regions, they may be termed foot-hill elements, since in respect of immediate derivation they belong to the latter region. MacMillan* has adopted a different method which deserves mention. He recognizes range-elements, of which there are in general an eastern, a western, a northern, and a southern, and in closer analysis nine, the north-east, the north-west, the north-east-west, etc. For representing the actual range of a species with reference to a particular territory, the purpose for which it was devised, this plan is excellent. But in dealing with a region as a whole, it is superficial and must be used with caution.

VEGETATION-ELEMENTS.—In the discussion of floral elements we have had to do only with species. But we must always take heed in phytogeography not to confound species with vegetation. A catalogue of species of itself gives one little notion of the actual vegetation, and we must always be careful to supplement and correct statistics of the flora by statistics of formations, or, in other words, to check statistics of species by statistics of vegetation. So, after one has determined the elements of the flora of a region, that is, the elements of which the list of species is made up, there is still the task of determining the elements of the vegetation of the region, that is, the elements in respect of derivation into which its vegetative covering may be analyzed. Determina-

**Metaspermæ of the Minnesota Valley*, 643 et seq.

of the floral elements does much of this for us, but there is much that it fails to do. Instances where the floral elements point out the vegetation-elements come to mind at once, such as woodlands in the prairie region and thickets in the sand-hill region, where a Mississippi basin vegetation-element is pointed out by Mississippi Basin floral elements. But in other cases we may see derived floral elements in an endemic vegetation, e. g., *Phlox douglasii* and *Abronia fragrans* on the sand-hills of the western portion of the sand-hill region in the bunch-grass or even blow-out formation. Derived floral elements may exist without a derived vegetation-element, though as a rule the two coexist or the one is a precursor of the other. In short, every region has its own vegetation, which its peculiar circumstances have called into being, and its derived vegetation, which favorable localities have enticed from other regions, or which is harbored by the peculiar environment in certain districts. For example, the mat and rosette formations are the characteristic and proper vegetation of the foot-hill region. But they often include a sand-hill element among their secondary species. Next to them, the foot-hill grass formation is characteristic. The latter harbors many floral elements which are to be referred to the prairie region. But the vegetation as a whole, that is, the formation, is proper to the foot-hill region. On the other hand, the undershrub formations of table-lands and bad lands are not proper foot-hill formations, nor are they proper to the prairie province. Where any of the species of these formations invade other regions of the prairie province, we may call them foot-hill elements. But in the province as a whole, these species are a Great basin floral element, and the formations are Great basin vegetation-elements in the vegetation of the foot-hill region. In the sand-hill region the proper vegetation is composed of the blow-out, sand-draw, and bunch-grass formations. These are the formations which the peculiar circumstances of the region have developed. But the thickets along streams are the outposts of a Mississippi basin vegetation which is invading the

region, and the dry valleys harbor an invading prairie vegetation. In addition the level sandy stretches in some parts of the region entice a foot-hill vegetation, represented by the foot-hill grass formations. Thus the vegetation of the sand-hill region is made up of four elements at least: a proper element, a Mississippi basin element, a prairie element, and a foot-hill element. To these one may add a Rocky mountain element, represented by the pine bluff formation along the Niobrara. The prairie region likewise has, in addition to its proper vegetation, represented by the prairie-grass formation, at least a sand-hill vegetation on the sub-sand-hills, and a Mississippi basin vegetation along streams. There are floral elements in these regions, however, that do not represent any element in the vegetation. Thus in the sand-hill region, *Betula papyrifera* represents a northern element in the flora, but it takes part in the Mississippi basin vegetation-element of the region. By vegetation-elements, then, we mean types of vegetation considered with reference to regional derivation. The principles of classification are the same as in the case of floral elements, and hence the chief groups are the same, namely, proper, or in most cases endemic, derived, and adventitious. The adventitious vegetation of a region comprises culture-vegetation and most of the vegetation indirectly due to human influence, or, in other words, ruderal formations. But there are often proper ruderal formations as well. In dealing with the proper vegetation-elements of a region, it is necessary to consider the nascence and decadence of the vegetation, or of formations; in considering the derived and adventitious elements, one meets with advancing and retreating vegetation. The general problems are much the same as in the consideration of floral elements. An incursion of species and the establishment of a derived element in a flora is apt to presage the establishment of a foreign vegetation-element. But derived species frequently take advantage of conditions enabling them to become secondary species in the proper vegetation of the region into which they have come. The invasion of river valleys in

the sand-hill region by woody species has already established a woody vegetation-element in that region. *Phlox douglasii* on the sand-hills of western Cherry county, on the contrary, makes itself at home in the bunch-grass formation, and there is no indication that the mat and rosette formations of the foot-hills will ever appear as a foot-hill vegetation-element in the sand-hill region.

THE GEOGRAPHICAL SIDE OF STATISTICS.—Though statistics may not properly be either geographical or biological exclusively, since for phytogeographical purposes they must be both, they may be considered as geographical or biological, according to the element which predominates. Thus in the former geographical data are chiefly regarded, in the latter, biological data. The most important illustration of the former is in the division of the world into zones and further subdivisions. The principles by which these subdivisions are limited and determined are set forth elsewhere. Since the delimitation of large subdivisions in the present state of the science must be done at long range and is not free from imperfections, a summary statement must suffice in this place.

Following Drude, the world may be divided thus:

I. Northern Zone.

1. Arctic realm.
2. Northern realm.
3. Middle North American realm.
4. Mediterranean-Oriental realm.
5. Lower Asian realm.
6. East Asian realm.

II. Tropical Zone.

1. Tropical American realm.
2. Tropical African realm.
3. Indian realm.
4. Malayan - New Zealand realm.

III. Southern Zone.

1. Andean realm.
2. South African realm.
3. Australian realm.
4. Antarctic realm.

In this arrangement, North America falls chiefly within the Northern zone, and the greater portion falls within the Northern and Middle North American realms. Nebraska lies almost in the center of the Middle North American realm.

Departing from Drude's arrangement, the Middle North American realm may be divided into the following five provinces: (1) the Alleghany province, (2) the Prairie province, (3) the Rocky Mountain province, (4) the Great Basin province, and (5) the California province. The greater portion of Nebraska lies in the Prairie province, but a small strip along the eastern edge represents an extreme western extension of the Alleghany province.

Under geographical statistics may be included also statistics as to elevation and the miniature plant-regions or divisions dependent thereon. For our purposes, the altitude-zones may be termed lowland up to 100 meters above sea-level, midland from 100 to 500 meters, upland from 500 to 1,000, foot-hills from 1,000 to 2,000 meters, subalpine from 2,000 to 3,600, alpine from 3,600 to 4,600 meters, and nival above 4,600 meters. Nebraska comprises but three of these: midland, upland, and foot-hills.

The unit of plant-distribution is the distribution of the species. The species is considered, first, with reference to the area geographica, or the entire geographical area in which the species is found, and, second, with reference to the distribution of the species within the geographical area—*distributio geographica*. The area geographica gives us the extreme limits to which the species has pushed in every direction, whether as a permanently established occupant, or as a mere transient; whether in great quantity or by a few stragglers. Hence the area geographica of species is of more importance in the study of the species than in the study of vegetation. In the latter we must determine also the area geographica of formations. This is especially important in the transition-areas between regions. The exact methods of determining the abundance of species which have

been worked out recently enable us to define the limits of formations in these areas with great accuracy. The area geographica of species tells us nothing here, but where the distributional boundaries not only of the species but of the vegetation are determined, we shall be able to make regional limitation exact and minute.

In distributio geographica we distinguish frequency and abundance. Frequency has reference to the number of stations of a species within its geographical area; abundance to the number and mode of occurrence of the individuals of that species in any given habitat or locality. Thus, as Drude points out, a species may have a large geographical area and manifest a considerable frequency, while its abundance may be small, that is, the individuals in any one station few; or within a small geographical area, containing but few stations, a species may cover large tracts more or less densely. Between these extremes there are all gradations, and exact limitation and definition of these grades or degrees of frequency and abundance, and graphic representation of them, are of importance in statistics of formations and in regional limitation.

Frequency is relatively easy of determination. It is little more than a cataloguing of localities. The degree may be indicated conveniently by the terms "frequent," "sub-frequent," and "infrequent." Where greater accuracy is required, the frequency-index is employed. Several schemes have been devised for this purpose. In the Botanical Survey of Nebraska, use is made of an adaptation of the scheme set forth by Drude.* According to his method the area in question is divided into quadrats 10 kilometers square. The number of these quadrats in the whole area in which the species occurs is ascertained, and this number, divided by the whole number of quadrats in the district and multiplied by one hundred, gives a number which is used as the frequency-index. If S represent the whole number of quadrats in the district, s the

*Drude, Deutschlands Pflanzengeographie, 17. 1895.

number of quadrats in which the species in question occurs, and F the frequency-index, the following formula may be given: $\frac{s}{S} \times 100 = F$. In our work we have taken the congressional township, 36 square miles = 9.216 sq. kilometers, as the quadrat. This is usually an easy area to determine. In localities where it has been necessary to resort to less accurate means, we have provisionally considered a circle with a radius of three miles as equivalent to a quadrat. The frequency-index should not be worked out for smaller areas than the district.

Abundance, the distribution of a species in a given locality, has two factors: number of individuals and mode of disposition of individuals. A species which occurs in such masses as to control the vegetation of a locality, or over wide areas, is said to be social. The individuals may be massed in large quantities, admitting no other species, or they may be massed in large quantities in such way as to admit other species to a greater or less degree as secondary or subordinate constituents of the vegetative covering. Species of the former type, such as *Bulbilis dactyloides* in the buffalo-grass formation, or *Ambrosia trifida* in a rag-weed waste, are said to be social-exclusive; those of the latter type, e. g., *Agropyron spicatum* in the foot-hill grass formation, are said to be social-inclusive. Again, the species may not be controlling, but the individuals may be present in large quantities, scattered here and there among those of the social type or occupying areas within formations characterized by other species. If the individuals occur in patches of greater or less extent scattered about in the floral covering in this manner, the species is gregarious, e. g., *Antennaria campestris*; if single individuals are thickly scattered in this manner, the species is copious, e. g., *Amorpha canescens*. Each of these types has many degrees, which may be designated by numbers thus: copious¹, copious², copious³, subcopious, and gregarious¹, gregarious², gregarious, and subgregarious. For the several lesser grades of abundance, the terms commonly used are sparse,

rare, and solitary. But it seems better to employ the latter term for another purpose. A species distributed sparsely in respect of number of individuals may occur in each spot either as a greater or smaller mass or patch or as an isolated individual. The latter is best expressed by the term "solitary." A plant may be neither distinctively gregarious nor copious in mode of occurrence, but may present both types in part. This is notably the case in the facies of certain ruderal and subruderal formations. The individuals do not stand in more or less well-defined groups, nor are they truly isolated. *Solidago rupestris* and *Vernonia gigantea* in pastures are examples of this mode of occurrence. From the confusion or mingling of the two principal types which this condition presents, it may well be termed gregario-copious. It is probable that similar confusion of other grades may be distinguished also.

Here, even more than in the determination of frequency, more definite limitation of the several grades is necessary. Actual field experience has shown that species which appear most prominent in the constitution of the prairies, even to the careful observer, are not necessarily the most abundant. Thus the prominent-flowered blazing stars and prairie clovers make a much greater impression on the eye than other species which are really more abundant. To insure accurate or even approximately accurate results, it is necessary to resort to some method of actual count. Actual count is usually practicable only when copious, gregario-copious, or sparse plants are in question. But it is only with respect to such species, which are as a rule secondary in formations, that it is important to determine minutely the grade of abundance manifested. Thus, in tracing the shading-out of the prairie-grass formation as we approach the sand-hills, the change in the grade of abundance manifested by the principal secondary species affords a striking character. The foundation of such investigation, as conducted in the Botanical Survey of Nebraska, is actual enumeration of the number of individuals of the species in question in a plot five meters square in a typical

spot unaffected by disturbing influences. The plot used is as large as can be adopted consistently with accuracy in counting. By the use of a few lines and stakes prepared in advance, such a plot may be laid out and counted accurately in a short time after one has become practiced. The deficiencies resulting from the small size of the plots are corrected by taking a large number of plots at each station and averaging the results. By making such observations in different portions of a district, one is able to trace the shading-out and disappearance of formations with great accuracy, and thus to limit regions and transition-areas with no little exactness.* This method of actual enumeration also makes it possible to represent abundance graphically, a matter of some importance for purposes of comparison. In the first place, as has been seen, it makes it possible to assign a definite meaning to each of the several grades of abundance. Collation of the results of a large number of enumerations has shown that six grades of copious plants may be recognized readily. The first, in which the average number of individuals in a plot five meters square exceeds 200, corresponds to copious¹. As examples, there may be cited from the prairie formation *Amorpha canescens*, with an average of 309 in the prairie region, *Aster multiflorus* with an average of 275 in the prairie region and about 230 in the sand-hill region; from the herbaceous layer of woody formations, *Verbesina alternifolia* (which is almost gregarious at times), with an average of 245. To the second degree (copious²) those species may be assigned in which the average number of individuals in a plot is from 150 to 200, such as *Plantago purshii* (162) in the peppergrass-cactus formation in the transition-area between the sand-hill region and the foot-hill region. Those species with an average ranging from 100 to 150 may be assigned to the third degree (copious³). Examples are: *Aster sagittifolius*, which has an average of 133 in the herbaceous layer of the bur-oak-elm-walnut formation in the Mississippi basin

* For further details see Pound and Clements, *A Method of Determining the Abundance of Secondary Species*, Minn. Bot. Studies, 2:19. 1938.

region, and *Solidago rupestris*, which has an average of 104 in the *Sporobolus-Koeleria-Panicum* formation in the prairie region. In the fourth degree (copious⁴) those species may be included which have an average of from 50 to 100, such as *Glycyrrhiza lepidota* in river valleys in the sand-hill region, where its average is 83. All of the foregoing are of sufficient abundance to be included in the general term "copious," taking the latter to represent a quantitative idea as well as the manner of association of the individuals. Where the average falls below 50 and exceeds 5, we call the species "subcopious." Comparison and collation of statistics have shown that subcopious species fall into two groups; in one, which we call subcopious¹, the average does not fall below 15. Examples are: *Kuhnistera candida* in the *Sporobolus-Koeleria-Panicum* formation in the prairie region, where it has an average of 18, *Solidago mollis* in the peppergrass-cactus formation in the transition-area between the sand-hill and foot-hill regions, where its average is slightly over 20, and *Artemisia gnaphalodes* in the transition between the prairie and the sand-hill regions, where its average is 16. Where the average number in a plot is between 5 and 15, the species is called subcopious². These are often very striking components of the prairie formations. Finally, in case the average is below 5 and above .10, or one individual in ten plots, the species is called "sparse." Gregario-copious species may be treated in the same way, giving gregario-copious¹, etc.

In the second place, the method of actual enumeration furnishes a sure basis for an abundance-index. After much experiment, the most convenient unit of space for the abundance-index has been found to be the government survey section, one thirty-sixth of the quadrat used in the frequency-index, or about 240 hectares. This is an easily recognizable unit in all parts of the State, and in many localities is the only division practically available. The extent to which one of these units, or better the average unit in the quadrat, maintains the species in question, i. e., the extent over which the species spreads therein, is readily ascertained. The formula

is: $\frac{t \times e \times a}{T} = A$ in which T represents the number of units in the quadrat, or 36, t the number of these units in which in typical situations the species occurs, e the mean extent covered by it, whether sparsely or thickly, in the t units, a the number of individuals in the average plot of 25 square meters in the unit, as determined by actual count, and A the abundance-index. The sole source of error is in the determination of the factor e , which must be largely a matter of interpretation and approximation. The other three are determinable with mathematical exactness, and would of themselves give a fairly accurate and useful abundance-index. When this result is controlled by careful approximation of the value of e , the abundance-index affords a reliable method of denoting and comparing the abundance of species. In another portion of the work the results will find a place; we are here concerned only with the method.

Principles of regional limitation.—It has been pointed out that distributional statistics, upon which an investigation of the floral covering must largely proceed, depend, on the one hand, upon regional limitation, that is, upon territorial divisions bounded phytogeographically, not politically, and on the other hand upon biological limitation of the flora, that is, upon groups having a biological basis instead of a taxonomic basis. We have already given an outline of the scheme according to which the earth is subdivided phytogeographically. It remains to state the principles upon which such subdivision proceeds and to apply them to the territory embraced in the political limits of Nebraska.

In the phytogeography of Nebraska we are not concerned with anything higher than the "*Vegetationsregion*" or region. Hence, although the underlying principles are much the same for the limitation of all phytogeographical subdivisions, we shall consider them here only in their application to the limitation of regions. Regional limits are first suggested by physiographic features, that is, a region must manifest peculiar topographic characteristics. This is necessarily so, since the

vegetative covering of the earth is everywhere bound up with its physiography. In delimiting regions it is first necessary to sketch roughly a geographical region and then to test this by means of biological data. Although in outlining a region it is essential to make use of geographical characters for the accurate limitation of its boundaries, biological characters in general are solely to be relied upon. Thus, naturally limited regions manifest a coincidence of physiographic and biological data in their limitation. Wherever the two conflict, the latter alone are to be considered. Hence, it follows that a phytogeographical region is not necessarily territorially continuous. In the further treatment of the subject it will be seen that detached portions of regions now appear in the territory of adjacent regions either through having been cut off by the encroachment of the region which now surrounds them or having been thrown forward as outposts of the regions to which they belong phytogeographically. Since regions are essentially natural as to boundaries, it is not to be expected that any region will be peculiar to a certain political division. This is emphatically the case in Nebraska, where each region extends over large areas in adjacent states. In fact, the portions comprised in the limits of the State are but a fraction of their whole extent.

FLORAL CONTRAST.—In the purely biological limitation of regions a chief criterion is the floral contrast. In comparing the floral covering of adjacent regions it is readily seen that either one differs from the other, first, in the forms which it contains that the other does not, and, second, in those which it lacks that the other contains. The first may be termed the proper flora of a region, the latter, the excluded flora. This may be made more clear by conceiving that in a region occupied by an original flora species of surrounding floras tend to invade this area. Those which are successful become, with the survivors of the original flora, the proper flora. The others are appropriately termed the excluded flora. Comparison of the proper and the excluded flora of a region gives us the floral contrast. If one region or district is compared

with another, commonly an adjacent one, it is called immediate contrast; comparison of one region or district with all others gives us remote contrast. The importance of the excluded flora is chiefly in indicating excluded vegetation. The proper flora, on the other hand, has an importance apart from its connection with proper vegetation, since a region may show proper species which take a secondary part in derived vegetation or in vegetation common to many regions. Thus the sand-hill region possesses many hydrophytes proper to its flora, but no proper hydrophytic vegetation.

FORMATIONAL CONTRAST.—Floral contrast depends simply upon the species represented in the floras, without regard to their biological connection or interrelation. Hence in making use of floral contrast in regional limitation we meet with the difficulty already encountered in the case of floral elements. We are dealing with species, not with vegetation, and in a list of species, a few stations where the species is of trifling abundance count as much as great frequency and a high degree of abundance. Again, a species may be present and yet its characteristic vegetation may be absent, as is strikingly illustrated wherever the bunch-grasses occur outside of the sand-hill region. If one were to limit nations by language-contrast, he would find centers of population in every land where a great variety of tongues was represented by some individual or individuals each. In consequence he would be forced to give up the contrast as a criterion, or else to supplement and correct it by another. So in the investigation of phytogeographical regions we continually meet with areas which invite a cosmopolitan plant-population. Stragglers and intruders from other regions are to be seen in every territory. These may be of importance in the vegetation of the region, but quite as often they are of little or no moment. Floral contrast is a contrast of the floral elements. Comparing or contrasting the vegetation-elements of regions, we get the vegetation-contrast, or, as Drude has termed it, the formational contrast. This is a criterion of the first importance in regional limitation. Since vegetation is shaped

in large degree by circumstances of physical and biological environment, a peculiar vegetation is strong evidence of peculiar environment. If the vegetation-contrast between two areas is marked, they must be recognized as distinct regions. Formational contrast is a contrast of vegetation with vegetation. It may be positive or negative, as the standpoint is the proper or the excluded vegetation of the region in question. Thus the foot-hill region is characterized positively by its peculiar mat and rosette formations, negatively by the absence of forest formations. The prairie region is characterized positively by its peculiar grass formation, negatively by the absence of the peculiar formations of the other three regions. The Mississippi basin region is the region of the red-oak-hickory and bur-oak-elm-walnut formations; the prairie region is the region of the *Sporobolus-Koeleria-Panicum* formation; the sand-hill region is the region of the bunch-grass, blow-out and sand-draw formations; the foot-hill region is the region of the mat and rosette formations. In no other way can we characterize these regions so well. The Mississippi basin region is not the region of the bur-oak, elm, and walnut, or any of them, for all of them, *as species*, wander far into the regions to the westward. The prairie region is not the region of *Sporobolus*, *Koeleria*, or *Panicum*, or any of them, nor is the sand-hill region the region of *Andropogon hallii*, though it happens to be the region of *Redfieldia flexuosa*. But these regions are the regions of the vegetation which these species control in their typical situations. Where one finds the blue-stem formation he may know he is in the sand-hill region. But one may find *Andropogon scoparius*, *A. hallii*, or *Calamovilfa longifolia* and yet no trace of the blue-stem formation.

DISTRICTS.—Since the three great lines of stress within the state cross the regions at right angles, the regions fall very naturally, though not so distinctly, into what may be termed districts. As a result of the different directions taken by the lines of stress within each region, it may be divided into positive and negative districts, the former being those in which

the primitive regional flora is modified by the influence of stress lines, that is, by positive distribution. The latter are those in which such disturbing influences have not been manifest, that is, those in which the distribution has been negative.

The primitive flora of the great plains.—During the greater portion of the Cretaceous period the great plains were an inland sea which divided the continent into an eastern and a western portion. At the beginning of the Eocene the plateau region was depressed and the plains region correspondingly elevated. Later, at the end of the Eocene or the beginning of the Miocene, the western plateau region was elevated and the prairie region depressed. In the Miocene, the White river basin occupied the western portion of the great plains. In the Pliocene the Niobrara basin extended from what are now the northern prairies to the Gulf of Mexico. In the Pleistocene or late Pliocene the great interior lakes disappeared, and their basins became covered with the characteristic Tertiary flora.

The climate during Tertiary times was very equable over the greater portion of the North American continent. A tropical or at least a subtropical flora extended not only over the great plains, but as far north as Greenland. All temperate, boreal, and arctic vegetation in the Tertiary period must have been crowded into the relatively narrow zone between 60° — 65° north and the polar ice cap. At that time the three groups of plants, temperate, boreal, and arctic, could not have attained the isolation and differentiation which they manifest to-day. At the close of the Tertiary, these primary distinctions were probably only potential modifications of the shading-out of the continental vegetation-mass. With the gradual refrigeration of the circumpolar area and the southward extension of the polar ice cap, the tropical flora was gradually forced to the south. The immediate effect of this was perhaps to present a broader zone for the elaboration of arctic and boreal species. Ultimately, however, these were driven far to the southward, and there must then have arisen in subtropical regions (below 38°) a congestion of floras

corresponding in the main to that theretofore characteristic of high latitudes. It would seem that such a retreat of an entire vegetation must have produced not only profound differences in vegetation but also in floristics. Actually, so far as we can determine, the glacial epoch produced comparatively slight effect upon the species as such. Its chief work was the sorting and rearranging of species and the extension of the resulting vegetation.

Whatever may have been the degree of development of the various floras at the end of Tertiary times, the main fact in the study of our floral elements is that the slowly encroaching ice cap must have driven southward in succession across our territory a tropical, subtropical, boreal, and arctic flora. During the maximum of the glacial epoch no vegetation whatever could have existed over the eastern portion of the State. The western portion was doubtless covered with an arctic vegetation. With the decadence of the glacial epoch, the arctic vegetation first overspread the State and then passed northward, naturally without leaving any permanent traces in the vegetative covering. The boreal vegetation again recrossed the State, this time from the south. This second migration, however, possessed little of the intensity of the first. The retarding force exerted by the ice cap and the forward pressure produced by the congested equatorial vegetation reached a state of equilibrium much sooner. Instead of returning to 60° — 65° north, the boreal vegetation-mass now had for its southern limit 48° — 49° . At the same time with their extension northward, boreal species occupied such elevations as they encountered. Where the altitude was slight, the retreat was simply retarded for a while in that portion of the line. Where the altitude was considerable, boreal species became permanently established. We see this in Nebraska in the Hat creek basin, where such boreal species as *Populus tremuloides*, *P. balsamifera*, and *Acer glabrum* are found. But the Black Hills of South Dakota afford a much better illustration. The striking similarity of their vegetation to that of the East is due almost wholly to the large number of

boreal species common to both. Irrespective of altitude, boreal species have maintained themselves in straggling bands far behind the main body, in certain rare cases where local conditions permitted. This is well exemplified in our flora by the thoroughness with which the paper birch, *Betula papyrifera*, a distinctively boreal species, occupies a stretch of deep, pocket-like canyons along the Niobrara. The temperate flora, with which we are here chiefly concerned, followed upon the heels of the boreal. But the equilibrium between polar and equatorial pressure was becoming rapidly established. In consequence, temperate species, like the boreal species, were unable even to approximate a return to the high altitudes formerly occupied by them. They were compelled to naturalize themselves in a new area, which in the Tertiary period had possessed a very different flora. Considered historically, from the beginning of phanerogamic vegetation, only the extremes, the polar and the equatorial areas have a flora characteristically indigenous.

Here, as elsewhere, we may use terms in a relative sense. Hence our endemic species are of two classes: species belonging to habitat-groups characteristic of our flora, which dominate the peculiar formations of prairies, sand-hills, or foothills, and on the other hand species resulting from rapid modification of unstable predecessors when subjected to intense and peculiar conditions. The former, in the strictest sense relatively endemic, are endemic but not peculiar to our flora. The latter are found only in our borders. As the prairies were produced by change of conditions that swept away the original woody vegetation, it would seem that we can have no endemic trees. Yet *Betula papyrifera*, left behind by the retreating northern flora, is as endemic as the species that rushed in in the wake of the retreat. Moreover, *Prunus besseyi* appears to be of the class of autochthons resulting from peculiar conditions of our region. Naturally the best examples of the latter class are furnished by herbaceous species. *Redfieldia flexuosa*; confined absolutely to the

sand-hill region and to one typical formation thereof, will suffice as an illustration.

Characterization of the regions.—Following the principles above outlined, our territory falls into four parallel regions, whose longest direction is north and south. These regions are: (I) The Wooded-bluff and Meadow-land region; (II) The Prairie region; (III) The Sand-hill region; (IV) The Foot-hill region. These regions are remarkable for the closeness with which they correspond to the topographical features of the State. The coincidence with the divisions of the State according to altitude is scarcely less significant. Thus, in general, the first two regions correspond to the midland, the third to the upland, and the fourth to the foot-hills. The boundaries of the several regions are sufficiently indicated on the accompanying maps.

I. THE WOODED-BLUFF AND MEADOW-LAND REGION.—This region occupies in our territory a narrow strip about 35 kilometers wide, comprising that portion of the Missouri river valley lying in Nebraska. As has been said, this region is by no means confined to, or characteristic of, Nebraska, but extends eastward and southeastward into Iowa and Missouri, and thence through the central and eastern states to the Alleghanies. Its physical characteristics in Nebraska are broad lowlands, abrupt wooded bluffs, with their numerous ravines, and back of these the higher meadows which form the transition to the prairies beyond. In our territory this region represents an extreme western arm of the central region of the Alleghany province, which may be called the Mississippi basin region. Its floral contrast with us is made up by a large number of eastern species, many of which here find their distributional boundary upon the west, and by the entire absence of typical western species. Its formational contrast is positive on account of the abundance of forest and thicket formations. The region in our limits has been divided into two districts, the Missouri district and the Ponca district. The former extends from the southeastern corner of the State to the mouth of the Niobrara, and possesses the

acteristics of the region. The Ponca district belongs almost entirely to South Dakota. It is represented in Nebraska by a single county, Boyd county, which is a portion of South Dakota in all respects except politically. It is made up of a high, gumbo table-land, with a more or less characteristic flora of a transitional character, and the valleys of the Missouri and Ponca rivers, in which the flora of region I gradually shades out.

The immediate floral contrast in our limits is shown by the following tables.

In the tables which follow, the flora adventitia has been included. The distribution of ruderal and introduced species is a matter of no little importance in our limits, where at least two regions are practically uninvaded. We have distinguished the species foreign to our flora in the type used.

SPECIES PECULIAR TO THE WOODED-BLUFF AND MEADOW-LAND REGION.

<i>Azelia macrophylla.</i>	<i>Arabis canadensis.</i>
<i>Asclepias obtusifolia.</i>	<i>A. hirsuta.</i>
<i>A. purpurascens.</i>	<i>Aralia racemosa.</i>
<i>A. ovalifolia.</i>	<i>Astragalus bisulcatus.</i>
<i>Asimina triloba.</i>	<i>Baptisia leucantha.</i>
<i>Aster azureus.</i>	<i>Betula nigra.</i>
<i>A. macrophyllus.</i>	<i>Bicuculla cucullaria.</i>
<i>A. turbinellus.</i>	<i>B. canadensis.</i>
<i>Acorus calamus.</i>	<i>Bidens bipinnata.</i>
<i>Adiantum pedatum.</i>	<i>Brassica alba.</i>
<i>Aesculus glabra.</i>	<i>Capnoides micranthum.</i>
<i>Agrostemma githago.</i>	<i>Carex eburnea.</i>
<i>Amelanchier canadensis.</i>	<i>C. livida.</i>
<i>Ampelopsis cordata.</i>	<i>C. rosea.</i>
<i>Anemone canadensis.</i>	<i>C. sartwellii.</i>
<i>A. quinquefolia.</i>	<i>C. shortiana.</i>
<i>A. virginiana.</i>	<i>C. tribuloides cristata.</i>
<i>Anthemis arvensis.</i>	<i>C. trichocarpa imberbis.</i>
<i>Anychia canadensis.</i>	<i>C. trisperma.</i>

- Carpinus caroliniana.*
Caulophyllum thalictroides.
Cephalanthus occidentalis.
Cercis canadensis.
Claytonia virginica.
Clematis simsii.
Cleome lutea.
Convolvulus arvensis.
Coreopsis palmata.
Corylus americana.
Crataegus mollis.
Crotalaria sagittalis.
Cuscuta polygonorum.
Cynoglossum officinale.
Cyperus engelmannii.
Cyripedium hirsutum.
Dactylis glomerata.
Delphinium urceolatum.
D. tricornis.
Dentaria laciniata.
Echium vulgare.
Elymus virginicus.
Erigeron annuus.
E. philadelphicus.
Eryngium aquaticum.
Erythronium albidum.
E. americanum.
Euonymus obovatus.
E. americanus.
Eupatorium altissimum.
Fraxinus americana.
Galactia volubilis.
Galium asprellum.
G. concinnum.
Gentiana flavida.
Gerardia besseyana.
Gleditsia triacanthos.
Gymnocladus dioicus.
Hamamelis virginica.
Hedeoma pulegioides.
Helianthus divaricatus.
H. hirsutus.
Hibiscus militaris.
Hicoria alba.
H. glabra.
H. laciniosa.
H. minima.
Hydrophyllum virginicum.
Hypericum ascyron.
H. sphaerocarpum.
Hypoxis hirsuta.
Hystrix hystrix.
Iris versicolor.
Impatiens aurea.
Juglans cinerea.
Korycarpus diandrus.
Leptandra virginica.
Leonurus cardiaca.
Lilium canadense.
Linaria linaria.
Linum striatum.
Lithospermum canescens.
Lonicera dioica.
Meibomia paniculata.
Melica diffusa.
Mesadenia atriplicifolia.
Monotropa uniflora.
Morus rubra.
Nelumbo lutea.
Notholaena nivea dealbata.
Orchis spectabilis.
Panicum proliferum.
Pellaea atropurpurea.
Pedicularis lanceolata.

<i>Panax quinquefolia.</i>	<i>Salix lucida.</i>
<i>Phaseolus polystachyus.</i>	<i>Sanguinaria canadensis.</i>
<i>Phlox pilosa.</i>	<i>Saponaria officinalis.</i>
<i>P. divaricata.</i>	<i>Salvia urticifolia.</i>
<i>Physostegia virginiana.</i>	<i>Sieglingia seslerioides.</i>
<i>Phytolacca decandra.</i>	<i>Sida spinosa.</i>
<i>Platanus occidentalis.</i>	<i>Solanum carolinense.</i>
<i>Podophyllum peltatum.</i>	<i>Solidago ulmifolia.</i>
<i>Polygonatum commutatum.</i>	<i>Sophia pinnata.</i>
<i>Polygonum virginianum.</i>	<i>Staphylea trifolia.</i>
<i>Potamogeton alpinus.</i>	<i>Trillium nivale.</i>
<i>Potentilla canadensis.</i>	<i>Tripsacum dactyloides.</i>
<i>Quercus acuminata.</i>	<i>Urtica dioica.</i>
<i>Q. alba.</i>	<i>Urticastrum divaricatum.</i>
<i>Q. coccinea.</i>	<i>Verbena officinalis.</i>
<i>Q. digitata.</i>	<i>Verbesina alternifolia.</i>
<i>Q. prinoides.</i>	<i>Vernonia noveboracensis.</i>
<i>Q. rubra.</i>	<i>Vleckia scrophularifolia.</i>
<i>Q. velutina.</i>	<i>Viburnum lentago.</i>
<i>Ranunculus recurvatus.</i>	<i>Vicia americana.</i>
<i>Reseda luteola.</i>	<i>Viola palmata.</i>
<i>Rhamnus caroliniana.</i>	<i>Vitis cinerea.</i>
<i>Rhus copallina.</i>	<i>Wolffia brasiliensis.</i>
<i>Robinia pseudacacia.</i>	<i>Xanthium strumarium.</i>
<i>Rosa setigera.</i>	<i>Zizia aurea.</i>
<i>Rubus villosus.</i>	

SPECIES COMMON TO THE WOODED-BLUFF, ETC., AND PRAIRIE
REGIONS, BUT PROPER TO OR MOST FREQUENT IN THE
FORMER.

<i>Abutilon abutilon.</i>	<i>Chrysanthemum leucanthemum.</i>
<i>Acer saccharinum.</i>	<i>Daucus carota.</i>
<i>Arctium lappa.</i>	<i>Datura stramonium.</i>
<i>Arisaema dracontium.</i>	<i>Euphorbia corollata.</i>
<i>A. triphyllum.</i>	<i>Geum virginianum.</i>
<i>Aster sagittifolius.</i>	<i>Lepachys pinnata.</i>
<i>Carduus lanceolatus.</i>	

<i>Meibomia rigida.</i>	<i>Sanicula marilandica.</i>
<i>Menispermum canadense.</i>	<i>Solidago arguta.</i>
<i>Megapterium missouriense.</i>	<i>S. speciosa.</i>
<i>Mesadenia tuberosa.</i>	<i>Smilax herbacea.</i>
<i>Prunus virginiana.</i>	<i>S. hispida.</i>
<i>Polygonum orientale.</i>	<i>Stachys aspera.</i>
<i>Ranunculus acris.</i>	<i>Triosteum perfoliatum.</i>
<i>Roripa sinuata.</i>	<i>Vleckia nepetoides.</i>

SPECIES COMMON TO THE WOODED-BLUFF, ETC., REGION AND THE PRAIRIE REGION, BUT PROPER TO OR MOST FREQUENT IN THE LATTER.

<i>Bromus secalinus.</i>	<i>Lappula lappula.</i>
<i>Callirhoe alcaeoides.</i>	<i>Linum sulcatum.</i>
<i>Cassia marilandica.</i>	<i>Salvia pitcheri.</i>
<i>Cornus asperifolia.</i>	<i>Silphium integrifolium.</i>
<i>C. candidissima.</i>	<i>Solidago rupestris.</i>
<i>Helianthus tuberosus.</i>	<i>Sonchus asper.</i>
<i>Laciniaria pycnostachya.</i>	<i>Viola pedatifida.</i>

SPECIES OF EQUAL FREQUENCY IN THE WOODED-BLUFF, ETC., AND PRAIRIE REGIONS.

<i>Acnida tamariscina dehis-</i> <i>cens.</i>	<i>Medicago arabica.</i>
<i>Acnida tuberculata.</i>	<i>Melilotus officinalis.</i>
<i>Asclepias tuberosa.</i>	<i>Rumex altissimus.</i>
<i>Bursa bursa-pastoris.</i>	<i>Salix nigra.</i>
<i>Carex cephaloidea.</i>	<i>Scirpus atrovirens.</i>
<i>Comandra umbellata.</i>	<i>Sicyos angulatus.</i>
<i>Deringia canadensis.</i>	<i>Silene stellata.</i>
<i>Euphorbia dictyosperma.</i>	<i>Sisymbrium officinale.</i>
<i>E. humistrata.</i>	<i>Thaspium barbinode.</i>
<i>Geranium robertianum.</i>	<i>Trifolium reflexum.</i>
	<i>T. stoloniferum.</i>

II. THE PRAIRIE REGION.—This region occupies a broad belt immediately west of region I, approximately 200 kilometers wide. It corresponds roughly to the topographical prairie region of the State. In our territory its area is

interrupted to the north by region I, but on the south this region includes a great part of Kansas and Indian territory. On the east it comprises the larger part of Iowa and Illinois, and the southern portion of Wisconsin and Minnesota. Thence, extending northwest through the Dakotas and western Manitoba, it comprises nearly the whole of Assiniboia and Saskatchewan, reaching its northern limit in Athabasca. The surface of the region presents little diversity, consisting of rolling hills and frequent sloughs, interspersed with broad river valleys. As to formational contrast, it is characterized positively through the prevalence of its peculiar grass formations, and negatively through the absence of forest formations on the one hand and of the bunch-grass formations on the other hand.

According to the directions of the lines of stress, in our territory the region falls into three districts. The Platte district is a rather narrow strip, characterized by a westward line of stress along the Platte river. To the north, the Elkhorn district is marked by an eastward line of stress. Most of the species enumerated as common to II and III, but proper to III, will be found in this district, while the species enumerated on a former page as common to I and II, but proper to I, will be found in the Platte and Blue districts. The Blue river district represents the most stable condition. It is the negative, and hence the characteristic district of the region. The others are more or less transitional in character.

On account of the predominance of the prairie-grass formation in the dry valleys of III, and in like situations in other regions, a large number of the most typical prairie species will be found in the table of species common to two or more regions.

The immediate floral contrast is shown by the following tables:

SPECIES PECULIAR TO THE PRAIRIE REGION IN OUR LIMITS.

- | | |
|----------------------------------|----------------------------------|
| <i>Agrimonia parviflora.</i> | <i>Cuscuta cephalanthi.</i> |
| <i>Allium canadense.</i> | <i>Cyripedium candidum.</i> |
| <i>Alsine media.</i> | <i>Cyrtorhyncha ranunculina.</i> |
| <i>Ammannia auriculata.</i> | <i>Didiplis diandra.</i> |
| <i>Apiastrum patens.</i> | <i>Eclipta alba.</i> |
| <i>Arabis brachycarpa.</i> | <i>Eleocharis atropurpurea.</i> |
| <i>A. dentata.</i> | <i>E. ovata.</i> |
| <i>Aristida tuberculosa.</i> | <i>Elymus condensatus.</i> |
| <i>Arrhenatherum elatius.</i> | <i>Equisetum fluviatile.</i> |
| <i>Asclepias sullivantii.</i> | <i>Erigeron ramosus.</i> |
| <i>Asclepiodora viridis.</i> | <i>Erodium cicutarium.</i> |
| <i>Aster patens.</i> | <i>Eryngium dichotomum.</i> |
| <i>A. puniceus.</i> | <i>Euphorbia cyparissias.</i> |
| <i>A. undulatus.</i> | <i>E. obtusata.</i> |
| <i>Baptisia bracteata.</i> | <i>Fuirena squarrosa.</i> |
| <i>Bidens cernua.</i> | <i>Habenaria grandiflora.</i> |
| <i>Brassica nigra.</i> | <i>Helenium nudiflorum.</i> |
| <i>Caltha palustris.</i> | <i>Helianthus laetiflorus.</i> |
| <i>Cardamine bulbosa.</i> | <i>Heteranthera dubia.</i> |
| <i>Carduus arvensis.</i> | <i>H. limosa.</i> |
| <i>Carex crawei.</i> | <i>H. reniformis.</i> |
| <i>C. crus corvi.</i> | <i>Hieracium scabrum.</i> |
| <i>C. davisii.</i> | <i>H. venosum.</i> |
| <i>C. granularis.</i> | <i>Hymenopappus flavescens.</i> |
| <i>C. gravida.</i> | <i>Hypericum mutilum.</i> |
| <i>C. grisea.</i> | <i>Isoetes melanopoda.</i> |
| <i>C. laxiflora blanda.</i> | <i>Lechea minor.</i> |
| <i>C. lupulina.</i> | <i>Legouzia leptocarpa.</i> |
| <i>C. squarrosa.</i> | <i>Lithospermum arvense.</i> |
| <i>C. tetanica.</i> | <i>Lolium perenne.</i> |
| <i>C. tribuloides bebbii.</i> | <i>Ludwigia alternifolia.</i> |
| <i>Castalia tuberosa.</i> | <i>Meibomia illinoensis.</i> |
| <i>Centunculus minimus.</i> | <i>Myriophyllum pinnatum.,</i> |
| <i>Cerastium vulgatum.</i> | <i>Malva rotundifolia.</i> |
| <i>Chaetochloa verticillata.</i> | <i>M. silvestris.</i> |
| <i>Cichorium intybus.</i> | <i>Mentha sativa.</i> |

<i>Onosmodium carolinianum.</i>	<i>Scirpus pauciflorus.</i>
<i>Panicum walteri.</i>	<i>Senecio integerrimus.</i>
<i>Pentstemon cobaea.</i>	<i>S. balsamitae.</i>
<i>P. pentstemon.</i>	<i>Silene alba.</i>
<i>Plantago aristata.</i>	<i>S. nivea.</i>
<i>Polytaenia nuttallii.</i>	<i>S. noctiflora.</i>
<i>Potamogeton diversifolius.</i>	<i>Solidago rigidiuscula.</i>
<i>P. spirillus.</i>	<i>S. serotina gigantea.</i>
<i>P. zosterifolius.</i>	<i>Syndesmon thalictroides.</i>
<i>Prunus angustifolia.</i>	<i>Thalesia uniflora.</i>
<i>Roripa hispida.</i>	<i>Thlaspi arvense.</i>
<i>R. palustris ovata.</i>	<i>Toxylon pomiferum.</i>
<i>Rotala ramosior.</i>	<i>Tragopogon porrifolius.</i>
<i>Ruellia ciliosa.</i>	<i>T. pratensis.</i>
<i>Rumex acetosella.</i>	<i>Trifolium agrarium.</i>
<i>R. patientia.</i>	<i>T. procumbens.</i>
<i>Sagittaria rigida.</i>	<i>Vaccaria vaccaria.</i>
<i>S. graminea.</i>	<i>Verbena angustifolia.</i>
<i>Salicornia herbacea.</i>	<i>Vernonia marginata.</i>

SPECIES COMMON TO THE PRAIRIE AND THE SAND-HILL REGIONS.

(1) Species proper to or most frequent in the prairie region.

<i>Bidens involucrata.</i>	<i>Foeniculum foeniculum.</i>
<i>Boehmeria cylindrica.</i>	<i>Habenaria leucophaea.</i>
<i>Boltonia asteroides.</i>	<i>Helianthemum majus.</i>
<i>Carex laxiflora.</i>	<i>Hemicarpha micrantha.</i>
<i>Clematis virginiana.</i>	<i>Hypericum canadense.</i>
<i>Cyperus acuminatus.</i>	<i>H. perforatum.</i>
<i>C. erythrorhizos.</i>	<i>Phalaris canariensis.</i>
<i>C. speciosus.</i>	<i>Scirpus robustus.</i>
<i>Datura tatula.</i>	<i>Sporobolus asper.</i>
<i>Eleocharis acuminata.</i>	<i>S. heterolepis.</i>
<i>Equisetum variegatum.</i>	<i>Stenophyllus capillaris.</i>
<i>Euphorbia serpens.</i>	

(2) Species proper to or most frequent in the sand-hill region.

<i>Aristida basiramea</i>	<i>Hypericum majus.</i>
<i>A. oligantha.</i>	<i>Lathyrus ornatus ochroleucus.</i>
<i>Astragalus lotiflorus nebraskensis.</i>	<i>Lemna minor.</i>
<i>Carex stenophylla.</i>	<i>Naias flexilis.</i>
<i>C. stipata.</i>	<i>Polygonum camporum.</i>
<i>Ceratophyllum demersum.</i>	<i>Potamogeton fluitans.</i>
<i>Cyperus schweinitzii.</i>	<i>P. pusillus.</i>
<i>Gaertneria tomentosa.</i>	<i>Ranunculus ovalis.</i>
<i>Gyrostachys cernua.</i>	<i>Utricularia minor.</i>

III. THE SAND-HILL REGION.—This region, lying directly beyond the prairie region, is nearly 300 kilometers wide on the average. It corresponds more or less to the topographical sand-hill region. It extends into the Dakotas on the north, Kansas, Oklahoma, Indian territory, and Texas upon the south, and northeastern Colorado and perhaps a portion of Wyoming on the west. Physiographically the loose, sandy soil is its chief characteristic, although the hills and valleys are more sharply defined than they are in the prairie region. Its formational contrast is furnished by the characteristic and peculiar bunch-grass, blow-out, and sand-draw formations. In our territory it falls into three districts, one negative, marked by entire absence of lines of stress, the other two positive, marked by lines of stress along the Niobrara and Republican rivers. The first comprises the central sand-hills, characterized by blow-outs and covered with the blue-stem bunch-grass formation. In this district the dry valleys with argillaceous soil covered with prairie formations, scattered among the hills, the frequent wet valleys with their ponds and lakes, presenting meadow and water-plant formations, and the extreme openness of the blue-stem formation make it possible for a large number of species to occur in a very sparse floral covering. In the Niobrara and Republican districts the hills are of the sub-sand-hill type and are covered with the beard-grass formation.

The following tables indicate the immediate floral contrast in our limits.

SPECIES PECULIAR TO THE SAND-HILL REGION.

(1) Species occurring throughout the region in Nebraska.

<i>Acnida tamariscina.</i>	<i>Gilia longiflora.</i>
<i>Allium nuttallii.</i>	<i>Helianthus petiolaris patens.</i>
<i>Arctostaphylos uva ursi.</i>	<i>Hypericum virginicum.</i>
<i>Aster canescens incanus.</i>	<i>Juncus marginatus.</i>
<i>Astragalus shortianus.</i>	<i>J. nodosus.</i>
<i>Beckmannia eruciformis.</i>	<i>Lappula deflexa.</i>
<i>Bidens trichosperma tenui- loba.</i>	<i>Lonicera hirsuta.</i>
<i>Calamagrostis confinis.</i>	<i>Lygodesmia rostrata.</i>
<i>Callitriche palustris.</i>	<i>Myriophyllum spicatum.</i>
<i>Cardamine hirsuta.</i>	<i>Naumbergia thyrsiflora.</i>
<i>Carduus undulatus mega- cephalus.</i>	<i>Oenothera rhombipetala.</i>
<i>Carex siccata.</i>	<i>Onoclea sensibilis.</i>
<i>Commelyna virginica.</i>	<i>Panicum dichotomum.</i>
<i>Cuscuta indecora.</i>	<i>P. dichotomum barbulatum.</i>
<i>C. coryli.</i>	<i>P. wilcoxianum.</i>
<i>Cymopterus acaulis.</i>	<i>Pentstemon haydenii.</i>
<i>Cyperus diandrus.</i>	<i>Polygonum hydropiperoides.</i>
<i>C. strigosus.</i>	<i>P. sagittatum.</i>
<i>Dryopteris spinulosa.</i>	<i>Potamogeton pectinatus.</i>
<i>D. thelypteris.</i>	<i>Redfieldia flexuosa.</i>
<i>Dulichium arundinaceum.</i>	<i>Rumex britannica.</i>
<i>Eragrostis caroliniana.</i>	<i>Salix tristis.</i>
<i>Eriophorum gracile.</i>	<i>Siegingia purpurea.</i>
<i>Euphorbia geyeri.</i>	<i>Sium cicutifolium.</i>
<i>Evolulus nuttallianus.</i>	<i>Stachys palustris.</i>
<i>Gentiana andrewsii.</i>	<i>Talinum teretifolium.</i>
	<i>Triadenum virginicum.</i>

(2) Species peculiar to the Niobrara district.

<i>Aristida gracilis.</i>	<i>Lilium philadelphicum.</i>
<i>Asplenium filix-foemina.</i>	<i>Menyanthes trifoliata.</i>
<i>Aster canescens viscosus.</i>	<i>Moehringia lateriflora.</i>
<i>Betula papyrifera.</i>	<i>Opulaster opulifolius.</i>
<i>Cactus missouriensis.</i>	<i>Philotria canadensis.</i>
<i>Carex durifolia.</i>	<i>Polygala sanguinea.</i>
<i>C. laxiflora.</i>	<i>Potamogeton heterophyllus.</i>
<i>Chenopodium boscianum.</i>	<i>Psoralea cuspidata.</i>
<i>C. urbicum.</i>	<i>Ribes cynosbati.</i>
<i>Crataegus macracantha.</i>	<i>Scirpus hallii.</i>
<i>Elymus striatus.</i>	<i>Sporobolus brevifolius.</i>
<i>Equisetum hiemale.</i>	<i>S. neglectus.</i>
<i>Euphorbia flagelliformis.</i>	<i>Ulmus racemosa.</i>
<i>E. heterophylla graminifolia.</i>	<i>Veronica anagallis-aquatica.</i>
<i>Juncus longistylis.</i>	<i>Woodsia obtusa.</i>

(3) Species peculiar to the Loup district.

<i>Agropyron caninum unil-</i> <i>terale.</i>	<i>Dryopteris cristata.</i>
<i>Alsine longifolia.</i>	<i>Eragrostis trichodes texen-</i> <i>sis.</i>
<i>Amaranthus torreyi.</i>	<i>Fimbristylis castanea.</i>
<i>Andropogon hallii flaveolus.</i>	<i>Geum macrophyllum.</i>
<i>Aster junceus.</i>	<i>Hippuris vulgaris.</i>
<i>A. umbellatus pubens.</i>	<i>Juncus balticus litoralis.</i>
<i>Azolla caroliniana.</i>	<i>J. balticus montanus.</i>
<i>Carex douglasii.</i>	<i>Naias guadalupensis.</i>
<i>C. filiformis.</i>	<i>Physalis heterophylla um-</i> <i>brosa.</i>
<i>C. lanuginosa.</i>	<i>Polygonum hartwrightii.</i>
<i>C. marcida.</i>	<i>P. punctatum leptostachyum.</i>
<i>C. nebraskensis praevia.</i>	<i>P. ramosissimum patulum.</i>
<i>C. pseudocyperus.</i>	<i>Potamogeton heterophyllus</i> <i>graminifolius.</i>
<i>C. scoparia.</i>	<i>P. oakesianus.</i>
<i>Chenopodium rubrum.</i>	<i>P. perfoliatus richardsonii.</i>
<i>Cicuta bulbifera.</i>	<i>Sagittaria arifolia.</i>
<i>Crataegus coccinea.</i>	<i>Scolochloa festucea.</i>
<i>Cyperus houghtonii.</i>	

<i>Solidago missouriensis glaberrima.</i>	<i>Spiesia inflata.</i>
	<i>Vagnera sessilifolia.</i>
(4) Species peculiar to the Republican district.	
<i>Arenaria stricta.</i>	<i>Polypteris hookeriana.</i>
<i>Asclepias latifolia.</i>	<i>Ptilepida linearifolia.</i>
<i>Gaillardia pulchella.</i>	<i>P. scaposa linearis.</i>
<i>Lippia cuneifolia.</i>	<i>Steironema quadrifolium.</i>
<i>Lobelia cardinalis.</i>	<i>Stenosiphon linifolius.</i>
<i>Lobelia inflata.</i>	<i>Thalesia fasciculata.</i>
<i>Martynia louisiana.</i>	<i>Vernonia baldwinii.</i>
<i>Physalis hederifolia rotundata.</i>	

SPECIES COMMON TO THE SAND-HILL AND FOOT-HILL REGIONS.

(1) Species proper to or most frequent in the sand-hill region.

<i>Agrostis alba.</i>	<i>Elymus macounii.</i>
<i>Andropogon hallii.</i>	<i>Epilobium lineare.</i>
<i>Anogra pallida.</i>	<i>Eragrostis trichodes.</i>
<i>Asclepias arenaria.</i>	<i>Erigeron bellidiastrum.</i>
<i>Astragalus gracilis.</i>	<i>E. annuus.</i>
<i>A. lotiflorus.</i>	<i>Eriogonum annuum.</i>
<i>A. lotiflorus brachypus.</i>	<i>Euphorbia petaloidea.</i>
<i>A. racemosus.</i>	<i>Euthamia graminifolia.</i>
<i>Calamovilfa longifolia.</i>	<i>Fimbristylis spadicea.</i>
<i>Carduus plattensis.</i>	<i>Froelichia floridana.</i>
<i>Carex filifolia.</i>	<i>Gerardia tenuifolia.</i>
<i>Catabrosa aquatica.</i>	<i>Habenaria hyperborea.</i>
<i>Chenopodium leptophyllum.</i>	<i>Hymenopappus filifolius.</i>
<i>C. leptophyllum oblongifolium.</i>	<i>H. tenuifolius.</i>
<i>C. leptophyllum subglabrum.</i>	<i>Ipomoea leptophylla.</i>
<i>Chrysopsis villosa.</i>	<i>Lechea minor.</i>
<i>Comandra pallida.</i>	<i>Lepachys columnaris pulcherrima.</i>
<i>Cristatella jamesii.</i>	<i>Linum rigidum.</i>
<i>Croton texensis.</i>	<i>Lycopus lucidus.</i>
<i>Cucurbita foetidissima.</i>	<i>Kuhnistera oligophylla.</i>

K. multiflora.
Mimulus jamesii.
Muhlenbergia pungens.
Munroa squarrosa.
Oryzopsis cuspidata.
Parosela enneandra.
Penstemon caeruleus.
Panicum virgatum glaucum.
Peucedanum nudicaule.
Phaca longifolia.
Polanisia trachysperma.
Prunus demissa.
Psoralea campestris.

Psoralea lanceolata.
Ribes aureum.
Rosa woodsii.
Rumex persicarioides.
R. venosus.
Scirpus americanus.
Scutellaria galericulata.
Selaginella rupestris.
Senecio compactus.
S. douglasii.
Solidago mollis.
Townsendia exscapa.
Veronica americana.

(2) Species proper to or most frequent in the foot-hill region.

Aster canescens.
A. longifolius.
Anogra albicaulis.
Artemisia frigida.
A. canadensis.
Amelanchier alnifolia.
Astragalus missouriensis.
A. mollissimus.
Berula erecta.
Bromus kalmii.
B. porteri.
Cactus viviparus.
Clematis ligusticifolia.
Cymopterus montanus.
Campanula rotundifolia.
Crepis runcinata.
Carduus ochrocentrus.
Chrysopsis villosa hispida.
C. villosa canescens.
C. villosa sessilifolia.
Cheilanthes gracilis.
Cleomella angustifolia.

Erysimum asperum.
E. asperum arkansanum.
Galium boreale.
Gnaphalium palustre.
Geum strictum.
Gyrostachys romanzoffiana.
Hordeum pusillum.
Juncus bufonius.
Laciniaria spicata.
Leucocrinum montanum.
Lychnis drummondii.
Mentzelia nuda.
M. decapetala.
Monarda citriodora.
Opuntia fragilis.
Orobanche ludoviciana.
Parosela aurea.
Physalis lanceolata.
Phlox hoodii.
Pentstemon gracilis.
Pinus scopulorum.
Plantago eriopoda.

<i>P. litorale.</i>	<i>Thelesperma trifidum.</i>
<i>Sophora sericea.</i>	<i>Thermopsis rhombifolia.</i>
<i>Sporobolus airoides.</i>	<i>Townsendia grandiflora.</i>
<i>Stipa comata.</i>	<i>Woodsia oregana.</i>

IV. THE FOOT-HILL REGION.—This region occupies a broad belt, 150 kilometers wide, in the western portion of the State. But a small portion of the whole region is within our limits. The region extends northward through the Dakotas, Montana, Assiniboia, and Alberta to its northern limit in Athabasca. On the south it extends along the mountains into Colorado and New Mexico. Physiographically it is a region of high, barren table-land, broken by numerous canyons and dotted with frequent buttes. Its floral contrast is especially marked on account of the great number of mountain plants which here find their distributional boundary on the east. The formational contrast is furnished by the characteristic and peculiar mat and rosette formations of buttes and rocky ridges.

The region in our limits has been divided into two districts. The Pine Ridge district is akin topographically and phytogeographically to the Black Hills of South Dakota. It is cut off from the remainder of the region by Pine Ridge. In the Lodge Pole district the flora of the foot-hills represents an eastward extension of the foot-hill flora of the Rocky mountains.

The immediate floral contrast in our limits is set forth in the following tables:

SPECIES PECULIAR TO THE FOOT-HILL REGION.

(1) Species occurring throughout the region in Nebraska.

<i>Abronia fragrans.</i>	<i>Anogra coronopifolia.</i>
<i>Agropyron spicatum.</i>	<i>Artemisia cana.</i>
<i>A. tenerum.</i>	<i>A. filifolia.</i>
<i>Antennaria dioica.</i>	<i>Atriplex nuttallii.</i>
<i>Arabis holboellii.</i>	<i>Astragalus adsurgens.</i>
<i>Aragallus lamberti sericeus.</i>	<i>A. microlobus.</i>
<i>Arenaria hookeri.</i>	<i>Bahia oppositifolia.</i>

<i>Carex aurea.</i>	<i>L. plattensis.</i>
<i>Cryptanthe fendleri.</i>	<i>L. pusillus.</i>
<i>Dodecatheon meadia.</i>	<i>Mertensia lanceolata.</i>
<i>Draba nemorosa.</i>	<i>Musineon tenuifolium.</i>
<i>Elymus elymoides.</i>	<i>Oreocarya glomerata.</i>
<i>Erigeron pumilus.</i>	<i>O. suffruticosa.</i>
<i>Eriocarpum grindelioides.</i>	<i>Orophaca sericea.</i>
<i>Eriogonum flavum.</i>	<i>Orthocarpus luteus.</i>
<i>E. multiceps.</i>	<i>Pachylophus caespitosus.</i>
<i>Euphorbia robusta.</i>	<i>Paronychia jamesii.</i>
<i>Eurotia lanata.</i>	<i>Phacelia heterophylla.</i>
<i>Fritillaria atropurpurea.</i>	<i>Phlox douglasii.</i>
<i>Gilia congesta.</i>	<i>Potentilla anserina.</i>
<i>G. gracilis.</i>	<i>Psoralea collina.</i>
<i>G. iberidifolia.</i>	<i>Ptilepida acaulis.</i>
<i>G. pungens caespitosa.</i>	<i>Ptiloria tenuifolia.</i>
<i>Gutierrezia sarothrae.</i>	<i>Rosa blanda.</i>
<i>Hedeoma drummondii.</i>	<i>Senecio canus.</i>
<i>Homalobus caespitosus.</i>	<i>Solidago montana.</i>
<i>H. tenellus.</i>	<i>Spartina gracilis.</i>
<i>H. montanus.</i>	<i>Thelypodium integrifolium.</i>
<i>Lesquerella alpina.</i>	<i>Viola nuttallii.</i>
<i>Lupinus argenteus decumbens.</i>	<i>Zygadenus elegans.</i>

(2) Species peculiar to the Lodge Pole district.

<i>Abronia micrantha.</i>	<i>Cercocarpus parvifolius.</i>
<i>Allium reticulatum.</i>	<i>Chaenactis douglasii.</i>
<i>Aragallus multiceps.</i>	<i>Chondrophora howardii.</i>
<i>Aster adscendens.</i>	<i>C. nauseosa glabrata.</i>
<i>A. ericifolius.</i>	<i>Coleosanthus grandiflorus.</i>
<i>A. foliaceus.</i>	<i>Delphinium geyeri.</i>
<i>A. tanacetifolius.</i>	<i>Erigeron canus.</i>
<i>A. tradescanti.</i>	<i>Eriogonum alatum.</i>
<i>Astragalus pectinatus.</i>	<i>E. campanulatum.</i>
<i>Batrachium divaricatum.</i>	<i>E. cernuum.</i>
<i>Capnoides curvisiliquum.</i>	<i>E. corymbosum.</i>
<i>Carex muricata gracilis.</i>	<i>E. jamesii.</i>

<i>E. microthecum.</i>	<i>Oreocarya sericea.</i>
<i>Erythraea exaltata.</i>	<i>Pectis angustifolia.</i>
<i>Euphorbia cuphosperma.</i>	<i>Pentstemon acuminatus.</i>
<i>E. fendleri.</i>	<i>Peucedanum kingii.</i>
<i>Froelichia gracilis.</i>	<i>Phlox bryoides.</i>
<i>Gaertneria acanthicarpa.</i>	<i>P. caespitosa rigida.</i>
<i>G. discolor.</i>	<i>P. douglasii andicola.</i>
<i>Galpinsia hartwegii.</i>	<i>Physalis chenopodifolia.</i>
<i>Gaurella guttulata.</i>	<i>P. comata.</i>
<i>Gilia pinnatifida.</i>	<i>Physaria didymocarpa.</i>
<i>G. spicata.</i>	<i>Physostegia parviflora.</i>
<i>Heliotropium curassivicum.</i>	<i>Polygonum douglasii.</i>
<i>Iva axillaris.</i>	<i>Populus acuminata.</i>
<i>Kuhnistera compacta.</i>	<i>Psoralea hypogaea.</i>
<i>K. tenuifolia.</i>	<i>P. linearifolia.</i>
<i>Lappula floribunda.</i>	<i>Puccinellia airoides.</i>
<i>Lesquerella engelmannii.</i>	<i>Ranunculus hispidus.</i>
<i>Limosella aquatica.</i>	<i>Roripa curvisiliqua.</i>
<i>Mentzelia albicaulis.</i>	<i>Sophia incisa.</i>
<i>Mimulus luteus.</i>	<i>Stenotus armerioides.</i>
<i>Opuntia rutila.</i>	<i>Zygadenus nuttallii.</i>

(3) Species peculiar to the Pine Ridge district.

<i>Acer glabrum.</i>	<i>Berberis aquifolium.</i>
<i>Actaea rubra.</i>	<i>Betula occidentalis.</i>
<i>A. rubra arguta.</i>	<i>Calochortus gunnisonii.</i>
<i>Agropyron dasystachyum.</i>	<i>C. nuttallii.</i>
<i>A. violaceum.</i>	<i>Carex jamesii.</i>
<i>Allium cernuum.</i>	<i>Cerastium arvense.</i>
<i>A. stellatum.</i>	<i>Chamaenerion angustifolium.</i>
<i>Anemone multifida.</i>	<i>Chondrophora nauseosa.</i>
<i>Antennaria dimorpha.</i>	<i>Clematis scottii.</i>
<i>Arnica cordifolia.</i>	<i>Corallorhiza multiflora.</i>
<i>Artemisia longifolia.</i>	<i>C. striata.</i>
<i>A. tridentata.</i>	<i>C. corallorhiza.</i>
<i>Astragalus drummondii.</i>	<i>Crepis glauca.</i>
<i>Avena striata.</i>	<i>C. intermedia.</i>

<i>C. tectorum.</i>	<i>Panicularia pallida.</i>
<i>Cryptanthe crassisepala.</i>	<i>Pentstemon cristatus.</i>
<i>Disporum trachycarpum.</i>	<i>Pirola chlorantha.</i>
<i>Eleocharis ovata.</i>	<i>P. secunda.</i>
<i>Erigeron caespitosus.</i>	<i>Populus angustifolia.</i>
<i>E. concinnus.</i>	<i>P. balsamifera.</i>
<i>E. subtrinervis.</i>	<i>P. tremuloides.</i>
<i>Euphorbia montana.</i>	<i>Potentilla hippiana.</i>
<i>E. polygonifolia.</i>	<i>Pterospora andromedea.</i>
<i>Festuca confinis.</i>	<i>Puccinellia distans.</i>
<i>Gilia pumila.</i>	<i>Ribes cereum.</i>
<i>Hieracium umbellatum.</i>	<i>R. oxycanthiodes.</i>
<i>Lathyrus ornatus incanus.</i>	<i>R. setosum.</i>
<i>Linum lewisii.</i>	<i>Rosa acicularis.</i>
<i>Lithospermum pilosum.</i>	<i>Salix bebbiana.</i>
<i>Loeflingia texana.</i>	<i>Sarcobatus vermiculatus.</i>
<i>Lupinus argenteus argophyl- lus.</i>	<i>Sedum stenopetalum.</i>
<i>Mertensia paniculata.</i>	<i>Silene menziesii.</i>
<i>M. virginica.</i>	<i>S. scouleri.</i>
<i>Musineon divaricatum.</i>	<i>Smilax herbacea.</i>
<i>Navarretia minima.</i>	<i>Stanleya pinnata.</i>
<i>Oreocarya fulvocanescens.</i>	<i>Symphoricarpos pauciflorus.</i>
<i>Orophaca caespitosa.</i>	<i>Vleckia anethiodora.</i>
	<i>Wulfenia rubra.</i>

SPECIES COMMON TO THE WOODED-BLUFF, ETC., AND FOOT-HILL
REGIONS.

(1) Species proper to or most frequent in the wooded-bluff, etc., region.

<i>Amelanchier botryapium.</i>	<i>Cornus amonum.</i>
<i>Amorpha nana.</i>	<i>Eatonia pennsylvanica.</i>
<i>Arabis glabra.</i>	<i>Fragaria americana.</i>
<i>Botrychium virginianum.</i>	<i>Habenaria bracteata.</i>
<i>Carex longirostris.</i>	<i>Lonicera dioica.</i>
<i>C. muhlenbergii.</i>	<i>Polygonum amphibium.</i>
<i>C. muricata.</i>	<i>Viola scabriuscula.</i>

(2) Species proper to or most frequent in the foot-hill region.

<i>Acerates viridiflora linearis.</i>	<i>Panicularia americana.</i>
<i>Collomia linearis.</i>	<i>Roripa nasturtium.</i>
<i>Heracleum lanatum.</i>	<i>Stipa viridula.</i>
<i>Lemna trisulca.</i>	<i>Viola canadensis.</i>
<i>Opuntia humifusa.</i>	<i>Washingtonia claytoni.</i>
<i>Oryzopsis micrantha.</i>	

The four regions outlined will be referred to hereafter as regions I, II, III, and IV respectively. In addition to the species enumerated as peculiar to the several regions, there are a large number which are of wider distribution, either occurring throughout the State, or in three of the regions. These are set out in the following tables. In making these tables, as well as the foregoing, it has been thought best to include the species of the flora adventitia as well as the native flora. The fact that species from other floras become naturalized here very rapidly and that a large and increasing number are constantly invading our limits makes it proper to indicate the distribution of these plants as well as of the native and derived species. When we come to discuss the elements of our flora these will be separated from the peculiar species of each region.

SPECIES COMMON TO THREE OR MORE REGIONS.

(1) Species common to the four regions—195.

<i>Acer negundo.</i>	<i>A. nyctaginea.</i>
<i>Acerates angustifolia.</i>	<i>Allium mutabile.</i>
<i>A. floridana.</i>	<i>Amaranthus blitoides.</i>
<i>A. viridiflora.</i>	<i>A. graecizans.</i>
<i>Achillea millefolium.</i>	<i>A. retroflexus.</i>
<i>Agrostis hiemalis.</i>	<i>Ambrosia artemisifolia.</i>
<i>A. vulgaris.</i>	<i>A. psilostachya.</i>
<i>Agrimonia striata.</i>	<i>A. trifida.</i>
<i>Agropyron pseudorepens.</i>	<i>Amorpha canescens.</i>
<i>Alisma plantago-aquatica.</i>	<i>A. fruticosa.</i>
<i>Allionia linearis.</i>	<i>Andropogon furcatus.</i>

- A. scoparius.*
Antennaria campestris.
Apocynum cannabinum.
Aquilegia canadensis.
Argemone intermedia.
Artemisia dracunculoides.
A. gnaphalodes.
Asclepias incarnata.
Aster multiflorus.
A. salicifolius.
Astragalus carolinianus.
A. crassicarpus.
Batrachium trichophyllum.
Bidens laevis.
Bromus ciliatus.
Brauneria pallida.
Carex hystericina.
C. straminea.
Cassia chamaecrista.
Celastrus scandens.
Celtis occidentalis.
Chenopodium album.
Chrysopogon avenaceus.
Cicuta maculata.
Cleome serrulata.
Convolvulus sepium.
Cornus stolonifera.
Cyperus inflexus.
C. rivularis.
Cystopteris fragilis.
Delphinium carolinianum.
Diplachne fascicularis.
Distichlis spicata stricta.
Draba caroliniana.
Dysodia papposa.
Eatonia obtusata.
Eleocharis acicularis.
E. palustris.
Elymus canadensis.
E. striatus.
Epilobium adenocaulon.
Equisetum arvense.
E. laevigatum.
E. robustum.
Eragrostis major.
Erigeron canadensis.
E. ramosus beyrichii.
Eupatorium perfoliatum.
E. purpureum.
Euphorbia glyptosperma.
E. maculata.
E. marginata.
Festuca octoflora.
F. ovina.
Fragaria illinoensis.
Fraxinus lanceolata.
F. pennsylvanica.
Galium aparine.
G. trifidum.
G. triflorum.
Gaura biennis.
G. coccinea.
G. parviflora.
Geum canadense.
Glycyrrhiza lepidota.
Grindelia squarrosa.
Hedeoma hispida.
Helenium autumnale.
Helianthus annuus.
H. maximiliani.
H. rigidus.
Homalocenchrus oryzoides.
Hordeum jubatum.
H. nodosum.

- Humulus lupulus.*
Isnardia palustris.
Iva xanthifolia.
Juncus tenuis.
Juniperus communis.
J. virginiana.
Koeleria cristata.
Kuhnistera candida.
K. purpurea.
K. villosa.
Lactuca canadensis.
L. ludoviciana.
L. pulchella.
Legouzia perfoliata.
Lepachys columnaris.
Lepargyrea argentea.
Lepidium intermedium.
L. virginicum.
Lithospermum gmelini.
L. angustifolium.
Laciniaria punctata.
Leptoglottis uncinata.
Lobelia syphilitica.
Lycopus sinuatus.
Lygodesmia juncea.
Lythrum alatum.
Macrocalyx nyctelea.
Marsilea vestita.
Mentha canadensis.
Meriolix serrulata.
Monarda fistulosa.
Muhlenbergia racemosa.
Nothocalais cuspidata.
Onagra biennis.
Oxygraphis cymbalaria.
Panicularia nervata.
Panicum capillare.
P. crus-galli.
P. scribnerianum.
P. virgatum.
Parietaria pennsylvanica.
Parosela dalea.
Parthenocissus quinquefolia.
Penstemon glaber.
Phragmites phragmites.
Phryma leptostachya.
Plantago purshii.
Polygala alba.
P. verticillata.
Polygonum aviculare.
P. convolvulus.
P. emersum.
P. incarnatum.
P. lapathifolium.
P. pennsylvanicum.
P. ramosissimum.
P. scandens.
Populus deltoidea.
Portulaca oleracea.
Potamogeton natans.
Potentilla monspeliensis.
P. paradoxa.
P. pennsylvanica.
Prunella vulgaris.
Prunus americana.
Psoralea argophylla.
P. esculenta.
P. tenuiflora.
Quercus macrocarpa.
Ranunculus sceleratus.
Rhus glabra.
R. radicans.
Ribes floridum.
R. gracile.

Roripa obtusa.	S. serotina.
R. palustris.	Sparganium eurycarpum.
Rosa arkansana.	Spartina cynosuroides.
Rubus occidentalis.	Spirodela polyrhiza.
R. strigosus.	Sporobolus asperifolius.
Rudbeckia hirta.	S. cuspidatus.
Rumex crispus.	Steironema ciliatum.
R. salicifolius.	Symphoricarpos occidentalis.
Sagittaria latifolia.	Thalictrum purpurascens.
Salix amygdaloides.	Tradescantia virginica.
S. cordata.	Triglochin maritima.
S. fluviatilis.	Typha latifolia.
S. vestita.	Ulmus americana.
Salsola tragus.	Urtica gracilis.
Sanicula canadensis.	Vagnera stellata.
Schedonnardus paniculatus.	Verbena bracteosa.
Scirpus lacustris.	V. hastata.
S. atrovirens pallidus.	V. stricta.
Silene antirrhina.	Veronica peregrina.
Sisyrinchium bermudiana.	Vicia linearis.
Solanum nigrum.	Vitis vulpina.
S. rostratum.	Washingtonia longistylis.
S. triflorum.	Yucca glauca.
Solidago canadensis.	Zannichellia palustris.
S. nemoralis.	

(2) Species common to regions I-III, 161.

Acalypha virginica.	Artemisia biennis.
Acerates lanuginosa.	Asclepias syriaca.
A. viridiflora ivesii.	A. verticillata.
Acuan illinoensis.	Aster laevis.
Adicea pumila.	A. novae-angliae.
Ammannia coccinea.	A. sericeus.
Androsace occidentalis.	Bidens connata.
Anemone caroliniana.	B. frondosa.
A. cylindrica.	Brassica sinapistrum.
Anthemis cotula.	Calamagrostis canadensis.
Apios apios.	Camelina sativa.

- Cannabis sativa.*
Campanula americana.
Capnoides montanum.
Carduus altissimus.
Carex laxiflora varians.
C. pennsylvanica.
C. straminea festucacea.
C. stricta.
C. tetanica meadii.
C. vulpinoidea.
Ceanothus americanus.
C. ovatus.
C. ovatus pubescens.
Cenchrus tribuloides.
Chaetochloa glauca.
C. viridis.
Chenopodium hybridum.
Cinna arundinacea.
Coreopsis tinctoria.
C. verticillata.
Cuscuta arvensis.
C. cuspidata.
C. glomerata.
Cyperus esculentus.
C. filiculmis.
Eragrostis pectinacea.
E. hypnoides.
Erigeron divaricatus.
Erysimum cheiranthoides.
Euonymus atropurpureus.
Eupatorium ageratoides.
E. perfoliatum.
Euphorbia dentata.
E. heterophylla.
E. nutans.
E. serpyllifolia.
Falcata comosa.
F. pitcheri.
Festuca nutans.
Galium circaezans.
Gentiana puberula.
Gerardia aspera.
G. purpurea.
Helianthus decapetalus.
H. giganteus.
H. grosseserratus.
H. strumosus.
Heliopsis scabra.
Heuchera hispida.
Hibiscus trionum.
Homalocenchrus virginicus.
Houstonia angustifolia.
Ilysanthes gratiolooides.
Iva ciliata.
Juglans nigra.
Laciniaria scariosa.
L. squarrosa intermedia.
Lactuca villosa.
L. scariola.
Lappula virginiana.
Lespedeza capitata sericea.
Lippia lanceolata.
Ludwigia polycarpa.
Lycopus virginicus.
Medicago lupulina.
Meibomia canadensis.
M. canescens.
M. grandiflora.
Melilotus alba.
Micrampelis lobata.
Mimulus ringens.
Monniera rotundifolia.
Myosurus minimus.
Nepeta cataria.

<i>Ostrya virginiana.</i>	<i>Sambucus canadensis.</i>
<i>Oxalis stricta.</i>	<i>Scirpus fluviatilis.</i>
<i>O. violacea.</i>	<i>Scrophularia marilandica.</i>
<i>Panicum depauperatum.</i>	<i>Scutellaria lateriflora.</i>
<i>Paspalum setaceum.</i>	<i>S. parvula.</i>
<i>Pastinaca sativa.</i>	<i>Senecio lugens.</i>
<i>Pedicularis canadensis.</i>	<i>S. plattensis.</i>
<i>Penthorum sedoides.</i>	<i>Silphium laciniatum.</i>
<i>Pentstemon grandiflorus.</i>	<i>S. perfoliatum.</i>
<i>Peucedanum foeniculaceum.</i>	<i>Solidago canadensis procera.</i>
<i>Phalaris arundinacea.</i>	<i>S. rigida.</i>
<i>Physalis virginiana.</i>	<i>Sporobolus vaginiflorus.</i>
<i>Plantago elongata.</i>	<i>Stipa spartea.</i>
<i>P. major.</i>	<i>Strophostyles helvola.</i>
<i>P. rugelii.</i>	<i>S. pauciflora.</i>
<i>Polygonatum commutatum.</i>	<i>Symphoricarpos symphori-</i>
<i>Polygonum punctatum.</i>	<i>carpos.</i>
<i>P. erectum.</i>	<i>Syntherisma sanguin-</i>
<i>P. persicarioides.</i>	<i>alis.</i>
<i>P. persicaria.</i>	<i>Taraxacum taraxacum.</i>
<i>P. tenue.</i>	<i>Teucrium canadense.</i>
<i>Potamogeton amplifolius.</i>	<i>Tilia americana.</i>
<i>Potentilla arguta.</i>	<i>Trifolium repens.</i>
<i>P. leucocarpa.</i>	<i>Ulmus fulva.</i>
<i>P. pentandra.</i>	<i>Vagnera racemosa.</i>
<i>Prenanthes aspera.</i>	<i>Verbascum thapsus.</i>
<i>Ranunculus abortivus.</i>	<i>Verbena urticifolia.</i>
<i>R. delphinifolius.</i>	<i>Vernonia gigantea.</i>
<i>Rhamnus lanceolata.</i>	<i>Vicia truncata.</i>
<i>Roripa sessiliflora.</i>	<i>Viola obliqua.</i>
<i>Rudbeckia laciniata.</i>	<i>Xanthium canadense.</i>
<i>Salix humilis.</i>	<i>Xanthoxylum americanum.</i>
<i>Salvia lanceolata.</i>	<i>Zizania aquatica.</i>

(3) Species occurring from region IV to II, rarely in I; western—66.

<i>Allionia hirsuta.</i>	<i>Apocynum androsaemifol-</i>
<i>Ambrosia trifida integrifolia.</i>	<i>ium.</i>

<i>Aragallus lamberti.</i>	<i>Helianthus petiolaris.</i>
<i>Asclepias speciosa.</i>	<i>Impatiens biflora.</i>
<i>A. verticillata pumila.</i>	<i>Juncus torreyi.</i>
<i>Aster incanopilosus.</i>	<i>Koellia virginiana.</i>
<i>A. oblongifolius.</i>	<i>Lappula texana.</i>
<i>A. paniculatus.</i>	<i>Lathyrus ornatus.</i>
<i>Astragalus plattensis.</i>	<i>Lesquerella ludoviciana.</i>
<i>Bouteloua curtipendula.</i>	<i>Lobelia spicata.</i>
<i>B. oligostachya.</i>	<i>Lotus americanus.</i>
<i>B. hirsuta.</i>	<i>Malvastrum coccineum.</i>
<i>Bromus breviaristatus.</i>	<i>Mollugo verticillata.</i>
<i>Bulbilis doctyloides.</i>	<i>Monolepis nuttalliana.</i>
<i>Calamagrostis neglecta.</i>	<i>Oenothera humifusa.</i>
<i>Callirhoe involucrata.</i>	<i>Onosmodium molle.</i>
<i>Campanula aparinoides.</i>	<i>Opuntia polyacantha.</i>
<i>Carduus discolor.</i>	<i>Pentstemon albidus.</i>
<i>C. undulatus.</i>	<i>Physalis heterophylla.</i>
<i>Castilleia sessiliflora.</i>	<i>P. longifolia.</i>
<i>Cerastium brachypodium.</i>	<i>Potamogeton foliosus.</i>
<i>Chenopodium fremontii.</i>	<i>Prunus besseyi.</i>
<i>C. incanum.</i>	<i>Psoralea digitata.</i>
<i>Corispermum hyssopifolium.</i>	<i>Pulsatilla hirsutissima.</i>
<i>Cycloloma atriplicifolium.</i>	<i>Ranunculus pennsylvanicus.</i>
<i>Draba caroliniana micrantha.</i>	<i>Rhus trilobata.</i>
<i>Elymus canadensis glaucifolius.</i>	<i>Ruppia occidentalis.</i>
<i>Epilobium coloratum.</i>	<i>Solidago missouriensis.</i>
<i>Eriocarpum spinulosum.</i>	<i>Teucrium occidentale.</i>
<i>Euphorbia hexagona.</i>	<i>Thalesia fasciculata lutea.</i>
<i>Eustoma russellianum.</i>	<i>Thelesperma gracile.</i>
<i>Euthamia caroliniana.</i>	<i>Utricularia vulgaris.</i>
<i>Festuca scabrella.</i>	<i>Verbena bipinnatifida.</i>
	<i>Vernonia fasciculata.</i>

It should be noted that the greater part of the foregoing species occur in II only in the Elkhorn district, and in I only along the bluffs of the upper Missouri.

The boundaries of the prairie province and its division into

vegetation regions are shown in map IV. Especial attention is called to the peculiar attenuation of the prairie region (II) to the south, and its final disappearance in the Indian territory. On the contrary, the sand-hill region, which is broadest in Kansas and Nebraska, and runs far south into Texas, disappears as a region in the Dakotas, being represented beyond them only by extraregional areas. The latter, however, are to be met with northward into Athabasca. The foot-hill region, of course, extends along the entire eastern border of the Rocky mountains, from Athabasca to New Mexico.

CHAPTER III.

THE VEGETATION-FORMS OF THE FLORA.

Introductory.—Phytogeography should be first an accurate record of biological facts and second an explanation of these facts. This is especially evident of the ecological aspect, though it is equally true from the floristic or the formational standpoint. In the former the record has been made in the individual; in the latter, it is found in aggregations or associations of individuals. The record preserved in the individual furnishes the data for morphology and is to be interpreted by means of morphological principles. The record left in the floral covering yields those facts which lie at the foundation of distribution and of formational association. When the operation of those causes of which the individual is the record has been remote and profound, we are enabled to group plants according to fundamental similarities and differences, to construct a phylogenetic scheme based upon morphology as cumulated effect. In this way taxonomy has arisen. The morphological study which is the foundation of it may be called taxonomic morphology.

It is impossible to draw any absolute distinction between remote and recent causes, or between profound and superficial differences. The most significant morphological differences are made use of by taxonomy to distinguish major groups. Lesser groups must be characterized by correspondingly less significant differences. As a result, there arises some confusion, since biological and ecological groups are likewise characterized, in part at least, by morphological facts of relatively minor importance. Nevertheless, it is generally true that taxonomic groups are distinguished by profound morphological characters, chiefly in the organography of reproduction, biological groups, i. e., vegetation-forms, trees, shrubs, etc., by less profound differences, and ecological

groups by still less important distinctions. It should be borne in mind that some biological groups, rosettes, mats, succulents, water plants, are vegetation-forms if considered from a purely morphological standpoint, and members of habitat groups if regarded from an adaptational standpoint. Indeed, the same is true of all vegetation-forms to some degree, though in the majority of them, trees, shrubs, bushes, etc., the morphological differences of the biological groups are more profound than those of the habitat-groups. Thus, rosettes, mats, and succulents are essential xerophytes and water plants are typical hydrophytes, while trees, shrubs, herbs, etc., may be xerophytic, mesophytic, or hydrophytic. The groups determined by secondary biological characters are of the most diverse importance. A few are of more fundamental significance than habitat-groups, while most of them are much less important.

The whole matter of the relative importance and sequence of taxonomic, biological, and ecological groups is further complicated by the fact that physiological factors play an important part in the characterization of certain vegetation-forms, saprophytes, parasites, helophytes, epiphytes, and a predominant part in the delimitation of habitat-groups. Whatever the respective parts that morphology and physiology assume in the different groups, taxonomic groups are fundamentally phylogenetic in character, biological groups morphological, and ecological or habitat-groups physiological or adaptational.

Biological groups are set off by biological characters, which are primary or secondary according to their significance. The distinction between primary and secondary characters rests upon the degree or amount of morphological characteristic which plants exhibit. Primary biological characters are concerned essentially with the structure of the plant as an individual. Within the main groups, trees, shrubs, and herbs, they are such as determine the duration of the individual and, hence, its power of occupation. As a result, they are important factors in stabilization, vegetation-pressure, and zonal

tion. Secondary biological characters are sometimes furnished by the plant as a whole, but they are usually derived from the morphology of some particular organ, such as leaf, stem, flower, and fruit. They are generally recent adaptations of the species to its particular mode of life, rather than essential facts in its phylogeny.

Primary biological characters are concerned with the gross structure of plants, with what may be called their skeletal morphology, and with those particular structures which bring about duration or perennation. The two are so interrelated that primary characters may be considered as fundamentally concerned with duration and occupation. The groups which primary characters set off are known as vegetation-forms. The vegetation-form is the unit in the biological consideration of the floral covering. In consequence of what has been said elsewhere, vegetation-forms are to be regarded as biological groups whose members possess similar plant-bodies. They fall into seven main groups, woody plants, half shrubs, pleiocyclic herbs, hapaxanthous herbs, water plants, hystero-phytes, and thallophytes. These are subdivided according to minor differences in structure and duration into thirty-four vegetation-forms.

The total number of species at present known for the flora of the State is 3,348. There are 1,490 flowering plants, of which 1,156 are dicotyledons, 331 monocotyledons, and 3 gymnosperms. The number of cryptogams is 1,858, of which 99 are vascular cryptogams. There are 1,260 species of fungi and 499 species of algae. The Myxomycetes, of which many species occur in Nebraska, have been excluded.

Enumeration and Characterization of Vegetation-forms.

I. WOODY PLANTS.—These include all plants that have a well-developed, perennial, woody stem or stem-cluster above the ground. They may possess leaves throughout the entire year (evergreen), or only during the vegetative period (deciduous). This first group comprises the most characteristic and dominant plants of the floral covering in those

formations in which they are found. Upon the size and general character of the trunk they may be divided into four vegetation-forms as follows:

I. TREES.—What has just been said of woody plants in general applies especially to trees as vegetation-forms. Wherever they occur, either aggregated or scattered, they are the controlling vegetation-form in a formation. This arises from the fact that trees, on account of their tall, compact stem and their dense expanse of foliage, determine the conditions not only of light and moisture but also of warmth and of soil for those plants which grow beneath them. Thus in a forest all the vegetation-forms are directly dependent upon the disposition of the trees. Even in open woodlands this also holds, though the controlling power of the trees upon other vegetation is reduced.

Trees react upon their environment more strongly than other vegetation-forms, thus causing an intensification of the forces which determine their distribution. One may suppose that trees first find their way into treeless regions on account of the more or less favorable conditions of moisture, soil, and drainage which prevail there. Once established, they tend to render these conditions stable, and hence to insure complete and continuous occupation of the soil. From this results a condition of equilibrium or inertia. Trees, therefore, not only tend to, but do perpetuate themselves when established, and their abundance is indicative of comparative primitiveness in the flora. On account of their inertia they follow lines of stress more slowly than other plants, and their advance or retreat becomes of great significance for the determination of profound changes in the floral covering.

Trees are either deciduous or evergreen. The latter may be divided into the broad-leaved and needle-leaved. The broad-leaved evergreen trees are entirely unrepresented in our flora. Of the needle-leaved, there are but two species represented.

The number of trees within our limits is 58. Of these 10 are common to the four regions. Region I possesses 45 species, of which 17 are peculiar to it. Region II has 18

species, none of which are peculiar. In region III there are 24, with 4 peculiar. Region IV has 23 species with 7 peculiar. It is readily seen that the greatest incursion of trees has been from the eastward, so much so that region I has taken its character from them. A number have come also from the northwest. A result of this is that one-third of the species of region IV are peculiar. The region poorest in species is the prairie region, which does not possess a single species peculiar to it. The exceedingly small number of species common to the four regions may be explained by the differences in soil and altitude between them.

2. SHRUBS.—Under shrubs are comprised woody plants of tree-like habit characterized by a smaller, shorter stem, often branching below, and with a smaller expanse of foliage. In distinguishing trees from shrubs the chief criterion is size, but the rôle which they play in the formation may sometimes be made use of.

Shrubs are usually accessory to and dependent upon the presence of trees. This is typically the case in heavily and uniformly wooded areas. In prairie regions, however, where trees can at most occupy but a small portion of the surface, the shrubs often separate themselves from the forest formation, and in their turn become controlling in considerable areas. This results from the fact that their inertia is in general less than that of trees, so that they respond more readily to distributing forces. This is especially true of thickets, which are in reality miniature forests in which the controlling vegetation-form is the shrub. The domination of woody plants as vegetation-forms is thus carried much farther than it could be by trees alone. The same principle may be applied as well to undershrubs, that is to say, bushes and dwarf shrubs. Characteristic examples may be found for the former in the prevailing prairie-rose and wolfberry facies, and for the latter in the *Amorpha canescens* facies, which occur throughout regions II and III.

The number of shrubs in Nebraska is 33, only one of which is evergreen. This is the cosmopolite *Juniperus communis*.

Of these 33, 5 are found throughout the entire State. As would be expected, region I is remarkable both for its large number of species and for its large per cent of peculiar species. It has 28 species of which 10 are peculiar. Region II is poorest in shrubs, having but 13 species, of which none are peculiar. Region III has 18 species with one peculiar (*Salix tristis*), and region IV, 11, with 2 peculiar.

Under this group should also be included the somewhat anomalous *Yucca glauca*. This is, in effect, a monocotyledonous, evergreen shrub. Its southern relatives are trees, but in our limits *Yucca* reaches no great height, its woody caudex rising not more than 20-30 centimeters. It occurs in all four regions, but is only found abundantly in the Loup and Republican districts of region III and in certain portions of region IV.

3. UNDERSHRUBS.—These are woody plants with erect, small stem, typically much branched above and forming a comparatively large top. Undershrubs fall naturally into the taller, much-branched forms, which are usually termed bushes, such as *Rhus trilobata* and *Cercocarpus parvifolius*, and the low, simpler forms, such as *Arctostaphylos uva-ursi*, which are termed dwarf shrubs.

Undershrubs are typically a layer in a tree or shrub formation, a statement which holds throughout for region I. But in region IV large areas are dominated by undershrub formations. Examples of these are the greasewood, *Sarcobatus vermiculatus*, and the sage-brush, *Artemisia tridentata*. These particular undershrubs are peculiar. They do not possess the ordinary characteristics of shrubs, but instead resemble huge, perennial herbs which persist from year to year. In many cases the year's growth dies back almost completely, so that, while the main stem increases in circumference, the plant grows but little each year.

The undershrubs are represented in our flora by 40 species, Of these, 32 are bushes and 8 are dwarf shrubs. Of the bushes, 4 are found throughout; 12, of which 2 are peculiar, occur in region I; 10 with a single peculiar species in region

II; 17 with one peculiar in region III; and 23 with 12 peculiar in region IV. As has been shown above, region IV is characterized by special abundance of undershrubs. It is peculiarly significant that two-thirds of our undershrubs are found in this region, and that more than one-fourth of the whole number are peculiar to it. Fourteen of our bushes are prickly. Our dwarf shrubs number 8, only 1 of which, *Amorpha canescens*, is common to the whole State. Of these, two are evergreens: *Berberis aquifolium* and *Arctostaphylos uva-ursi*. One, *Rhus radicans*, is often a climber. Region I possesses 3 species, of which 1 is peculiar; region II has 2, one common to the State and the other found also in III. Region III has 6 species, with 1 peculiar, and region IV, 4 species with likewise 1 peculiar. While the number of dwarf shrubs in any region is perhaps of little significance, the fact that the dry, barren sand-hill region possesses the largest number may have some meaning.

4. CLIMBERS AND TWINERS.—These are woody plants with a small stem, and with no top, climbing or twining about the trunks of trees or shrubs. Climbers and twiners are absolutely dependent upon the presence of trees and shrubs, and hence give character to layers only and never to formations. Likewise their distribution must coincide with that of trees, or at least of shrubs, so that we should expect to find them most abundant in wooded regions.

In our flora there are 13 species of this group, of which 4, *Smilax hispida*, *Celastrus scandens*, *Vitis vulpina*, and *Parthenocissus quinquefolia*, are common to the four regions. Thirteen species, of which 5 are peculiar, are found in region I. There are 8 and 7 in regions II and III respectively, with none peculiar. Region IV contains but a single species in addition to the four common to the entire State. It will hardly be necessary to call attention to the predominance both in number of species and in peculiar species in region I. All but 1 of our species of this group are found in that region. The exception is *Clematis ligusticifolia*, which is in reality the submontane representative of the eastern *C. virginiana*.

II. HALF SHRUBS.—These might, perhaps, without doing great violence to biological distinctions, be included in undershrubs in group 3. The characteristically rudimentary development of the stem, however, seems to warrant their separation as a special group.

5. HALF SHRUBS.—Our flora contains but 4 representatives: *Gutierrezia sarothrae*, *Chondrophora howardii*, *Artemisia frigida*, and *Meriolix serrulata*. All of these are confined to the high plateaux of region IV, except *Meriolix serrulata*, which is common to the entire State.

Herbs.—In contrast with woody plants and half shrubs are herbs, which include all those flowering plants destitute of a caudex. No exact line can be drawn between some herbs and half shrubs; in fact one species, *Meriolix serrulata*, is in regions I and II a perennial herb, while in region III especially, through the persistence of its stem, it becomes a half shrub.

In the consideration of the woody vegetation-forms, size and mode of growth have been made the criteria upon which to base the groups and subdivisions. It would be entirely feasible to classify herbs in the same manner. *Helianthus annuus* is a veritable herbaceous tree. It covers large areas completely, growing to a great height, often 4 meters or more, and in a sunflower waste there are successive layers as truly as in any woody formation. The sunflowers, by reason of their great height and expanse of broad leaves, control the conditions in these wastes absolutely. *Ambrosia trifida*, species of *Vernonia*, and to a less degree *Grindelia squarrosa* and *Verbena stricta* owe a portion of their dominant character in the formations in which they take part to their size. Another very marked group might be made up of those herbs which grow spreading along the ground and choke out other vegetation. Notable examples of this type are species of *Euphorbia*, which from their mode of growth are very abundant in pastures, *Portulaca oleracea*, *Isnardia palustris*, *Amaranthus blitoides*, *A. graecizans*, *Polygonum aviculare*, *Astragalus crassicaarpus*, and other *Astragali*. Between these extremes, those herbs, lower than the first group, which send

up simple stalks of middle height, such as among prairie plants *Pentstemon grandiflorus*, *Solidago rupestris*, species of *Kuhnistera*, *Euphorbia marginata*, and those which are spreading and bush-like in habit, such as *Psoralea floribunda*, and other species of *Psoralea*, might be ranged as distinct groups. In such an arrangement, also, many of the groups hereafter referred to, such as mats, rosettes, turf-builders, and creepers and climbers would find a place. But size is a criterion somewhat difficult of application even in woody plants, where the same species is in this region a tree and in that a shrub. With herbaceous plants, where a species may be a giant in one patch and a dwarf in an adjacent one, the difficulty would be far greater. *Helianthus annuus*, for example, in a sunflower waste may be 5 meters high, and is generally from 2-4. Not 100 meters distant, in a roadside waste, it may be less than a meter, and patches of stunted individuals not more than 4 or 5 decimeters in height often occur. The great objection to such an arrangement, however, is that its biological significance is trifling. In the case of woody vegetation size is of the first importance. It is by reason of their size and mode of growth that trees, and to a less degree shrubs, become controlling in woodland and thicket. Their size and the superior position of their foliage give them possession and enable them to hold possession. With herbaceous plants it is otherwise. While size is undoubtedly of importance to such plants as *Helianthus annuus* and *Ambrosia trifida*, and enables them to hold the large areas they occupy so thoroughly, yet they gain possession by means of their enormous seed-production and the oil or bitter sap which prevent animals from eating the young plants. Their very late start in the summer compels them to seek waste places exclusively, and they find little or no place on the prairies, where the smaller but perennial *Grindelia squarrosa*, *Solidago rigida*, and *Pentstemon grandiflorus* flourish. Moreover, the diminutive *Dysodia papposa* is enabled by its seed-production and its contrivances for dissemination to cover areas almost as extensive as those

ruled by the taller species of *Ambrosia*. *Solidago rigida*, *Grindelia squarrosa*, and other large plants of the prairies owe their controlling importance principally to the advantage of early start and preoccupation of the soil afforded by their duration. Compared with duration, in these species, size and mode of growth are a secondary consideration. They are, in fact, of less importance with the species in question than the internal protective devices which cause grazing animals to avoid them. This is even truer of the smaller species, such as *Psoralea* and *Kuhnistera*, which play such an important part in the floral covering of the prairies. Duration, therefore, must be taken as the primary criterion in classifying herbaceous vegetation-forms.

In a prairie region herbs are of the first importance. Wherever woody formations prevail, herbs necessarily play a subordinate rôle, but in the absence of woody formations those herbs which are especially adapted to the prairie conditions quickly become controlling. Thus, in forests and thickets, and even in open woodlands, the herbs are generally found scattered and are in many respects the least important layer in the formation. In meadow lands and on the open prairies and plateaux, however, the reverse is true. The herbs here have complete control of the soil, and the result is a rapid development of vegetation-forms. While in woodlands the herbaceous vegetation-forms are chiefly due to the changed conditions effected by the woody plants, on the prairies the vegetation-forms are due to the direct action of physical forces. In further explanation of this it needs only to be pointed out that in a forest or thicket formation the herbs are not only in direct competition with each other in their own layer, but also, and chiefly, have to contend with the individuals of the layers above them. On the prairies and plateaux, the physical conditions confine the trees to small fringes along streams, and the herbs have undisputed possession of great open areas.

The true estimate of the value of herbs in the floral covering can be obtained only through determination of the areas

covered by them and of their abundance in these areas. The actual number of species, however, inasmuch as it is closely connected with the foregoing, is of some significance. While it is of more importance to know that Nebraska is covered with prairies and plateaux on which herbaceous vegetation-forms alone occur in abundance, the ratio of herbaceous to woody vegetation in the number of species has cumulative meaning. A comparison of the flora of our State with the floras of other states and countries which possess extensive forests shows that the preponderance of herbaceous species in our flora is noticeably greater. In our flora 90 per cent of the species are herbaceous. In New Jersey the percentage of herbaceous species is 86. In Spain the herbaceous species are 83 per cent of the flora, and in Germany 89 per cent.

As regards distribution, herbs in comparison with woody plants are essentially unstable. Their migrations and shiftings indicate superficial disturbances, sometimes of a permanent character, but often merely transient. In rare cases the meaning of such shiftings may be more profound, but in such cases the movements foreshadow or accompany those of the woody forms. Obviously the movements of herbaceous forms are much more rapid than those of woody forms.

According to duration, herbs fall into two groups, which may be limited almost absolutely except in a few rare instances known as di-tricyclic herbs. The primary division is into pleiocyclic or perennial herbs and hapaxanthous herbs, or those having but one flowering period. In certain cases important biological modifications take precedence, so that we set off also water plants and hysteroptytes.

III. PLEIOCYCLIC HERBS.—While, as has been said, pleiocyclic herbs are contrasted directly with hapaxanthous herbs, most of the species included under water plants and hysteroptytes are in fact pleiocyclic.

In pleiocyclic herbs duration may be secured in two ways: by persistence of the plant or a portion of it above ground through modification of the stems or of the stems and leaves, or by persistence beneath the surface, as for example by root-

stalks, bulbs, or tubers. The forms which make use of the latter method fall very naturally into two subdivisions, rhizomata and turf-builders. The former constitute one subdivision. In addition to these there is one group based on the habit of growth instead of on the method of persistence, because of the importance which this particular character assumes.

6. ROSETTES.—This group includes those pleiocyclic, rarely hapaxanthous, herbs with a persistent basal tuft or rosette of leaves. In some cases the tuft persists throughout the year; in others it serves merely to carry the plant through the winter.

Rosettes are of two kinds: close rosettes and open rosettes. In the former the petioles are contracted, and the tuft becomes closely compacted, and is often protected by a more or less dense growth of hairs. In the latter the tuft is looser and the petioles are longer, so that the rosette is more or less irregular. Typical examples of close rosettes are *Onagra biennis*, *Gaura parviflora*, and species of *Carduus*. Examples of open rosettes are *Viola obliqua* and *Aster sagittifolius*. In woody formations where they are protected through the winter by leaf mold, rosettes are apt to be open, while on the prairie they are usually close. The same species will often form an open rosette in one situation while in another it approximates to the close form. Thus the species of *Solidago*, which form open rosettes on the edge of woodlands, tend to form close rosettes on the prairie. Many plants which do not live through the winter above the surface are enabled to gain an early start in the spring by forming rosettes which are able to withstand frosts. Examples of this are *Aster multiflorus*, *Grindelia squarrosa*, and *Plantago major*.

The number of rosette-forming species in our flora is 27, of which 9 occur throughout the State. Region I has 23, of which 3 are peculiar, II has 21, with 1 peculiar, and regions III and IV, 15 and 10 respectively.

7. MATS.—This group is composed of acaulescent or low-stemmed plants which grow aggregated into dense cushion-

like mats. Mats are due to the peculiar conditions present in dry, barren highlands. Their origin may be traced to either of two causes. In alpine regions they arise from the reduction of the individual necessitated by the altitude. In submontane regions their formation is due to lack of moisture and infertility of the soil. From their characteristically compact growth, mats tend to exert a controlling influence in the formations in which they occur. This tendency is held in check by the small size of the individual mats and their scattered disposition. Nevertheless, they give a special character to any region in which they are found.

The number of mat-forming species in our flora is 18. One of these, *Antennaria campestris*, is found in regions I and II. The remaining 17, with one exception, *Ptilepida lineariifolia*, are confined entirely to the high table-lands and buttes of region IV, where they are of great abundance and special importance.

8. SUCCULENTS.—These are plants with normal stem and thick, fleshy leaves, or with greatly reduced, fleshy stems bearing small, scale-like leaves and numerous spines or bristles. Succulents as a class are adaptations either to high, alpine conditions or to the conditions of barren wastes, or deserts. In the former case this adaptation finds its expression in the thickening of the leaves, while the stem generally remains normal. In the latter case both stem and leaves become greatly modified as a direct result of the necessity for reduced transpiration. The stem usually becomes a much-thickened, flattened, or columnar mass of fleshy tissue, bearing upon its surface the leaves now reduced to mere bracts or sometimes obsolete. On the deserts of Arizona and New Mexico, several monocotyledonous genera occur, such as *Agave*, which represent a third group, similar to the first, inasmuch as the leaves are enormously thickened, but differing in that the stem is obsolescent. From the general distribution of succulents it follows that they are represented in our flora by but few species. The total number of our succulents is 10, 3 of which occur in region IV only.

One of these, *Sedum stenopetalum*, is the only succulent in our limits which may be regarded as alpine in its derivation. The other two, *Opuntia rutila* and *O. fragilis*, are typical examples of modification arising from desert conditions. The same is true of the three species which are common to regions III and IV, all of which are cacti. Region II possesses one especially characteristic succulent, *Salicornia herbacea*. It is perhaps the most typical halophyte in our flora. Its distribution is limited wholly to the numerous salt basins in the Blue river district. *Salsola tragus*, which is a true succulent when young, though losing this character with age, now occurs throughout the State. A species of *Opuntia* likewise wanders into certain portions of region II, especially the sandy valley of the Little Blue river. With the exception of the recently acquired *Salsola tragus*, region I is practically destitute of succulents. A few scattered patches of *Opuntia polyacantha* have been found in the ravines of the upper Missouri.

9. CREEPERS AND CLIMBERS.—These are plants with a creeping or trailing or a more or less ascending stem, climbing over bushes or tall herbaceous plants or spreading over the surface and choking other vegetation.

This group connects on the one hand with ordinary, erect herbs through the creeping and trailing species. The latter, however, are scarcely to be separated from the climbers, which represent an herbaceous group as distinct as the one comprising the woody climbers. From the nature of the case it is to be expected that creepers occur generally throughout the State, while the climbers, on the contrary, are restricted chiefly to regions I and II. These plants often play an important part in the constitution of the floral covering. This is especially true in certain forest and thicket formations, where many climbers, such as *Humulus lupulus*, *Micrampe-
lis lobata*, *Apios apios*, and *Falcata pitcheri* form a layer which exerts a secondary controlling influence on the lower layers of the formation.

The whole number of members of this group in the State

is 35. Of these 14 are creepers and 16 climbers. Besides these, especial mention should be made of *Galium*, 5 species of which in our flora may be creepers, or climbers by means of their bristly stems and leaves, or finally sometimes erect.

The number of creepers and climbers common to the four regions is small, 5 only. Region I has 28 species, 10 of which are peculiar. Region II has 19 with 1 peculiar, region III, 16 with 2 peculiar, and region IV, 5 with 1 peculiar variety. It will be seen that region I contains four-fifths of the representatives of this group, while on the other hand region IV contains but one-seventh, of which all but one are common to the entire State. It is evident that, like woody climbers, herbaceous climbers are in reality dependent upon the distribution of the woody plants in the floral covering. This is proved not only by their great abundance in region I and their comparative absence in region IV, but by the fact that in regions II and III the fairly large number of representatives is accounted for by the wandering in of woody formations from region I along the principal streams.

TURF-BUILDERS.—The most important subclass of pleiocyclic herbs comprises the turf-builders. These are necessarily monocotyledonous. They are principally grasses, though not a few carices must likewise be included. The importance of turf-builders in a prairie region is similar to that of trees in a well-forested country. They are the controlling forms, and the entire floral covering of the prairies takes its character from them. Their controlling influence is unlike that of trees, in that it is not due to superior position of the foliage but entirely to the method of aggregation of the individuals. Turf-builders may be divided into two groups: those in which the individuals are densely aggregated, forming a mat or sod, and those in which the aggregations of individuals are smaller and scattered here and there, that is to say, the individuals occur in tufts or bunches. The first may be termed sod-formers, the second bunch-grasses. To show the different degree of importance of these two groups, the sod-formers may be compared to the trees in a forest

formation, the bunch-grasses to the trees in open woodlands. But while in dense forest formations the trees permit subordinate formations or layers, in many cases sod-formers, on account of the dense collection of individuals especially adapted to the locality, practically crowd out all other vegetation-forms. A remarkable instance of this is to be found in the stretches of buffalo-grass, *Bulbilis dactyloides*, which sometimes cover several square kilometers of plains to the practical exclusion of other forms. On the other hand, it is hardly necessary to point out that the bunch-grasses, from their peculiar manner of growth, permit the fullest entrance to numerous other plants, though retaining in all cases control of the formation. An analogy to the layered constitution of forest formations may be seen in the long-stemmed meadow-grass formations, where the grasses belong almost exclusively to the sod-forming type. For instance, *Spartina cynosuroides*, *Andropogon furcatus*, and *Stipa spartea*, while they have absolute control of the meadows in which they are found, not only permit but favor the growth of certain smaller forms which may be considered as constituting a layer.

10. SOD-FORMERS.—These are grasses or sedges with more or less erect, generally short, jointed stems, arising from a basal tuft of leaves. The individuals are invariably grouped into dense, continuous mats, forming a turf.

Between the sod-formers and the bunch-grasses stand a few common grasses which, while approaching more nearly to the sod-forming type, cannot be said strictly to form a sod. Examples of these are *Agrostis alba*, *Homalocenchrus virginicus*, and *Hystrix hystrix*.

The sod grasses of our flora are 44. They are found for the most part in regions II and III, though some occur throughout the State, such as *Bouteloua*, *Bulbilis*, *Koeleria*, and *Eatonia*. In addition to these, our chief sod-forming grasses are the species of *Poa*, excluding *P. tenuifolia*, *Panicum*, excluding *P. capillare*, *Stipa*, excluding *S. viridula*,

Distichlis spicata stricta, *Eragrostis hypnoides*, *E. purshii*, and *Phleum pratense*.

11. BUNCH-GRASSES.—Morphologically these do not differ from sod-formers. The distinction is based entirely upon the manner of aggregation; that is, upon the formation of scattered bunches rather than of a compact mat.

Our flora comprises 49 species of bunch-grasses. They preponderate in regions III and IV. The bunch-grass *par excellence* is *Andropogon scoparius*. Next to that species stand *A. hallii* and *Calamovilfa longifolia*. Other important representatives of the group are species of *Aristida*, *Festuca*, *Oryzopsis*, *Redfieldia flexuosa*, *Muhlenbergia pungens*, *Eragrostis trichodes*, and *Munroa squarrosa*.

RHIZOMATA.—Under this subdivision are included all of those herbs which possess a perennial underground stem, that is to say, a rootstalk, bulb or tuber, or a perennial root.

As a group rhizomata are characterized by great tenacity in the original habitat, and, from the mode of propagation, by increasing loss of seed-production, and hence diminished sensibility to distributional factors. It is in no sense an exactly definable group. What has been said above of pleiocyclic herbs applies with equal force to this, which is numerically the largest subdivision. In general they must respond but slowly to distributional agencies, and hence their exact distribution would be of considerable importance in determining the relative primitiveness of parts of the floral covering. To make this of accurate value, however, it would be necessary to determine for each species the ratio between its habitat-stability, as indicated by the preeminence of its chief biological character, and its sensibility to stress, as shown by accessory biological characters, such as seed-production, dissemination, and so forth. For example, *Bicuculla* and *Sanguinaria*, which produce few seeds, without modification for purposes of dissemination, are confined to a single region, while in *Laciniaria*, *Lactuca*, etc., characterized by enormous seed-production and a highly specialized pappus for dissemination, the tendency to stability inherent

in their method of propagation is overcome by the accessory biological characters which insure reproduction, and hence these genera are found throughout the State. Other instances are to be found in larger groups. Thus in Liliaceae and related families the tendency is toward negative distribution on account of the predominance of propagation over reproduction, while in the Compositae and other families of the dicotyledons, distribution is positive on account of the excessive development of reproductive characters. The ratio between propagation and reproduction is to be obtained only from careful and continuous field observations of individual species, a matter which, with many others, awaits the further development of phytogeography.

This subdivision falls into three groups, of which the first is the most important, the others being based on slight, though constant, modifications.

12. ROOTSTALK PLANTS.—Under this group all rhizomata are included except bulb and tuber plants and ferns. Numerically it is the largest group of the herbs, though it is probable that more extended investigation of its members will result in further subdivision. *Pirola*, of which Drude makes a distinct group under the name of root-sprouters, has been included here. There are 472 representatives of this group in our flora.

13. BULB AND TUBER PLANTS.—These include all rhizomata in which the rootstalk is represented by a bulb or tuber.

What has been said above with reference to the stability of rhizomata in general applies with especial force to this group in which propagation is much more restricted because the bulb or tuber continues to occupy very nearly the same position, while in the case of rootstalk plants a slight or sometimes a considerable distribution is effected by the yearly extension of the rootstalk.

The total number of bulb and tuber plants in our flora is 37. It is significant of the stability of these plants that only one occurs throughout the State, while of the 7 species which occur in three or more regions 5 are furnished with

highly specialized adaptations for purposes of dissemination. Region I has 26 species, of which 7 are peculiar. Region II has 17 with none peculiar, region III has 16 with 3 peculiar, and region IV has 7 with 5 peculiar. It will be noticed that region IV is characterized by a large proportion of peculiar species. This is readily explained by the fact that the 5 species confined to its limits are entirely submontane.

14. FERNS.—Ferns are in reality rootstalk plants set apart as a distinct group on account of their especial value in the consideration of the floral covering.

Ferns are of most significance in our flora on account of their comparative absence. The direct cause of their absence is not to be ascertained clearly, but it may be due in great part to lack of distributional adaptations and also to the fact that the State as a vast transition region possesses no endemic forms.

Ferns are represented in the State by 16 species, 2 of which, *Cystopteris fragilis* and *Marsilea vestita*, are common throughout. In region I, 6 species are found, of which 2 are peculiar; region II contains 5 representatives, none of which are peculiar; region III has 9 species of which 5 are peculiar; and region IV has 7 with 2 peculiar.

IV. HAPAXANTHOUS HERBS.—Hapaxanthous herbs are herbs having a single flowering period. They are distinguished from the pleiocyclic herbs by the fact that their perpetuation is dependent upon reproduction alone, propagation being entirely wanting, or in a few rare cases perhaps obsolescent. In other words, perpetuation of the plant is directly dependent upon seed-production and dissemination, and as regards the occupation of the soil they are essentially unstable. This instability is brought about by enormous seed-production supplemented in some cases by the modification of the seed itself for distribution, or, notably in the *Chenopodiaceae* and *Amaranthaceae*, by the formation of tumble-weeds.

Hapaxanthous herbs are subdivided into dicyclic plants, or biennials, and monocyclic plants, or annuals. The line

between the two is difficult to draw, and many plants are either annual or biennial, depending upon the length of the season and other conditions.

15. DICYCLIC HERBS.—These are represented in our flora by 59 species.

16. MONOCYCLIC HERBS.—These number in our flora 197 species.

V. WATER PLANTS.—This subdivision comprises plants of diverse character brought together by reason of their aquatic or amphibious habit. It includes not only those plants which are constantly aquatic in habit, but those as well which may be either aquatic or terrestrial and are called amphibious. The term hydrophytes may be applied to the group as a whole, and the individuals may be called hydrophilous. Schenck divides water plants into two groups: floating plants and submerged plants. He states that those plants rooting below the water whose leafy stems are aerial are to be excluded from the class of water plants proper. Owing to the conditions prevailing in a prairie country, many typically aquatic plants often become terrestrial. Hence it becomes necessary to establish a group of amphibious plants. This group includes all those hydrophytes which are not constantly aquatic and hence corresponds to those plants excluded by Schenck and to the marsh plants of Willkomm. The fact that it is often impossible to draw a sharp line between aquatics and marsh plants, because many species may often be one or the other, depending upon different conditions, has led us to unite all of these plants in one principal group. As is always the case, it is easy to distinguish between the extremes. Thus, *Triglochin maritima*, *Scirpus lacustris*, or *Phragmites phragmites* are regularly marsh plants, while *Myriophyllum spicatum*, *Utricularia vulgaris*, and others are as regularly submerged aquatics. But *Heteranthera reniformis*, *Mimulus jamesii*, and *Roripa nasturtium* are as often terrestrial as submerged, and in fact most frequently occupy a middle position, that is, they are truly amphibious. Even *Utricularia* has been found growing

in a wet meadow, entirely or substantially terrestrial. These three subdivisions, as is often the case with biological groups, can not be set off sharply. On the one hand, Potamogeton connects submerged plants with floating plants; on the other, truly amphibious plants connect marsh plants with submerged plants.

17. FLOATING PLANTS.—These are plants rooting in the mud and sending up foliage leaves which lie upon the surface of the water, or in rare cases they are small thalloid plants floating freely upon the surface.

Floating plants have no special significance in our flora. This is due chiefly to the fact that the State is peculiarly destitute of ponds and lakes, but also to the fact that many representatives of the group are of limited frequency. This results from the periodicity of the ponds, in region I especially, and from their inconstant character throughout the State. The chief rôle which they play in our floral covering is assumed by the Lemnaceae, which contains half of the species of the group. In late summer and autumn these plants often form a continuous covering over large areas of ponds and sluggish streams in all parts of the State.

The floating plants of the State are few in number, but 12 being known within our limits. One, the cosmopolite *Spirodela polyrhiza*, occurs throughout, while both *Lemna minor* and *L. trisulca* are lacking only in region IV. Region I contains 9 representatives, 3 of which are peculiar. Region II has 5 with none peculiar, region III, 6, with 2 peculiar, and region IV, 2, with 1 peculiar.

18. SUBMERGED PLANTS.—These are aquatics rooting in the mud and sending up a leafy stem which is constantly submerged.

The submerged plants are typically the aquatics of the swift-running streams of the State. In more senses than one they are the exact opposites of floating plants. This is shown particularly by their distribution. The floating plants are generally confined to the eastern portion of the State, a region of shallow, muddy pools and sluggish streams. Submerged

plants occur most abundantly in the sand-hill region where the ponds are much more constant and the streams are clear and swift. This is necessitated by the very nature of the plants. Submerged plants require light for assimilation. They obtain this in two ways: either by growing in clear water, or by sending their leaves up to the surface. The few representatives found in muddy waters always bring their leaves as near to the surface as possible, while those which occur in clear pools and streams are regularly leafy for a considerable distance beneath the surface.

This group contains but a single species common to the entire State, namely, *Batrachium trichophyllum*, which appears to flourish equally in the muddy pools of region I and in the cold, clear spring branches of regions III and IV. Region IV, with its high, dry table-lands, is poorest in representatives of this group. Only 5, of which 2 are peculiar and submontane, occur here. Region I is scarcely richer in these forms. It contains but 7 species, 3 of which, however, are peculiar. Submerged plants are most abundant in regions II and III, the former possessing 13 with 8 peculiar, and the latter 16 with 10 peculiar. The total number of submerged plants in our flora is 31.

The preponderance of these forms in regions II and III is due to the numerous spring pools and branches and to the ponds and clear lakes in the wet valleys and lake regions of III. In the eastern part of the State, as has been pointed out, the nature of the pools and streams precludes submerged plants to a considerable degree, though the inconstancy of the water supply is a not less potent factor.

In this group are also to be included the stoneworts, which, while they are of a very different character taxonomically, possess substantially the same physiological and biological characters and play a similar part in the floral covering. Twelve species of Characeae occur in the State. One, *Chara coronata*, is common throughout. Four have been found only in region II, while four likewise occur only in region III. The remainder occur in both II and III. It will be observed

that their distribution is substantially that of other submerged plants.

19. AMPHIBIOUS PLANTS.—These are plants which root in the mud, and, though sometimes growing through a stratum of water, always have their foliage aerial.

Amphibious plants consist of typical marsh plants, examples of which have been given above, and also of submerged plants which, owing to disturbed conditions, have been obliged frequently to take on a semiterrestrial habit. Aquatic plants become amphibious either on account of the periodicity and inconstancy of ponds and streams in eastern Nebraska, or through the wandering out of individuals upon the moist sand-bars and sandy banks of regions III and IV. Thus amphibious plants become, in region I at least, the representatives of submerged plants. From their peculiar adaptation to wet, marshy ground, amphibious plants are controlling factors wherever they occur in abundance, namely, in marshes and in extremely wet places.

The number of amphibious plants in our flora is 45. Eight, most of which are cosmopolitan, occur throughout the State. In region I, 17 occur, none of which are peculiar. Region II possesses 28, 8 of which are peculiar; region III, 31, with 4 peculiar; and region IV, 17, with 3 peculiar.

VI. HYSTEROPHYTES.—These are herbaceous plants growing upon humus or growing upon and obtaining their nourishment from other plants.

Hysterophytes, for our flora at least, are to be regarded as biological accidents, and will in consequence receive summary treatment. They fall readily into two groups, saprophytes and parasites.

20. SAPROPHYTES. — These are characterized by their growth upon humus and consequent absence of chlorophyll. Our flora contains but three representatives, all species of *Corallorhiza*, and all confined to the deep canyons of the Pine Ridge district.

21. PARASITES.—These are characterized chiefly by their parasitic habit upon the stems or roots of other plants.

Parasites fall roughly into two classes: root parasites and stem parasites. The former, in our flora at least, are infrequent, and have but little significance. The latter, with us all species of *Cuscuta*, play an important part as a layer in many thicket and herbaceous formations.

The total number of parasites in our flora is 14. Of these, the species of *Cuscuta* are found more or less widely distributed throughout the State. *Monotropa uniflora* is confined to the lower portion of the Missouri district, while *Pterospora andromedea* occurs only in the Hat creek basin. *Thalesia uniflora* occurs very rarely in regions I and II, while *Orobanche ludoviciana* and *Thalesia fasciculata* with its variety, *T. fasciculata lutea*, are rather common in regions III and IV.

VII. THALLOPHYTES.—This term, objectionable if used to define a taxonomic group constituted as we have constituted it, is convenient for the present purpose of denoting a biological group of some moment.

Thallophytes are characterized by the possession of a thallus or of a thalloid vegetative body, or in the mosses and some liverworts by an upright, slightly differentiated stem.

22. MOSSES.—These are of very little importance with us, on account of the small number of species and their general lack both of abundance and of frequency.

It is probable that none of our mosses are endemic. They have either come to us from the east along the Missouri, or they are submontane forms which have wandered down into the foot-hills and sand-hills along the river systems. In either case, the great extent of the prairie and sand-hill regions has acted as a barrier to their intermingling, and the conditions everywhere have been such as to prevent them from gaining much of a foothold.

So far as our present knowledge of the group goes, only two mosses have been able to pass the barrier interposed by the prairies and the sand-hills. These are *Orthotrichum strangulatum*, found in regions I, II, and IV, and *Hypnum radicale*, which occurs in regions II and IV. Region I has

10 species peculiar to it, and region II, 8 species, while 6 more are found only in these two regions. Region III has 4 peculiar species and region IV, 10, with 2 species which are common to both. The total number of mosses occurring in the State is 50.

23. LIVERWORTS.—What was first said of mosses above is even more true of liverworts. With us but four species play even a subordinate part in formations. As will be shown at greater length elsewhere, *Riccia glauca* is an important factor in the evolution of certain adventitious formations. *R. fluitans* in some parts of regions II and III is characteristic of many shallow ponds. *Marchantia polymorpha* and *Conocephalus conicus* in wooded regions often play an important part in the constitution of the lowermost layer of forest formations.

The total number of liverworts in the State is 16, only one of which, *Marchantia polymorpha*, occurs throughout. As would be expected, region I is richest and region IV is poorest in these forms, the former containing 9 species, 6 of which are peculiar, the latter but 3 with none peculiar. In addition, region II possesses 6 species, with 4 peculiar, and region III, 6, with none peculiar.

24. FOLIACEOUS LICHENS.—This group includes all those lichens possessing a flat, expanded, continuous thallus.

From the relatively large extent of the thallus, the foliaceous lichens play, in some respects, a more important part in formations than the remaining groups of the fungi. As a matter of course, their rôle is purely a subordinate one. Their occurrence is limited almost wholly to forest formations, where they constitute a portion of the lowermost layer, *Collema*, or are to be regarded as forming a superior layer, *Parmelia*. In the latter case they are tree-inhabiting, and their distribution is necessarily coincident with that of woody vegetation. In the former case, they grow upon the ground, and this habit permits of wider range.

The foliaceous lichens contain 42 representatives in our flora. Of these, two, *Peltigera canina* and *Physcia stellaris*,

occur throughout the State. Region I is by all odds richest in forms, containing 30 species, of which 14 are peculiar to it. Regions III and IV are extremely poor, each possessing but 6 species. It is again significant that the sand-hill region (III) contains only a few species, all but one of which, moreover, are derived from the adjacent regions. The occurrence in region IV of 5 peculiar species out of a total of 6 is explained by the submontane character of these species. Region II possesses 15 species, only 2 of which are peculiar—conclusive evidence that most of its representatives have wandered up into favored spots from region I.

25. FRUTICULOSE LICHENS.—These are characterized by a more or less branched, upright, or pendent thallus.

The fruticulose lichens are invariably tree-inhabiting, and correspond in their position in the formation to the tree-inhabiting foliaceous lichens. They belong to but three genera, *Theloschistes*, *Usnea*, and *Ramalina*. As to the aggregate of species, they are not numerous, but the individual species, in favored localities, exhibit both considerable frequency and great abundance.

The number of fruticulose lichens in Nebraska is 11. One of these, *Theloschistes chrysophthalmus*, is common throughout. Region I contains 3 species peculiar to it, while 7 occur both in regions I and II.

26. CRUSTACEOUS LICHENS.—This group is characterized by a more or less interrupted or even obsolescent, crustaceous, squamose, or even granular thallus.

The members of the group are typically tree- or even rock-inhabiting, though in a few cases, notably in *Cladonia*, they grow upon the ground. To a considerable extent they are independent of moisture and woodland conditions. In consequence crustaceous lichens are found very generally over the entire State. Their wide distribution is chiefly effected by the rock-inhabiting species, which occur throughout on the drift-hills and upon the sandstone hills of II, III, and IV. Their biological importance is not very great, except inasmuch as they constitute the sole floral covering of rocky cliffs

and buttes in region IV, or when they function as the origina-
tive factor in a formation.

The whole number of crustaceous lichens reported for our
flora is 104. But one of these, *Lecanora muralis*, occurs
throughout. Region I contains 71 representatives, of which
30 are peculiar to it. As is to be expected, region IV, though
possessing only 21 species of this group, has a relatively large
number of peculiar ones, namely 14. Region II exhibits 35
species with 7 peculiar, and region III, 21, of which 8 are
peculiar.

FUNGI.—The fungi, depending as they do entirely upon
other organisms for their habitats, have no such interest for
the phytogeographer as the lichens. They make up no forma-
tions themselves, and are at best only a layer, and no very
important one at that, in formations controlled by other
plants. But it does not seem proper to pass over a group
which includes more than one-fifth of the known species of
plants and which is likely to include two-thirds of the world's
flora when fully known, without some attempt to indicate
the rôle it plays in the vegetative covering of the State.
Drude divides the fungi into two groups: saprophytic fungi
and parasitic fungi. The former he characterizes as living
on humus, or on dead animal or vegetable remains, chiefly
in forest formations. The latter includes parasites infest-
ing all manner of hosts, animal and vegetable. But this
grouping is far from satisfactory. Two groups stand out
especially in every flora, the fungi growing upon humus in
the woody formations, and the leaf and stem parasites. Next
to them, the wood and bark parasites and the saprophytes
growing on wood and bark in the woody formations are con-
spicuous. Besides these, there are the saprophytes of decay-
ing organic matter in the cities and of offal in pastures,
which are largely pantogenous, growing everywhere and on
every organic substratum that may be assailed, the algae-
like aquatic fungi, and the insect parasites. Each of these
groups has peculiarities which entitle it to be considered as
a vegetation-form in any adequate representation of the

fungus flora of a region. We have therefore divided the fungi into six groups.

27. GEOPHILOUS FUNGI.—These are fungi growing on the ground on decaying vegetable matter.

Drude observes that the geophilous fungi which take part in forest formations are of some importance. The greater part of the geophilous fungi necessarily are to be found in woody formations. But several of the Lycoperdaceae, such as *Calvatia maxima*, *Lycoperdon cyathiforme*, *Tylostoma campestre*, and *Geaster campester*, occur on the prairie, and one species, *Ithyphallus aurantiacus*, is to be found on the sand-hills in region III.

The total number of geophilous fungi thus far reported from the State is 210. They are species of the Pezizaceae, Helvellaceae, Lycoperdaceae, and Agaricaceae.

28. XYLOPHILOUS FUNGI.—These are fungi growing on wood, living, dying, or dead. Obviously they are directly dependent upon the presence of woody plants, and are confined to woody formations.

The xylophilous fungi are chiefly Pyrenomyceteae, and Polyporaceae, including also some Agaricaceae. We have at present reported 266 xylophilous fungi in our flora.

29. BIOPHILOUS FUNGI.—These are fungi parasitic in or on the leaves and stems of the higher plants.

On the prairies they are of considerable importance, often by their depredations producing an important, though indirect effect upon the floral covering. With us they are the largest group in the fungus flora, being represented by 445 species, mostly Uredineae and Ustilagineae, but including also many species of *Septoria*, *Ramularia*, *Cercospora*, and other Imperfect Fungi.

30. SATHROPHILOUS FUNGI.—These are fungi growing upon decaying organic matter of all kinds indiscriminately, or upon offal, etc.

A large proportion of these fungi are pantogenous. Others are more restricted in their habitats, and some are confined to dead herbaceous stems, etc., though the latter are usually

apt to be more or less biophilous, and should in most cases be placed in the foregoing group. The sathrophilous fungi reported for the State number 75. The most typical representatives are Mucoraceae, Aspergillaceae, and such Imperfect Fungi as Cladosporium.

31. HYDROPHILOUS FUNGI.—These are algae-like aquatic fungi.

The hydrophilous fungi are all Phycomycetes, and with us are chiefly Saprolegniaceae. Eighteen species occur in Nebraska.

32. ENTOMOPHILOUS FUNGI.—While this group has, like the preceding, very little general importance for the phyto-geographer, in certain seasons the Entomophthoraceae which are parasitic on grasshoppers and other destructive insects, by keeping the latter in check or destroying them more than usually, may have some effect upon the floral covering. The parasite of the chinch-bug, *Sporotrichum globuliferum*, is a notable example of this. Thus far 9 entomophilous fungi are reported from the State. They are species of *Cordyceps*, *Botrytis*, *Sporotrichum*, and *Laboulbenia*.

ALGAE.—Inasmuch as the algae are autonomous plants, their rôle in the floral covering is of more importance than that of the fungi, which are wholly dependent upon the distribution of other plants. On the other hand, since they are not fixed either to the earth or to a host plant, but move freely here and there in accordance with currents, floods, and other disturbing agencies, their distribution becomes a complicated matter, and hence the value of distributional statistics concerning them is greatly reduced. The algae, however, like terrestrial plants and like parasitic plants, do respond to the situation in which they grow to a certain extent. This fact scarcely needs illustration, so familiar is the characteristic difference between the algae of muddy pools and streams, and those of subalpine brooks.

In contrast to the fungi, the algae often take an especial part in the constitution of the floral covering. This may result in two ways. Many algae, as *Hydrodictyon*, *Spirogyra*,

Vaucheria, etc., often completely cover the surface of ponds and streams, by which means a continuity of the vegetative covering is brought about. Others, especially the diatoms and desmids, form a dense, slimy layer upon the bottom of often the same ponds and streams, in which case the continuity may be said to be two-fold. In many ponds, however, filamentous algae are entirely lacking, and in this case the continuity preserved by the algal layer at the bottom is a more perfect one. This may be explained by the fact that, while the water is necessary for such plants, the formation which they constitute connects at either edge of the pool or stream with terrestrial formations. Indeed this formation often takes on a more or less amphibious character, especially in the periodical and inconstant ponds of eastern Nebraska.

The number of algae reported is 438. They may be divided into two groups.

33. FILAMENTOUS ALGAE.—Eighty-one species of filamentous algae are thus far reported.

34. COENOBIOID ALGAE.—Under this term we include all one-celled algae. The number of reported species is 357. Owing to the peculiar method of occurrence of the forms, they will receive fuller treatment elsewhere.

Accessory biological characters.—In the foregoing discussion it has been noted that other characters than those taken as the basis of the general arrangement in vegetation-forms often assume equal or even greater importance with individual members of the groups. The characters made use of are those which have chief importance biologically and morphologically, and are the most stable of biological characters in the individual. There remain a number of biological characters which can not be made use of in the general classification of vegetation-forms, but which are of more or less importance in dealing with individual species. These characters are not of equal moment. Some of them deserve great attention in phytogeography, since the development and the distribution of the individual are directly and

conspicuously affected or even determined by them. Others are of indirect effect, and some of scarcely more than trifling importance. These characters have been termed accessory biological characters.

FOLIAGE.—The character of the foliage, whether evergreen or deciduous, which is of no little importance with woody plants, is a matter which has already been touched upon. The two great evergreen groups, the Coniferae and the Ericaceae, are meagerly represented with us. Among half-shrubs, *Yucca glauca* has already been noticed. Among herbs, the rosettes, the mats, as for example *Antennaria campestris*, and the succulents contain many examples of a more or less evergreen foliage. In our flora the latter are the most important evergreen groups. Rosettes are generally potential, often actual evergreens. Of the rosettes, the prairie species of *Solidago* and *Pentstemon grandiflorus* and, among the mats, *Antennaria campestris* probably owe a portion of their great and sometimes controlling abundance to the advantage afforded by this character. Many grasses also have a more or less evergreen foliage. A notable instance of this is to be found in those grasses which form a sort of rosette. Several of the bunch-grasses preserve a basal tuft of leaves throughout the winter, more or less protected by the dead leaves above. Others form almost typical rosettes. For example, in thickets in the winter it is not uncommon to find diminutive rosettes of *Panicum scribnerianum* in which very short, broad leaves, protected by hairs, are in all respects comparable to the typical close rosettes of *Onagra* or *Gaura*.

Another character of considerable moment is afforded by sun leaves and shade leaves. There is a well-marked group of shade plants which require shade as a condition of development and are not able to endure the bright sunlight. The leaves of these species are adapted to shade and are killed when removed from it. A familiar example with us is furnished by *Impatiens aurea* which, in the eastern portion of the State, grows in deep woods exclusively. It is not uncommon, when from clearing or some like cause the individuals

become exposed to bright sunlight, to see large patches completely killed. Other typical shade plants with us are *Arisaema triphyllum* and *A. dracontium*, *Erythronium albidum*, *Polygonum virginianum*, and *Adicea pumila*, all found in the deep woods of region I and the close woods along streams in region II. In the deep woods and glens of region I occur also *Circaea lutetiana*, *Fragaria americana*, *Caulophyllum thalictroides*, and *Sanguinaria canadensis*, which are confined to the shade. *Chenopodium fremontii*, differing from others of its kind, is also a shade plant, and in region II *Lycopus virginicus* and *Solidago arguta* occur only in deep woods along streams. In region IV the shade plants of the deep canyons are *Viola canadensis*, *Corallorhiza multiflora* and *C. striata*, and *Mertensia virginica*. The number of shade plants in our flora is small, as would be expected from the restricted area covered by woody formations. In the open woodlands of region II and in the edges of the dense woods of region I, another type of plant is met with which has become adapted to the moderate shade afforded by such localities and is partially a shade plant. These open woodland plants are also to be found in the deep shade of the dense woods of region I, but they flourish in the stronger light of the open woods. Though they are directly dependent upon and occur only in the shade, occasional exposure to bright light does not affect them as quickly and noticeably as it does the true shade plants. In region I examples are *Bicuculla canadensis*, *Claytonia virginica*, and *Meibomia paniculata*; in region IV, in the canyons, *Habenaria hyperborea*, and common to I and IV *Cypripedium pubescens*. *Ranunculus pennsylvanicus* is an open woodland plant of region IV and the Niobrara district in region III. The remaining, and by far the largest, portion of the group is common to regions I and II, as would be expected. The true shade plants, on the other hand, are mostly inhabitants of region I. The open woodland plants of regions I and II are: *Bicuculla cucullaria*, *Deringia canadensis*, *Washingtonia longistylis*, *W. claytoni*, *Meibomia grandiflora*, *M. canescens*,

Hydrophyllum virginicum, *Phryma leptostachya*, *Physostegia virginica*, *Galium circaezans*, *Aster macrophyllus*, *A. sagittifolius*, and *Eupatorium ageratoides*. Some of these are almost to be classed as true shade plants, while others are strictly open woodland plants. The majority are to be found both in the dense woods and in the more open ones, and are more or less ambiguous in character. All of them, however, require shade as a condition of growth. It appears that a species may adapt itself to different conditions in other localities. Thus *Galium trifidum*, which is an open woodland plant in regions I and II, occurs also in the plum thickets of region III, where the light is very strong. Undoubtedly many of the plants enumerated may take on a different character in other regions.

PROTECTIVE DEVICES FOR WINTER BUDS.—In woody groups this is a character of some importance where the plant is exposed to variations of temperature and to severe winters. In Nebraska, as has been seen, the temperature during the winter is very unequal, sometimes falling very low, but often keeping at a rather high point for considerable periods, and changing quickly. Under such conditions the protection of winter buds becomes of no little moment to the individual. The early development of these in the spring is an obvious advantage to the plant in the struggle for maintenance or mastery, and this is largely dependent on such protective devices.

The commonest method of protection is by scales, or reduced, modified leaves, which envelop the bud. These may be smooth or more often pubescent, and even felty or woolly. In some cases the buds are naked, and then felty pubescent, or villous, as in *Asimina triloba* and *Rhus glabra*. In others, as *Menispermum canadense*, *Xanthoxylum americanum*, and *Ceanothus ovatus*, the scales are obscure, and the buds again are pubescent or villous. Where the buds are protected by scales, the protection may take the form of a single scale completely covering the bud, as in species of *Salix* and *Platanus occidentalis*; of a few more or less glabrous scales

(2-3) as in *Tilia americana*, *Parthenocissus quinquefolia*, *Cercis canadensis*, species of *Cornus*, *Hicoria minima*, and others, or pubescent as in *Juglans nigra*, or gummy as in *Populus deltoidea*; of several (3-6) either glabrous, as in *Rhamnus lanceolata*, species of *Amorpha*, *Prunus*, *Malus ioensis*, *Crataegus*, *Catalpa speciosa*, *Hicoria ovata*, and others, or pubescent as in *Corylus* and *Ostrya*; or of still a larger number, as in *Ribes gracile*. Again, there may be two outer scales enclosing several smaller ones, as in *Celastrus scandens*, or, more commonly, the scales may be arranged in pairs enveloping the bud on each side instead of in the form of a cap as in preceding examples. Of this sort, the number of pairs varying from 1 to 6 are *Celtis occidentalis* (1), *Acer saccharinum* (1-3), *Acer negundo*, *Staphylea trifolia*, *Sambucus canadensis*, *Symphoricarpos*, *Fraxinus pennsylvanica* (2-3), and species of *Ulmus* (3-6). In some cases, as in *Amorpha canescens* and *Gymnocladus dioica*s, the buds are protected by a protuberance of the bark. In *Robinia* the buds are hidden by leaf scars, and in *Cephalanthus* by stipule scars or persistent stipules. Finally the buds may grow superposed, as in *Fraxinus pennsylvanica*, *Gymnocladus dioica*s, and others. For additional information as to the winter condition of the commoner woody plants of the plains, the reader is referred to the papers of Trelease and Hitchcock.*

PROTECTION OF THE PLANT-BODY.—In a prairie country another secondary character of considerable moment is furnished by protections of the plant-body. In regions which were formerly grazed over by great herds of buffalo and are now made to sustain large herds of cattle, these protective devices, serving to exempt individual species from being eaten, exert a great influence upon distribution and upon the nature of the vegetative covering. In a lesser degree those devices which protect the plant from the ravages of insects are important. But protections against grazing

*Trelease, Sugar Maples, and Maples in Winter, Rep. Mo. Bot. Gard., 5, 1894. Hitchcock, The Woody Plants of Manhattan in Their Winter Condition, 1893; Key to Kansas Trees in Their Winter Condition, 1893.

animals are chiefly worthy of attention on account of the effect they produce upon the vegetative covering of pastures and grazing lands. These protective devices may be internal or external. With us the most noteworthy examples of the effect of protective devices are furnished by the former.

Internal protective devices are oil, bitter sap, or milky juice. In the pastures of region II *Grindelia squarrosa* and *Dysodia papposa* attain great abundance by reason of internal protections. The former holds its own in pastures everywhere and is spreading rapidly, and the latter, invading overstocked fields in which the native species have been destroyed, obtains and keeps possession of large patches because it is not eaten. *Dysodia* is oily, while *Grindelia* possesses a gum which is very irritating to cattle. On the prairies of region II *Peucedanum foeniculaceum* and on the sand-hills in region III *Psoralea lanceolata* are avoided because of the oil they contain. A more common and no less effective protection is afforded by bitter sap. *Vernonia fasciculata*, *Solidago rigida*, and *Verbena stricta* become controlling in pastures in regions II largely because of the bitter sap that prevents their being eaten. On the prairies *Erigeron ramosus* and *Salvia pitcheri* and in regions III and IV *Cucurbita foetidissima* possess the same character and thereby gain noticeably on other species. *Cicuta maculata*, *Cleome serrulata*, and species of *Artemisia* may also be cited. A third form of internal protective device is milky juice. Species of *Lactuca*, *Asclepias*, *Acerates*, and *Apocynum* are familiar examples. In *Euphorbia* the effect is more noticeable. *E. marginata* especially gains a strong foothold in pastures by means of its milky juice. The juice in this species is very irritating, often producing a blister on the hand when a stem is broken off, and in consequence the plants are avoided. After a dry season in which the pastures have been overstocked, *Euphorbia marginata* sometimes takes more or less complete possession. *E. corollata* and, in less degree, several other species gain great advantage by the same means.

Species poisonous to grazing animals may also be mentioned in this connection. Three, *Ranunculus sceleratus*, *Cicuta maculata*, and *Helenium autumnale*, occur throughout the State. In addition, region IV has nine species, among which *Delphinium geyeri* and the loco weeds, *Aragallus lamberti* and *Astragalus mollissimus*, are especially noteworthy; region I has eight species, of which *Crotalaria sagittalis* is the most noteworthy, almost all of the remainder being ruderal and adventitious, and regions II and III four each, none of them specially poisonous, nor, except *Linum rigidum*, of considerable frequency.*

External protective devices are hairs and glands, or spines, prickles, and thorns. Hairs often serve to protect the plant against leaf-eating insects. But in many cases rough-hairy plants are avoided by cattle. The effect of such a protection is less noticeable than in the case of internal protections, as cattle will eat hairy plants when vegetation is sparse. The introduced *Verbascum thapsus* is the most notable example. This species is slowly acquiring some foothold in pastures in regions I and II. Stinging hairs, such as are possessed by *Urtica* and *Urticastrum*, afford a very effective protection, as may be observed in open woodlands in region II where cattle have been turned in to graze. Glands, where they amount to external protection, are chiefly available against insects. We have a number of species provided with such protections, either as glands or as glandular hairs, such as the two species of *Cassia*, *Silene antirrhina*, species of *Kuhnistera*, *Glycyrrhiza lepidota*, *Epilobium adenocaulon*, but the character assumes little or no importance. Spines, prickles, and thorns, on the other hand, often afford a very complete protection against grazing animals. A good example is *Solanum rostratum*. This species was first observed in the neighborhood of Lincoln in waste places in 1885. But a few isolated individuals were to be found for some time.

* On this head see Chestnut, Preliminary Catalogue of Plants Poisonous to Stock, Rep. U. S. Bur. Animal Industry, 1898: 337.

It has spread steadily till it is now very frequent in pastures, and often covers large patches. *Cenchrus tribuloides* covers large areas of the sandy bottoms along the Platte. The cacti in regions III and IV should also be mentioned. Some statistics as to the woody plants have been given. Of these, *Smilax hispida*, *Xanthoxylum americanum*, species of *Rosa*, *Ribes gracile*, *R. cynosbati*, and *R. setosum*, *Prunus americana*, *Crataegus mollis*, *C. coccinea*, *C. macracantha*, and *Gleditsia triacanthos* are prickly or thorny. Of the herbaceous plants, *Argemone intermedia*, all of the Cactaceae, *Leptoglottis uncinata*, *Acuan illinoensis*, *Solanum carolinense*, *S. rostratum*, and species of *Carduus* are prickly or spiny. *Salsola tragus* also is prickly in age. In addition to these devices, which are primarily protective, devices designed for dissemination may incidentally serve the same purpose. The spines of *Cenchrus tribuloides*, which render it so formidable, are on the involucre. In like manner, in species of *Stipa* the sharp-pointed callus at the base of the glumes in age serves as a protection, so that while the individuals are eaten freely when young, at maturity they are avoided.

CONTRIVANCES FOR THE PROTECTION AND DISPERSION OF POLLEN.—The numerous modifications which are concerned directly or indirectly with the pollen fall into four general groups according to their purpose. Often the same structure will serve more than one purpose, while several structures, each of which has some special duty in connection with the pollen, will sometimes act in unison to accomplish some definite result. In such cases, structures are classed according to their primary or most significant purpose, though they are also considered with reference to their secondary functions. Many of the structures which have to do with the care and distribution of pollen are hardly to be regarded as secondary biological characters. This is especially true of those structures resulting in diclinism or monoclism, dichogamy or homogamy, which are of profound meaning. As these are intimately related to secondary characters and are quite distinct from primary biological characters, which

have to do with the form and duration of the plant-body, it is most logical, as well as convenient, to consider in one place all contrivances which have to do with pollination, no matter what their relative significance.

Modifications of the sort just mentioned fall into the following groups, according to their purpose: 1, production of pollen; 2, protection of pollen; 3, disposition of stamens and pistils; 4, transfer of pollen.

1. The Production of Pollen. Definite modifications for this purpose are relatively few, since many structures which have to do with pollen production are primarily concerned with protection or transfer. They are considered with reference to amount and manner of production and are found chiefly in those flowers where there is great waste of pollen, either in actual transfer, as in wind-pollinated flowers, or by reason of the consumption incident to carriage, as in the case of pollen flowers visited by insects. The two common methods of obtaining enormous pollen production are by increasing the number of stamens or of staminate flowers. The Rosaceae offer good examples of the former, while the latter is illustrated by many polygamous and pleogamous species.

2. The Protection of Pollen. Flowers protect their pollen against injury from rain or dew by means of the most diverse modifications. In many instances, the protection afforded is secondary, the structure or modification having been developed chiefly for other reasons. The most striking devices, however, especially those involving a movement of the plant or its members, have arisen primarily for the purpose of protection. A number of plants, particularly wind-pollinated ones, seem to have no protection against injurious moisture. In many of these we shall doubtless find that the protection, though obscure, is effective. The period of flowering and the time of flowering, when thoroughly investigated and understood, will suffice to explain why certain flowers seem unprotected. It is certain that plants in which the pollen is not protected in some way—even though in the extreme cases

the protection is simply an indifference to the effect of moisture—do not occur, since the existence of a species is proof of the protection of its pollen. The damage which results from wetting is not the same for every plant. In some, access of moisture causes premature germination; in the majority, it interferes seriously with the transfer of the pollen. In these plants the protection afforded the pollen must also be effective in protecting the nectar. In some instances it is possible that the protective device has really been developed for the latter purpose. In autogamous flowers in which the pollen grains do not germinate readily, we may expect to find especial protective contrivances lacking, since it is not essential that the nectar, if present, be preserved.

Pollen must be protected against dryness as well as against moisture. This is usually accomplished so effectually by the structure of the grain itself that special modifications for this purpose are obscure, if not altogether lacking. In the case of intense xerophytes, it is possible that the period or time of flowering, the structure or position of the flower, may result in a certain degree of protection. In this connection, it should be noted that the stigma, while in a receptive condition, must be guarded against excessive dryness—perhaps also against moisture. This is usually brought about by the same devices that insure the protection of the pollen. Finally, the pollen must be guarded against those insects which would devour it without effecting its transfer. These modifications, which are relatively unimportant, are of a different character and will be touched upon elsewhere.

The devices which insure pollen protection are of three sorts, (1) morphological, (2) mechanical, (3) seasonal. The first and third, as a rule, accomplish protection incidentally. Structures of the second class owe their very existence to the necessity for protection of the pollen. Morphological contrivances are purely structural or positional. To the first class belong all flowers in which the protection results from the structure or shape of the flower, of the flower parts, or of

the flower-cluster. Protection of this sort may arise from the structure or sculpturing of the pollen grain itself, or from the structure of stamen, pistil, corolla, calyx, bract, or inflorescence. The thick wall of the pollen grain is itself a very considerable protection, often increased by oil or viscin, as in *Onagra*, *Circaea*, etc. Protection is also brought about by the position of the anther, or by the location of the pore by which the latter opens. In conifers, the swelling of the microsporophylls, when moist, closes the entrance to the microspores. *Iris versicolor* covers the stamen with a broadly expanded petaloid stigma. Instances of protection by means of the shape of the corolla occur abundantly among Gamopetalae, *Gentiana*, *Lithospermum*, *Androsace*, and sometimes in the Choripetalae, *Bicuculla*, *Aconitum*. Certain cleistogamous flowers also belong here. More rarely, the calyx serves the same purpose, as in some species of *Clematis*. In many, Aroideae, *Arisaema*, etc., protection is brought about by the form of the spadix. In certain catkin-bearers, *Populus* especially, a considerable amount of shelter is afforded by the large bracts. Protection as a result of the position of the flower or inflorescence occurs in a large number of Choripetalae and Gamopetalae, in which the flowers are turned toward the earth, and in many Gamopetalae which deviate even slightly from an upright position. To this class belong *Erythronium*, *Pentstemon*, *Teucrium*, species of *Gilia*, etc. In *Tilia* the flower-clusters are placed in such a position that they are sheltered by the leaves, a device which also occurs in some species of *Impatiens*.

Mechanical devices for protection comprise movements of the flower or its parts, or of the flower-cluster. The movement is one of closing or of drooping. In the greater number of plants of this class, protection takes place by the closing of the corolla, more rarely by the closing of other parts of the flower. This is especially well shown in hemeranthous and ephemeral flowers, perhaps also in some nyctanthous ones. In fact, hemeranthous and ephemeranthous are to be explained in large part by the need for pollen protection. The

sepals sometimes close for protection in apetalous forms. The swelling of microsporophylls in pine cones and the closing of pores in some anthers should be mentioned here, though closure does not result from a series of definite movements, as in the case of the perianth. The protection which is obtained in some flowers by a pendulous or ascending position is secured in many erect flowers by the bending or drooping of the flower-stalk. This is notably the case in *Campanula rotundifolia* and, to a less extent, in *C. aparinoides*, in which the bud is erect but the flower is drooping. In *Oxalis*, *Anemone*, etc., the bending takes place more quickly and lasts over night only, or, more rarely, throughout rainy or cloudy days. In some inflorescences, the entire cluster droops, as in the geraniums, umbellifers, and composites. In the radiate and ligulate flowers of the last family, protection is afforded by the folding over of the ligules. In the radiate flowers, such as the asters, the protection of the disk florets by the ray florets is only partial, but in most plants of the *Liguliflorae*, each floret is protected by its own ligule and by the longer ligules of the florets nearer the margin.

The seasonal phenomena which plants manifest in connection with the protection of pollen are concerned with the period of flowering. As has been pointed out, many plants are hemeranthous or ephemeral, i. e., they open only in bright sunshine and close upon the approach of rain or at nightfall, thus effectively sheltering the pollen. The arrangement of plants into vernal, estival, and serotinal bloomers doubtless has some connection with the presence or absence of definite protective devices. Many plants, xerophytes especially, have come to flower at the season in which there is least danger from rains and excessive moisture. Moreover, it often happens that plants possessing protective contrivances also flower at the season most favorable to pollen, in which case the latter is protected by a double adaptation. Other modifications may occur in the same plant, and in this way there arises a large number of combinations of protective devices.

3. Disposition of the Sexes. Since the pollen must be transferred from the anthers to the stigma in some way in order to insure fertilization, the position of the stamens and pistils with relation to each other becomes a matter of great importance, not only with respect to the method of transfer, but also with reference to the kind of fertilization which results. The separation of the stamens and pistils in space is known as *diclinism*. It is termed *monoecism* when the stamens and pistils occur in different flowers on the same plant and *dioecism* when the staminate and pistillate flowers occur on different plants. A plant with perfect flowers is *hermaphroditic* and is said to manifest *monoclinism*. *Monoclinic* flowers in which the stamens and pistils mature at different times exhibit *dichogamy*. *Dichogamous* flowers are *proterandrous* when the anthers ripen their pollen before the stigmas become receptive, and *proterogynous* when the stigmas mature first. *Proterogynous* flowers are either *brachybiostigmatous*, i. e., with short-lived stigmas, or *macrobiostigmatous*, i. e., with long-lived stigmas when the latter are receptive for several days or more. In *homogamy* the anthers and stigmas mature at the same time. *Homogamy* is divided into *chasmogamy*, in which the flowers open before or upon the maturity of the anthers and stigmas, and *cleistogamy*, in which the flowers remain completely or partly closed at maturity. *Herkogamy* is characteristic of *chasmogamous* flowers in which the relative position of anthers and stigma prevents self-pollination, while *mychogamy* occurs in those in which self-pollination is rendered possible by the contiguity of anthers and stigma. *Mychogamy* is *homomorphic* when the stamens and pistils of all the flowers are similar in length, *heteromorphic* when the flowers of different plants have stamens or styles of different lengths. *Heteromorphy* is termed *heterostyly* when the styles as well as the stamens are of different lengths. If the stamens alone show a constant variation in different flowers, the arrangement is called *heteranthery*. *Heterostyly* is known as *heterodistyly* when

certain flowers have long filaments and short styles and others short filaments and long styles, and heterotristyly when there are three sets of these, long style, medium and short stamens, medium style, long and short stamens, short style, long and medium stamens. Cleistogamous flowers are archocleistogamous when none of the flowers open at any time and pseudocleistogamous when the flowers are ordinarily chasmogamous and remain closed only under unfavorable conditions. Some plants bear both open and closed flowers and are termed chasmo-cleistogamous. Pseudocleistogamy is known as photocleistogamy, hydrocleistogamy, etc., according to the physical factor which induces it. Hemicleistogamous flowers open only partially; if the stamens are exerted, such flowers are chasmantherous; if they remain included, cleistantherous. The presence of monoclinal and diclinal flowers in the same species is termed polygamy. Monoecious polygamy results when the different forms occur upon the same plant, dioecious polygamy when they are found upon different plants. The presence of perfect and staminate flowers on the same plant is termed andromonoecism; of perfect and pistillate flowers, gynomoecism; and of perfect, staminate, and pistillate, coenomoecism. Similarly, there may be distinguished androdioecism, gynodioecism and coenodioecism or trioecism. Combinations of various types of polygamy are known as pleogamy.

4. The Source and Destination of Pollen. Plants of the same species exhibit allogamy, or cross-pollination, alloautogamy, or either cross- or self-pollination, and autogamy, or self-pollination. Plants of different species sometimes pollinate each other, resulting in nothogamy or hybridization. Allogamy is by far the most frequent. All diclinal plants and many dichogamous ones can be pollinated only in this way, while allo-autogamous species also are self-pollinated only in the case of the failure of cross-pollination. Allogamy between two flowers of the same plant is termed geitonogamy; between flowers of different plants, xenogamy. Either may occur in perfect or monoecious

plants, but the latter alone is possible in dioecious species. As would be expected, geitonogamy is less advantageous to the plant than xenogamy, notwithstanding the fact that in plants where both are possible the former is the much more frequent. On the other hand, geitonogamy, is of greater advantage to the plant than autogamy. This fact, which has also been demonstrated by experiment, is well shown by the large number of allo-autogamous plants.

The various devices connected with the transfer of pollen from one flower to another have been developed in consequence of cross-pollination. They are characteristic of allogamous and nothogamous plants and, to a large extent, also of allo-autogamous plants. In accordance with the agency by which the transfer of the pollen is effected, cross-pollinated species are hydrophilous, anemophilous, or zoidiophilous. Hydrophilous species are hyhydrogamic when pollination occurs under water, as in *Zostera* and *Ceratophyllum*, and ehydrogamic when the pollen is borne on the surface of the water, as in *Ruppia*, *Callitriche*, etc. Anemophilous flowers are either astigmatic, as in the Gymnospermae, or stigmatic, as in the Angiospermae. The latter, or Stigmaticae, are divided by Delpino into five groups, according to the type of flower. These are the Amentiflorae, or catkin-bearers, *Salix*, *Populus*, *Betula*; Penduliflorae, with pendulous flowers, *Acer negundo*, *Rumex*; Longistamineae, with long, slender filaments, *Plantago*, Gramineae, Cyperaceae; Explodiflorae, with explosive anthers, *Urtica*, *Parietaria*; Immotiflorae, with fixed flowers, *Typha*, *Potamogeton*, *Sparganium*. Delpino further divides the Zoidiophilae into Ornithophilae or bird-pollinated flowers, *Impatiens*, *Bignonia*, *Lonicera*; Malacophilae or snail-pollinated flowers, *Arisaema*; and Entomophilae or insect-pollinated flowers. In addition to these, a few tropical plants seem to be fertilized by bats and are placed in a group Cheiropterophilae. The Entomophilae are by far the most important and are very many times more numerous than all the other zoidiophilous species. It is in connection with the

great predominance of insect pollination that flower structures have undergone the extreme modification exhibited in the Orchidaceae and in the zygomorphic Gamopetalae. As a concomitant of insect-pollination, flowers have developed color and scent in the most manifold fashion for the attraction of insect visitors. They have modified their form to afford landing places for welcome visitors, to enable the latter to find their way quickly to the nectar and pollen, and to repel or frighten away unwelcome visitors. Flowers have produced various contrivances to effect the sprinkling or loading of insects with pollen and to insure the deposition of the latter in the proper manner. Finally, the opening of the flower at a certain time of day or of the season is an expression of adaptation to the habits of the insects upon which it depends for pollination. Entomophilous flowers are termed pollen flowers when the pollen itself is the attraction, with the result that part of the pollen is sacrificed for the sake of the transfer of the remainder, and nectar flowers, when nectar constitutes the attraction and the removal of the pollen is incidental. Nectar flowers fall into a number of subclasses based upon the position of the nectar and the kinds of insects attracted to the flowers.

Autogamy occurs as the alternative method of pollination, rarely the preferred method, in allo-autogamous species, and as the sole method in cleistogamous flowers and in those whose size, structure, and position make them little adapted to cross-pollination, or whose homes present conditions unfavorable to the latter, as in the case of arctic and alpine plants. Autogamy is direct in those flowers where contiguity of stamens and pistil, or the position of the stamens above the pistil, permits the pollen to fall directly upon the stigma, and in most cleistogamous flowers. It is indirect where the transfer of the pollen is the result of movement or growth, as in the majority of autogamous plants. Indirect autogamy is brought about by various contrivances, of which the movements of stamens or style, their elongation or contraction, the closing of the perianth and the falling of the corolla are the most frequent.

PERIOD OF FLOWERING.—The time in which a plant opens its flowers and matures its fruits is the result of long, continuous endeavor on the part of the plant to adapt itself to a more or less definite mean of climatological conditions. The resultant tendency to a somewhat stable period of anthesis and of fructification is necessarily modified by the need of the plant to insure or prevent cross-fertilization, to assure seed-distribution, occupation, etc. In consequence, the period of flowering, inasmuch as it is wholly a result of external factors, comes to be an expression of the forces which determine the behavior of the plant. Its stability is dependent upon the degree of variation in time-occurrence of that favorable coincidence of conditions which determines anthesis. Such a statement is mere redundancy for a native plant in its ordinary habitat, where the acquired tendency to a fixed period of blooming receives accentuation or diminution dependent upon coincidence in time of the successive annual impacts. Naturally, such a plant comes to be characterized by constant stability, or constant instability in period of anthesis. The amount of stability which a plant has acquired in this regard can be measured only when the plant undergoes a great change of habitat. In such a case, a plant characterized by extreme stability preserves undisturbed its customary flowering period, while one characterized by similar instability responds to changed conditions by a rapid modification of the flowering period. In nature, however, it is impossible to stabilize conditions and often equally difficult to determine the existing degree of stability for any length of time. In consequence, it is with great difficulty and only after long investigation that the amount of correspondence between external and internal stability can be determined. As a general rule, those plants which possess a relatively short period of flowering with well-developed termini, and an inconspicuous maximum or none at all, may be considered stable in their flowering. Those characterized by a comparatively long period of flowering, which is relatively feeble in the vicinity of the broad termini, and

possesses a well-marked maximum, are to be regarded as unstable.

Necessarily, much that is true for the period of flowering holds equally well for the period of fructification, or maturation. From the nature of things, there is an essential correspondence between the two. Thus, a plant that has a prevernal flowering period usually possesses a vernal period of maturation, a vernal bloomer, estival maturation, etc., i. e., anthesis is quickly followed by maturation. This is in general typical of herbs. The greater number of trees and shrubs require a long time to ripen their fruits, and the relation of flowering period to period of ripening is not so immediate. This is exemplified in the Amentales where, in most cases, flowering is vernal and maturation serotinal. Since the latter usually extends over a considerable length of time, it follows that it does not manifest the close dependence upon conditions shown by the period of flowering, i. e., the environment to produce visible modification must react more strongly and through a greater period of time. Exact observations are as yet lacking, however, and the correct status of these relations awaits the foundation afforded by long-continued series of observations.

The period of flowering concerns itself chiefly with the time of earliest appearance, and with duration of flowering, i. e., the period between the time of earliest appearance and the beginning of the period of maturation. The time of earliest appearance may be considered both with respect to time and place, either of which may have an earliest and a latest terminus. Thus, in the vicinity of Lincoln, *Acer saccharinum* has an earliest terminus of February 20, and a latest terminus of April 1, an amplitude of forty days. As an example of spatial variation, *Acer negundo*, which blooms along the Missouri bluffs April 6-10, flowers two weeks or more later on the western foot-hills.

Drude's division into those plants whose flower buds come through the winter, and those whose buds are first formed in the spring, though in some respects a primary distinction, is

not the most important one. It merely explains the reason of the early blooming of some prevernal plants. The determination of this or that blooming-period for a particular species is dependent upon deeper-seated factors, and at present the time of flowering, as the expression of these, is the only available datum for elaborating periods of flowering.

The period of flowering, while it is in a certain sense the result of acquired or inherited morphologic and physiologic interrelations within the plant, is of wide variation, and of such varying equilibrium that it is rarely to be connected with any definite morphological peculiarity. Of all the phases in the life of the plant, it is one of those most directly dependent upon physiographic and climatologic conditions. Environment, as expressed in these two factors, reacts most powerfully upon it, and it comes to be an especially sensitive index of the annual permutations of physiography and climatology. In other words, changes in the period of flowering generally correspond to important topographical and meteorological changes. This principle is fully exemplified in most plants which experience a great or sudden change of habit. Those few whose flowering period remains constant despite such changes are to be considered as having attained an equilibrium of almost perfect stability.

From the above it follows that the coincidence of certain geographic and meteorologic conditions, and of the blooming period of certain plants, through the dependence of the latter upon the former, furnishes a means of marking out certain general periods of flowering, which, though permitting more or less of arbitrary limitation, always lack definite natural limits. This is so evident that it scarcely needs postulation. It should be emphasized, however, that, disregarding the above mentioned winter flower-bud bearers, spring, summer, or autumn plants are distinguished only through the comparison of the central group, comprising those forms whose flowering falls constantly and entirely within a certain period. Thus, each flowering period is characterized by a maximum, during which the floral covering displays none but flowers of

the particular period, except in the case of aianthous flowers, *Convolvulus sepium*, *Cassia chamaecrista*, *Psoralea tenuiflora*, and of sporadic bloomers, *Viola obliqua*, and of cleistogamic ones, *Impatiens biflora*. Between the maxima of two adjacent flowering periods, there is a gradual decrease in the predominance and in the number of bloomers of the first period, and a corresponding increase in those of the second period. If it were possible to determine for the whole floral covering the time when the flowers of both periods were in exact equivalence, a natural limit could be set for each period. This can be done in simple formations of definite constitution, but in large and complex formations, and especially for the whole floral covering, it is at present an impossibility.

Accordingly, the beginning and the termination of a flowering period, i. e., its duration, are to be obtained, not by analysis but by synthesis. In other words, the determination of the behavior of its elements is of less importance for limitation than the aggregate interrelations of these elements, i. e., the "port" of the period. The popular division of flowers into spring, summer, and autumn bloomers is a recognition of this fact. Such a division is fundamental, and phytogeography can merely render it more definite.

The mean duration of flowering time for Lincoln (latitude $40^{\circ} 45'$, altitude 350 m.) is 234 days; the maximum for eight years has been 282 days, the minimum 213 days. This length of time falls into four periods, the prevernal, vernal, estival, and serotinal. The prevernal period begins with the first blooming after the period of rest, and lasts until the foliation of the proteranthous trees, altogether hardly more than two weeks. The vernal period commences with the foliation of the trees, and extends through a period characterized by diminution of flowering, and closed by the appearance of excessively warm days. The estival period begins with the cessation of the latter, and closes only upon the approach of the dry, hot winds of late July and August. The serotinal period dates from this point, and extends to the time of killing frosts.

The prevernal period for the southeastern portion of the State begins usually during the last week in March. For the past eight years, its earliest terminus has been February 20, its latest April 1. Its close is less readily determined; the foliation of the proteranthous trees usually occurs from April 10-12, sometimes as early as April 7, rarely as late as April 15. The mean duration of the prevernal period is 17 days, the maximum 48 days, the minimum 14 days. The meteorological characteristics of the period are clear, cool days, with little precipitation, and a tendency to sudden and considerable falls in temperature. In consequence, the prevernal bloomers are mostly proteranthous trees, whose buds and flowers are best adapted to withstand the effects of sudden temperature changes. The remaining members of this group are almost wholly bulb and tuber plants. As a rule, prevernal bloomers are confined to forest formations; in a few cases they occur upon the prairies. In the latter instance, they are invariably vegetation-forms whose particular modifications permit of early blooming.

The earliest prevernal species is always *Acer saccharinum*. Its distribution, however, is so restricted, except in plantations, that *Ulmus americana* and *U. fulva* assume the leading rôle among the earliest bloomers, though they usually flower two or three days later. About the same time, *Peucedanum foeniculaceum* appears on the southern slopes of sandstone and drift-hills. It is invariably the earliest of our herbaceous flowers, a fact directly traceable to its large, tuberoid root. Perhaps a day or two later, *Anemone caroliniana* makes its appearance in prairies and on the warmer slopes of the sub-sand-hills. With it are found the rosettes of *Draba caroliniana* with their small, white flowers, and the extensive mats of *Antennaria campestris* which have begun to push up their scapes. On the tops of the high bluffs and hills of the Missouri river in the northeast, the scapes of *Pulsatilla hirsutissima* open their beautiful, large flowers before other vegetation has started. By the end of the first week in April, not only the two elms and the maple are seen in bloom in the

forest formations, but *Fraxinus lanceolata* and *Acer negundo* have also opened their flowers. At the same time, in open woodlands or along streams, *Populus deltoidea* and *Salix fluviatilis* exhibit their catkins. During this period *Erythronium albidum*, which occurs in extensive patches on the bluffs and in the wooded ravines of regions I and II, and *E. americanum*, which is found rarely along the bluffs of the lower Missouri, brighten the woods with their abundant purple-white and yellow flowers. Rather less common and a few days later are to be found in deep woods of I the pink flower-clusters of *Bicuculla cucullaria*. The last flowers to appear in the prevernal period are the aianthous *Bursa bursa pastoris*, and the somewhat rare *Erythronium mesachoreum*, which grows in low, woodless ravines. Not infrequently a few individuals of the *Cupuliferae* and *Juglandaceae* bloom during the latter part of this period; their appearance, however, marks its close, and they are to be considered as belonging to the next period.

The beginning of the vernal period is characterized by the simultaneous flowering of the oaks, hickories, and walnuts in the forest formations, and of the violets, puccoons, and corydalis in the meadows and on the prairies; moreover, by the foliation of the prevernal trees. It commences about April 12-16, and lasts for nearly two months, namely, until about the tenth of June; its average duration is fifty-six days. The meteorological features of the period are prevailing easterly and northeasterly winds, with frequent showers, and a more or less constant temperature, at least until the last week or so, when the mean daily temperature increases very rapidly.

The earliest vernal bloomers are *Astragalus crassicaarpus* and *Lithospermum angustifolium* on the prairies, *Viola pedatifida* in the meadows, and *Viola obliqua* in the woodlands. Early in this period the catkin-bearing trees of forest formations, *Salix*, *Quercus*, *Juglans*, *Hicoria*, come into bloom, as likewise *Prunus* and *Amelanchier* in thickets and open woodlands along the banks of

streams. The first woodland herbs are *Ranunculus abortivus*, *Claytonia virginica*, *Caulophyllum thalictroides*, *Aquilegia canadensis*, and *Sanguinaria canadensis*; all but the first one are confined to the bluffs of the Missouri. During the maximum of the period, *Celtis*, *Cercis*, *Crataegus*, *Pirus*, and *Robinia* among the trees, and *Ribes* among the bushes are characteristic flowers. At the same time, *Arisaema triphyllum* and *dracontium*, *Delphinium urceolatum*, *Macrocalyx nyctelea*, and *Podophyllum peltatum* abound in the deeper woods, *Amorpha fruticosa* blooms freely along the streams, *Poa pratensis*, *Tradescantia virginica*, *Allionia nyctaginea*, *Callirhoe alcaeoides*, and *Phlox pilosa* are found in flower in low meadows and pastures. On the prairies and hillsides, the vernal flowers are *Baptisia bracteata*, *Comandra umbellata*, *Lithospermum gmelini* and *canescens*, *Pentstemon grandiflorus*, *Castelleia sessiflora*, *Sisyrinchium bermudiana*, and *Hymenopappus flavescens*. Those plants whose flowering marks the beginning of the close of this period are, among the trees, *Gleditsia triacanthos* and *Gymnocladus dioica*; among the shrubs and climbers, *Ceanothus americanus*, *C. ovatus*, *Euonymus atropurpureus*, and *Menispermum canadense*; among herbs, *Polygonatum biflorum*, *P. commutatum*, *Sanicula canadensis*, and *Smilax herbacea* in the woods, *Lappula lappula*, *Baptisia leucantha*, *Delphinium carolinianum*, *Psoralea floribunda*, and *Scutellaria parvula* on the low prairies, and *Kuhnistera purpurea* and *candida*, *Anemone canadensis* and *caroliniana*, *Gaura coccinea*, and *Meriolix serrulata* on the hills.

Naturally, from the number of flowers in bloom or coming into bloom at the end of the vernal period, it is more than usually difficult to approximate the beginning of the estival period. The close of the vernal period is characterized by a cessation in flowering, a time which is marked by little precipitation and increasing temperatures. The estival period begins usually about June 6-10, and closes late in July, about 26-27, with the beginning of the hot, dry season of southerly and southwesterly winds. Its average duration is 47 days.

The floral covering during this period is so extremely diversified and complicated that it is impossible to treat fully of the interrelations and significance of all its elements. It is important to note that the flowering of such large families as Cyperaceae, Gramineae, Umbelliferae, and Labiatae, and of such representative ones as Polygonaceae, Chenopodiaceae, Malvaceae, Cactaceae, Verbenaceae, Euphorbiaceae, and Scrophulariaceae occurs almost entirely within this period.

The serotinal period begins during the last few days of July and lasts till the time of continuous frosts. Its duration is very variable; the average length of the period is ninety days, during only about the first twenty of which additional species bloom. A few plants of this period may be called real autumnal bloomers. Such are *Thalesia* and *Hamamelis*, the former flowering in September, the latter in November. All the others flower during the latter part of July or in August. With the exception of *Aristida*, *Campanula*, *Epilobium*, *Gentiana*, and *Mentzelia*, they are all species of *Compositae*. They number more than sixty, of which only *Lactuca villosa*, *Verbesina alternifolia*, *Helianthus decapetalus*, *Aster sagittifolius*, *A. novae-angliae*, *Solidago arguta*, and *Eupatorium ageratoides* are woodland plants, the remainder being found entirely in herbaceous formations. The close of the serotinal period is the reverse of the beginning of the prevernal. Aianthous species and those of the period proper gradually drop out, until only a few, *Aster salicifolius*, *A. sericeus*, *Artemisia gnaphalodes*, *Grindelia squarrosa*, *Solidago rigida*, and *Vernonia gigantea* remain to buffet against the repeated frosts.

The bearing of the time of flowering upon distribution and occupation is most intimate. To appreciate this it must be continually borne in mind that any area covered with vegetation is one vast battle-ground, where not only this and that formation, the one and the other vegetation-form, in line of battle wage incessant strife, but where is a perpetual conflict between the individuals of the floral covering. Occupation is the most potent factor by which a species maintains itself

in its geographical area or an individual in its situation. Hence the individual, in order to survive in its descendants and to perpetuate the species, must undergo such modifications as will increase its chances of occupation and as will insure continued occupation when established. A great number of plants have accomplished this result wholly or in part by perennation and its attendant modifications. The trees furnish, of course, examples of what may be called complete occupation. Here, apparently, the influence of perennity has been overshadowed by that of the accompanying changes of structure and habit. With perennial herbs, the increase in the period of duration was at first alone productive of greatly increased power of occupation. As perennial herbs became common, however, their duration gave them advantage only over annuals. The outcome of the struggle for occupation between perennials came then to depend wholly upon the development of adaptations favorable to that end. As has been pointed out elsewhere, the plant, to maintain occupation, had recourse to protective devices of all sorts, and especially to increased seed-production. In obtaining occupation, the latter is likewise a potent factor, though in general subordinate to seed-distribution. It is difficult as yet to point out concrete examples of the dependence of seed-production and dissemination upon the period of flowering and of maturation. The difficulty is the greater for the fact that it is impossible to determine now what vicissitudes and mutations these periods have undergone before assuming the present condition, which is, theoretically at least, the one most favorable to the plant. Thus we are reduced to conjecture concerning the exact method by which the uniformly late blooming of prairie Compositae has entailed immense seed-production and highly specialized dissemination contrivances. It scarcely needs to be pointed out that late summer conditions on prairies and sandy plains, where strong winds are continuous and aridity prevalent, demand almost perfect adaptations to wind-dispersion, and require unparalleled seed-production. In the case of prevernal bloomers,

such as the willows and cottonwoods, their preference for moist situations and their little-protected seeds necessitate dissemination during a time when moist conditions prevail. In consequence, with them the period of maturation follows closely upon that of flowering, and the seeds are borne about upon the wind during the most humid portion of spring time. The whole matter of the intimate dependence of seed-production and distribution upon time of flowering and of ripening is but another of the questions which await the future.

In addition to the period of flowering considered with respect to season, plants possess a time of flowering which has reference to the period of day in which they open their flowers. Though all flowering plants have such a time of flowering, it is of importance only with comparatively few, because of exceeding variability. Two groups of plants, however, possess a distinctive time of flowering: in the one, the flowers open only in the sunlight; in the other, at the approach of twilight or in the night time. The former may be termed *hemeranthous*, the latter *nyctanthous*. *Hemeranthous* flowers are frequently also *ephemeral*. This is especially true of *Portulaca oleracea*, the petals of which, opening only in direct sunlight, close after a few hours and begin to collapse. In *Linum sulcatum* and *L. rigidum*, the flowers, which open shortly after sunrise, drop their petals in the afternoon of the same day. Other *ephemeral* species are *Commelyna virginica*, *Helianthemum canadense*, *Silene antirrhina*, and *Talinum teretifolium*. *Tradescantia virginica*, though generally opening its flowers in sunshine, after a day's exposure to which they collapse, occasionally blooms on cloudy days and is not typically *hemeranthous*. *Cactus viviparus*, *C. missouriensis*, *Opuntia polyacantha*, etc., though opening their flowers in bright sunshine, are not *ephemeral*. The flowers usually close with the approach of twilight, and reopen with the next day's sun.

Nyctanthous species may bloom only during the night time, or they may open their flowers in the diffuse light of cloudy

days, or in early twilight. Examples of the first are rare: *Silene noctiflora* is the only constant night-bloomer in our flora. *Mentzelia decapetala*, *M. nuda*, *Oenothera rhombipetala*, and *Anogra pallida*, though usually flowering in deep dusk, and withering upon the approach of the next day's sun, sometimes, but rarely, open their flowers on cloudy days. *Onogra biennis* and *Megapterium missouriense*, while regularly nyctanthous, occasionally bloom on sunny days. *Allionia hirsuta*, *linearis*, and *nyctaginea* are exceedingly constant in their time of flowering. They blossom between five and six o'clock in the evening and close their flowers about eight o'clock in the following morning. As a general rule, nyctanthous flowers are ephemeral. Apparent exceptions to this occur in almost every species, when the evening of blooming is followed by a cloudy day, during the greater part of which the flowers maintain their usual form, collapsing usually about 24 hours after blooming.

SEED-PRODUCTION.—As has been suggested in the preceding section, the occupation of the soil by any plant may be defensive or offensive; moreover, the same plant may manifest both. Naturally, those modifications which insure defensive occupation are first to be developed. Most accessory biological characters are of this nature. Necessarily, inasmuch as they tend to the preservation of the individual, they have a direct effect upon the defensive occupation which the species manifests. Of such characters, bud-protection, stinging hairs, prickles, etc., have for their primary object the protection of the individual, while seed-production alone has to do directly with the maintenance of the species. In consequence, it is, primarily at least, the chief factor in defensive occupation, though often also a potent aid to offensive occupation, especially where it coexists with modifications adapted to the same end.

Seed-production has a close, but not easily explicable, relation to the possession of ruderal habit. Those families in which seed-production reaches its maximum contain a large percentage of ruderal species, while of all the families in

which seed-production is enormous, but one contains no species of ruderal habit. Whether this habit has preceded or followed increased seed-production is difficult to say; in many instances the two have been so interdependent and correlated that the influence of the one upon the other has been mutual. For the typical dwellers in the waste places, *Chenopodium*, *Amaranthus*, *Euphorbia*, it is probable that greatly increased seed-production through the multiplication of flowers came first, and that such plants, on account of their increased powers of occupation, originated wastes. That wastes are formed in this manner is evinced in the sand-hills at the present time, where the typical sand-hill resident, *Chenopodium leptophyllum*, has fairly converted itself into a waste plant, constituting great wastes hundreds of meters in extent. On the other hand, it is by no means improbable that greater seed-production is sometimes the direct result of a tendency to assume the ruderal habit. This would naturally follow where seed-production depends upon the number of flowers, from the fact that most plants grow larger and flower more abundantly in ruderal situations. In some cases the same effect is produced, with suppression of individual growth, by the production of a number of individuals.

Enormous seed-production is characteristic of most annuals, a fact easily explained by the necessities of the case. It is, to some extent at least, the result of an attempt upon the part of the annuals to compensate for the lack of a perennial rootstalk, and, further, in many cases for the absence of any special device for dissemination. That seed-production often outweighs dissemination in the modification of the floral covering is shown by the prevalence and importance of ruderal formations, composed for the most part of naked-achened annuals.

Although flowers accomplish seed-production in various ways, they resolve themselves into three general groups. In the first, the amount of seeds produced depends upon the number of flowers; in the second upon multiovulation. The third group is characterized by the presence of both methods.

Accordingly, a plant may manifest either polyanthous or polyspermous seed-production, or it may manifest both.

The most typical examples of polyanthous seed-production are to be found in the apetalous families of the Caryophyllales, in the Compositae, in the Graminaceae, and Cyperaceae, and in a few genera scattered through various families, where each flower possesses a single achene. In this class are to be included the Umbelliferae, and most of the Euphorbiaceae, notwithstanding the biovulate ovaries of the one and the triovulate ovaries of the other. Certain genera of the Leguminosae, such as *Kuhnistera*, *Parosela*, *Psoralea*, and *Amorpha*, are typically polyanthous. As would be expected, and as is borne out by the predominance of the above plants in the floral covering, polyanthous seed-production is most favorable to both defensive and offensive occupation.

Polyspermous seed-production may result from multiovulate ovaries or it may be due to apocarpy. The best illustrations of the first are to be found in the Onagraceae, Loasaceae, Apocynaceae, and Asclepiadaceae, and among trees, in the Salicaceae; of the second, in Alismaceae, Typhaceae, and in many of the Ranunculaceae and Rosaceae. *Portulaca oleracea* affords the best example of polyanthous and polyspermous seed-production in the same plant. The same feature is also well manifested by *Oxalis stricta* and to a less extent by *Viola*, and certain genera of the Cruciferae.

Primarily, the value of seed-production depends upon the number of seeds produced. In reality, this value is greatly modified by lack of vitality, immaturity, and abortion of the seeds. These influences are most prominent in polyspermous seed-production, e. g., *Mentzelia*, or in *Portulaca*, etc.; in polyanthy their effect is much less evident. The degree of vitality of seeds in nature is extremely difficult to determine. Experiments in gardens and plantations, where changed conditions exist, are wholly unreliable, while investigation of natural sowings presents so many sources of error that only the most careful observations, extending over a long period of years, could be regarded as approaching conclusiveness.

In general, it can be postulated that the degree of seed-vitality in most plants is low. This is evident in *Chenopodium* and *Helianthus*, where, though immaturity and abortion are rarely present to any considerable degree, out of thousands of seeds produced annually comparatively few survive until the following spring. Immaturity rarely affects seed-production to any appreciable extent. In the rare cases where it assumes importance, its cause is almost invariably to be found in unfavorable climatic conditions, and its extent is easily determinable. Abortion is a common phenomenon in myriovulate plants, and is especially frequent in *Portulaca*, *Solanum*, etc. Since it is physiomorphological in character, its extent can be readily determined. In individuals of *Portulaca* growing in the usual waste places, the per cent of abortive ovules is sometimes as high as 30, while in the reduced plants found in the greenhouses, more than half the ovules are abortive.

DISSEMINATION.—The floral covering is the exact expression of the endemicity and of the distribution of plants, hence, of defensive and offensive occupation, or of negative and positive distribution. As has already been shown, the maintenance of the species is first conserved by the degree of defensive occupation which the individuals manifest, while its distribution, which also tends to perpetuate the species, is effected by the power of offensive occupation which it develops. Thus an indigenous plant will remain so as long as it possesses sufficient power of defensive occupation to maintain itself in its original station, and so long as it avoids those modifications which render it capable of offensive occupation. But endemics have often to stand their ground against plants highly specialized for offensive occupation, and they are obliged, in order to maintain their position, to undergo specializations, which are to be regarded strictly as adaptations for defense, though ordinarily they are devices for positive distribution. The lilies and the orchids furnish an excellent illustration of the fate of such plants, which, while

entirely lacking offensive occupation, possess the power of defensive occupation in but a slight degree.

Axiomatically, all plants were originally endemics. They either remained such, or, through their ability to acquire distribution, they came to be transported to various and widely separated stations. Frequently, in the case of algae and some aquatic flowering plants, this transportation affected the entire plant. With the great majority of phanerogams, however, fixed terrestrial habit precluded such distribution, and in general the plant has been forced to modify its organs of propagation or of reproduction to accomplish this end. Naturally, this modification concerned itself chiefly with the seed and with the fructification, though modification of the whole plant-body, or of parts of it, for similar purposes is not unknown. As a result, seed-distribution or dissemination, considered in the broad sense, has become the most powerful of all distributional factors.

Contrivances for seed-distribution and devices for the protection of seeds stand in the most intimate relation; in fact, the same modification often subserves both ends. This is especially true for those fructifications which are distributed by animals, either through attachment or through deglutition. In the first case, the fructification is protected by means of barbs and prickles, which serve likewise as carriers; in the second, the pulpy or fleshy covering of the fruit insures deglutition, while the seed proper is preserved by its sclerenchymatous envelope, the hull or stone. Other protective devices, such as in the glandular fruits of *Rhus trilobata*, *Polanisia trachysperma*, have no direct connection with dissemination, but serve simply to keep animals from devouring the fruit. In such instances, the seeds almost invariably lack a protective envelope. In addition, such fruits as are wind-distributed, or water-distributed, must, in the former case, in a xerophytic region at least, be enabled to resist excessive desiccation and, in the latter, they must be of such a nature as to preclude the excessive imbibition of water.

Dissemination in general is accomplished by the distribution of seeds, through transportation either of the seed itself or of the fructification. Infrequently, a vegetative organ is the part distributed; more rarely still, the entire plant is transported. With respect to the agency of distribution, plants are distributed through wind, water, or animals. In a prairie region, where strong winds prevail, one would expect to find wind-distributed plants in large number. This is borne out in our flora, in which out of 136 genera with dissemination contrivances, 82 are wind-distributed.

According to the contrivances made use of for wind distribution, plants may be divided into four classes: 1, those with comate or pappose seeds; 2, those with winged seeds; 3, those in which the fructification is winged; 4, tumble-weeds. The first class falls into two groups, in the first of which are comprised plants with typically comate seeds. This group contains all our species of Apocynaceae, Asclepiadaceae, and Salicaceae, as well as the genus *Epilobium*. It is significant of the great value of the coma in seed-distribution that, of the eight genera of this group, six are represented by species which occur throughout the State. The other two genera, *Asclepiadora* and *Ampelanus*, are as yet of restricted range in Nebraska, since they are southern species which have but recently invaded our flora. The group of pappose-seeded plants is composed almost wholly of species of Compositae, distributed among 38 genera. Besides these, there are *Typha*, *Eriophorum*, *Phragmites*, and *Calamagrostis* among the Monocotyledons, *Eurotia* among Chenopodiaceae, and *Anemone*, *Clematis*, and *Pulsatilla* among the Ranunculaceae. Here, perhaps, should also be placed *Froelichia*, in which dissemination is brought about by means of the densely woolly calyx. The entire class comprises 56 genera and about 218 species.

The class of plants in which distribution results through winged or flattened seeds is small; with us but five genera and seven species are included in it. It comprises *Pinus scopulorum*, *Onagra biennis*, *Yucca glauca*, *Mentzelia decapetala*,

M. nuda, and species of *Arabis*. Disregarding structure, and considered biologically with reference to seed-distribution, the third class is identical with the second. This class shows great structural diversity of fructification, all agreeing, however, in the possession of wings, or broad margins, by means of which the seeds are transported. The achene may be winged, a samara, as in *Acer*, *Betula*, *Fraxinus*, *Ptelea*, and *Ulmus*; the ribs of the fruit may be prolonged into wings, *Cymopterus*, *Peucedanum*, *Thaspium*, etc.; the angles of the seed-pod may be broadly winged, *Onagra*, *Megapterium*. In *Rumex* and *Eriogonum*, the persistent calyx lobes become more or less enlarged to form membranaceous valves, which are the biological equivalents of wings. In *Humulus*, the calyx is similarly enlarged and scale-like. *Sarcobatus* possesses a calyx with an abruptly spreading membranaceous limb. *Physalis* and *Hibiscus trionum* have an inflated calyx, which in function is strictly homologous with wings. With *Staphylea*, the same result is effected by the bladdery-inflated pod. This class comprises 20 genera and 47 species.

Tumble-weeds are characteristic of plains, or of level, barren stretches, where the prevailing winds are continuous and forceful. They are the only flowering plants in which the plant-body as a whole is the object transported. It is a notable fact that of the ten tumble-weeds in our flora, not a single one has seeds, or fructifications adapted to wind-distribution; in every instance, the fruit is a small, naked achene, or caryopsis. Tumble-weeds are of two sorts: typical tumble-weeds, characterized by a rounded, diffusely branched top, which dries up in late summer and autumn, and, breaking away from the caudex, or the root, goes tumbling over the prairie; tumble grasses, in which sometimes the whole plant, more often the large, spreading panicle, is transported. Tumble-weeds never separate from the root until the seeds are fully matured. As they roll before the wind, often for hundreds of kilometers, the seeds are dropped here and there along the course. In habitat the tumble-weeds are almost invariably xerophilous, the tumble-grasses subxerophilous.

The most striking of all tumble-weeds is *Cycloloma atriplicifolium*, which has been enabled to assume much prominence in III and IV through the perfect adaptation of the subglobose, compact top with its innumerable seeds to the tumbling habit. *Amaranthus graecizans*, *Corispermum hyssopifolium*, and *Salsola tragus* are familiar examples of the development of a similar type of plant-body. *Psoralea esculenta*, and *P. floribunda*, though typical in habit, separate less frequently from the caudex, and are not so often seen tumbling. Of the tumble grasses, *Panicum capillare*, and *Schedonnardus paniculatus* are the only ones in which the whole plant regularly tumbles; even here the inflorescence alone sometimes tumbles. In *Eragrostis pectinacea*, *E. trichodes*, *Agrostis hiemalis*, and *Sporobolus airoides*, the hard, wiry stem prevents the separation of the upper part of the plant, and the panicle is the part which rolls before the wind. *Townsendia sericea* affords an interesting example of the combination of pappus distribution and tumbling habit. According to Bessey (*Am. Nat.* 22:645, 1888), the scales of the involucre force out the mass of achenes, which are held together by the hooked hairs. At the same time, the flowers and pappus are directed outward in a radiate fashion. The corollas soon fall away, and the light, fluffy ball tumbles before the wind exactly after the manner of a tumble-weed.

Distribution through the agency of water may result in two ways: either by streams or by surface drainage. In the first case, the current of the stream is the distributing agent. Frequently, however, the stream overflows its banks, and the flood waters become active factors in the transportation of seeds. Of a similar nature is the part taken in seed-distribution by surface drainage. Though its action is frequently overlooked, surface drainage is the most important method of water distribution. It not only concerns itself with the transportation of a great number of seeds at all times, but also with numerous species deprived of all other means of distribution. The result of its power of dissemination is manifested in the predominance of low-ground wastes which

are composed almost wholly of *Chenopodium*, *Amaranthus*, *Helianthus*, *Ambrosia*, *Artemisia*, etc., whose seeds are wholly or practically destitute of distribution contrivances. Examples of dissemination by means of the currents of streams are few. In this class are included plants with flat or more or less flattened seeds, such as *Micrampelis*, *Zanichellia*, and *Homalocenchrus*. More rarely, propagative organs are carried about by streams. A familiar instance of this is found in the tubers of *Sagittaria*.

Dissemination through the agency of animals may be divided into three groups, in which transportation results through attachment, carriage, and deglutition respectively. Attachment and carriage, which may seem at first to be identical, are really easily distinguished, since in the one the transportation is involuntary and often unconscious, while in the other it is intentional. Distribution by attachment is undoubtedly the most important as respects number of species and quantity of seeds. Transportation by deglutition has probably the greatest influence in extending the geographical area, on account of the immense distance to which seeds are often carried.

Modifications for the purpose of attachment may be arranged in two groups. The first includes prickly or barbed fructifications, the second, awned fructifications. It is notable that out of 43 species of the first group, 27 are inhabitants of woodlands. These are scattered through many groups, and present several types of modification. The commonest is that in which the whole fruit is barbed, as in *Galium*, *Sanicula*, *Circaea*, *Daucus*, *Lappula*, *Washingtonia*, *Tribulus*, *Glycyrrhiza*, and *Solanum rostratum*. In addition, the achene may be crowned with a barbed, awn-like pappus, *Bidens*, *Thelesperma*; the awns may be smooth as in *Verbesina*, or the pappus may be awn-like and the involucre scales hooked, as in *Arctium*. *Agrimonia* and *Phryma* develop hooked awn-like processes upon the calyx, while the long, hamate, or jointed styles of *Geum* are similar modifications. In some plants, it is the involucre which is modified; in *Xanthium*,

the involucre is covered with hooked prickles; in *Cenchrus* it is furnished with acute prickles. Both *Sicyos* and *Micrampelis* possess prickly or barbed fruits. In the latter, the prickles are weak and practically functionless, and distribution occurs regularly through wind distribution of the dry, bladderly fruit, or by means of the water-distributed flat seeds. Awned fructifications proper are confined to the Graminaeae. These fructifications may be arranged morphologically into several groups: 1, in which the flowering glume is awned, *Bromus*, *Agropyron*, *Aristida*, *Andropogon*, *Hystrix*, *Avena*, *Festuca*, *Oryzopsis*, *Stipa*, *Sieglingia*, etc.; 2, in which the empty glume is awned, *Zizania*; 3, where the flowering glume is awned, and the empty glumes awned or awn-like, *Elymus*, *Hordeum*; 4, where the empty glumes are reduced to awns, *Chaetochloa*. In function, all these modifications correspond closely. In *Elymus*, *Hordeum*, and *Chaetochloa*, the close aggregation of the spikelets and the extreme development of awns render the spike a light object easily distributed by the wind. The same is true of the joints into which the rhachis often separates. In *Stipa*, the sharp callus at the base of the flower serves as a means of attachment also. The flowers are frequently intertangled by the awns which twist as they dry, and are carried by the wind in such masses.

It is a difficult task to determine the influence of dissemination by carriage, or by deglutition upon the floral covering. Distribution through carriage is confined chiefly to woodlands, where the nut-fruits of many genera of Juglandaceae and Cupuliferae are carried off and stored away by squirrels and other small mammals. In similar situations, and on prairies and in meadows, in addition, achenes, generally of Compositae and Umbelliferae, meet with the same fate. Small seeds are likewise carried away by ants as winter provision. Deglutition by birds is of much more importance than that by mammals. Though a great number of fleshy fruits are eaten by the latter, only a few, *Pirus*, *Cactus*, possess seeds sufficiently protected to resist the action of digestive fluids. In the case of fruits consumed by birds, the seeds are not only

in general well protected, but often are never swallowed, the pulp being eaten away and the seed dropped. The latter usually happens with fruits possessing a stony seed or pit, *Prunus*, *Vitis*, *Parthenocissus*, *Rhamnus*, and the distribution is then local. In the case of berry fruits, such as those of *Morus*, *Rubus*, *Ribes*, *Fragaria*, *Amelanchier*, *Physalis*, etc., the entire fruit is swallowed, and the seeds are, as a rule, dropped a long distance from their station.

The projection of seeds, though often due to reflex mechanical action of the plant, is to be reckoned among dissemination contrivances. Projectile processes are none the less modifications for offensive occupation, though they have come to conserve best defensive occupation, on account of the small distance to which the seeds may be thrown. This method of distribution probably explains the fact that *Impatiens*, *Oxalis*, and *Viola* occur almost invariably in dense, if somewhat restricted, patches. The same is true of *Hamamelis* to a certain extent.

CHAPTER IV.

THE ECOLOGICAL AND BIOLOGICAL RELATIONS OF THE NATURAL GROUPS

The factors in ecology.—Ecology treats of the relation of plants to their surroundings, both physical and biological. It deals with the life of a plant in its home, whether the latter be original or acquired. Ecology can not be set off sharply from physiology. Indeed, it is simply that particular phase of physiology which is manifested in the structure and habits of plants in their various homes. It is preeminently the division of phytogeography which seeks the connection between causes and effects. Its meaning is best understood by regarding the habitat of a plant as an aggregate of influences or factors acting upon the plant and causing it to exhibit certain phenomena and structures more or less peculiar to the habitat and plant in question. In any habitat or aggregate of factors, the factors are not coordinate nor are all of them necessarily effective. Each habitat is dominated by one or more controlling factors in the presence of which other factors are insignificant or ineffective. Certain predominant factors will be more or less similar in all habitats, but the control exercised by these will be modified from one habitat to another by secondary factors. The effect of some factors will be more general, and these—temperature and light—may be considered as controlling with respect to vegetation, while others—water-content, soil—have a definitely expressed structural effect upon the individual and are controlling with respect to the vegetation of distinct habitats, i. e., habitat-groups. In addition to these ecological factors which may be termed physical, there are others arising out of the interrelations of animals and plants and of associated plants which may be termed biological.

PHYSICAL FACTORS.—These are the various factors which, taken as a whole, constitute the physical environment of a plant, or its habitat, in the ordinary sense. They are temperature, light, water-content, soil, atmosphere, precipitation, and physiography.

Temperature.—The general effects of temperature or heat are easily recognized in all the purely physiological processes of the individual. It is a prerequisite of germination, nutrition, growth, transpiration, motion, and reproduction. In short, the life of a plant as an individual is not only wholly dependent upon a proper temperature, but the maintenance of the species also depends upon it. Notwithstanding the essential connection between temperature and plant-function, the former is a vegetational factor rather than a morphological one. Its influence is predominant in the vegetative covering with respect to the distribution and arrangement of plants in zones of vegetation, but with reference to the response induced in the plant-body, it is less important as an ecological factor than light, and much less important than water-content. In connection with light and water-content, temperature plays a considerable part in plant structure, a fact well illustrated by arctic and desert xerophytes.

Each species, habitat-group, or formation is characterized by a maximum and minimum temperature, between which extremes it grows and maintains itself. The individual plant is most active at a certain point, the optimum, which is more or less equidistant from the extremes in plants of temperate zones. The optimum lies much nearer the maximum than the minimum in the case of both arctic and tropic plants. In nature, there seems to be no absolute minimum temperature at which all plant life ceases. Certain arctic vegetation is able to maintain itself through temperatures of -50° C. to -70° C., while many reproductive bodies, spores and seeds, are capable of resisting much lower temperatures. In

the prairie province, buds, seeds, rootstalks, etc., are frequently subjected during the winter to temperatures of -20° C. to -40° C. without injury. Many rosettes also live through the winter under similar conditions. An absolute maximum is likewise rarely found in nature, even in the case of boiling springs in which certain thermal algae live. Plants reach their maximum more quickly, however, in consequence of progressive acceleration of function. As a result, the active, turgid plant-parts and watery plants perish most quickly, while those plants or parts, seeds, spores, etc., which possess relatively little moisture resist the effect of heat much longer. Thus, completely dry seeds have been found to resist a temperature of 120° C. to 130° C. The spores of bacteria withstand a temperature of 130° C., while the bacteria themselves are destroyed by continuous exposure to 80° C. Many flowering plants are killed by a short exposure to 45° C. Many desert plants, however, are capable of resisting a temperature of 75° C., and it seems probable that rock-plants, especially lichens, withstand even higher temperatures, despite the difference between the extremes -80° C. to 130° C. Any particular plant or vegetation possesses a very much smaller range between its minimum and the maximum, so far as the plant-body is concerned. Bacteria are possible exceptions. Naturally a tropical plant or vegetation which is characterized by a high maximum possesses a correspondingly high minimum, while arctic plants capable of withstanding great cold are peculiarly incapable of resisting extreme heat. Among phanerogams the sole exception to this rule seems to be furnished by alpine plants, which are often subjected to great differences of heat and cold during the course of twenty-four hours.

The presence of a plant in any habitat is conditioned by correspondence between its minimum and maximum temperatures and the temperature extremes of the habitat. Lines connecting places in which the temperature extremes are the same, i. e., in which occur plants characterized by the same

minimum and maximum, are termed isophytotones. Temperature considered alone would make the equator an isophytotone with all others equally distant from it. Numerous disturbing factors, such as physiography and soil-composition, make of the isophytotone an extremely irregular line, now deflected to the north and now to the south. Each isophytotone marks a limit beyond which certain southern species can not go because of too high a minimum, while northern species are checked because of too low a maximum. The isophytotone is thus a barrier, a line of adjustment or a shifting; in other words, a line of stress. Certain isophytotones, because of their cumulative character, are of primary importance. These produce primary lines of stress which limit vegetation-zones. In consequence, vegetation-zones of continents cross them from east to west. Such zones depend primarily upon amount of heat, modified in a large degree by local factors. In addition, the zones of mountain ranges, peaks, and mountainous islands are simply miniature vegetation-zones and are likewise due to the influence of temperature.

The source of the heat and the direction of impact are matters of considerable importance. The effect of direct heat is to be observed in a large number of devices which xerophytic plants make use of to reduce transpiration, and in the immense plant-bodies of trees, which are the immediate result of an enormous transpiration current. The results of indirect heat are to be found along with, and scarcely distinct from, modifications due to light in the secondary layers, especially the herbaceous ones, of all forest and thicket formations. Many plants growing on rocks, in rock fields, or on sandy stretches have been modified in response to heat of conduction and also in response to heat of radiation. Plants are forced to protect themselves against the loss of heat, either from direct impact or as a result of radiation from the substratum. Hairs and scales are the chief modifications by which parts of the plant-body are protected, while the rosette

and mat habits are familiar examples of the way in which the plant prevents radiation.

The duration of heat, i. e., the maintenance of an optimum temperature favorable to the succession of physiological processes manifested by plants, determines the division of the year into a growing period and a resting period. In this respect temperature is again primarily a vegetational factor, but its influence is also exhibited very clearly in each species. The various divisions of the growing period into period of flowering, period of maturation, etc., and the time of the opening of flowers are most intimately related to duration of heat.

Temperature plays an important, though secondary, part in the modification of plants and vegetation in connection with practically all other physical factors. This relation is most marked in relation to light and water-content, but it is also important in connection with atmosphere, precipitation, soil composition and physiography.

Light. The relation of light to the functions of the plant is in many cases the relation of cause to effect. Its influence is controlling in photosynthesis and movement, and is important in transpiration, growth, and respiration. Light, like temperature, is vegetational in its influence, but it has also a marked effect upon the individual, both with respect to morphology and mechanical function. It is of primary importance in association, especially in layered formations. It is likewise, in a large measure, determinative of subordinate association, as shown in the plant societies, epiphytes, helophytes, parasites, and saprophytes. Its effect upon the individual plant is best seen in the movements of plants, heliotropism, nyctitropism, hemeranth, nyctanth, etc., in the arrangement of leaves and the foliage shoots, and in the increase and reduction of tissues and members.

The effects of light may be considered as resulting from intensity, duration, quality, or direction of the light, or from various combinations of these different factors. The two factors, intensity and duration, are hard to distinguish. They

act together as a rule, and hence produce a cumulative effect. With reference to the intensity of light in their habitat, plants are photophilous, light-loving, or sciaphilous, shade-loving. Photophilous plants are typical of one-layered herbaceous formations, and of the primary layer or facies of all layered formations. Sciaphilous plants are confined almost exclusively to layered formations, particularly forests, in which the herbaceous layers are composed of them almost wholly. Sciaphilous plants are characterized by an elongated, slender stem due to the drawing effect of diffuse light and thin, broad, dark green leaves arising from an attempt to make the most of the weak illumination. The epiderm of the leaf possesses an extremely thin cuticle. Palisade tissue is underdeveloped or lacking, and the stomata are numerous and superficial. Flower and leaf movements are comparatively few on account of the slighter difference between day and night in so far as the intensity of the light is concerned. Photophilous plants, on the contrary, exhibit a large number of movements, and practically all hemeranthous and most nyctanthous species belong to this class. The modification of stem and leaf are not so evident, for the reason that it is practically impossible to distinguish the effects of light from those of heat and water-content. The intense illumination in the case of xerophytes has doubtless something to do with the character of the plant, but this influence is overshadowed by that of the factors just mentioned. The effects of the quality of light are to be found in the maintenance of particular physiological functions. The connection, however, between this factor and definite morphological and histological modifications is obscure. The direction of the light has a considerable influence upon vegetation as a rule, but sometimes, also, upon individuals. Lateral illumination produces heliotropic effects and originates compass-plants. The obliqueness of the rays of light is one of the causes of the dwarfing of arctic and alpine plants.

Water-content. The influence of the water of the soil upon the form and structure of the plant-body is much more

marked than the influence of any other factor or group of factors. The response which the plant makes to the soil water of its habitat is so pronounced and so complete that other factors are entirely overshadowed, and their influence is to be noticed chiefly in so far as it affects the water of the plant. Practically every other factor has a more or less intimate bearing upon the amount or kind of water in the soil, and hence in the plant. This fact must be kept constantly in mind when studying the relation of water to the plant, in order that each factor may be assigned its proper value. The amount of water in the habitat of the plant, moreover, can not be taken as a factor of absolute value. Its effect upon the plant must be determined with reference to the composition of the soil, the humidity and movement of the air, the topographical and biological features of the habitat as well as with reference to the light and temperature. As a matter of fact, however, these various factors are simply modificative of the influence of water-content, increasing or decreasing it, and they are not to be regarded as acting directly upon the plant-body, as is the case with temperature and light.

The effect of water depends primarily upon the amount present in the substratum. The maximum quantity present in plant habitats occurs in ponds, streams, lakes, etc.; the minimum quantity in epiphytic situations, or in intensely xerophytic ones, rocks, frozen ground, etc. In habitats characterized by maximum quantity, the amount of water present corresponds to the amount available, and the physiological water-content of the substratum is as great as the physical water-content. In all other cases there is a considerable and variable difference between the two, the amount of water available for the plant being actually much less than the amount present in the soil, as Schimper points out. Many errors have been made in considering the influence of water-content upon the plant because this fundamental distinction has been overlooked. As a rule, a large proportion of the physical water of the soil is physiological, i. e., available for the plant, but in many instances the difference between the

two is so great that a habitat rich in water will be incapable of supporting vegetation requiring a large amount of water. Hence it happens that habitats physically very diverse and extremely unlike in the amount of physical water present—deserts and marshes—possess very nearly the same amount of physiological water, and are characterized by plants very similar in form and structure. In consequence, in determining the ecological equivalent of the water in the soil, results based upon the amount of soil water, i. e., upon the physical water-content, are of little value, except indeed, in the case of substrata closely related in composition and structure. The physiological water alone is active in modifying plant structure and form, and all accurate methods of determining water-content must be based upon this fact. It has been impossible up to the present to devise a satisfactory apparatus for this purpose. The only accurate method available is to determine the physical water-content of a soil sample taken from the surface through the mean depth to which the roots penetrate. This is done by weighing, thorough dessication, and a second weighing. The difference between the two weights gives the amount of physical water in the soil. The quantity of the latter not available for plant use is determined in the same way by means of a soil sample, taken when the plant is completely wilted. The difference between the physical water-content and the amount of unavailable water will give the amount of physiological water, and will afford a satisfactory basis for determining the relation between water-content and the ecological effect.

The vegetation of habitats characterized by a large degree of physiological water-content is termed hydrophilous, and the plants are known as hydrophytes. Habitats characterized by a small quantity of physiological water bear xerophilous vegetation, and the component individuals are xerophytes. The great mass of vegetation occurring in neither typically hydrophytic nor xerophytic situations, and responding much less noticeably to the influence of soil water, is termed mesophytic or tropophytic. Corresponding to

these primary divisions, vegetation may be arranged in three habitat-groups, i. e., associations of species similarly responsive to the amount of physiological water in the substratum. These groups are hydrophytes, mesophytes, and xerophytes. They are fundamental and include all plants. Within them, however, certain minor groups possess such marked characteristics that they are also set off apparently as coordinate. In reality, with respect to the primary factor, water-content, they are subordinate. Thus halophytes are distinguished by the quality of the soil water, though with respect to the quantity of the latter they may be either xerophytes or hydrophytes. The mesophytes especially, since they are not affected so noticeably by water-content, are divided into three groups based upon characteristic biological differences. These groups are hylophytes, poophytes, and aletophytes.*

The response of vegetation to the quality of soil water is well shown in the case of halophytes, the inhabitants of sea coasts, beaches, salt marshes, alkaline plains, etc. Hydrophytic vegetation also varies with reference to the kind of water in which it occurs. It is glacial when found in the cold spring streams of foot-hills and in icy mountain brooks and torrents; and fluvial, when it grows in the warmer streams and ponds of the lowlands.

Xerophytes. Xerophytic habitats are characterized by physical factors which tend to decrease the water-supply or to maintain it near a minimum, by factors which increase the water-loss of a plant or keep the latter at a maximum, or by both. The former are: steepness of slope and considerable exposure, as a result of which water is carried off rapidly from the surface; loose texture of the soil, often combined with slight depth, owing to which the water quickly dries out; low temperature of the soil, in consequence of which the water present is not available, and abundance of humic acid or of salt solutions in the soil, which has the same influence; the absence of subterranean or surface waters, small precipita-

* Greek, ἀλη΄της, vagabond.

tion, strong winds, and a thin vegetative covering. The latter are extreme dryness of the air, high temperature, low atmospheric pressure, intense illumination, and the absence of a superior vegetation. The characteristic xerophytic modifications arising from these conditions are of three sorts: (1) those having to do with the increase in size and effectiveness of the root-system by which absorption is increased; (2) those developed in root, stem, and leaf for the storage of water; (3) those in which the surface of the plant is reduced, and those arising in or near the epiderm, in consequence of which transpiration is decreased. Typical xerophytic situations are: (1) deserts, sand-hills, foot-hills, gravel slides, rock fields, dunes, prairies and steppes, characterized by extremely porous soil, high temperature, strong winds, small precipitation, intense illumination, and scanty vegetation; (2) arctic and alpine stretches with low soil temperature and scanty vegetation, in the latter also with intense illumination and slight atmospheric pressure; (3) rocks, cliffs, twigs, tree-trunks, etc., with a nonporous substratum and direct exposure; (4) marshes, moors, and bogs with large quantities of humic acid; (5) strand, salt basins, brackish marshes and alkaline plains impregnated with large quantities of mineral salts. Xerophytes exhibit one or more of the following typical modifications of the plant-body: decrease and sinking of the stomata; thickening of the cuticle, with cellulose reinforcement and doubling of the epidermal row; thickening of the leaf resulting in succulence; reduction and disappearance of the leaf; increase of palisade tissue; development of thorns, spines, and prickles or of dense coatings of wax, hairs, or scales; the formation of water reservoirs in the leaf; the reduction and succulence of the stem; increase of the root system along with the development of reservoirs, and the assumption of the mat or rosette habit.

Hydrophytes. So far as water conditions are concerned, hydrophytic and xerophytic situations are diametrically opposite in character. The former show much less difference in the factors which affect transpiration. In this regard, the

one fundamental distinction between the two is that xerophytes have been compelled by inadequate water-supply to undergo those modifications which would reduce water-loss, while hydrophytes have been obliged, in consequence of excessive water-supply, to develop adaptations for the purpose of increasing transpiration. The modification of the hydrophytic plant-body has taken place under two pressing necessities: the need for the movement of the superabundant water with its crude food materials, and the need of aeration. Out of these conditions has arisen a type of structure fundamentally the same for the large number of amphibious and floating hydrophytes. The root-system is only moderately developed, while special absorptive structures, such as root-hairs, are under-developed or lacking. Modifications for the storage of water are absent from all parts of the plant. Water-loss and, hence, water-movement are increased to a maximum by the complete lack of protective contrivances in the epidermis, by the great abundance of stomata, and by the presence of water-pores. The aeration of the plant-tissue is brought about by the development of immense intercellular passages, often exceeding in size the tissue-masses of the stem. The presence of stellate or latticed diaphragms stretching across such intercellular spaces is also typical of hydrophytes. Finally, in consequence of the small need of support within the plant, the fibrovascular system is greatly reduced and the stereome generally lacking.

Mesophytes. (Tropophytes.) Mesophytic habitats are characterized by middle or moderate conditions with respect to water-supply and water-loss. Both of these factors may be intermediate with respect to the same factor in hydrophytic or xerophytic situations, or either one of them may approach the hydrophytic or xerophytic mean. When this is the case, this particular factor must be counterbalanced by the other, or the habitat passes into a hydrophytic or xerophytic condition. Thus, the water-supply of the plant may be small, without its becoming xerophytic, if the factors in the habitat which determine the amount of water-loss are

such as to make the latter slight. On the other hand, a plant will remain mesophytic notwithstanding large water-supply, if the latter is properly balanced by water-loss. Mesophytes show many xerophytic modifications with respect to transpiration. Such modifications are rarely pronounced and are operative or purposeful only during those periods which the mesophytes must pass through as a xerophyte, i. e., during the winter or dry season. Mesophytes are characterized as a rule by strong transpiration current, resulting in a massive plant-body, and by a well-developed epidermal system. In the present treatment they have been divided according to biological characteristics into hylophytes or forest plants, poophytes or meadow plants, and aletophytes, ruderal or waste plants.

Halophytes.- These are essential xerophytes produced by the abundance of salt solutions in the soil, and should be properly classed among xerophytic plants. A few, however, *Ruppia*, *Zostera*, etc., are aquatic, and in the event of the division of the group should be classed as halophilous hydrophytes.

Soil. The soil factors in ecology are physical or chemical. Physical factors are texture, pressure, capacity for water or air, porosity, and capillarity. The last three, all of which are concerned with the air- and water-content of the soil, are the most important. Their influence may be best seen in connection with the water-supply of the plant. Chemical factors arise from the varying constitution of the soil, whether arenaceous, argillaceous, calcareous, granitic, etc., or from the presence of chemical substances in the soil, such as humus, salts, etc., as in leaf-mold, alluvium, saline lands, and fluvial and glacial waters. They produce considerable effect upon vegetation, though in many cases it is difficult to distinguish their influence from that of physical factors. Biological factors are of chief importance in modifying the physical and chemical characteristics of the soil. The vegetative covering exerts a constant influence upon the texture, porosity, and capillarity of the soil, and hence upon its water-content. The

chemical constituents of the soil are each year decreased as a result of their use by the vegetation, and concomitantly replenished by the decomposition of dead vegetable matter. In addition, the weathering of the soil is modified to a large degree by the character of the vegetative covering.

Atmosphere. The composition, density, humidity, and movement of the air, as well as the kind and amount of air present in the substratum, have a more or less direct effect upon plants as individuals and upon vegetation. The importance of the composition of the air is obscure. Even in the case of hydrophytes, where the variation from the normal is most marked, the immediate effects are not obvious. The effect of atmospheric density, though recognized as considerable, is likewise little understood. Its influence is shown to a marked degree in alpine and subalpine plants, but here its exact working on account of other factors is undetermined. The humidity of the air is a primary factor in the determination of hydrophytic and xerophytic conditions. It is of first importance in connection with water-loss. The effect of a low degree of humidity is expressed in the numerous protections against water-loss manifested by xerophytes, while the result of a high degree of humidity is illustrated by the hydrophytes.

The force, constancy, and direction of winds are intimately concerned in the modification of other physical factors, and with various structures and functions in plants. Winds emphasize the effect of low humidity in the case of xerophytes, and tend to overcome the influence of great humidity in the case of hydrophytes. They decrease the water-content of the soil very materially in xerophytic situations. Winds exert a pronounced influence upon the condition of the sky and the relation of the latter to dew. Their bearing upon precipitation is best seen in open, hilly countries where the summits are constantly swept bare of snow which is piled high in hollows and canyons. Notable results of the action of winds are to be found in sand-hills, blow-outs, dunes, beaches, and surf. The peculiar nature of such situations is a direct

expression of wind agency, and their vegetation is largely developed with reference to this factor. The effects of the direct action of wind upon plant-form are shown on plains and steppes, along mountain ranges and seashores. The prevalence of forceful winds over plains and steppes is explanatory in a large degree of the absence of forests and of the characteristic presence of grass vegetation. On mountain ridges, especially at the heads of canyons, winds exert a powerful influence upon the branching of trees, usually giving rise to unilateral branching, but in many cases apparently causing the development of excurrent trunks into deliquescent ones. Winds have had, of course, a predominant influence upon the structure of anemophilous flowers, and upon the development of coma, pappus, wings, etc., by which seeds and fruits are distributed. Tumble-weeds are excellent examples of wind agency. In consequence of the distribution of seeds, fruits, and plants, winds play a great part in the migration of species and in the extension of vegetation over plains and steppes. Such extensions take place in the direction of the prevailing wind, and in the case of many plains species can be accurately determined from year to year.

Precipitation. Vegetation is indirectly affected by precipitation through the relation of the latter to other factors, such as atmosphere, soil-composition, physiography, and water-content. The period of precipitation determines, in subtropical climates, the growing period of the year. The time of day of precipitation has a direct bearing upon the various protective contrivances of the flower. The kind of precipitation, whether rain, dew, snow, sleet, or hail, has much to do with its effect. A covering of snow is a protection to vegetation and to underground parts, while both snow and sleet, by reason of their weight, call forth certain modifications in the form and arrangement of branches. Excessive precipitation in connection with physiography results in the distribution of great quantities of seeds by surface drainage. With reference to their behavior toward precipitation, plants are ombrophilous, or rain-loving, or ombrophobous or rain-

fearing. These two groups correspond in some degree to hydrophytes and xerophytes respectively. A considerable number of hydrophytes, however, are remarkably ombrophobous while many xerophytes are ombrophilous.

Physiography. Elevation, slope, and exposure exert a pronounced effect upon all other physical factors, especially heat, light, water-content, and soil. The direct influence of physiographical factors is best seen, however, in the migration and distribution of plants. Drainage basins furnish natural pathways for the extension of vegetation, and are hence conductive in the direction of their length. Physiographical features, such as mountain ranges, large streams, and other great bodies of water, are barriers to vegetation advancing toward them, and are obstructive to migration. Such barriers produce lines of stress and are of primary importance in zonation and in the arrangement of the floral covering.

BIOLOGICAL FACTORS.—The influence of animals, especially man, upon vegetation, and the reaction of vegetation upon vegetation are direct ecological factors of great importance. The effects of animal agency are to be seen in protective devices in pollination, in dissemination, and in ruderal formations. The effect of plants upon plants is of much deeper significance. Out of it rise primary factors, such as stabilization, forward pressure, and the various laws of coordinate and subordinate association. Coordinate association produces zones, formations, and species-guilds (*Artgenossenschaften* of Drude). Subordinate association gives rise to layers and to plant societies, epiphytes, parasites, etc. (*Genossenschaften* of Schimper). A brief consideration of those biological factors will be found in the chapter on plant formations.

Habitat-groups.—When species are looked at from the point of view of phylogeny and taxonomy, they are classified in the several groups of the natural system; when looked at from the point of view of the effect of habitat and of environment upon the plant-body, they are divided into vegetation-forms;

when considered with reference to the habitats in which they occur they are arranged in habitat-groups. All of these are groups of species. When we look at the floral covering and attempt to distinguish its constituent parts, we find them set off in formations. A formation is a piece of the floral covering, not a group of species. A habitat-group is a group of species which are subject to similar physical conditions and frequent like habitats.

While the term habitat-group has been restricted to a group of species put together by reason of occurrence in like habitats, it might be applied to a different conception, namely, to the aggregate of individuals found within a certain habitat. The latter application of the term would be more natural, but in such case the conception of a habitat-group would correspond closely to that of a formation, and the two terms would be synonyms. In dealing with a flora phytogeographically, it is desirable to regard it from several standpoints. Since the conception of the habitat-group here adopted permits us to consider the flora from an additional point of view, and to express the part played by the various species to better advantage, it has been preferred.

The general habitat-groups in our territory are 16.

I. Hydrophytes.

1. Floating or submerged plants of ponds, small lakes, and streams in I-III..... 43
2. Amphibious plants of marshes and margins of ponds and streams in I-IV.....152
3. Inhabitants of wet meadows and wet sand-bars in I-IV 44

II. Xerophytes.

4. Inhabitants of rocky bluffs, hills, and ridges in I-IV 44
5. Inhabitants of high prairies in I-IV, sand-hills in III, and table-lands in IV.....247
6. Inhabitants of submontane table-lands and foot-hills in IV 85

III. Halophytes.

7. Inhabitants of salt basins, and alkaline marshes
in II and IV 11
8. Inhabitants of alkaline ponds in II and IV..... 1

IV. Hylophytes.

Woody plants.

9. Woody plants of forest formations chiefly in
I-II 55
10. Woody plants of open woodlands and thickets in
I-IV 31
11. Woody plants of banks of streams and low mead-
ows in I-IV 9

Herbaceous plants.

12. Inhabitants of deep, shady woods chiefly in I-II. .106
13. Inhabitants of open woodlands, edges of woods,
and thickets in I-IV111

V. Poophytes.

14. Inhabitants of meadows and low prairies in I-IV .188
15. Inhabitants of dry, grassy banks of streams in
I-IV 46

VI. Aletophytes.

16. Ruderal species and introduced species of spor-
adic occurrence165

Statistics, ecological, biological, and distributional, of the taxonomic groups.—The natural groups of the lower plants have been treated with sufficient fulness in a prior chapter. Few of them have any especial phytogeographical importance with us, and, to avoid repetition, it has been thought best to dispose of them finally in one place.

Pteridophyta.—The first group in the natural system which it becomes necessary to consider is the Pteridophyta. All of the Pteridophytes have been placed in the vegetation form of the ferns. In our flora they are represented by 15 genera and 25 species distributed among 6 families as follows: Equisetaceae, 1 genus and 7 species; Isoetaceae, a single species; Filicaceae, 9 genera and 12 species; Selaginellaceae, 1 species; Salviniaceae, 1 species; Ophioglossaceae, 1 genus

and 2 species. Their regional distribution has been given in the preceding chapter.

Considered ecologically, the Pteridophytes may be divided into the following habitat-groups:

1. Growing in humus in the shade of forest formations,
I-IV 8
2. Xerophilous species, growing on rocks, I-IV..... 3
3. Inhabitants of low, wet meadows, or of springy situa-
tions, I-IV 5
4. Inhabitants of high, dry sand-hills, I-IV..... 1
5. Inhabitants of dry, grassy meadows, I-IV..... 8

(1) Woodland ferns. Two of these, *Cystopteris fragilis* and *Botrychium virginianum*, though growing most abundantly and luxuriantly on the shady bluffs of region I, occur sparingly in favored situations throughout the prairie and the sand-hill regions, again attaining considerable abundance in the deep canyons of the Pine Ridge district. *Adiantum pedatum*, an eastern species, is confined entirely to the woodlands of the lower Missouri. Of the remaining 5 species, 4, *Dryopteris spinulosa*, *D. cristata*, *Woodsia obtusa*, and *Asplenium filix-foemina*, are found only in dark thickets and woodlands in the canyons of region III. *Woodsia oregana*, though occurring in shady situations in region III, occasionally ventures out upon the denuded buttes of the Bad Lands.

(2) Xerophilous ferns. The 3 species of this group are exceedingly rare. One, *Notholaena nivea dealbata*, grows upon dry limestone rocks along the bluffs of region I. Another, *Pellaea atropurpurea*, haunts similar situations in region I, but is found in the crevices of sandstone rocks at a single station in region II. *Cheilanthes lanuginosa* occurs on high, barren rocks in regions III and IV, a situation to which its dense, woolly covering has adapted it.

(3) Hydrophilous fernworts. Of this group, one, *Marsilea vestita*, grows throughout the State, most frequently occurring as terrestrial in the eastern portion and as amphibious or even aquatic in the foot-hill region. *Onoclea sensibilis*,

which, in addition to being hydrophilous, is generally also ombrophilous, occurs in boggy and springy situations, chiefly in regions III and IV, rarely in region I. *Dryopteris thelypteris* is one of the characteristic plants of wet meadows throughout region III. Two other members of this group, *Azolla caroliniana* and *Isoetes melanopoda*, have each been found in the State once.

(4) Sand-hill fernworts. The sole representative of this group is *Selaginella rupestris*, which often forms a dense carpet upon high, barren hills and buttes in region IV, and occurs in small carpet-like mats on sand-hills in region III.

(5) Meadow fernworts. This group is composed entirely of species of the genus *Equisetum*. Three, *E. arvense*, *E. laevigatum*, and *E. robustum*, occur throughout upon low prairies and meadows, sometimes wandering into wetter situations along the banks of streams, along ditches, or upon sand-bars. *Equisetum hiemale* and *E. variegatum* are confined to low sandy meadows of region III, while *E. pratense* is recorded for similar situations in the Hat creek basin.

Gymnospermae.— The Gymnosperms are represented in Nebraska by 2 genera and 3 species, all of them needle-leaved evergreens. Of these, 2 are trees and 1 is a shrub. Region IV contains all three species; regions I and III, 2 each. The 3 species might fall into two groups, the one comprising both species of *Juniperus*, which are members of forest formations, the other including *Pinus scopulorum*, which is really a xerophilous species of the northwestern sand-hills and of the foot-hills. The latter will be considered more fully hereafter.

MONOCOTYLEDONS.

Alismaceae-Lemnaceae. — This division includes the following families: *Alismaceae*, represented by 2 genera and 6 species; *Naiadaceae*, with 5 genera and 20 species; *Typhaceae*, with 2 genera and 2 species; *Aroideae*, with 2 genera and 3 species; and *Lemnaceae*, with 3 genera and 6 species—a total of 14 genera and 36 species. These are distributed as follows:

	Alism.	Naiad.	Typh.	Aroid.	Lemn.	Total.	Peculiar.
Common to the four regions.....	1	1	2	0	1	5	..
I. Wooded bluff, etc., region..	3	3	2	3	3	14	3
II. Prairie region.....	4	9	2	2	2	19	5
III. Sand-hill region.....	2	16	2	1	5	26	10
IV. Foot-hill region.....	1	6	2	0	3	12	0

The species are distributed among the following vegetation-forms:

(13) Bulb and tuber plants.....	3
(17) Floating plants.....	5
(18) Submerged plants.....	20
(19) Amphibious plants.....	8

Five habitat-groups may be distinguished as follows:

1. Floating plants of ponds and sluggish streams, I-IV....	5
2. Submerged plants of ponds and streams, I-IV.....	20
3. Inhabitants of marshes, wet meadows, and sand-bars, I-IV.....	9
4. Halophyte, in saline ponds in II, and alkaline ponds in III.....	1
5. Shade plants, I-III.....	2

The interdependence of distributional data, of vegetation-forms, and of habitat-groups, and the close connection of these, are well illustrated in this division. Region III, which is characterized by numerous ponds and lakes, possesses, out of a total of 36 species in the State, 26, of which 10 are peculiar to the region. Moreover, all but two of the species of these families are water plants.

(1) Floating plants of ponds and sluggish streams, I-IV. The only plant of this group which is a frequent constituent of the floral covering is *Spirodela polyrhiza*, an inhabitant of the surface of ponds and streams throughout the State. The others, *Wolffia brasiliensis* and three species of *Lemna*, are of the rarest occurrence.

(2) Submerged plants of ponds and streams, I-IV. With four exceptions, these are species of the genus *Potamogeton*, and are in general characteristic of the clear streams and ponds of region III. *Potamogeton natans*, however, occurs throughout the State, while *P. foliosus* and *P. ampli-*

folius are equally common in regions I and II. The two species of *Naias*, *N. flexilis* and *N. guadalupensis*, have been found in but a single station outside of region III. *Lemna trisulca* occurs abundantly in the shallow spring pools along the Missouri, the Niobrara, and the swift streams of region III, and also in small pools in the sand-hills. The cosmopolitan *Zannichellia palustris* grows throughout the State indifferently in the muddy pools of the eastern portion or in the clear, sandy pools of the sand-hills and foot-hills.

(3) Inhabitants of marshes, wet meadows, and sand-bars, I-IV. This group contains three widely distributed marsh plants, *Sparganium eurycarpum*, *Typha latifolia*, and *Alisma plantago-aquatica*, which grow across the State from the muddy marshes along the Missouri to small swampy places about springs in the western foot-hills. In addition to these, *Triglochin maritima* haunts wet, sandy situations throughout regions III and IV, and often wanders down into region II; in region IV it is not infrequently a halophyte as well. Here also belong several species of *Sagittaria*, which, in their various forms, abound in pools and marshes throughout. A single species, *Acorus calamus*, is confined to a particular locality. It is found in swamps along the lower course of the Missouri.

(4) Halophyte in saline ponds in II and alkaline ponds in III. The single species here included, *Ruppia occidentalis*, occurs in the salt basins in the Blue river district of region II and sparingly in isolated alkaline ponds in region III.

(5) Shade plants in regions I-III. The two species here included, *Arisaema triphyllum* and *A. dracontium*, are confined to deep shady woods along the bluffs and ravines of the Missouri and along the larger streams in region II. *Arisaema triphyllum* has wandered some distance up the Republican and the Niobrara into region III, where it occurs sparingly in the thicket-like, woody formations.

Graminaceae.—This family is represented with us by 50 genera and 161 species. They are distributed as follows:

	Species.	Peculiar.
Common to the four regions.....	29	..
I. Wooded bluff, etc., region.....	72	3
II. Prairie region.....	81	16
III. Sand-hill region.....	119	20
IV. Foot-hill region.....	89	13

Classified according to vegetation-forms, they fall exclusively into the following three groups:

- (10) Sod-grasses61
- (11) Bunch-grasses58
- (19) Amphibious plants16

The chief genera, considered numerically, are *Poa*, represented by 16 species; *Panicum*, by 13; and *Sporobolus*, by 11. The grasses which are common to the four regions are, on the one hand, introduced species, which are weeds for the most part, such as *Panicum capillare*, *Eragrostis major*, and *Hordeum jubatum*, but also such native species as *Aristida purpurea*, *Schedonnardus paniculatus*, *Koeleria cristata*, *Distichlis spicata stricta*, *Bulbilis dactyloides*, *Bouteloua oligostachya* and *B. curtispindula*, *Bromus ciliatus*, *Andropogon scoparius*, and *Agropyron pseudorepens*.

The members of this family in our flora may be divided into the following habitat-groups:

- 1. Inhabitants of low prairies and meadows.....41
 - 2. Hydrophilous species of marshes, edges of streams, and pools, wet sand-bars, and wet meadows.....16
 - 3. Xerophilous species of high prairies and sand-hills....42
 - 4. Frequenters of woods and thickets, especially along the banks of streams22
 - 5. Halophyte occurring in alkaline as well as saline situations 1
 - 6. Ruderal grasses, inhabiting old fields, roadsides, and waste places; also introduced grasses of sporadic occurrence22
 - 7. Grasses of very diverse habitat 4
- (1) Inhabitants of low prairies and meadows.—

Of this group, the most important species in the constitution of the floral covering belong to the genera *Elymus*, *Agropyron*, and *Spartina*. Of these, the most abundant and widely distributed is *Elymus canadensis*, which occurs in meadows throughout the State, and in the sand-hills not infrequently becomes entirely xerophilous in habitat. *Elymus elymoides*, *E. macounii*, and *E. condensatus* are found sparingly over the prairies of regions III and IV. The most common species of *Agropyron*, *A. pseudorepens* and *A. tenerum*, are abundant in meadows and through the canyons of region IV. *A. violaceum*, *A. dasystachyum*, and *A. caninum unilaterale* are somewhat less common in similar situations. *Spartina cynosuroides*, which occurs in lowlands throughout the State, is the characteristic grass of extensive low meadows and ravines throughout regions I and II. *Spartina gracilis*, which is confined entirely to the western portion of the State, never assumes more than a secondary rôle. In numbers the genus *Poa* is an important member of this group. With the exception of *P. pratensis*, *P. arida*, and *P. compressa*, which are most abundant in the eastern portion of the State in low meadows and ravines, the species of this genus are of rare occurrence. *Stipa spartea* in the eastern half of the State covers extensive tracts of low prairie land.

(2) Hydrophilous species of marshes, edges of streams and pools, wet sand-bars, and wet meadows. The most widely distributed of these are *Phragmites phragmites*, which occurs in marshes throughout, and *Homalocenchrus oryzoides*, which, though found along the edges of ponds in I and II, grows most luxuriantly in the cold spring branches of III and IV. All our species of *Panicularia* and *Puccinellia* belong to this group. *Panicularia nervata* is a common grass of pools and streams throughout regions II, III, and IV. *P. americana*, which occurs frequently in the sand-hill region, has been reported for a single station along the Missouri. *Scolochloa festucacea* and *Beckmannia eruciformis* are apparently entirely confined to region III, while *Catabrosa aquatica* occurs likewise in IV. The only peculiarly

eastern species is *Eragrostis hypnoides*, which forms dense, carpet-like patches on both muddy and sandy banks throughout I and II. *Phalaris arundinacea*, *Diplachne fascicularis*, and *Zizania aquatica* occur in both II and III. They are, however, abundant only in the latter region.

(3) Xerophilous species of high prairies and sand-hills. From the prevailing conditions of moisture in the State, the members of this group belong chiefly to regions III and IV, though there are not a few of wide distribution which abound on high prairies in region II and occur occasionally on bare bluffs in region I. The most universal grass of this sort is *Aristida fasciculata*, which seems to thrive equally upon the hills of the eastern part of the State and the parched sand-hills and buttes of the western part of the State. In all four regions it not infrequently gives a decided character to the floral covering in late summer and autumn. On very dry and barren hilltops throughout the State the dense tufts of this grass are often the sole vegetation. A grass of similar nature and equally wide distribution is *Andropogon scoparius*. This species, however, does not confine itself to extremely dry, barren situations, but often loses its xerophilous habit to a considerable extent, and passes from the hillsides into low prairies and even meadows. In its characteristic habitat it is a typical xerophyte. Like *Aristida purpurea*, it occurs in great abundance on the summits and slopes of high ridges, and it is the prevailing and characteristic grass of the sand-hills of region III. In the sand-hills, the tufts of this grass alone often prevent the formation of blow-outs, the roots preventing the sand from being blown away. In consequence, and from the fact that blowing sand lodges in the dense tufts, the grass gives a very peculiar appearance to exposed hillsides and hilltops, the tufts or bunches standing out the more prominently since the bases of the culms are often 10 to 15 centimeters above the surface of the sand. In direct contrast to the grasses just mentioned, are buffalo-grass, *Bulbilis dactyloides*, and the grama grasses, *Bouteloua oligostachya* and

B. curtipendula. These three, which are very similar in habit, are the most widely distributed of our xerophilous grasses. Among them the buffalo-grass probably takes first rank. It is the most constant xerophilous grass of wide distribution within our limits. Although it occurs from the low prairies of region I to the extremely dry table-lands of region IV, it is always to be found on the most exposed slopes. No other grass of this class is comparable to it as regards the formation of a dense sod; perhaps *Poa pratensis* is the only one of all our grasses that approaches buffalo grass in this respect. Throughout the Niobrara country, in the dry valleys of the sand-hills, on the western table-lands, and even in some favored localities in region I, it maintains an undisturbed stand against the encroachments of other species. It is unique among our grasses in its habit of forming large areas of sod by means of long runners which root at the nodes. These runners give rise to small patches of a more or less circular appearance. In large areas covered solely by buffalo-grass the floral covering presents a peculiar appearance due to the pseudo-diclinism of the species. In one part, the sods send up great numbers of crowded culms bearing at the top the yellowish staminate spikes. In other parts, the peculiarly leafy stalks of the pistillate flower give a knotted appearance to the sods. Looked at from a hilltop, the floor of a dry valley inhabited by buffalo-grass has a mottled aspect, the yellowish patches of the staminate flowers and the greenish patches of the pistillate flowers being distinguished from a considerable distance. The taller flowering culms of the grama grasses, wherever the latter occur over large areas, give a somewhat similar appearance to the floral covering. In general, however, these grasses occur in small patches of a few decimeters, especially in typically xerophytic situations. The buffalo-grass is never to be found on the sparsely covered sand-hills of region III. But the grama grasses are frequent inhabitants of such situations, and here they manifest the peculiarity already spoken of in the case of *Aristida fasciculata* and *Andropogon scoparius*,

the patches of sod rising above the general level of the sand. These patches are very small, but are as exclusive as the larger areas of *Bulbilis*. It is only in the intervals that other plants are to be found. In the prairies in region II, and in wet valleys in region III, both species, but chiefly *B. oligostachya*, form thick sods often comparable to those of buffalo-grass. In such habitats, though normally rarely more than 2 decimeters high, the flowering culms often attain a height of 7-8 decimeters, and then, with their dark purple spikes, are a striking feature of the floral covering.

The most typical xerophytes among the grasses are confined almost wholly to the sand-hill region, and particularly to the Loup district. Of these, the most constant in habitat is *Redfieldia flexuosa*. This grass is almost wholly confined to the blow-outs. So far as is known at present, it has been found at but a single station outside of the region of blow-outs, and in the sand-hills it is to be met with in every blow-out, and nowhere else. Its constant companions in blow-outs are *Oryzopsis cuspidata*, *Stipa comata*, and to a less extent *Muhlenbergia pungens* and *Munroa squarrosa*. The four latter are not like the former—exclusively inhabitants of blow-outs—but occur as well on the sand-hills. The ridges and slopes of the sand-hills possess a grass flora of their own, of which, after *Andropogon scoparius*, *Stipa comata* is the predominant member. This grass grows in thin tufts composed of but a few stems, which are scattered rather thickly over the hills. It does not form bunches like *Andropogon scoparius*, since the tufts are too thin to hold sand, and the individuals too few to prevent sand from blowing away. But its tufts occur more frequently in areas occupied by the bunch-grass, growing between the more scattered tufts of the *Andropogon*. Next in importance to *Stipa comata* are *Andropogon hallii* and *Calamovilfa longifolia*. A striking peculiarity of these two grasses is that the former with its tall, blue culms and leaves is confined to the crests and upper slopes of the hills, while the dense, ragged bunches of the latter, with their pale stems, occupy the lower slopes, and

contrast sharply with the tall, straight stems of the *Andropogon*. It is notable that the two rarely intermingle, though they are almost invariably associated on the same hill. On the broad tops of some sand-hills, *Sporobolus cryptandrus* is a distinctive grass, not so much on account of its abundance, since the individuals are always single and more or less scattered, as on account of its long, ascending culms and its lead-colored panicle. In like situations is frequently found *S. cuspidatus*, which grows in low, dense tufts, but is never so striking. On those hills on which *Andropogon hallii*, *Calamovilfa longifolia*, and *Sporobolus cryptandrus* occur, a common grass of the intervals is *Bouteloua hirsuta*, sometimes associated with *B. oligostachya*. On certain sand-hills, however, particularly those which rise immediately back of the Niobrara river, the two latter are supplanted to a great extent by *Aristida gracilis* and *A. basiramea*, which sometimes take as complete possession of the soil here as does *Aristida purpurea* in other localities. A typical sand-hill grass of somewhat curious habitat is *Eragrostis trichodes*, which, though growing in the most sandy of situations, is rarely, if ever, found on the hills, but occurs regularly in sandy valleys where the soil has been slightly disturbed and in the passes between wet valleys in the Loup district. Two or three sand-hill xerophytes, though they occur at rare intervals throughout the region, are confined mostly to sandy ravines and to sand-draws. Such are *Munroa squarrosa*, with its peculiar, spreading mats, the small, delicate sand-grass, *Sieglingia purpurea*, and more rarely *Paspalum setaceum*. Two grasses of wide distribution in the sand-hill region are particularly important because of their abundant occurrence in prairie-dog towns. *Aristida oligantha*, which is elsewhere rare in sandy meadows, grows here in such profusion as to form a thick, though rather incoherent sod, while *Schedonnardus paniculatus*, which affects dry, barren slopes throughout the State, is not less abundant, and is especially characteristic of prairie-dog towns in the Platte district.

(4) Frequenters of woods and thickets, especially

along the banks of streams. The characteristic grasses of this division are naturally to be found along the wooded bluffs and ravines of the Missouri, though many occur likewise in dense thickets or in deep, wooded canyons throughout the unforested regions III and IV. *Cinna arundinacea* and *Korycarpus diandrus* are uniformly inhabitants of deep woods, chiefly in regions I and II. Neither grows in profusion, and both usually occur in secluded spots. Among others which, though frequently growing in shady situations, occur sometimes in more exposed places along the bluffs of the Missouri, are *Festuca nutans* and *Hystrix hystrix*, both bunch-grasses, which are to be met with here and there in widely separated tufts. Of similar habit are *Melica cuspidata* and *Oryzopsis micrantha*, the former confined to somewhat dense woods of the eastern portion of the State, the latter growing not only in deep recesses along the Missouri bluffs, where it attains a length of about a meter, but likewise on the dry bluffs of the Niobrara and in dry canyons in the Hat creek basin. In dense thickets and copses in the northern and eastern portions of the State, where there is little other herbaceous vegetation, *Elymus striatus* is the sole grass. Like others of the genus, it is not in strictness to be classed either as a bunch-grass or as a sod-grass. Its long, slender culms and drooping spikes are a peculiar feature of the wooded bluffs where it grows. The two most common grasses of this group are *Bromus ciliatus* and *Muhlenbergia racemosa*, both of which occur throughout the State. They are rarely to be found in deeply shaded localities, but prefer open woodlands or the borders of thickets along streams, where they frequently form dense patches. Both, but the latter especially, when they occur in forest formations, grow scattered and do not attain normal height. In regions I and II, in the more open woods, *Elymus virginicus* forms a somewhat dense growth, in general taking entire possession of the ground to the exclusion, not only of other grasses, but of all herbaceous forms as well. In the wooded canyons of the Bad Lands several species of

Bromus and two or three species of *Poa* are of frequent occurrence.

(5) Halophytes, occurring in alkaline as well as in saline situations. There is but a single halophyte among our grasses, though one other grass sometimes becomes more or less halophilous. *Distichlis spicata stricta* occurs throughout the State, though it is rarely found in region I. It has so thoroughly established itself as a halophyte that its mere presence is taken as sufficient evidence of an alkaline or saline soil. As it usually occurs in sods, it is often the only inhabitant of considerable stretches of alkaline wastes. It never grows, as some of our halophytes, in a soil thoroughly impregnated with salt, but is to be found in great abundance in the near vicinity of such spots.

(6) Ruderal grasses, inhabiting old fields, roadsides, and waste places; also introduced grasses of sporadic occurrence. Most of the grasses of this group belong to the four genera, *Panicum*, *Chaetochloa*, *Hordeum*, and *Eragrostis*. In addition to these, *Cenchrus tribuloides* and *Sporobolus vaginiflorus* occur in waste places, old meadows, and along roadsides. In this group are included a few introduced or purely adventitious species, such as *Bromus secalinus*, *Phalaris canariensis*, and *Lolium perenne*.

(7) Species of very diverse habitat. This group includes four grasses which occur throughout the State in such diverse habitats that it is impossible to place them in any of the foregoing classes. The most important of these is *Andropogon furcatus* which occurs in low meadows and along roadsides in regions I and II, on the sand-hills in some localities in region III, and on the table-lands of region IV. Of similarly diverse habitat is *Agropyron pseudorepens*, which, occurring on low meadows and low prairies throughout the State, in many localities is essentially a halophyte. The same is true to some degree of *Agropyron spicatum*, which is one of the commonest inhabitants of high table-lands of region IV, and is also a common halophyte. *Elymus canadensis*, which is normally an inhabitant of low mead-

ows and low prairies from region I to IV, often covering areas of several hectares in extent, grows scatteringly in the sand-hills, where it becomes almost xerophilous. *Koeleria cristata* grows throughout except in shady situations. It is, perhaps, of greatest interest because it is the only native grass which is a vernal bloomer.

Cyperaceae. — The Cyperaceae in our flora number 10 genera and 89 species, of which *Carex* alone contains 52, being thus the largest genus of flowering plants within our limits. The species are distributed as follows:

	Species.	Peculiar.
Common to the four regions.....	6	..
I. Wooded bluff, etc., region	32	9
II. Prairie region.....	48	14
III. Sand-hill region.....	51	16
IV. Foot-hill region	17	3

The following seven species occur throughout the State: *Scirpus lacustris*, *S. americanus*, *Eleocharis palustris*, *E. acicularis*, *Cyperus inflexus*, *Carex hystericina*, and *C. vulpinoidea*. It should be noticed that all but one of these species belong to the same vegetation-form and to the same habitat-group, amphibious plants, inhabitants of marshes and edges of ponds and streams.

Three vegetation-forms are represented in our sedges:

- (10) Sod-formers22
- (11) Bunch-grasses and sedges.....26
- (19) Amphibious plants33

The first two groups are constituted almost wholly by species of *Carex*, while the latter consists almost entirely of species of *Scirpus*, *Cyperus*, etc.

The family exhibits the following habitat-groups:

- 1. Inhabitants of low prairies and meadows I-IV.....16
- 2. Hydrophytes of the edges of ponds and streams, wet meadows and sand-bars, and marshes, I-IV.....48
- 3. Xerophilous prairie or sand-hill plants I-IV.....12
- 4. Inhabitants of high, more or less shaded bluffs, chiefly in I 9

(1) Inhabitants of low prairies and meadows. Cyperaceae rarely play an important part in the floral covering of low, dry meadows and prairies. Out of the 16 species of this group, but 4, *Scirpus atrovirens*, *Carex vulpinoidea*, *C. trichocarpa*, and *C. scoparia*, occur in sufficient abundance to give character to the floral covering. The first, which with its variety, *Scirpus atrovirens pallidus*, extends through the entire State, frequently covers considerable areas in low meadows. It is, however, frequently amphibious, especially in meadows which are wet during only a part of the year. In the vicinity of saline basins in region II it sometimes becomes a halophyte, in situation at least, though perhaps only through stress of circumstances. *Carex vulpinoidea*, especially in regions I and II, is the most characteristic sod-forming sedge, often covering meadows to the exclusion of the ordinary grasses. *C. trichocarpa*, though of less frequent occurrence, assumes a like rôle in the floral covering of meadows. *C. aurea*, which is confined almost wholly to the foot-hill region, often assumes more or less of the character of a sod-former, though, on account of its small size and the thinness of its sods, it is usually overtopped by stronger forms. In such cases the floral covering becomes a thick carpet, into the coarser, taller elements of which are densely interwoven compact tufts of this sod. With the exception of *Cyperus esculentus*, *C. acuminatus*, and *Stenophyllus capillaris*, the other members of this group have been found only in single stations, and hence are of little importance. The three species mentioned, though occurring more or less widely over the prairie and sand-hill regions, are never abundant and rarely affect the complexion of our meadows.

(2) Inhabitants of edges of ponds and streams, wet meadows and sand-bars, and marshes. The most striking genus of this group, and the one which plays the most important and the most conspicuous part in the marshes and wet meadows throughout the State, is *Scirpus*. The most widely distributed species is *S. lacustris*, which haunts wet, sandy, or muddy situations everywhere. It is found almost

invariably in one of two favorite situations, either occurring along the muddy banks of ponds and streams as a narrow fringe, or growing in compact patches in the midst of swamps. Wherever it occurs, its straight, leafless culms, with their drooping, brown panicles, have undisturbed possession of the muddy or sandy situations in which they grow. *Scirpus fluviatilis*, though often the companion of *S. lacustris*, generally prefers the deeper and more inaccessible portions of swamps, growing to a great height and completely covering large areas. In the deep swamps along the Missouri river, *S. fluviatilis* forms what seems at a distance an almost impenetrable jungle, and reaches here its maximum height of 3-5 meters. This compact appearance, however, results from the leafy nature of the stems, and in reality numerous marsh plants and aquatic plants occur in such formations, growing between the towering stems of the rush. *Scirpus americanus*, which, compared with the two preceding, is diminutive, usually affects sandy situations. It grows most abundantly about springs in the sand-hills and about the sandy margins of lakes and streams. *Eleocharis palustris* rivals *Scirpus lacustris* in the importance it assumes in wet meadows and boggy tracts. It is common throughout the State, but reaches its maximum of development in the sand-hills, although it covers extensive areas throughout the lowlands of the Missouri and grows intermingled with amphibious sedges in the wet meadows of region II. In the marshes which abound in wet valleys near the head waters of most of the sand-hill streams, and particularly along the edges of wet marshes and back from the swampy margins of shallow sand-hill lakes and ponds, *Eleocharis palustris* forms a green carpet unexcelled in compactness by any sod-forming grass. In such situations this species usually is the sole constituent of the floral covering, except here and there where a few stragglers of *Oxygraphis cymbalaria* creep in. Often, however, the culms stand less thickly together, and *E. acicularis* forms a sort of second layer in the covering. The latter is also found grow-

ing in low, tufted patches, which simulate mats, upon the margins of sand-bars and sandy banks. The hydrophilous species of *Cyperus*, though not confined entirely to the sand-hill region, form a distinctive feature in many parts of it. *C. strigosus* is usually present on the sandy margins of the innumerable springs and spring branches throughout the region. Almost equally common and even more distinctive are *C. diandrus* and *C. rivularis*, the latter with its dark purple-brown spikelets giving especial prominence to certain situations. The most widely distributed species is *C. inflexus*, which, though occurring occasionally in the other three regions, is in some senses peculiarly a sand-hill plant. Its occurrence elsewhere may be accounted for by its wandering down upon the sand-bars of the other regions from its characteristic haunts, i. e., the wet sandy meadows and sand-bars of region III. *C. erythrorhizos* and *C. engelmannii*, though comparatively infrequent, should be mentioned on account of their peculiarly striking appearance. The former has been recorded for a single station in region II and one in region III; the latter has been found but once in region I. *Hemicarpha micrantha*, which almost always favors wet sand-bars, grows not uncommonly in delicate tufts in connection with *Cyperus rivularis*. On the other hand, where *Cyperus rivularis* occurs in the wet edges of pools, it is very commonly associated with *Fimbristylis spadicea*. The most important hydrophilous carices are those which form a rather dense covering in wet meadows. Such are *Carex filiformis* and *C. lanuginosa* in the western portion and *C. stricta* and *C. aristata* in the eastern portion of the State. Others, such as *C. hystericina*, *C. lupulina*, and *C. lurida*, are most often confined to swampy situations. The latter, especially, is predominant in muddy marshes along the Missouri.

(3) Xerophilous prairie or sand-hill sedges. With a single exception, this group is made up entirely of species of *Carex*. The exception is *Cyperus schweinitzii*, which is the most distinctive xerophyte of the group, and one of the

typical sand-hill plants of our flora. A striking peculiarity of this species is that while it is very abundant it is never massed. Even in the sand-hills, where it is often an important element in the floral covering, the individuals occur singly or in groups of two or three. On the foot-hills and table-lands of region IV *Carex stenophylla* plays a part of similar importance. But it is a bunch-sedge, and is in consequence more controlling. On high prairies of region II, another low bunch-sedge, *Carex pennsylvanica*, dominates the hillsides. This is often merely local. Thus, for instance, *C. pennsylvanica* is an important element in the floral covering of the high, rocky hills in the northern part of the region, while in the southern portion it is hardly noticeable except in the spring, when its prominent staminate spikes dot the prairies here and there. *C. straminea*, *C. gravida*, and *C. cephaloidea* are all more or less abundant, tall-growing bunch-sedges on the hillsides and in the dry ravines of regions I and II. *C. siccata*, *C. marcida*, and *C. muricata* are sedges intermediate between the bunch and the sod-forming forms in habit, and occur over considerable areas of dry prairies, especially in the dry valleys of region III.

(4) Inhabitants of high, more or less shaded, bluffs, chiefly in region I. This group is small in number, and its members are confined almost entirely to the bluffs of the Missouri river, though in a few cases they have wandered up the main tributaries into similar situations. Two species, *Carex rosea* and *C. laxiflora*, are common throughout region I on the Missouri bluffs, especially on steep and more or less exposed places. With them occur less frequently the delicate tufts of *Carex eburnea* and the tall, coarse bunches of *C. longirostris*.

Juncaceae.—This family is represented with us by the single genus *Juncus*, of which our flora exhibits 14 species. A single species, *J. tenuis*, grows throughout. Region I contains 2 species, region II, 4, with 2 peculiar, region III, 11, with 5 peculiar, and region IV, 7, with 1 peculiar. All of the species of this family as to vegetation-form belong to (20).

amphibious plants. They are, indeed, to be regarded as rather typical examples of this last group, since they are never true aquatics in any sense, and are always found confined to wet or marshy situations except in the case of *J. tenuis*, which adapts itself to very diverse habitats. Though typically amphibious, it is found not infrequently in low, dry meadows, and it has been found rarely in xerophytic localities on hillsides.

The rushes of our flora, though always hydrophilous, give character to two different portions of the floral covering. *Juncus tenuis* and *J. nodosus* often form nearly the entire covering of wet meadows in the prairie and sand-hill regions, where they not infrequently grow so dense as to simulate sod-formers. On the other hand, *J. bufonius*, *J. torreyi*, and *J. balticus* are typically inhabitants of low, wet sand-bars and the broad, sandy margins of lakes in region III. *J. longistylis* is confined to the margins of lakes in the same region. On the sand-bars, the two tall-growing species, *J. marginatus* and *J. alpinus insignis*, are to be found more rarely.

Liliaceae—Orchidaceae.—This group is represented by 29 genera and 50 species distributed among the following families: Liliaceae, with 17 genera and 28 species, Pontederiaceae, with 1 genus and 3 species, Commelynaceae, with 2 genera and 2 species, Hydrocharitaceae, with 1 genus and 1 species, Amaryllidaceae, with 1 genus and 1 species, Iridaceae, with 2 genera and 2 species, and Orchidaceae, with 5 genera and 13 species.

These are distributed as follows in the regions:

	Lil.	Pont.	Com.	Hydr.	Am.	Irid.	Orch.	Tot.	Pec
Common to the four regions.....	4	0	1	0	0	1	0	6	..
I. Wooded bluff, etc., region.	12	0	1	0	1	2	4	20	5
II. Prairie region.....	9	3	1	0	0	1	3	17	5
III. Sand-hill region.....	13	0	2	1	0	1	6	23	5
IV. Foot-hill region.....	15	0	1	0	0	1	6	23	13

Those which occur throughout the State are *Yucca glauca*, *Vagnera racemosa*, *V. stellata*, *Sisyrinchium bermudiana*, and *Tradescantia virginica*.

They arrange themselves according to vegetation-forms as follows:

(2) Shrubs	1
(4) Woody climbers	2
(9) Creepers	2
(12) Rootstalk plants	22
(13) Bulb and tuber plants	13
(18) Submerged aquatics	1
(19) Amphibious plants	3
(20) Saprophytes	3

As to habitat-groups, the species may be arranged as follows:

1. Xerophilous plants of high prairies, sand-hills, and foot-hills, I-IV	9
2. Shade-loving species of the deep forests, rooting in leaf mold	13
3. Growing in the edges of woods or in open woodlands, I-IV.	8
4. Plants of dry meadows and low prairies, I-IV.....	7
5. Hydrophilous species of muddy flats and spring banks, II-III	8
6. Hydrophilous species of pools and streams, III.....	1

(1) Xerophilous plants of high prairies, sand-hills, and foot-hills. The most widely distributed of this group is *Yucca glauca*, which grows on high, rocky hills in region I, on barren, sandstone hills in region III, and table-lands in region IV. From its evergreen, frutescent habit, *Yucca* is a striking feature of the floral covering wherever it occurs, especially when in bloom, on account of the long racemes of cream-colored flowers. As it invariably occurs in open formations on ridges and barren hills, where it has only to compete with sparsely distributed, low-growing herbs and bunch-grasses, it stands out prominently in the landscape and assumes additional importance. Notwithstanding its general occurrence over the State, *Yucca glauca* is a typical xerophyte, not merely in situation, but also in contrivances by which it compensates for its xerophilous habit. Like all

inhabitants of arid regions, its leaf system is greatly modified by the reduction in the number of leaves, by the compacting of the leaf tissue, and by the development of a highly specialized epidermis. *Yucca* is chiefly enabled to maintain itself as a xerophyte, however, by means of its extremely long, thick tap-root which often penetrates the soil to a depth of 3-4 meters. When it is remembered that in the sub-sand-hills of II and in the sand-hills of III there is often a persistent stratum of water at a depth of 2 or 3 meters, the occurrence of *Yucca* in the driest of situations is readily understood. In late spring, sandy plains of region III and the more or less sandy table-lands of region IV are brightened by the pure white flowers of the sand-lily, *Leucocrinum montanum*, which grows in the sand in the full blaze of the sun. With it often appear the purplish umbels of *Allium nuttallii* and more rarely those of *A. reticulatum*. On exposed hillsides of region IV, *Zygadenus elegans*, with its racemes of white flowers, is abundant in midsummer. A nearly related species, *Z. nuttallii*, has as yet been found at but a single spot along the Pumpkinseed. Hardly less rare is *Fritillaria atropurpurea*. The Commelynaceae are represented in our flora by two plants, which, though xerophytic as to habitat, present many points of departure from typical xerophytes. Thus, *Commelyna virginica*, while it is found in very exposed situations, on sandy bluffs and hillsides throughout region III, has the appearance of a hydrophyte. Its stem is thick and presents the characteristically turgid appearance of a water plant. *Tradescantia virginica* agrees in general, as far as plant-habit is concerned, with *Commelyna virginica*, but differs in its remarkable adaptability to extremely diverse habitats. One who knew the plant only from its habitats in region III would regard it as a xerophyte pure and simple, since here it is always confined to the sides and summits of sand-hills, and is most common on high, barren, sandy ridges. It is a very common inhabitant of blow-outs. On the other hand, one might traverse nearly the whole of region II without finding *Tradescantia* other than

amphibious. It generally occurs in low, wet meadows, and especially in the edges of ditches. As would be expected under these very diverse conditions, *Tradescantia* exhibits several different forms. Indeed, some of these have recently been set off as species, not without warrant, it would seem, if plants from different habitats were to be studied in the herbarium alone. A thorough field study of these many perplexing differences shows that they are mere modifications of one and the same species arising from its various situations. While this may be shown to a certain extent by a careful comparison of the forms in region II with those in III, it is demonstrated beyond a doubt on the sandstone hills in the southern part of region II. Here within a space of less than 100 meters the extreme forms of the species can be found. In the wet ditches along the railroad embankments, and often extending a short distance back upon the springy hillsides, *Tradescantia* is typically amphibious. It roots in the mud and sends up a thick, juicy stem often more than a meter in height, furnished with numerous long, flexuous leaves. The stems and leaves are invariably smooth and glaucous. The flower-cluster is always large, and the flowers themselves are much larger than in the ordinary forms. In addition, they are uniformly deep blue-violet in color. As one ascends the hillside, the first change noticed is a diminution in the size of the plant, followed by loss of its peculiar glossiness and the development of a few scattering hairs. At the same time, both the flower-cluster and the individual flowers diminish in size and manifest a tendency towards slight variation in color. Midway up the hill the plants are rarely more than three decimeters in height. Towards the top of the hill the stem grows shorter and shorter, the leaves become more reduced in number, the hairiness of the stem and leaves increases greatly, the flower-cluster is reduced to usually less than half a dozen flowers, and the flowers themselves become very small and are exceedingly variable in color. On the very hilltops the plants rarely possess more than two leaves, the stem is usually buried in the sand,

and with the leaves is densely hairy. In such situations the plants rarely display more than two or three small flowers, whose petals are almost invariably rose-red. It is evident that the plant which grows in wet situations at the base of the hill and that which is half buried in the sand of the summit represent but the extremes of a single species, since the hillside is covered with forms which represent almost imperceptible gradations. What is true of *Tradescantia* in the case cited must necessarily hold true for the different forms, however widely separated in habitat, of regions II and III. In fact, a similar progression from one form to the other is to be seen in passing from the prairies of eastern Box Butte county into the sand-hills of Sheridan county. In the former situation, *Tradescantia* grows about 3-4 decimeters high, with a strict, thick stem, is glaucous, and has large clusters of blue flowers. It passes gradually into the dwarf, hairy forms, with stems buried in the sand and small clusters of 2-3 purple flowers, characteristic of the blow-outs. That *Tradescantia* exhibits the same diversity in the heart of the sand-hills is shown in Rydberg's report,* where he says: "In eastern Nebraska this plant grows only in low lands with alluvial soil, but here it is found from the tops of the sand-hills down to the valleys, most commonly on the top."

(2) Shade-loving species of deep forests, rooting in leaf-mold. These obviously are almost wholly confined to two regions. They grow in deep recesses or along shady bluffs of the Missouri river, or are restricted almost entirely to the damp, shaded canyons of the Pine Ridge district. The several species of *Smilax*, however, possess a more extended distribution, one, *S. herbacea*, occurring in woodlands and in the deeper thickets of canyons and ravines along watercourses throughout the State. *S. hispida*, on the contrary, is confined to the bluffs of the Missouri, with the exception of a single station. Five species of this group are typical of canyons of the Pine Ridge district. Three of these,

* Contrib. U. S. Nat. Herb. 3: 181. 1895.

Corallorhiza multiflora, *C. corallorhiza*, and *C. striata*, have been found only in the damp recesses of Warbonnet canyon. The other two, *Habenaria hyperborea* and *H. bracteata*, abundant there along the wet banks of shady streams and about spring pools, occur also elsewhere. The former occupies similar situations along streams in the sand-hills, while the latter has been found in a single place on the Missouri bluffs. The members of this group which occur along the bluffs of the Missouri are all immigrants from the eastward, and in general have ascended but a short distance along the stream. The sole exception is *Erythronium americanum*, which is found along the bluffs of the Republican in Franklin county. This plant has ascended the Missouri only a short distance, its northern station being hardly more than 45 kilometers from the State line. Although one of the earliest plants to bloom with us, it is of relatively small importance on account of its restricted distribution. On the contrary, the nearly related *E. albidum* plays an exceedingly important part in the constitution of the early spring vegetation of woodlands, not only along the Missouri, but along a few of the principal streams of region II. Often in especially favorable spots it forms a glossy carpet, a hectare or more in extent, and this, when the plants are in bloom, gives a characteristic appearance to such woods. Three species, *Cypripedium pubescens*, *Orchis spectabilis*, and *Trillium livale*, are found only on the Missouri bluffs. The most northerly station for them is Bellevue. Each occurs singly, and but few individuals are to be met with in any locality. *Orchis spectabilis* grows at the base of the ravines in low, shaded situations. *Cypripedium pubescens* is found well up on the south side of the ravines, where the sun never penetrates. The latter is very conspicuous among the low ferns that cover the sides of the ravines.

(3) Plants growing in the edges of woods or in open woodlands. Of these the most important is *Vagnera stellata*, which grows in open woodlands and lowland thickets throughout the State. It is one of the earliest of the vernal

bloomers, and, from its habit of growing in extensive patches, its bright white racemes give a distinctive feature to open woods in early spring. Later in the year it is no less distinctive on account of its striped, bright purplish berries. Rather less common but even more striking is the larger, broader-leaved *V. racemosa*, whose broad, white panicles are the first objects to strike the eye in the thickets along the upper course of the Missouri and westward along the Niobrara. Scarcely less frequent than *Vagnera stellata* is *Polygonatum commutatum*. Notwithstanding its much greater size and more conspicuous foliage, it is never so distinctive as the former. This is due chiefly to the fact that it occurs when other vegetation is abundant, but partly to the peculiar inconspicuousness of its nodding, bell-shaped flowers. But *Polygonatum* is always prominent where it occurs, on account of its tall, somewhat nodding, stems and the striking arrangement of its large leaves. In addition to these, in the thickets of the western highlands, two species of *Calochortus*, *C. nuttallii* and *C. gunnisonii*, are especially conspicuous in the floral covering on account of their very large, solitary, purplish tinged flowers.

(4) Plants of dry meadows and low prairies. Of this group the most important by all odds is *Sisyrinchium bermudiana*, which, with its great abundance and wide distribution, is often the prevailing element in low prairies and meadows. In many respects it plays the rôle of a grass, though its colored flowers give it relatively more importance in the aspect of the floral covering. Of almost equal importance are the wild onions, *Allium mutabile* and *A. canadense*, which occur over large tracts of low prairie and pasture land. *Iris versicolor*, a plant of striking beauty and profusion in its few favored haunts, is of rather rare occurrence on the lowlands of the Missouri. It deserves to be ranked as the most gorgeous, if not the most beautiful, of our wild flowers. In similar situations, but more infrequent, is *Cypripedium candidum*, which with us seems to be a disappearing species.

(5) Hydrophilous species of muddy flats and spring banks II-III. The two principal genera of this group are *Gyrostachys* and *Heteranthera*, the former confined almost wholly to wet meadows and springy banks in region III, the latter entirely to muddy flats in II. Besides these, the showy *Lilium philadelphicum* and *Habenaria leucophaea* are common in the wet valleys of the sand-hills. The latter occurs also in region II, where, however, it is a disappearing species. It was formerly abundant in wet meadows in the Blue river district, but is now met with but rarely and occurs only scattered and at distant stations.

(6) Hydrophilous species of pools and streams, III. The single representative of this group, *Philotria canadensis*, is as yet of rather uncommon occurrence. In its few stations, however, it is to be found in the greatest abundance. It usually affects cool, shallow streams in region III. It has been found recently choking artificial ponds in the eastern part of the State.

DICOTYLEDONS.

Ranales—Polygalales.—With us this group contains 53 genera and 107 species, distributed among the following families: Ranunculaceae, 14 genera, 38 species; Anonaceae, 1 genus and 1 species; Menispermaceae, 1 genus and 1 species; Berberidaceae, 3 genera, 3 species; Nymphaeaceae, 3 genera, 3 species; Papaveraceae, 4 genera, 7 species; Cruciferae, 18 genera, 39 species; Capparidaceae, 4 genera, 5 species; Resedaceae, 1 genus, 1 species; Cistaceae, 2 genera, 3 species; Violaceae, 1 genus, 6 species; Polygalaceae, 1 genus, 3 species.

The species are distributed as follows:

	Ran.	Anon.	Menis.	Berb.	Nymph.	Papav.	Cruc.	Cap.	Resed.	Cist.	Viol.	Pol.	Tot.	Pec.
Common to the four regions	5	0	0	0	0	1	3	1	0	0	0	1	11	..
I. Wooded bluff, etc., region	24	1	1	2	2	6	19	3	1	1	5	2	57	14
II. Prairie region	14	0	1	0	2	3	21	1	0	3	4	1	50	12
III. Sand-hill region	16	0	1	0	1	1	15	4	0	2	3	3	46	3
IV. Foot-hill region	18	0	0	1	0	3	19	4	0	0	2	2	48	17

The following are the species common to the four regions: *Anemone cylindrica*, *Aquilegia canadensis*, *Batrachium trichophyllum*, *Oxygraphis cymbalaria*, *Delphinium carolinianum*, *Argemone intermedia*, *Lepidium intermedium*, *Roripa obtusa*, *R. palustris*, *Cleome serrulata*, *Polygala verticillata*. It should be noted that the largest and most typical genus of the whole group, *Ranunculus*, does not contain a single species distributed over the entire State.

The following vegetation-forms are represented:

(2) Shrubs	1
(3) Undershrubs	1
(4) Woody climbers and twiners	4
(6) Rosettes	7
(7) Mats	2
(9) Creepers and climbers	1
(12) Rootstalk plants	29
(13) Bulb and tuber plants	7
(15) Dicyclic herbs	6
(16) Monocyclic herbs	24
(17) Floating aquatics	3
(18) Submerged aquatics	7
(19) Amphibious plants	3

The species may be arranged in the following habitat-groups:

1. Frequenters of grassy meadows and low prairies, often in the edges of open woodlands. Vernal bloomers, I-IV	14
2. Amphibious hydrophytes, generally found growing in marshes, on sand-bars, or on muddy banks, not infrequently also in wet meadows, I-IV.....	19
3. Inhabitants of deep, shady woods in regions I and II, or of dense thickets along streams in regions III-IV, 25	
4. Xerophilous species almost wholly confined to the sand-hills, though occurring rarely in sandy situations in the foot-hill region, III-IV.....	4
5. Xerophytes of high prairies, sand-hills, and table-lands I-IV	17

6. Floating or submerged plants, I-IV..... 5
 7. Weeds growing in waste places or along roadsides; sparingly introduced species, I-IV.....16
 8. Prevernal bloomers of xerophytic situations, more rarely found in low meadows or in waste places, I-IV. 3

(1) Frequenters of grassy meadows and low prairies. In this habitat-group are comprised several of the most common and most characteristic of our vernal species. The two which play the most important part in the earlier aspect of the floral covering are *Capnoides montanum* and *Viola pedatifida*. The former generally occurs in dark green patches in low meadows and pastures and along river banks. Its dense racemes of yellow flowers usually appear before other vegetation has more than started. On the prairies *Viola pedatifida* plays a similar rôle. Its scattered tufts, with their glossy leaves and blue-purple flowers, are strikingly contrasted with the stiff leaves of the grasses and sedges. *Anemone canadensis*, which blooms almost equally early, but usually during a longer period, is confined almost wholly to ravines and draws of region I. It flowers most profusely and not infrequently gives a continuous white covering to large tracts of meadow land. Two rather late vernal bloomers, *Thalictrum purpurascens* and *Delphinium carolinianum*, occur throughout the State. The former throughout its range is confined to low meadows and to open woodlands and clearings along the banks of streams. The plants usually occur singly, but none the less are conspicuous on account of their numerous spreading leaves and the tall panicles. This is especially true when staminate plants predominate, as is usually the case. *Delphinium carolinianum*, which in regions I and II is a typical inhabitant of low hillsides and meadows, occurs in regions III and IV as a xerophyte. In the dry valleys of region III it preserves much the same form as that it possesses in the eastern portion of the State, but on the sand-hills and table-lands it undergoes considerable modification. Rydberg* says of it: "A low leafy form,

*Contrib. U. S. Nat. Herb. 3: 149. 1895.

peculiar to the sand-hills and dry table-lands of western Nebraska. The plant is glandular as well as pubescent, especially on the peduncle. It is the same form as that of my western Nebraska collection." An especially interesting plant in low meadow land is *Myosurus minimus*. It seems to be rapidly going out before the encroachments of other plants, chiefly those brought in by cultivation. Less than ten years ago dozens of stations were known for it in the valley of Salt creek near Lincoln, where it is now much more infrequent. It grew formerly in sod-like patches nearly a meter square, but in late years especially it had lost this habit and was to be found here and there in small, isolated tufts. In some places, notably in the vicinity of the salt basins of region II and the alkaline meadows of IV, it occurs as a potential halophyte. That this tendency was never fully realized may be ascribed to the rapidity of the changes wrought in the floral covering by increasing population and cultivation. In consequence the plant was unable to change its habitat at a rate equal to that of the disturbing forces, and was driven out before it could establish itself in halophytic situations.

(2) Amphibious hydrophytes. The species of this group belong almost wholly to the genera *Ranunculus* and *Roripa*. The former is represented by 9 species, the latter by 6 species. *Roripa palustris* is of chief importance among these, though more on account of its wide distribution than of any prominence which it assumes in the floral covering. It is confined almost entirely to wet river banks and to the edges of pools, where it often grows to a considerable height, 3-6 dm. The low-growing *Roripa obtusa* is frequently found with it. The most important plant of this group in the constitution of the floral covering is *Oxygraphis cymbalaria*, which forms an almost perfect sod over large areas of wet meadows along the Missouri and the Niobrara and the streams and wet valleys of the sand-hill region, driving out the usual sedges and rushes and admitting but few intruders. Of similar habitat, but of much less tenacity, is the taller-

growing *Ranunculus delphinifolius*. This species has been divided into two forms, one aquatic and the other terrestrial, a division entirely warranted by a comparison of the extremes. Thus, where it has been found in the ponds of region II, it is a tall-growing, submerged aquatic. The leaves, which are a decimeter or two in diameter, are as finely dissected as in species of *Batrachium*, and the stem is very thick and fleshy. On the other hand, the plant which grows along the muddy margins of the swamps of the Missouri bottoms is rarely more than a decimeter or two in height, and is especially characterized by its ternately compound leaves, the leaflets of which are slightly cleft. It is invariably a low, slender plant with but few leaves. In certain places in these swamps, however, it grows up through a thin stratum of water, and the plants of such situations invariably begin to take on the aspect of the submerged form. At one station along the margin of the great Green Island swamp, at Aten, a fairly complete succession of forms was seen, the low, slender type growing in the mud at the edge, and passing through successive gradations into the semi-submerged plants that grew where the water was two or three decimeters deep. The cold spring branches of the Niobrara are characterized by two plants, *Roripa nasturtium* and *Cardamine hirsuta*, which are typically almost submerged, forming dense borders in the edge of the water and in some cases entirely filling the stream. More rarely they wander out on the wet margins, and here they usually undergo some reduction in size.

(3) Inhabitants of deep, shady woods in I and II or of dense thickets along streams in III and IV. The two typical plants of the group are *Viola obliqua* and *Ranunculus abortivus*. They not only occupy the same habitat, but flower at practically the same time. They are two of the earliest vernal bloomers among the herbs. They agree also in their distribution, both being found along wooded streams from the Missouri river to the sand-hills. Where *Viola obliqua* occurs in the woods and especially in clearings, it

forms a carpet-like covering, which contrasts strongly with those areas in which the slender, straggling plants of *Ranunculus abortivus* grow scattered. Almost, if not quite, as early as these two, are the two species of *Bicuculla*, *B. canadensis*, which has been found as yet in but one station, and *B. cucullaria*, which is common throughout shaded woodlands along the lower course of the Missouri, and extends more rarely into deeply wooded portions of region II. Compared with the two species previously mentioned, they are retiring, being found only in the deeper recesses and ravines. The most typical plant of the Missouri bluffs in early spring is *Aquilegia canadensis*, which is found not only along the entire course of the Missouri, but at rarer intervals in region II, and along the Niobrara to the western foot-hills. It always affects the deep shades of steep and often almost inaccessible bluffs, the plants growing isolated here and there, most commonly on a shelf of dirt formed by some tree or shrub. Although scattered, the large plants and the numerous bright-colored flowers give an aspect to the bluffs on which they occur given by no other plant. Two extremely rare plants of the Missouri bluffs are the bloodroot, *Sanguinaria canadensis*, and the blue cohosh, *Caulophyllum thalictroides*. They both grow in the deepest and shadiest ravines, rooting deep beneath the thick layers of leaf mold. The individuals are always solitary, and usually but a few are to be found in one station. Among the later vernal plants of this group the most important are the three climbing species, *Menispermum canadense*, *Clematis virginiana*, and *C. ligusticifolia*. The first two are common elements in forest formations everywhere in regions I and II. *Clematis ligusticifolia*, which is the western representative of *C. virginiana*, climbs everywhere in the thickets and woodlands in the northern portions of regions III and IV. Two species, one a tree, the pawpaw, *Asimina triloba*, and the other the mandrake, *Podophyllum peltatum*, are found only in the deep woods of the Missouri below the mouth of the Platte. *Delphinium urceolatum*, which is rather more frequent in similar

situations, is found likewise in deep woods in the eastern portion of region II. With it, though more rarely, grows *Arabis glabra*. Two woodland violets are of rather common occurrence along the bluffs of the Missouri, from which they extend westward along the Niobrara. One, *Viola canadensis*, occurs in the ravines of Pine Ridge. The other, *V. scabriuscula*, with the exception of a single station, is confined to regions I and II.

(4) Xerophilous species of the sand-hills, occurring also in sandy situations in the foot-hills. This group is distinguished by its constant habit. Although none of the four species are confined entirely to the sand-hill region, yet, when encountered elsewhere, they are found only in extra-regional sand-hills and sand-draws. The most widely distributed is *Polanisia trachysperma*, which, though frequently local, is found in sand-draws and dry, sandy ravines throughout III and IV. *Cristatella jamesii*, though its range is less extensive, is much more abundant in its stations, which are confined almost exclusively to the sand-hill region proper. *Lesquerella ludoviciana* is uniformly an inhabitant of high sandy ridges, and as such is characteristic of isolated patches of sand-hills in region II.

(5) Xerophytes of high prairies and table-lands. Notwithstanding its early blooming and peculiar distribution, one of the typical members of this group is *Pulsatilla hirsutissima*. This species blossoms in earliest spring here and there over the barren bluffs and ridges of the northern portions of regions II and III, and on rocky ridges in region IV. The plants always occur singly, and are so scattered in the floral covering that they take their only importance from the prevernal flowers which appear when other vegetation is but starting. Of similar habitat, but of much more general distribution, is *Anemone cylindrica* which occurs on hills and hillsides in the northern part of the State, in dry draws in the Blue river district, and in dry valleys in the sand-hills. It resembles *Pulsatilla* in the manner in which it occurs in the floral covering. It never forms definite

patches, but is always solitary—or at least subsolitary. It does, however, give character to certain more or less definite areas, in which the tall, densely leafy stems are a striking feature. In contrast to the two foregoing species, *Polygala alba* occurs in large patches upon sandy hillsides. In somewhat dry situations, as in the sub-sand-hills of region II, these patches are often very dense, and the plants when in bloom render the hillsides entirely white with their masses of flowers. In truly xerophytic situations, however, such as the sandy hillsides of Box Butte county, the plants, though always gregarious, are neither exclusive nor controlling. *Argemone intermedia*, which, perhaps, was originally a sand-hill inhabitant, has spread over the sub-sand-hills of region II and the sandy and even the dry argillaceous plains of region IV. It is always of some importance in the constitution of the floral covering on account of the gregarious nature of the plants, their large size, and their tendency to invade waste places. Throughout the entire summer its large, white flowers are very conspicuous on hillsides, often causing the few plants of *Argemone* to completely overshadow the more controlling elements of the floral covering. *Erysimum asperum* and *E. asperum arkansanum*, two submontane species typical of the foot-hill region, have invaded the sand-hill region and have even penetrated to the prairies of region II in a few stations. On the rolling plains of the Lodge Pole district, *E. asperum* grows in great profusion, though the individuals are scattered, and its bright yellow flowers, mingled with the prevailing blue color given to the floral covering by species of *Astragalus*, *Aragallus*, and *Lupinus*, are very striking. The only representative of this group confined to the eastern portion of the State is *Helianthemum majus*, whose bright yellow flowers are found in no little profusion on exposed, sandy bluffs in late spring. This group also contains a number of montane species, such as *Clematis scottii*, *Anemone multifida*, *Berberis aquifolium*, and *Physaria didymocarpa*, which are of rather infrequent occurrence upon the dry foot-hills of IV.

(6) Floating or submerged plants. This group contains one of the most widely distributed of our native plants, *Batrachium trichophyllum*, which occurs from the stagnant pools along the Missouri bottoms to the clear, swift streams of the sand-hills and foot-hills. Wherever it is found, it is of considerable importance in the floral covering on account of the dense masses which it forms. In many small streams it fairly chokes the channel. A closely related species, *B. divaricatum*, has been found as yet at but a single station in Lodge Pole creek. *Castalia tuberosa*, which was once a characteristic inhabitant of shallow ponds in the southern portions of regions I and II, during the past few years has entirely disappeared from the most of its old haunts because of the disturbing influence of herds of cattle. *Nelumbo lutea*, which likewise was once common along the lower Missouri and especially near the mouth of the Platte, has shared the same fate. *Nymphaea advena*, which has also been practically driven out of region II, still persists in great profusion in numerous ponds of the sand-hill region.

(7) Weeds and sparingly introduced species. This group includes on the one hand weeds of wide distribution, such as *Cleome serrulata*, *Roripa sinuata*, *Brassica nigra*, and *Lepidium virginicum*, and on the other hand plants which, though weeds in the East, still occur but sparingly with us. These last are *Thlaspi arvense*, *Ranunculus acris*, *Lechea major*, *Brassica alba*, and *Sisymbrium officinale*.

(8) Prevernal bloomers of xerophytic situations. This group comprises two species and a variety, *Anemone caroliniana*, *Draba caroliniana*, and *D. caroliniana micrantha*. These are characterized by their prevernal flowers and by a considerable variability in habitat. In their typical habitats, moreover, they always occur together. They are to be found regularly and in great abundance over the sides and summits of sandy hills, and particularly of sub-sand-hills or sandstone hills. Here they play rather different rôles in the constitution of the floral covering. The individual plants of *Draba caroliniana* are so small as to be inconspicuous, except when

the scape is crowned with the white flowers or the long, sickle-like pods. The individuals, though scattered, are found uniformly over hill after hill, while *Anemone caroliniana*, on the contrary, occurs in conspicuous patches, not infrequently several meters in extent. From the dense manner in which the plants are aggregated, these patches are carpet-like in nature, and when variegated with the diversely colored flowers, which run from white to deep purple through several shades of blue, give a most striking character to the floral covering. Frequently it is to be found as well in low meadows, in which habitat the whole plant is generally reduced in size, and the patches are much diminished or are often represented by a few straggling individuals. *Draba caroliniana* likewise evinces a disposition to seek more favorable situations, and in consequence is becoming a not infrequent inhabitant of waste places.

Caryophyllales.—This suborder is represented in our flora by 33 genera and 104 species, members of the following families: Caryophyllaceae, 8 genera, 19 species; Portulacaceae, 3 genera, 3 species; Ficoideae, 1 genus, 1 species; Nyctaginaceae, 2 genera and 6 species; Illecebraceae, 2 genera, 2 species; Amaranthaceae, 3 genera and 9 species; Chenopodiaceae, 10 genera and 23 species; Phytolaccaceae, 1 genus, 1 species; Polygonaceae, 3 genera and 40 species. With us, the group contains but a single large genus, *Polygonum*, represented by 25 species.

The distribution of the species is indicated by the following table:

	Ca.	Por.	Fic.	N.	Il. Am.	Ch.	Phy.	Pol.	Tot.	Pec.	
Common to the four regions	1	1	0	1	0	2	3	0	3	11	..
I. Wooded bluff, etc., region.	5	2	0	3	1	4	6	1	17	39	6
II. Prairie region	1	1	1	4	0	4	12	0	20	49	6
III. Sand-hill region	7	2	1	4	1	6	14	0	26	61	14
IV. Foot-hill region	8	2	1	5	1	4	18	0	23	62	18

The species occurring in all four regions are *Polygonum emersum*, *P. ramosissimum*, *P. aviculare*, *Salsola tragus*, *Chenopodium album*, *C. fremontii*, *Amaranthus blitoides*, *A. graecizans*, *Allionia linearis*, *Portulaca oleracea*, and *Silene antirrhina*.

The vegetation-forms are represented as follows:

(3) Undershubs	3
(6) Rosettes	1
(7) Mats	7
(8) Succulents	2
(9) Creepers	3
(12) Rootstalk plants	19
(16) Monocyclic herbs	44
(18) Submerged plants	1
(19) Amphibious plants	4

Eight habitat-groups may be distinguished as follows:

1. Hydrophytes, floating in ponds and small lakes, I and III	1
2. Hydrophilous species of marshes, river banks, sand-bars, etc., I-IV.	15
3. Inhabitants of low prairies and meadows, I-IV.	3
4. Halophytes, peculiar to salt basins and alkaline areas, II and IV	9
5. Xerophilous species of the sand-hills, a few of wide distribution occurring on high prairies throughout.	21
6. Xerophytes of submontane table-lands and of the foot-hills, IV	17
7. Shade or subshade plants of open woodlands; a few in thickets, I-IV	8
8. Ruderal species of general distribution; introduced species of uncommon occurrence.	30

(1) Floating hydrophytes of ponds and small lakes, I and III. *Polygonum amphibium* is the sole member of this group. It occurs sparingly in the ponds along the Missouri bottoms and in the lakes of the sand-hills. It gives a distinctive appearance to these, since it usually forms a patch or island in the deeper, central portion. These green, floating islands are particularly conspicuous in midsummer, when they are thickly dotted with the long spikes of pink flowers. On account of its peculiar habit, *P. amphibium* has in most places yielded to *P. emersum*, which has adapted itself to amphibious habitats.

(2) Hydrophilous species of marshes, river banks, sand-bars, etc., I-IV. With the exception of four species, *Rumex patientia*, *R. maritimus*, *R. britannica*, and *Alsine longifolia*, the members of this group are all species of *Polygonum*. *Rumex maritimus* is a distinctive feature of low, wet sand-bars in the Niobrara river and in the upper course of the Platte. In such places it always assumes a low bushy form, which is often prostrate on the sand. In the wet meadows it is much more slender and upright, and instead of growing singly, as upon the sand-bars, it tends to form extensive patches. *R. britannica* is confined to shallow ponds and lakes in region III. It is always a prominent feature of the margins and even of the deeper portions on account of its towering stem furnished with broad, long leaves and a large spreading panicle. *Alsine longifolia* has been found only along low, wet banks of the Dismal river. Of the genus *Polygonum*, several, notably *P. pennsylvanicum*, *P. lapathifolium*, and *P. incarnatum*, though occurring regularly in low, wet meadows and even in marshes, are often found in dry, even xerophytic situations. This is especially true of *P. pennsylvanicum*, which is not only a constituent of several waste formations, but is a persistent weed in many culture formations, particularly in stubble fields. *P. incarnatum* and *P. lapathifolium* are much more constant in their hydrophilous habit, but in low prairies and along roadsides they tend to become ruderal. One of the constant hydrophytes is *P. sagittatum*, which is an inhabitant of the margins of springs and of springy marshes throughout the sand-hill region and in a few stations in the sub-sand-hills. It is a rather shy plant, never occurring in great abundance, and often in the shade. It frequently grows associated with tall, amphibious grasses and sedges, and by reason of its barbed stems and leaves often assumes more or less of a climbing habit. The most widely distributed of the amphibious species of *Polygonum* is *P. emersum*, which occurs along the margins of pools and lakes throughout the State. It is one of our prettiest *Polygonums*, and wherever it occurs in dense masses, as is

usual along the margin of water, its long, pink spikes give a characteristic appearance to the floral covering. This is an especial feature of the wet valleys in the Loup district, where the bright red masses of this plant may be seen from sandy ridges several kilometers distant. *P. emersum* is nothing more than *P. amphibium* which has assumed an amphibious habit. This has been rendered necessary, as has been shown in the case of other plants, by the fact that the aquatic form, *P. amphibium*, was driven out of most ponds by their periodical drying-up, in consequence of which it had to assume more or less of a terrestrial habit. To the plant thus modified the name *P. emersum* has been given. In the marshes at the head of the North Loup, *P. emersum* is replaced to a great extent by *P. hartwrightii*, which plays a like rôle. It often assumes two forms, according to the situation in which it is found, whether somewhat terrestrial or in marshes. In the first case it is upright and similar to the ordinary forms of *P. emersum*, but is usually very hairy. The typically amphibious form is almost invariably creeping and roots at the joints in the mud, forming an almost impenetrable tangle along the margins of lakes. Two very common species which, though growing regularly in wet meadows and in swampy situations, are frequently found in damp, shady places, are *P. punctatum* and *P. hydropiperoides*. The last is especially abundant along spring branches in the Niobrara and Republican districts, where it forms dense borders of green a meter or so wide in the margin of the water or along the wet banks. *P. punctatum* is found in wet situations throughout from I to III, and is especially abundant in the wet draws of I and II, where for areas of several hectares in extent it grows in very dense patches and often forms almost the sole constituent of the covering. In region III it often grows associated with *P. hydropiperoides*. These species are also common along muddy creek banks in region II, particularly in the shade.

(3) Inhabitants of low prairies and meadows, I-IV. Of these, the most widely distributed is *Silene antirrhina*,

which occurs throughout the State. In region II it also inclines to grow on hillsides, and it is not uncommon in dry valleys in III. The individuals grow scattered and are never abundant. *Allionia nictaginea* is more or less abundant in low fields in regions I and II, but is, like the preceding, often an inhabitant of waste places. As a ruderal plant, it frequents low places in yards and along roadsides, while *Silene antirrhina* seeks waste places in fields. *Allionia nictaginea* is occasionally met with in meadows in region II and in canyons in the foot-hill region.

(4) Halophytes peculiar to salt basins and alkaline tracts. This group is represented in our flora by 8 species, which comprise nearly three-fourths of the total number of our halophytes. None are of wide distribution in the State. In fact, they are entirely lacking in regions I and III. They are restricted to the numerous alkaline lowlands and ponds in the foot-hills and to the peculiar salt basin formation in region II. *Atriplex*, which is represented by three species, is the most important member of the group. These species all agree very closely in their general disposition within the habitat. They always occur along the margin of alkaline ponds and salt basins, never extending into the basin proper. Here, especially along the basins, they are to be found over large areas, in dense, grayish-white patches, scarcely to be distinguished in color from the salt-incrusted soil. In the valley of Salk creek, which drains the saline basins of region II, the species of *Atriplex*, and even of *Dondia*, tend to become ruderal plants. This tendency is first manifested in the low, saline meadows along the banks of the stream, but in some cases the halophytic habit is eventually lost, and *Atriplex* in particular comes to be an abundant weed in clayey waste lands. The most widely distributed species is *Atriplex patula hastata*, which occurs very abundantly in the salt basins of II and in saline situations through region IV. *A. argentea* and *A. nuttallii*, though likewise found in II, are restricted to one or two stations in IV. *Dondia depressa* generally occurs associated with *Atriplex*, and resembles it greatly in the part

which it assumes in the floral covering of saline and alkaline tracts. Its distribution is the same as that of *Atriplex*. *Monolepis nuttalliana* appears to be restricted to dry saline hills in Deuel county. It has been reported in the sand-hills of the Niobrara district, but is probably entirely sporadic there. The two halophytes of the most restricted distribution are the greasewood, *Sarcobatus vermiculatus*, which is entirely confined to the bad lands of the foot-hill region, and the glasswort, *Salicornia herbacea*, which occurs only in the salt basins of Salt creek valley. The former is a low, spinescent shrub, which covers long stretches in the denuded bad lands, frequently forming the sole element of the floral covering. *Salicornia herbacea* grows in the salt basins proper, always preferring the saltiest and most exposed situations. As would be expected, it is the sole inhabitant of the basins themselves, and hence assumes considerable importance.

(5) Xerophilous species of the sand-hills, a few found throughout. The most striking xerophyte of the group is *Rumex venosus*, though some others, perhaps, are more constant in habitat. It is generally found in the most exposed portions of sand-hills and sandy plains, but in the Niobrara district, and especially in the valley of the Verdigris, it seems to prefer patches of glaring white sand in which nothing else can grow. When in fruit, the patches of broadly winged, reddish-brown, valved fruits lend an especial character to denuded sand-hills, and are even more conspicuous on the bare patches of white sand in the Niobrara country. *Froelichia floridana* and *Talinum teretifolium* are equally constant sand-hill xerophytes. *Froelichia floridana*, though sometimes occurring scattered upon the summits of sand-hills, and then represented by giant individuals often more than a meter high, is usually gregarious, and on account of the white, woolly pubescence constitutes an element of the floral covering that may often be recognized at a distance of several kilometers. As is the case with many other species of this group, it exhibits a decided tendency to take on the ruderal habit. It is becoming particularly abundant on

deserted claims and in abandoned fields throughout the sand-hills. *Talinum teretifolium*, on the contrary, is a most inconspicuous member of the floral covering. It occurs in more or less well-defined areas, but the plants are so small and so overshadowed by the taller members of the formation that they are never to be distinguished at a distance of more than a meter or two. *Eriogonum annuum* affects situations similar to those in which *Froelichia* is found, and frequently grows associated with it. It is, however, not only more widely distributed in the sand-hills, but occurs throughout the foot-hill region as well. It rarely evinces a tendency to grow in masses, but is none the less a distinctive feature. Its white, strict stems, surmounted by the abruptly spreading, white, woolly inflorescence, may be seen on nearly every hill and in blow-outs throughout its geographical area. In many respects the most remarkable xerophyte of the sand-hills is the giant tumble-weed, *Cycloloma atriplicifolium*, which is of wide distribution in region III, and from its tendency to become ruderal is spreading into portions of regions II and IV. In its typical form it is a great bush-like herb, with an almost globose top, a half to two meters in diameter and a meter or more high. In typical situations in the Niobrara district it occurs on the exposed summits of sand-hills, or on sandy plains in patches often several hectares in extent. The close aggregation of the plants and the spreading tops admit of no competition, and other plants never get farther than the edges of such patches. Seen from the hillside as one approaches the summit, the areas covered by this plant seem veritable miniature forests in which, as it were, the elements have lost their trunks and have been reduced to masses of spreading foliage. In the dry valleys of Cherry county the importance of *Cycloloma* in the formation is greatly diminished. It occurs here in small patches, rarely exceeding 5 or 6 meters in extent, and the greatly branched forms of the sand-hills are reduced to low, slender, little-branched individuals, which are nevertheless thickly congested. *Corispermum hyssopifolium*, though more widely distributed, plays

a similar but lesser rôle in the floral covering. The plants never attain the great size of *Cycloloma*, but resemble the latter much in the diffusely branched tops and the habit of growing aggregated in patches. Two species of *Chenopodium* are of great importance in constituting subruderal portions of the floral covering in the sand-hills. One, *Chenopodium incanum*, though originally a xerophyte of the open sand-hills, has come to be practically restricted to the prairie-dog towns. The plants are usually subsolitary, and the species acquires its importance from the peculiar prominence which its spreading, grayish foliage gives it in its favorite habitat. *Chenopodium leptophyllum*, together with its two varieties, *C. leptophyllum subglabrum* and *C. leptophyllum oblongifolium*, occupy extensive stretches throughout regions III and IV. Although probably endemic on the sand-hills, *Chenopodium leptophyllum* is chiefly prominent on account of the fact that it is rapidly becoming the characteristic waste-place plant of the sand-hill region. The nearly related *C. album*, which is one of the leading ruderal plants of regions I and II, is here entirely replaced by *C. leptophyllum*, which has assumed the most striking feature of *C. album*, that of taking entire possession of large areas. Several species of the genus *Polygonum* are more or less abundant in xerophytic situations in the sand-hills and foot-hills. But one, however, *P. ramosissimum*, assumes any considerable prominence. It grows throughout the State, occurring in rather scattered patches, which in regions I to III are mostly confined to roadsides and other subruderal situations. In region IV, *P. ramosissimum* is apparently a halophyte, occurring along the margins of alkaline pools. It appears to be more or less of a halophyte in the salt basin area of region II also. Two xerophilous species of *Allionia*, *A. hirsuta* and *A. linearis*, are common in exposed situations on hills and hillsides throughout the State. Their usually tall, slender habit renders them conspicuous objects in open formations, notwithstanding the fact that the individuals grow singly. In dry valleys in the sand-hills *A. hirsuta* is very common.

Here it grows low, and is scarcely recognizable. *Abronia fragrans*, which occurs rarely in the sand-hills, grows abundantly in dry valleys and in sandy situations in the foot-hill region, where the dense patches of the bright white flowers are conspicuous objects in the landscape.

(6) Xerophytes of submontane table-lands and of the foot-hills. This group is composed of species of *Eriogonum*, with a few exceptions. The most important exceptions are *Paronychia jamesii*, *Arenaria hookeri*, and *Eurotia lanata*. *Paronychia jamesii* is a typical mat-former, and occurs in mats of a few decimeters to a little less than a meter in extent over sandy or stony hillsides and barren plains of region IV. Notwithstanding the relatively small size of the mats, and their scattered distribution, they are somewhat controlling in the formation in which they occur. But the small size of the plants and their peculiar color render the mats almost indistinguishable from a distance. In most respects, *Arenaria hookeri* is the exact double of *Paronychia*. It is almost uniformly to be found on high, rocky hills, where it occurs in rather small, inconspicuous mats. In the dry prairies of the Bad Lands, and here and there over hillsides in the foot-hills, the white sage, *Eurotia lanata*, is a conspicuous object. In the part which it takes in the formation, and in general appearance, it very much resembles the white, shrubby *Artemisias*. The submontane species of *Eriogonum* are familiar objects on barren hillsides and dry plains throughout the foot-hills, whether they occur in mats, as is more frequently the case, or in patches of thickly gregarious, much-branched individuals. The two species of widest distribution are *Eriogonum cernuum* and *E. flavum*.

(7) Shade or subshade plants of woodlands and thickets. Four representatives of this group are confined entirely to the deep woods of the Missouri bluffs, or occur rarely in forest formations in the extreme eastern edge of region II. Two, *Anychia capillacea* and *Silene nivea*, are of little importance, as they have been found in few stations. Both

Polygonum virginianum and *Claytonia virginica* are frequently to be met with in shady woods along the Missouri. The former is invariably an inhabitant of the ravines or of low, damp places in woodlands, while the latter is usually to be found on the shady side of steep bluffs. *Chenopodium fremontii*, which is regularly to be found in more or less shady woodlands, is of much wider distribution, occurring throughout the State. It grows in the drier situations, and the tall, slender plants, a meter to a meter and a half high, form extensive patches which are entirely controlling in the herbaceous layer. *Polygonum scandens* is likewise of wide distribution, climbing over bushes and tall herbs in the edge of woodlands and in thickets throughout regions I to III. One of our prettiest flowers in open woodlands and thickets is *Silene stellata*, whose nodding white blossoms and whorled leaves make it a striking object in the early summer vegetation of our woodlands. It is a shy plant, rarely growing in profusion, though found in a great number of stations along streams from the bluffs of the Missouri to the sand-hills. In the Hat creek basin in region IV its place is taken by *S. menziesii*.

(8) Ruderal and introduced species. The Caryophyllales as a group are characteristically ruderal or sub-ruderal. In proportion to the number of species, it contains more species of this nature than any other group of our flora. They are the omnipresent plants of roadsides, dooryards, and of wastes of every description. Several genera, such as *Amaranthus*, *Acnida*, and *Salsola*, are entirely ruderal. Others, as *Chenopodium*, consist almost wholly of ruderal species, while still others, as *Polygonum* and *Rumex*, are represented by several ruderal species, and by many more which tend to become ruderal. Among the plants of this group which are as yet of occasional or sporadic appearance in our flora are *Alsine media*, *Phytolacca decandra*, *Vaccaria vaccaria*, *Agrostemma githago*, and *Cerastium vulgatum*.

Guttiferales—Urticales.—In our flora this division is represented by 24 genera and 59 species, distributed as follows:

Hypericaceae, 1 genus, 8 species; Euphorbiaceae, 3 genera, 24 species; Malvaceae, 6 genera, 9 species; Tiliaceae, 1 genus, 1 species; Urticaceae, 11 genera, 15 species; Platanaceae, 1 genus, 1 species; and Ceratophyllaceae, 1 genus, 1 species.

The members of the various families are distributed among the several regions as follows:

	Hyp.	Euph.	Malv.	Til.	Plat.	Urt.	Cerat.	Tot.	Pec.
Common to the four regions ...	0	4	0	0	0	5	0	9	..
I. Wooded bluff, etc., region.	3	10	7	1	1	11	1	34	6
II. Prairie region.....	3	14	6	1	0	10	1	35	3
III. Sand-hill region.....	5	12	3	1	0	9	1	30	3
IV. Foot-hill region	0	11	2	0	0	6	0	19	4

The species common to all regions are: *Celtis occidentalis*, *Humulus lupulus*, *Parietaria pennsylvanica*, *Ulmus americana*, *Urtica gracilis*, *Euphorbia marginata*, *E. maculata*, *E. glyptosperma*, and *E. serpyllifolia*.

The vegetation-forms represented are:

(1) Trees	8
(6) Rosettes	1
(9) Creepers and climbers	1
(12) Rootstalk plants	18
(15) Dicyclic herbs	1
(16) Monocyclic herbs	13
(18) Submerged aquatics	1
(19) Amphibious plants	1

According to habitat-groups, the species may be arranged as follows:

1. Hydrophytes growing in wet meadows and on sand-bars, I-III	5
2. Inhabitants of meadows or the dry banks of streams, I-IV	11
3. Xerophilous species of the sand-hills and high, barren prairies, I-IV	7
4. Xerophytes of the foot-hills, IV.....	3
5. Herbs growing in deep woods, or more rarely in the edge of thickets: estival and serotinal bloomers, I-IV.....	11

6. Trees of the forest formations in regions I and II, a few extending along streams across the State; prevernal and vernal bloomers 8
7. Immersed hydrophyte of pools and streams, I-III..... 1
8. Ruderal or introduced species, I-IV.....12

(1) Hydrophytes of wet meadows and sand-bars, I-III. Species of *Hypericum*, which alone represent this group, are of rather rare occurrence in the State. Two, *H. ascyron* and *H. sphaerocarpum*, are confined to the wet meadows of the lower Missouri. *Hypericum majus* and *H. virginicum* are somewhat frequent in the sand-hill region, though they are never to be found in any abundance. They are generally confined to wet, sandy marshes in the vicinity of cold springs. Here they are somewhat conspicuous on account of their bright yellow flowers. Their habit of growing singly, however, prevents their assuming any considerable rôle in the formation.

(2) Inhabitants of meadows or the dry banks of streams, I-IV. *Callirhoe alcaeoides* is a typical inhabitant of the low prairies and meadows of regions I and II during late spring. It is never very conspicuous on account of its peculiarly procumbent growth. In the southwestern portions of region II and along the Republican river, *Callirhoe alcaeoides* is replaced wholly or in part by *C. involucrata*, whose bright red flowers make it a striking feature of prairie formations. A plant which is likewise conspicuous on account of its large flowers is *Hibiscus militaris*, which is localized in low meadows in region II. With the exception of *Euphorbia corollata*, the species of *Euphorbia* which belong to this group are of importance in the floral covering solely on account of the great aggregation of individuals. *E. corollata* owes its prominence to its tall, strict stem and in particular to the large, white bracts of the involucre. It is a familiar plant in high pastures and grassy places at the edge of woodlands in regions I and II. Of the low-growing spurge, *Euphorbia nutans* is the most important on account of the dense patches which it forms. It is widely distributed

in the prairie and sand-hill regions. *E. obtusata* and *E. dictyosperma*, which are very similar in habit, have much more restricted geographical areas. The former has been found only in low pasture lands in region II, while the latter occurs as well at a few stations in region I. To this group likewise belong the procumbent spreading species, *Euphorbia serpens* and *E. serpyllifolia*. Neither is abundant.

(3) Xerophilous species of sand-hills and high barren prairies I-IV. The members of this group are almost wholly typical xerophytes of the sand-hills. In one or two cases incipient ruderal habit has caused them to wander into regions II and IV. *Malvastrum coccineum*, however, must be regarded as equally at home upon the dry plains of IV and the barren hills of III. The species exhibits a decided tendency toward an eastward extension of its range, as is shown by the fact that it is somewhat common in the edge of II and is abundantly localized on barren bluffs in the northern portion of I. On high, barren prairies and hills, both in the northern portion of region I and in eastern Box Butte county, this species occurs in great abundance and takes a somewhat controlling part in the vegetation. In the sand-hills the individuals grow low and scattered, and, while the species occurs more frequently, it does not assume the same importance in the floral covering. In such localities it tends to become slightly woody and is excessively hairy. A species of wider distribution is *Euphorbia hexagona*, which has followed the railroads into region I, and has become common along sandy embankments, especially near the mouth of the Platte. It is a typical sand-hill resident, more frequent, however, in the Niobrara and Republican districts and on the eastern edge of the sand-hills and the sub-sand-hills than in the heart of the sand-hill region. While in the eastern edge of the region it is present in the *Andropogon* bunch-grass formation, it is typically to be met with in the *Aristida* type which prevails over the sub-sand-hills and the lower hills of the Niobrara and Republican districts. In the eastern edge of the sand-hills it is commonly associated with

Cycloloma atriplicifolium, and it is the only plant which succeeds in invading the dense patches of the tumble-weed. It is never a conspicuous plant, though it attains some height, since it is entirely green, with thin, narrow leaves, and always occurs associated with other plants and not in patches of its own. It is also of frequent occurrence in region IV, being found on Pine Ridge, on the sandy table-lands in Box Butte county, and in sandy canyons and in sand-draws in the Lodge Pole district. The low-growing *Euphorbia petaloidea* is more common in the heart of the sand-hill region. This species is a frequent inhabitant of blow-outs and occurs upon hillsides and the summits of sandy ridges throughout the Loup district. Along the Niobrara and the Republican it is found upon the barren sides of the sandy canyons, where its bright, white involucrel bracts make it a conspicuous object. In such places it is usually gregarious, though rarely forming either dense or exclusive patches. In the sand-hills, on the contrary, it is always solitary. Following the course of the Platte, this species has invaded regions I and II to some extent, occurring at various stations in dry, sandy barrens along the river bottom. In region IV this species occupies diverse habitats. It is a frequent inhabitant of sand-hills and sandy canyons, but also occurs on barren spots on the buttes. Here it is quite variable in aspect, the leaves varying from linear to broadly oblong, the seeds from gray to reddish. *Euphorbia geyeri* is restricted in its distribution. It occurs in very open places on the summits of sandy ridges and bluffs, often covering patches of pure sand with a closely applied carpet of green. A species of wide distribution on high barren prairies of region IV and in the sand-hills is *Croton texensis*. While growing singly in the sand-hills, in which situations the individuals occupy the upper slopes and tops of the hills, and at a distance, on account of their color, simulate *Eriogonum annuum*, on barren prairies in region IV and in dry sandy meadows along the Niobrara and the Republican, as well as along the larger streams of the central sand-hills, it is gregarious, occurring

in small patches dotted here and there over the lowland and lending a peculiar tone to the floral covering.

(4) Xerophytes of the foot-hills, IV. This group is composed entirely of species of *Euphorbia*. The most widely distributed is *E. montana*, which occurs upon sand-hills, in sand-draws, and on sandy canyon sides throughout the region. *Euphorbia fendleri*, which is confined to the Lodge Pole district, is a low-growing, appressed species very similar to *E. geyeri*. *Euphorbia polygonifolia* is found upon high, barren plains about Pine Ridge.

(5) Herbs growing in woods and thickets: estival and serotinal bloomers, I-IV. The most important and the most abundantly and widely distributed member of this group is *Urtica gracilis*. In woodlands and thickets in regions I-III, the common nettle takes possession of large areas over which it has more or less complete control. In woodlands it grows to a height of one and a half meters and is an important layer in the formation. Though generally a shade plant, it not infrequently extends into clearings and open meadows. It is likewise common along the edge of woodlands. In region III, where the thickets are restricted in area and of very limited density, the nettle does not constitute patches to any noticeable extent, but grows in scattered clusters. Scarcely less frequent, but of less abundance, are *Parietaria pennsylvanica* and *Adicea pumila*, which generally occur in the same woodlands and thickets. *Parietaria* seeks the higher and drier spots where, though forming close, tufted patches, it is inconspicuous and of little importance. In the sand-hills where the thickets permit the sunlight to penetrate and the ground is very dry, it is commonly the sole herbaceous inhabitant of the thicket. *Adicea pumila* prefers damp or even wet spots, often rooting in the mud along shady streams. In the latter situations, where it grows aggregated, covering fairly large areas, it is of some importance as it constitutes almost the sole herbaceous covering of flat, muddy banks. While both of the foregoing species haunt shaded situations, the difference in habitat is

shown by the thin, dry stems of *Parietaria* and the fleshy, turgid stems of *Adicea*, adaptations to the water-content of the soil in which they grow. The three-seeded mercury, *Acalypha virginica*, is no less abundant in regions I and II and along the Niobrara and the Republican. In its usual habitat this species is a woodland shade plant. In such places it attains a height of 2-3 decimeters, and, though subgregarious, is by no means exclusive in its occupation of the soil. It would seem, however, that this species is a shade or woodland plant of necessity rather than of choice. In clearings and in places where it has taken possession of barren spots adjacent to woodlands, it appears to flourish much more than in its ordinary haunts. Here it grows rank, attaining a height of 7-8 decimeters, is densely aggregated, and has complete possession. It is a particularly conspicuous plant in deep woodlands during late autumn, when its crimson-brown leaves and inflorescence give a reddish cast to the entire herbaceous layer. The wood nettle, *Urticastrum divaricatum*, a typical shade plant, is one of the most important herbaceous constituents of forest formations in regions I and II. It is confined to deep shade, where it grows in great profusion. Commonly the individuals, while occurring in more or less definite areas, are not densely aggregated, and do not attain any considerable height. But in some instances, particularly in the Little Blue valley, the wood nettle forms large, thick patches in which the individuals often reach a height of more than a meter. This species is very conspicuous by reason of its large, spreading leaves and its spreading, umbel-like inflorescence, especially when the broadly winged fruits make their appearance. *Boehmeria cylindrica* is an occasional inhabitant of woods and thickets in regions II and III. Wherever found, it is almost strictly interchangeable with *Adicea pumila*, with which it is often confused. It is identical in port and habitat with the latter, but is more western in its distribution. Along the Middle Loup this species is also to be met with among bushes in the wet meadows. If this habitat seems somewhat strange, it

should be borne in mind that the shade in a thicket in the sand-hills is very slight, and that the step from such a thicket to a wet meadow is by no means violent. In woodlands and thickets throughout the State, *Humulus lupulus* is of the first importance among herbaceous plants. By twining in and out among the underbrush and over shrubs on the edges, it not only forms almost impenetrable jungles, but exercises a controlling influence on the lower layers. It shows a tendency to escape from the shade and to become a creeper, especially when its habitat has become modified by railroad embankments, etc. Occasionally it leaves the edge of woodlands entirely and sprawls over herbaceous plants in the open sunlight. *Euphorbia heterophylla* is a conspicuous though not abundant dweller in woodlands and thickets. It is a very shy plant, found only here and there in groups of a few individuals, often in deep shade, though sometimes in moist situations at the edge of woodlands as well. It is usually tall and slender, and from the bright bases of the upper leaves makes a very curious appearance in a background of green. *Euphorbia cuphosperma*, which resembles the preceding in many respects, is confined to shady canyons in the foot-hills.

(6) Trees of forest formations, chiefly of I and II. By far the most important member of this group is the white elm, *Ulmus americana*. The white elm is one of the principal constituents of forest and woodland formations in I and II, and occurs along streams throughout the State. As one of the earliest bloomers of our trees, it gives character to the vernal aspect of woodlands. The smaller *Ulmus fulva* is less frequent and is confined principally to the forests of the lower Missouri, though extending somewhat into region II. The hackberry, *Celtis occidentalis*, presents two somewhat divergent forms according to its habitat. In the deep woods of the Missouri and more rarely in region II, it is a tall, commanding tree, with a straight trunk and a large, though compact top. In such locations it grows more or less solitary, and attains a height of 20-30 meters. In the sand-hills

and in the foot-hills, it is reduced to a low, straggling shrub, with a thin trunk and spreading, ragged top. The basswood, *Tilia americana*, is characteristic of bluffs and ravines along the Missouri, extending into region II and along the Niobrara into III. Its dense foliage and cream-colored flowers make it a conspicuous object where it is at all abundant. *Morus rubra* is a rare tree of deep forests along the bluffs of the Missouri.

(7) Immersed hydrophytes. The sole representative of this group is *Ceratophyllum demersum*, which is of wide distribution in streams in regions I and II and in lakes and ponds in III. It resembles *Batrachium trichophyllum* in the manner in which it takes possession of small ponds and streams.

(8) Ruderal and introduced species. Of the typically ruderal species, the most important is *Euphorbia marginata*. Through its milky juice it is enabled to get a strong foothold in pastures, and in dry seasons, when the ordinary constituents of the formation are driven out through overstocking, it quickly becomes controlling. It extends throughout from the lowlands of the Missouri to the western foot-hills, but is frequent and abundant only in I and II. It never grows in sandy situations, and in the northern portion of the State its presence is regarded as a sure index of clay soil. Wherever found, it grows abundantly, although usually it does not form definite patches. In abandoned "hog lots," however, where it grows to a great height, it forms patches many meters in extent. Its size and conspicuous, white-margined floral leaves and bracts make it a notable feature of pastures and waste places during the summer and autumn. Its common name, "snow on the mountain," refers to the characteristic appearance of hillsides covered by it. *Euphorbia dentata* occupies much the same habitat as the preceding species, but is less abundant and less widely distributed. It rarely assumes any particular prominence in the floral covering, since the individuals lack all of the peculiar conspicuousness of those of *E. marginata*. It has in a few

instances, notably in the Otowanie woods in II, become a resident of forest formations. Two abundant weeds of waste formations are *Euphorbia maculata* and *E. glyptosperma*. These species not only enter into many waste formations, but are frequent invaders of pastures, where, in dry seasons, they are prominent features. Both are to be found throughout the State. *Abutilon abutilon* forms extensive wastes along roadsides and in pastures in region I and the eastern portion of region II. This weed grows to a considerable height, 2-3 meters, and from the size of the individuals and their large, broad leaves, patches of it in early summer greatly resemble sunflower wastes. In extent and general constitution also, they simulate sunflower wastes, from which, at some distance, they are to be distinguished only during the period of flowering. *Cannabis sativa*, which has escaped from cultivation, is a weed along roadsides and in waste places here and there. Several species of Malvaceae, *Hibiscus trionum*, *Malva silvestris*, *M. rotundifolia*, and *Sida spinosa*, are introduced plants which have become common in region I and are slowly extending into regions II and III. They are as yet of little importance in the floral covering.

Geraniales—Sapindales. — This group comprises 10 families, represented by 19 genera and 36 species, distributed as follows: Linaceae, 1 genus, 4 species; Zygophyllaceae, 1 genus, 1 species; Geraniaceae, 4 genera, 7 species; Rutaceae, 1 genus, 1 species; Elaeagnaceae, 1 genus, 1 species; Celastraceae, 2 genera, 4 species; Rhamnaceae, 2 genera, 5 species; Vitaceae, 3 genera, 4 species; Sapindaceae, 3 genera, 5 species; and Anacardiaceae, 1 genus and 4 species.

The geographical distribution of the species is as follows:

	Lin.	Zyg.	Ger.	Rut.	El.	Cel.	Rha.	Vit.	Sap.	An.	Tot.	Pec.
Common to the four regions.....	0	0	1	0	0	1	0	2	1	1	6	..
I. Wooded bluff, etc., region.....	2	0	6	1	1	4	6		3	4	31	9
II. Prairie region....	1	0	5	1	1	2	4	2	2	2	20	1
III. Sand-hill region...	1	1	4	1	1	2	4	2	1	3	20	2
IV. Foot-hill region ...	2	0	1	0	1	1	0	2	2	2	11	2

The species common to the four regions are: *Rhus radicans*, *Acer negundo*, *Parthenocissus quinquefolia*, *Vitis vulpina*, *Celastrus scandens*, and *Oxalis stricta*.

The following vegetation-forms are represented:

(1) Trees	6
(2) Shrubs	5
(3) Undershrubs	8
(4) Woody climbers	6
(12) Rootstalk plants	2
(13) Bulb and tuber plants	1
(16) Monocyclic herbs	9

The species may be arranged in six habitat-groups.

1. Woody plants, inhabitants of woodland and thickets, I-IV 21
2. Xerophilous bushes, inhabitants of dry prairies, I-III. 3
3. Shade and open woodland plants, I-IV..... 3
4. Frequenters of wet meadows and low prairies, I-III.. 2
5. Xerophytes of high prairies and sand-hills, I-IV..... 3
6. Introduced species of sporadic occurrence, I-III..... 4

(1) Woody plants of woodland and thickets, I-IV. The most widely distributed of all our trees is the box-elder, *Acer negundo*. This is the typical tree of woodlands, especially along streams and water courses, throughout the State. In the forest formations of the Missouri bluffs it is neither an abundant nor an important constituent, except along the edges of the forests or in the tops of ravines. Being the characteristic tree of open woodlands, it is to be found in region I chiefly, and most abundantly where streams pierce the bluffs and the woodland formation of the banks mingles with the forest formation. The box-elder is not a large tree, since it branches low, rarely more than 2-4 meters above the ground, and the top is usually spreading and ragged. In the foot-hills and in the Niobrara and Republican districts of III, it occurs only in canyons about springs or along streams. It is also to be found here and there on the banks

along the larger rivers of the central sand-hills. Though the box-elder is a considerable tree in open woodlands and in pastures of regions I and II, in the canyons of the Niobrara and along the upper Loups it is reduced to a pretty shrub, rarely more than 3-5 meters high. Another typical tree of forests and open woodlands in regions I and II is the soft maple, *Acer saccharinum*. It is much less widely distributed than the preceding, being confined to region I and a few of the larger streams of II. It is a comparatively large tree, and, in woodlands along banks of streams, tends to become controlling, especially in low meadows. In the forest formations of the Missouri bluffs, it takes little part, except in the southern portion of the State, where it is a common tree of the islands of the river. A characteristic shrub of the open woods is *Rhus glabra*, which also forms thickets of some size and importance in low meadows in the neighborhood of streams. It is chiefly confined to I and II, but occurs in a few stations along the larger streams of the sand-hills. It is one of the few conspicuous species of woodlands in the winter time on account of its large panicles of scarlet berries. *Rhus copallina* forms similar thickets on the bottoms of the Missouri river in the southeastern portion of the State. The prickly ash, *Xanthoxylum americanum*, forms thickets which are often the secondary layer in the forest formations of the ravines of the Missouri bluffs. Higher up along the edges of the bluffs, individuals occur scattered, and here the species has a peculiar straggling aspect. Two species of buckthorn, *Rhamnus lanceolata* and *R. caroliniana*, are occasional inhabitants of forest formations in I, extending into III along the Niobrara, sometimes also occurring isolated on the tops of high bluffs, where the former is reduced to a low, spreading shrub, conspicuous in spring through its yellow flowers, and in late summer and autumn on account of its deep blue berries. The buffalo berry, *Lepargyrea argentea*, frequent sand-bars of the principal rivers of the sand-hills. Along the Platte it extends also well into the prairie region. In the foot-hills and sand-hills it is a frequent inhab-

itant of bluffs. In ordinary situations it is a thorny bush, forming thickets of wide extent. Its clusters of crimson berries unite with the shining, scaly leaves to give a peculiar complexion to formations in which it occurs. The bladder nut, *Staphylea trifolia*, is a rather abundant shrub of forest formations of the Missouri bluffs, extending somewhat above the mouth of the Platte. *Acer glabrum*, which haunts the low, wet canyons of the Hat creek basin, is a beautiful shrub with shining foliage, which might easily be taken for a miniature *Acer saccharinum*. The bittersweet, *Celastrus scandens*, is to be found in abundance in forests and woodlands along streams in all parts of the State, with the possible exception of the Lodge Pole district. In the forests of the Missouri and along the larger tributaries, the bittersweet is a high climber which is nearly concealed in the summer time by the foliage of the trees. In the winter, its stems, as they climb here and there, may readily be followed by the clusters of bright orange fruits. Along the steep, rocky bluffs of the northern portion of the course of the Missouri, an upright, leafy form, rarely more than a meter in height, is found just at the upper edge of the bluff, where other woody vegetation is lacking. The wahoo, *Euonymus atropurpureus*, is a tall-growing bush of forest and woodland in region I, extending somewhat into II and III. It is rarely an important element in the shrubby layer of forests, though conspicuous both from its masses of dark purple flowers and its red, lobed fruits. *Euonymus americanus* and *E. americanus obovatus* are confined to a few stations in the forest formations of region I. The Virginia creeper, *Parthenocissus quinquefolia*, climbs over trees and shrubs in forests, woodlands, and thickets along streams in every portion of the State. In forests and woodlands, by climbing in and out among underbrush and trees, it forms dense tangles and exercises a considerable influence in the formation. Of equally wide distribution and commonly associated with the foregoing is the wild grape, *Vitis vulpina*. Unlike the Virginia creeper, it confines itself to the sunny side of the high trees,

and is never found in the underbrush. Both in flower and in fruit it is very conspicuous, while the Virginia creeper is noticeable chiefly for its shining leaves. *Vitis cinerea* and *Ampelopsis cordata* are confined to a single station along the lower Missouri bluffs. The poison ivy, *Rhus radicans*, is very inconstant in habitat. It occurs in forest and woodland in the eastern portion of the State as a climber, reaching a considerable height. In the meadows and wet valleys of the sand-hills and foot-hills it is a strict, upright bush, from 2–10 decimeters high, never climbing, and without aerial rootlets. In wet valleys, especially, it forms patches of no little extent. In such situations the plants are leafy, and rarely more than $\frac{1}{2}$ decimeter high. On the bluffs of the Missouri, about Ponca, the plant is usually a meter high, furnished with only two or three immense leaves, and bearing a panicle-like inflorescence very like that of *Rhus glabra*. In the foot-hills and along the larger streams in the sand-hills, *Rhus trilobata* forms dense, low thickets along the upper sides of canyons and in open spots in high woodlands. It has pushed itself some distance from the Niobrara into the bluffs of I. It is a low, spreading bush with bright red, glandular berries and small leaves.

(2) Xerophilous bushes of dry prairies, I–III. *Ceanothus americanus* and *C. ovatus* are characteristic of dry prairies and exposed hilltops in I and II. In the sand-hills, *C. ovatus* is one of the common woody plants, growing abundantly on the hills about the Dismal river. *Ceanothus americanus* extends into the sand-hill country along the Niobrara. In the sand-hills, *C. ovatus pubescens* is scarcely less common than the species, into which it grades. All three are low, dwarf shrubs which, during the flowering period, give a characteristic white color to the high hills on which they grow. *C. americanus*, especially, plays this rôle upon the rocky hillsides along the Missouri river in Dixon county.

(3) Shade and open woodland plants, I–IV. *Impatiens aurea* is strictly a shade plant in forest forma-

tions of I, but occurs in deep woodlands in a few stations of II. It is one of the most exclusive shade plants of our flora. Along the Missouri bluffs it commonly grows in the lower end of ravines, especially about springs. In deep woods on the river bottoms it often forms large patches, in which the individuals, growing from 1-2 meters high, are closely aggregated and maintain exclusive possession. It is not uncommon along sunny banks of streams in I and II, where it is usually subsolitary, and always a conspicuous object on account of its large, golden flowers and silvery leaves. *Impatiens biflora* is rather an open woodland plant in the eastern part of the State. Along the Missouri bluffs it rarely occurs associated with *I. aurea*, but is more commonly found along streams and spring branches in the edge of the woods. It occurs also in thickets and deep woods along the principal streams of the sand-hills. In the valley of the Dismal river it is found in swampy meadows. The "touch-me-not" is the typical inhabitant of the sandy spring marshes of deep canyons throughout the Niobrara district. The patches are of the densest, and always occur in deep shade, where the shining, cane-like stems and the deep golden flowers render the mass of plants very prominent.

(4) Frequenters of meadows and low prairies, I-III. *Oxalis stricta* presents a great number of forms in its usual habitat, though in respect to habitat it is not a little inconstant. In deep woods along the Missouri, and in thickets along the Niobrara, it is a densely leafy, much-branched plant, which often is the sole element of the herbaceous layer. It grows in solid masses, in which the innumerable, small, bright yellow flowers contrast vividly with the solid green background. Generally, in woodlands of I and II, *Oxalis stricta* is much smaller and less aggregated, usually occurring here and there in isolated patches. It invariably manifests a tendency to a ruderal habit. This is accomplished in lawns and pastures, where the diminutive plants form carpets of green and yellow. In such situations the individuals are scarcely more than 1-3 centimeters

high. In the sand-hills it is a common inhabitant of waste places about marshes. *Oxalis violacea* is commonly found in damp places in I and II, extending into the sand-hill region along the Niobrara. Sometimes an inhabitant of the borders of woodlands, it is most common in wet draws, on the sides of which it forms considerable carpet-like patches, brightened here and there by the violet flowers.

(5) Xerophytes, inhabitants of dry prairies, sand-hills and foot-hills, I-IV. These are species of *Linum*. *Linum lewisii* is a submontane species, localized in the canyons of the Hat creek basin, where its tall, slender stems and bright blue flowers are especially conspicuous in the sparse floral covering. *Linum sulcatum* grows on high ridges throughout regions I and II. In the western edge of II and in III and IV, its place is taken by *L. rigidum*. The two play exactly the same part in the floral covering of xerophytic situations, notwithstanding they are rarely if ever to be found together. They are copious, occurring often on hill-top and hillside for stretches of many kilometers. They are low, slender plants, with numerous diffuse branches bearing the bright yellow flowers. The latter are ephemeral, and when they fall off give a decided yellow appearance to the entire floral covering.

(6) Introduced species of sporadic occurrence, I-III. *Erodium cicutarium* and *Geranium robertianum* are low, spreading plants occurring rarely in lawns and pastures in regions I and II. *Geranium maculatum* has been found in but a single station in the canyons of the Niobrara at Long Pine, where a small patch has persisted for several years. *Tribulus terrestris* has appeared in the State in two localities, the one in the Republican district, the other in the Niobrara district.

Amentales.—This group comprises in our flora 9 genera and 35 species, representing but three families: Cupuliferae, 5 genera, 17 species; Juglandaceae, 2 genera, 6 species; Salicaceae, 2 genera, 14 species. The two largest genera are *Quercus*, represented by 9 species, and *Salix*, represented

by 9 species. Of the whole number, 32 species are trees, while 3 only are shrubs.

The following table indicates the distribution of the species:

	Cupulif.	Jugland.	Salicac.	Total.	Pecul.
Common to the four regions.....	1	0	2	3	..
I. Wooded bluff, etc., region.....	11	6	5	22	12
II. Prairie region.....	4	3	5	12	0
III. Sand-hill region.....	4	1	7	12	1
IV. Foot-hill region.....	2	0	12	14	6

The species common throughout are *Salix fluviatilis*, *Populus deltoidea*, and *Quercus macrocarpa*.

Since this group is composed entirely of woody plants, the number of habitat-groups is necessarily small.

1. Trees, rarely shrubs, of forest formations along the bluffs of the Missouri, extending into II, and infrequently into III, I-III.....18
2. Tree or low shrub, growing in forest formations in I and II, and becoming a low, bush-like xerophyte on the dry bluffs of III and IV 1
3. Trees and shrubs of canyons in III and IV..... 8
4. Trees and shrubs, growing for the most part along the banks of streams and in low meadows and wet canyons, I-IV 8

(1) Trees and shrubs of forest formations. Eight representatives of this group are species of *Quercus*. All but two are confined to the bluffs of the Missouri below the mouth of the Platte. Here they occur in the deep woods in considerable numbers, as *Q. coccinea* and *Q. prinoides*, or isolated, as is the case with *Q. alba*. *Quercus rubra* and *Q. velutino* are important constituents of the river-bluff formation of the Missouri as far north as Washington county. *Q. rubra* is also found scattered here and there in forests in the eastern edge of the prairie region. The hickories rarely pass north of the mouth of the Platte river, but are of somewhat wider distribution in the woodlands of region II.

Hicoria glabra and *H. alba* are prominent features in forests in region I, the former also occurring abundantly in portions of II. Their prominence is due chiefly to their tall, straight trunks, often unbranched for 6 meters or more, and their compact tops. *Hicoria minima* plays a similar rôle in forests, though it is usually much smaller and is less widely distributed. The black walnut, *Juglans nigra*, is an abundant tree in forest formations along the Missouri and most of the streams of region II. It is also found for some distance along the Niobrara. Along the Missouri especially, it is a large tree with a massive trunk and a large expanse of foliage. In the Niobrara country, where it usually occurs more or less isolated, the individuals are hardly more than large shrubs. The butternut, *Juglans cinerea*, which resembles the walnut very much, is restricted to a small area in the southeastern part of the State. One of the familiar small trees of the Missouri bluffs, and particularly of the deep ravines which run back from it, is *Ostrya virginiana*. Along the Missouri it rarely occurs in large numbers, but grows here and there in groups of two or three over the face of the bluffs. In the canyons of the Niobrara, however, it forms dense woodlands, in which few intruders are found. Canyon sides in many places are covered with dense thickets consisting entirely of ironwood. The hazel, *Corylus americana*, coincides almost exactly with *Ostrya* in geographical area. The thickets of this shrub, ordinarily termed hazel brush, are to be found in great frequency along the edge of woodlands and in clearings in region I. In the eastern portions of the Niobrara country it appears to be entirely lacking, but in the canyons of the Niobrara in Brown county it attains an importance equal to that manifested in region I. Wherever it grows solitary, it is a tall, straight shrub, but in its ordinary stations it becomes a low, diffusely branched, and very leafy bush.

(2) Tree or low shrub growing in forest formations in I and II, and becoming a low bush-like xerophyte on the dry bluffs of III and IV. *Quercus macrocarpa* is the sole

species of oak which grows over the whole State. It extends from the bluffs of the Missouri to the canyon sides of the foot-hills. The individuals exhibit the greatest variation in different habitats. In the deep forests of I and II, *Quercus macrocarpa* is a tall, commanding tree, which is usually the principal element in the formation. But even here it evinces a disposition to become shrubby along the edges of the formation. Northward along the Missouri, and thence along the Niobrara, the bur oak steadily decreases in size in forest formations and becomes a conspicuous object along the tops of high, dry bluffs. The front of the bluffs of both the Niobrara and the Republican is covered almost exclusively with individuals of this species. At the base of the bluffs they are usually small trees, 3-5 meters high. But toward the top they decrease regularly in size, and become diffusely branched, so that the tops of the bluffs are covered with a dense thicket of low, straggling bushes, 5-10 decimeters high.

(3) Trees and shrubs of canyons in regions III and IV. With a single exception, the four species of *Populus* are confined to the extreme northwestern portion of our foot-hills. Both *Populus balsamifera* and *P. angustifolia* are rare trees, which are confined entirely to the Hat creek basin. *Populus tremuloides*, which, unlike the foregoing, often covers large areas, is a low tree whose bright green foliage and greenish white trunks render the canyon sides very conspicuous. *Populus acuminata* has as yet been found only in the deeper parts of Carter's canyon in Scott's Bluff county. *Salix tristis* and *S. bebbiana* are both low, bushy willows. The former occurs in dense but small thickets in the canyons of the Niobrara and in wet valleys in the sand-hills. The latter is found only in canyons of the Pine Ridge district. *Betula occidentalis* is a low, symmetrical tree, growing in the deep canyons of the Hat creek basin in company with *Populus tremuloides* and *Acer glabrum*. *Betula papyrifera*, which is one of the prettiest of our trees, is extremely localized in the canyons of the Niobrara in Brown and Cherry counties.

It is most abundant in the former, where for a distance of nearly 25 kilometers every wet canyon is fairly filled with it. Its large, white trunk and dark green mass of foliage give to all these paper birch canyons a very distinctive appearance.

(4) Trees and shrubs, growing for the most part along the banks of streams, and in low meadows and wet canyons, I-IV. The two most important members of this group are *Populus deltoidea* and *Salix fluviatilis*. Although not infrequently occupying similar habitats, they differ widely in their method of occupation. With the exception of certain small islands in the Missouri and muddy banks along this river, where dense patches of forest are often formed exclusively of cottonwood, *Populus deltoidea* is usually subsolitary in its distribution. It never occurs in the heart of a forest formation, but is to be found along the edge in the neighborhood of streams, or it is found dotted here and there over low pastures. It is by far the largest of all our trees, often attaining a height of 50-60 meters, and a diameter of 2-3 meters. It is a remarkably rapid grower, attaining in the course of a few years a size which is equaled by but few of our common forest trees. *Salix fluviatilis* is invariably a low, slender shrub, growing in the densest masses upon sand-bars and along the low banks of streams throughout the State. Its most striking characteristic is the manner in which it takes possession of its habitat to the practical exclusion of everything but a few scattering herbs. From the fact that it is most frequently confined to sand-bars, it is a distinctive feature of the Platte, the Niobrara, and the Republican, and some smaller streams as well. In the neighborhood of pools in the passes between wet valleys in the sand-hills, *Salix fluviatilis* is reduced to a dwarf shrub, scarcely more than a decimeter or two in height. In such situations it never grows in masses, but individuals are scattered sparsely over a narrow area extending out on all sides of the pool. Along the Missouri river, *Salix cordata* is often the exclusive inhabitant of large islands, known as diamond willow islands. In such places it grows in the

greatest abundance, and attains an unusual height—as much as 20 meters. Occasionally it is to be found as a shrub, forming loose thickets about swampy situations in the bluffs. In lake regions in the sand-hills and in marshy valleys about the heads of the principal rivers in the Loup district, scattered individuals of this species are frequently to be met with. They are much reduced in size, being little more than straggling bushes. *Salix amygdaloides* and *S. nigra* are very similar, not only in size and general appearance, but in the part which they play in the floral covering. They are rarely inhabitants of woodlands, but seem to prefer low, open meadows and pastures, where they may be found in groups of a few individuals along the edges of streams or in draws. From their peculiar preference for open places, they assume a special importance in the floral covering.

Leguminosae.—In our flora this family is represented by 33 genera and 103 species. There are but 2 large genera, *Astragalus*, with 18 species, and *Psoralea* with 9 species.

The regional distribution of the species is as follows:

	Total.	Pec.
Common to the four regions	12	..
I. Wooded bluff, etc., region	48	4
II. Prairie region	55	3
III. Sand-hill region	57	3
IV. Foot-hill region	57	20

In the 20 species peculiar to region IV, all the representatives of the genera *Homalobus*, *Orophaca*, and *Phaca* are included. The species which are to be found throughout are *Amorpha fruticosa*, *A. canescens*, *Astragalus crassicaarpus*, *Cassia chamaecrista*, *Glycyrrhiza lepidota*, *Lespedeza capitata*, *Lotus americanus*, *Melilotus alba*, *Strophostyles pauciflora*, *Psoralea esculenta*, *P. argophylla*, and *Vicia linearis*.

The vegetation-forms represented are:

(1) Trees	4
(2) Shrubs	1
(3) Undershrubs	2
(7) Mats	2

(9) Creepers and climbers	11
(12) Rootstalk plants	64
(13) Bulb and tuber plants	2
(15) Dicyclic herbs	4
(16) Monocyclic herbs	8

The habitat-groups are as follows:

1. Trees of deep woodlands; vernal, I-III	4
2. Shrub of river banks and canyons, I-IV	1
3. Herbaceous plants of woodlands and copses, I-III.....	10
4. Inhabitants of low prairies and meadows; typically vernal, I-IV	23
5. Xerophilous species of exposed sandy bluffs, high prairies, and sand-hills, I-IV	36
6. Xerophytes of the western table-lands and foot-hills, IV.	16
7. Introduced or naturalized species of subruderal habit, I-IV	8

(1) Trees of deep woodlands; vernal, I-III. Three representatives of this group are substantially confined to the bluffs of the Missouri. In many respects the most striking member is *Cercis canadensis*, which, with its dense clusters of rose-colored flowers borne on leafless twigs, is a conspicuous object in woodlands during early spring. It is not often found in the deeper woodlands, but seems to prefer somewhat open bluffs or sparsely wooded ravines. The individuals are never really gregarious, though in the former situation they are sufficiently numerous to lend a very decided color to the formation during their flowering time. The red bud, apparently, is not found farther north than a few miles beyond the mouth of the Platte. *Gymnocladus dioica*, on the contrary, grows along the Missouri bluffs as far north as the mouth of the Niobrara, and one or two individuals have even been found along the lower course of the latter. In forest formations, *Gymnocladus* is more or less gregarious, and the tall, straight trunks and large tops make the areas covered by the Kentucky coffee tree striking features of the formation. Along the upper Missouri, where *Gymnocladus* has

moved higher up on the bluffs, it is reduced to a small, spindling shrub. *Gleditsia triacanthos* is rather more widely distributed than either of the foregoing. It is found not only along the entire course of the Missouri, but extends also into the Niobrara district, and occurs along streams everywhere in region II. It is rarely a tree of dense woody formations, but prefers the open woodlands or thickets along the banks of streams. Notwithstanding the honey-locust rarely attains any considerable height, it is always a conspicuous object in low meadows and pastures, not only from its dark green foliage and reddish, thorny stem, but as well because it overtops the woody plants with which it is commonly associated. In the winter time it stands out prominently on account of its large numbers of persistent, long, red-brown pods. *Robinia pseudacacia*, though occurring here and there in I and II, is probably to be regarded as introduced. It is becoming naturalized more and more in region I, and will in time become a characteristic tree of that region.

(2) Shrub of river banks and canyons, I-IV. *Amorpha fruticosa* grows throughout the State in pastures along streams, in deep ravines, in wet valleys in the sand-hills, and in wet canyons. In the first habitat it usually occurs as a narrow fringe on the banks of the stream, often, indeed, rooting in the mud. In such situations, though of importance, since as a rule it is the only woody plant present, it never forms thickets. The fringe, however, does occasionally become very dense and almost impenetrable. In wet valleys in the sand-hills the individuals grow scattered and are very low. In broad ravines and in wet canyons *Amorpha fruticosa* assumes its maximum size, occurring as a tall, almost tree-like shrub, which forms rather close thickets. Indeed, along the upper Missouri such thickets occur here and there in the sparser portions of the woodland formations. When in bloom, the false indigo is of unusual prominence in any formation in which it occurs, because of the dense masses of gold and violet flowers with which it is covered.

(3) Herbaceous plants of woodlands and copses,

I-III. Out of the 10 representatives of this group, 5 are species of *Meibomia*, 2 of which, however, are confined to woodlands in the extreme southern portion of region I. *Meibomia canadensis*, which occurs in thickets along streams from the Missouri river well into the sand-hill region, is in some respects the most important species of the genus. It is found invariably either in the border of open woodlands or in low thickets, where it forms, especially in the latter, dense masses, the individuals of which rival the woody plants of the formation in height. Along the Niobrara river, a thicket which contains *Meibomia canadensis* may be recognized at some distance from the contrast which its bright green foliage and panicles of dark purple flowers make with the dark green leaves of the shrubs. In the edge of open woodlands it is of much less consequence, as the individuals are much lower and subsolitary. In certain portions of regions I and II, and rarely in III, *Meibomia canescens* assumes a similar rôle. It occurs in less definite patches, and from the smaller size of the individuals and the less conspicuous panicles is never a striking feature. *Meibomia grandiflora* confines itself almost wholly to deep woodlands, though along the Niobrara it grows luxuriantly in very dense thickets. Not infrequently, where the shade is intense, it is the sole constituent of the herbaceous layer of the formation. In such cases it presents a very odd appearance, since its leaves are borne at a considerable distance from the ground, where they spread out almost simultaneously. Looking through such a layer, one sees a small forest of stems with broadly expanded foliage, surmounted by long, slender, nodding racemes of pink or light blue flowers. The three climbers, *Apios apios*, *Falcata comosa*, and *Falcata pitcheri*, are almost equal in distribution and importance in regions I, II, and III. The true *Falcata comosa*, which has been confounded with *F. pitcheri*, is probably somewhat less common than the other two. In general, *Apios apios* and *Falcata pitcheri* occur associated in woodland formations throughout their geographical area. They are usually found climbing

over bushes and shrubs in such a manner that the two are often completely intertwined, so that the chocolate-brown flowers of the one and the bright blue flowers of the other come to be striking features of such woodlands. *Falcata pitcheri*, at least in regions I and II, is rather more common than *Apios*. It not infrequently takes almost entire control of low river banks and of clearings, where of necessity it usually assumes a creeping habit.

(4) Inhabitants of low prairies and meadows, typically vernal, I-IV. The first plant of this group to appear in the spring is the ground-plum, *Astragalus crassicaucus*, which occurs on prairies and hills throughout the State. In such situations, from its early flowering, it is one of the most striking plants of the prairies. The individuals are invariably low and spreading, sometimes as much as 5 decimeters in diameter, and are very prominent, since the dense masses of the reddish blue flowers appear at a time when the floral covering is almost destitute of color. The ground-plum does not grow in patches of any definite extent, but the individuals occur scattered here and there over hill and low prairie for distances of many kilometers. Though the plants while maturing their fruits persist the whole season through, they become inconspicuous after the flowering period is past and the floral covering has begun to take on more varied hues. *Astragalus carolinianus*, notwithstanding its large size and wide distribution, never assumes the same importance in formations. It occurs much later in the season and in situations where it is overtopped by its associates. Moreover, its long racemes of greenish white flowers, though large, are never conspicuous. Several species of *Psoralea* are of abundant occurrence in meadows and pastures throughout the greater portion of the State. *Psoralea argophylla* is very striking on account of its bright white stems and foliage, a character greatly emphasized by its habit of occurring in very large, definite patches. In situations which are somewhat xerophytic, the individuals become less robust and are more isolated, and hence are less evident in the floral cover-

ing. *Psoralea tenuiflora* and *P. floribunda*, though much taller and more diffusely branched, lack the peculiarly conspicuous foliage of *P. argophylla*, and are in this respect less striking constituents of prairie formations. Their tall, bushy habit, and the occurrence of the individuals in dense, almost thicket-like patches, rendered the more prominent by the innumerable small, blue flowers, make them none the less important members of the floral covering of the prairies. *P. esculenta*, on the contrary, plays an insignificant part on low prairies and hillsides. The plants occur isolated and are often almost wholly concealed in the mass of other vegetation in which they are found. They are readily visible only in midsummer, when the erect racemes of blue flowers give them a certain degree of prominence. *Baptisia bracteata* is commonly associated with the latter, though always much more abundant. It appears to prefer slightly xerophytic situations on western and southern slopes. The rather tall, coarse-leaved plants, with their very large racemes of bright, cream-colored flowers, are among the most striking features of hillsides in late spring. *Baptisia leucantha*, which is confined wholly to low prairies and clearings, is much less abundant. The individuals, however, are even more striking than those of *B. bracteata*, on account of the tall, strict stem, a meter or more high, crowned with a long raceme of yellow flowers. It is apparently localized in a few stations in regions I and II. The rattle-box, *Crotalaria sagittalis*, is confined almost wholly to the lowlands of the Missouri, where it is a familiar object in grassy meadows. *Cassia marilandica*, which occupies similar situations in II as well as in I, though less frequent, grows much taller and is much more conspicuous on account of its masses of deep yellow flowers. *Meibomia illinoensis*, the only species of *Meibomia* that grows in low, open prairies, is apparently disappearing from our flora. It has never been found in abundance, occurring at most in patches of scarcely more than a dozen plants, which are not frequent. In low meadows, and especially those which tend to become wet, *Parosela dalea* grows in

dense patches which, though frequent, are never of much extent. From its low habit and inconspicuous flowers, it is rarely an important element in the vegetation. *Glycyrrhiza lepidota*, though of very wide distribution in the State, never occurs abundantly over large areas, and in consequence does not assume the importance which its frequency might warrant. It is sometimes subgregarious, but its patches are neither large nor distinctive, except, perhaps, when the stems are set off by the rusty brown pods. *Acuan illinoensis* is very noticeable in lowland formations on account of the dense masses formed by its tall, leafy stems. It is one of our two sensitive plants. Of the three species of *Vicia*, *V. linearis* is the most important both in frequency and in abundance. Though regularly an inhabitant of low meadows, where it is gregarious, it tends to become more or less ruderal, and is fast becoming a common plant of railroad embankments and of roadsides. *Vicia americana*, though of much the same habit, is usually more robust. It commonly haunts meadows in the vicinity of thickets. *Vicia truncata* is an aberrant form which occurs sparsely at widely separate stations over the State.

(5) Xerophilous species of exposed, sandy bluffs, high prairies, and sand-hills, I-IV. Ten representatives of this group are species of *Astragalus*, which are confined almost wholly to the sand-hills of III and the table-lands and buttes of IV. One of the most characteristic species is the loco weed, *Astragalus mollissimus*. On high prairies and table-lands of IV, it commonly grows associated with *A. adsurgens*, which, however, is of narrower range. The two species are characteristic of the grass formation of high prairies in the foot-hills, and give a distinctive appearance to the grassy table-lands. In these situations *A. adsurgens* grows tall, 3-6 decimeters, and flowers a trifle later than the lower, spreading *A. mollissimus*, so that the latter is usually to be found coming into fruit as the former is coming into flower. *A. adsurgens* is practically confined to region IV, while *A. mollissimus* extends also throughout region III.

Astragalus racemosus occurs scattered throughout the northern and western portions of the State, but is most abundant along the upper course of the Missouri river. Here the individuals form large tufts, 3-7 decimeters high, which are rendered very conspicuous by the dense racemes of cream-colored flowers. Frequently the exposed side of a crumbling bluff will present little other vegetation. On the grassy bluff tops of the Ponca river, and on hilltops in the western foothills, the plants are generally small and insignificant in comparison with other constituents of the vegetation. *Phaca longifolia* is one of the characteristic plants of sand-hills in region III, where it is to be found on every sand-hill, or at least every hill occupied by the bunch-grasses, *Andropogon scoparius* and *A. hallii*, and in almost every blow-out throughout the region. Its habit is that of a grass rather than of one of the Astragali, and from its grayish color it is not readily distinguished except when in fruit. The large, beautifully mottled pods, from which it derives its common name of bird's-egg pea, make it a notable object in a barren blow-out or on a hill between tufts of bunch-grass and *Stipa comata*. If the prairies were to be characterized by the presence of any one species, that species would be the low under-shrub, *Amorpha canescens*, commonly called shoestring or lead plant. It is not only the controlling plant of drift-hills, sandstone hills, limestone hills, and high prairies in regions I and II everywhere, but is common on sand-hills and in dry valleys in region III, and on the table-lands of region IV. Its woody stem and deep roots give it a controlling influence wherever it occurs abundantly, and its more or less considerable height, grayish leaves and stem, and its bluish terminal raceme make *Amorpha* hills most striking objects in the landscape in region II. *Amorpha nana* is restricted entirely to the barren bluffs in the neighborhood of the confluence of the Missouri and the Niobrara. In habit it is almost a duplicate of *A. canescens*. The stem and leaves, however, are bright green, and although the individuals stand in dense patches on the hilltops, the latter are never conspicuous at a

distance. *Kuhnistera candida* and *K. purpurea* are notable inhabitants of *Amorpha* hills, upon which they are constantly to be found. They are most striking on such hills when the individuals of one species grow more or less associated, as is frequently the case. The bright red of the one contrasts most effectively in such cases with the clear white of the other. Not infrequently the individuals of the two species mingle indiscriminately, and this character is lost, although *K. purpurea* still gives a reddish cast to the vegetation. *Kuhnistera villosa*, which is restricted in its distribution almost wholly to the foot-hills and sand-hills, descending along the Platte into region II, plays a part in the sand-hill formations not unlike that of *Amorpha canescens*. It is, however, rarely, if ever, controlling. *Aragallus lamberti*, which grows all over regions III and IV, is found only in the extreme northern portion of regions I and II, where it is apparently an intruder. On high, barren hills, whether arenaceous or argillaceous, it assumes in early summer much of the importance of, and takes very much the same part in the formation as *Astragalus crassicaarpus* on the low hills of I and II in early spring. On high prairies of eastern Box Butte county, it is a prominent constituent of the *Stipa* formation. In regions I and II it is invariably low and spreading. The individuals are copious and subgregarious. Except when it displays its blue flowers, it owes its prominence entirely to its occurrence in very open formations. In the foot-hills *Aragallus lamberti* is a striking member of such formations on account of its pure white woolly stems and leaves. In the eastern portion of the State the leaves are brownish white or cream-color, and are not particularly noticeable. *Psoralea lanceolata* and *P. digitata*, which are confined for the most part to the western half of the State, occur in great abundance over sand-hills and table-lands. Although resembling *Psoralea digitata* very much in the manner in which it occurs in its usual habitat, *Psoralea lanceolata* is chiefly important in region III because it has become in many places the sole inhabitant of large tracts of fallow land, of which

it takes exclusive possession. On the sand-hills, where it is very common, it has a tendency to grow in small, dense patches about 3 decimeters in diameter, in striking contrast to most sand-hill inhabitants, which grow widely scattered. It is also a frequent inhabitant of blow-outs. *Psoralea digitata*, though occurring upon sand-hill after sand-hill for long distances, is usually subsolitary, and, while a taller plant with a much greater expanse of foliage, never catches the eye as quickly as the masses of dark green plants of *P. lanceolata*. *Psoralea cuspidata*, which resembles *P. digitata* very much, has been found in a single station on the dry, grassy bluffs of the Niobrara. *Parosela aurea* and *P. enneandra* are frequent inhabitants of the same station. The latter is the more abundant, and is frequently to be found in subxerophytic situations, while *P. aurea* is regularly xerophilous. They both occur typically in barren places, where *P. enneandra* is a striking feature on account of its tall stems and long, leafy racemes, and *P. aurea*, though less abundant, is none the less conspicuous from its spikes of bright yellow flowers. *Lotus americanus* occurs ordinarily in dense patches on dry hillsides and plains over the State. In the sand-hills, especially in the lake regions, it tends to become a common inhabitant of wet valleys. *Strophostyles helvola* and *S. pauciflora* are familiar objects on dry banks and exposed sandy bluffs throughout the State. They are both extensive creepers, and their prominence is due chiefly to this fact. In a few situations which are subruderal *S. helvola* manifests a tendency to form patches. *Lespedeza capitata*, which extends throughout the State, owes its prominence in formations to its tall, leafy stems, which are to be found almost invariably in small but definitely circumscribed areas. *Lathyrus ornatus incanus*, though small and inconspicuous, about 1 decimeter, is very abundant upon the sand-hills of the Loup district. It is one of the first plants to invade recent blow-outs in the wake of *Redfieldia flexuosa*. *Leptoglottis uncinata*, which is the most typical of our two sensitive plants, is also the most beautiful on account of its bright, rose-colored

flower-heads. It is rather a shy plant, rarely found in scattered groups of more than a dozen individuals. It is remarkably conspicuous when in full bloom, though at all times easily recognized on the barren clay bluffs which are its usual habitat.

(6) Xerophytes of the western table-lands and foothills, IV. Most of the representatives of this group are species of *Homalobus*, *Orophaca*, or *Lupinus*. One of the most important species of *Homalobus* is *H. montanus*, which is found in Dawes county and is abundant on hillsides throughout the Lodge Pole district. *Orophaca caespitosa* and *Astragalus bisulcatus* are confined to high ridges along the canyons of Dawes county. *Astragalus microlobus* is abundant on flat, barren stretches in many localities, where it grows low and spreading, almost as a creeper. *Lupinus plattensis* is a common constituent of the *Stipa* formation of high prairies. From its tall growth and large clusters of blue flowers, it is by no means the least striking of the many beautiful species which characterize this formation. *Lupinus pusillus* is a common inhabitant of sand-draws and of exposed stretches of pure sand, where, though low, it is important on account of its densely woolly leaves and panicles of bright blue or bluish flowers. *Kuhnistera compacta*, which is localized in the sand-hills of Scott's Bluff county, is the most remarkable species of this genus in our flora. Its stems, which are densely leafy, are often a meter high and are very conspicuous on account of the long (1 decimeter) nodding spikes of white or yellowish flowers.

(7) Introduced or naturalized species, chiefly of subruderal habit. These are, for the most part, species of *Trifolium* and of *Medicago*, as yet almost entirely sporadic. *Trifolium repens*, however, is fast becoming naturalized in blue grass glens along the Missouri river, while *Medicago sativa* is already a familiar plant along roadsides and in waste places throughout the State. Though *Melilotus officinalis* is of rare occurrence in regions I and II, *M. alba* is a common naturalized species of I, II, and III, growing in

dense patches in which the individuals are often 2-3 meters in height. The most widely distributed and characteristic plant of the group is *Cassia chamaecrista*, which forms immense patches, conspicuous through the innumerable yellow flowers. It is a frequent inhabitant of sandy roadsides and railroad embankments.

Rosaceae.— This family contains in our flora 11 genera and 40 species. With us none of the genera are large, *Potentilla* comprising but 9 species, *Prunus* 5, and *Rosa* 5.

The distribution of the species is as follows:

	No. spec.	Pec.
Common to the four regions	6	..
I. Wooded bluff, etc., region.....	24	5
II. Prairie region	20	1
III. Sand-hill region	23	3
IV. Foot-hill region.....	21	6

The species which are distributed throughout the State are *Agrimonia striata*, *Geum canadense*, *Potentilla monspeliensis*, *Prunus americana*, *Rosa arkansana*, and *Rubus occidentalis*.

The vegetation-forms represented are:

(1) Trees	7
(2) Shrubs	4
(3) Undershrubs	11
(4) Woody climbers and twiners.....	1
(6) Rosettes	2
(12) Rootstalk plants	12
(15) Dicyclic herbs	1
(16) Monocyclic herbs	1

The habitat-groups are seven, as follows:

1. Woody plants, inhabitants of forests, woodlands, and thickets, I-IV
2. Shrubs and bushes, growing on dry prairies, sand-hills, and sandy plains, II-IV
3. Shade plants and open woodland plants, I-IV
4. Hydrophilous species of wet meadows, I-IV.....

5. Xerophytes, inhabitants of high prairies in IV and dry valleys in III 2
6. Halophyte of brackish meadows in IV..... 1
7. Introduced species of sporadic occurrence in I and II.. 2

(1) Woody plants, inhabitants of forests, woodlands, and thickets, I-IV. This group is composed almost wholly of shrubs or of low, rather shrub-like trees. Of the species of *Prunus*, *P. americana* is the most widely distributed in the State, in different parts of which it occupies different habitats. In regions I and II it regularly forms thickets, which are usually a part of forest formations, though sometimes, especially in clearings, isolated. Rarely in the prairie region, but more commonly in the sand-hills, the wild plum occurs in small, isolated patches in which the individuals are reduced to low bushes, scarcely more than a meter high. *Prunus americana* attains its greatest prominence in woodland formations in early spring, when its masses of white blossoms stand out sharply against the background of barren twigs. *Prunus virginiana*, the common choke-cherry, and *P. demissa*, the western choke-cherry, are to be regarded as geographical modifications of the same species. *P. virginiana* is found abundantly in woodlands along the banks of streams in the prairie region and especially in forests along the Missouri bluffs. It is a small tree or shrub, which usually occurs in small clumps, though sometimes growing scattered in the formation. Along the northern course of the Missouri, it passes through the most gradual gradations into *P. demissa*. The latter with *Quercus macrocarpa* is distinctive of the high bluffs of the upper course of the stream. Along the lower edge of the bluffs, or in woodlands, it has essentially the habit of *P. virginiana*. But as it ascends the slopes it decreases in size, until on the tops of the bluffs it forms dense thickets of bushy, thorny individuals, rarely a meter in height. Along the banks of streams in the sand-hills, the western choke-cherry grows in loose clumps in which the individuals do not exceed 2 meters in height. In

wet valleys, and sometimes also in dry valleys in the same region, similar clumps are to be found. But they usually contain a smaller number of individuals—rarely more than 4-5. *Malus ioensis* is localized in deep woodlands along the Missouri and the lower course of the Niobrara. It usually occurs as a tall, slender shrub, growing isolated in the second layer of the formation. In Holt county, however, the dense thickets formed by this species are so characteristic of one stream that it has received from them the name of "Apple creek." Along this stream, *Malus ioensis*, though small, is invariably tree-like in habit. *Crataegus mollis* and *C. tomentosa* are confined to the deep woodlands of the Missouri and to similar formations in the extreme eastern edge of region II. They are both rather low trees, ranging from 4-10 meters in height. They always occur isolated in the deeper portions of the woodland, and are invariably overtopped by their neighbors. As a rule they are inconspicuous, except in the flowering period and in late autumn after leaf fall, when they are readily distinguished by their clusters of reddish fruits. *Crataegus coccinea* and *C. macracantha* are restricted to the northern portion of the sand-hill region. They are never very abundant in any one station, though occasionally forming small clumps which are conspicuous on account of the dark green foliage and bright red twigs. The three species of *Amelanchier* grow either in the forest formations of the bluffs of the Missouri and its chief tributaries in region I, or they occur here and there as a marginal fringe along the banks of such streams. *Amelanchier canadensis*, which is the most tree-like in habit and the tallest, is not infrequent along the bluffs of the lower Missouri from which it extends a short distance up the Platte. *Amelanchier alnifolia*, which differs from *A. canadensis* in being a low, slender shrub, is very abundant in the Pine Ridge district, from which it has wandered far eastward along the Niobrara and even along the Missouri. *A. botryapium*, which occurs rarely from the mouth of the Platte to Dakota county, appears to be intermediate between *A. canadensis* and *A. alni-*

folia. At any rate it bridges over the interval between the northwestern limit of the one and the southeastern limit of the other. The two roses belonging to this group are extremely local in their distribution. *Rosa acicularis* occurs only in Sowbelly canyon in the Hat creek basin, while the climbing rose, *R. setigera*, has been found only in wooded bottoms in the extreme southeastern portion of the State. *Opulaster opulifolius* grows scatteringly in a few counties in the very heart of the Niobrara district. Neither its frequency nor its abundance are such as to make it an important element in the woody vegetation. The raspberries, *Rubus strigosus* and *R. occidentalis*, occur in woodlands and cleared meadows throughout the State. *R. strigosus* is perhaps most abundant in the eastern portion of the State, while *R. occidentalis* occurs more commonly in the sand-hill region and in the foot-hills. But the two are often found in the same thicket, and are to be distinguished easily only when in fruit. The blackberry, *R. villosus*, has been found at but a few stations along the lower Missouri. It is probably to be regarded as escaped from cultivation.

(2) Shrubs and bushes, growing on dry prairies, sand-hills, and sandy plains, II-IV. The most typical member of this group is *Cercocarpus parvifolius*, the most widely distributed is *Rosa arkansana*. The former is confined entirely to rocky hills in the western portion of region IV. Like all true xerophytes, the individuals are sparsely distributed, though they are sufficiently numerous upon hillsides to give them a distinctive appearance. *Rosa arkansana* is a familiar plant upon dry prairies and hills throughout the State. According to its situation, it grows in more or less dense patches, often covering several hectares, or, where it is more typically xerophilous, the individuals are scattered here and there over the plain, much after the fashion of *Cercocarpus*. Generally the prairie rose is a slender bush, considerably less than a meter in height. But in the ravines of the upper Missouri, where it grows in thickets, which, though small, are often impenetrable, it is 2-3 meters high, and during the

flowering period is a veritable mass of flowers. *Rosa woodsii*, which is rare on high barren hills in region IV, is represented much more abundantly by its variety, *R. woodsii fendleri*, which is an inhabitant of sandy hillsides in IV, and in the western portions of III forms loose but exclusive patches in the passes between wet valleys and over the lower slopes of sand-hills. These patches are of considerable extent. On the tops of sand-hills, particularly on the divides or watersheds, long stretches are occupied more or less exclusively by *R. arkansana*. The individuals are not closely massed, but very few individuals of other species are to be met with in the area covered by the roses. Even the characteristic sand-hill grasses are absent. *Prunus besseyi*, the sand-cherry, is restricted to sandy situations in III and in the edge of IV. It is a constant inhabitant of sand-hills, where it occurs not only on the tops, but equally on the slopes and in the depressions. In the Niobrara district, the patches of the sand-cherry are extensive, often covering 2-3 hectares. In such situations they bear some resemblance to diminutive forests, since they exclude everything except occasional tufts of *Bouteloua hirsuta* or *B. oligostachya*. Here the individuals, which are very leafy, are rarely more than 2 decimeters high. Although these patches, on account of the aggregation of individuals, are always prominent features of the floral covering, this prominence is greatly increased in late summer when the plants hang full of blue-black fruits. On the eastern edge of the sand-hills, the sand-cherry forms patches similar to those described. But in the heart of the region, where on the sand-hills the vegetation is very sparse, the plants occur at wider intervals, and other plants are seldom to be found mingled with them. Here the patches are much smaller. Although the sand is penetrated in all directions by the subterranean woody stems, they are unable to retain it, and hence projecting dead stems, where the sand has blown away, and heaps of dried stems in the bottoms of blow-outs are among the commonest features of the sand-hills.

(3) Shade plants and open woodland plants, I-IV. This group contains two species common to woodlands throughout the State and often found associated, namely, *Geum canadense* and *Agrimonia striata*. Though of nearly equal frequency, the first is the more abundant and is more constant in habitat. The latter often becomes subhydrophilous, and wanders out into wet meadows or upon more or less exposed banks. Both are somewhat abundant in forest formations in the eastern half of the State. They are rarely conspicuous elements of the herbaceous layer because of their solitary habit and the fact that they are overtopped by many taller herbs. Three other species occur more rarely in our flora. One is confined to the bluffs of the lower Missouri. The other two grow along the wooded banks of streams of the sand-hills and foot-hills. *Fragaria americana* has found its way down from the Pine Ridge district along the bluffs of the Niobrara and the Missouri. It is also found in similar situations along the Dismal river. It is a constant inhabitant of dry, shady bluffs, where it generally occurs to the exclusion of all other flowering plants.

(4) Species of low meadows, I-IV. Five of the six members of this group are species of *Potentilla*. With the exception of *Potentilla arguta* they agree almost exactly in habit and in habitat with *P. monspeliensis*, though the stems and leaves are usually not so coarse. *Potentilla monspeliensis* is a common plant of the edges of woodlands and of low, wet meadows throughout the State. In whatever formation it may be found, it stands out very prominently, despite the apparent insignificance of its flowers, on account of its tall, shaggy stems and coarse leaves. For the same reason, *P. arguta*, which is taller and more erect, stands out as a striking feature of low hillsides and meadows in the central and eastern portions of the State. *Fragaria virginiana* is of common occurrence in the low meadows and open ravines of I and II. In such situations the plants are very small, and on account of their propagation by means of runners they commonly form carpet-like patches of considerable extent.

Not infrequently the plants occur more or less scattered and are in consequence of much larger size. When such is the case the large, white flowers make them conspicuous objects in early spring.

(5) Xerophytes of high prairies and dry valleys, III and IV. *Potentilla pennsylvanica* occurs more or less commonly on dry, barren hills in region IV and in dry valleys in region III. It has been met with occasionally on high, dry hills in region II. In the dry valleys of the sand-hills, it occurs rather thickly over definite areas. While the general aspect of the plants makes them noticeable in the vegetation of such situations, they derive their most conspicuous feature from a rust, *Phragmidium potentillae*, which in mid-summer gives a bright red appearance to the whole patch, being found on almost every individual in almost every spot. *Potentilla hippiana*, which resembles *P. pennsylvanica* in many respects, is a common plant of high prairies in the Pine Ridge district.

(6) Halophyte of brackish meadows, IV. The sole representative of this group is *Potentilla anserina*, which occurs in halophytic situations at a few stations in IV.

(7) Introduced species, I and II. This group comprises but two species. One, *Potentilla canadensis*, is recorded for a single station in the southern portion of region I. The other, *Sanguisorba sanguisorba*, has found its way into a few localities in II.

Saxifragaceae—Onagraceae.—This group contains in our flora 25 genera and 42 species, distributed among 6 families as follows: Saxifragaceae, 2 genera and 7 species; Crasulaceae, 2 genera, 2 species; Hamamelidaceae, 1 genus, 1 species; Halorhagaceae, 3 genera, 4 species; Lythraceae, 4 genera, 5 species; and Onagraceae, 13 genera and 23 species. The only genus of any size is *Ribes*, which is represented by but 6 species.

The regional distribution of the species is:

	Saxif.	Cras.	Ham.	Halorh.	Lyth.	Onag.	Tot.	Pec.
Common to the four regions.....	3	0	0	0	0	4	7	..
I. Wooded bluff, etc., region	3	1	1	0	2	10	17	1
II. Prairie region.....	3	1	0	2	5	14	25	6
III. Sand-hill region.....	4	1	0	3	2	18	28	3
IV. Foot-hill region.....	6	1	0	0	0	15	22	7

The species common to the four regions are: *Gaura biennis*, *G. parviflora*, *Heuchera hispida*, *Meriolix serrulata*, *Onagra biennis*, *Ribes floridum*, and *R. gracile*.

The vegetation-forms represented are:

(2) Shrubs	1
(3) Undershrubs	6
(6) Rosettes	2
(8) Succulents	1
(12) Rootstalk plants	12
(15) Dicyclic herbs	3
(16) Monocyclic herbs	6
(18) Submerged plants	4
(19) Amphibious plants	8

The habitat-groups are nine in number.

1. Xerophilous shrubs of the foot-hills and sand-hills, III-IV 4
2. Shrubs of woodlands, rarely found in thickets, I-IV.. 3
3. Herbs inhabiting woody formations, for the most part on wet banks, I-IV 2
4. Immersed aquatics of pools and streams, II-III..... 4
5. Hydrophytes of wet meadows, marshes, and spring bogs, I-IV12
6. Subruderal species of meadows, roadsides, and low prairies, I-IV 1
7. Inhabitants of canyons in IV 1
8. Xerophytes of high barren prairies and sand-hills, I-IV10
9. Xerophytes of dry table-lands and foot-hills, IV 5

(1) Xerophilous shrubs of the foot-hills and sand-hills. This group is composed of four species of *Ribes*, two of

which, *R. cereum* and *R. setosum*, are confined to rocky hills and canyon sides of the foot-hills. They are both low and bushy, scarcely playing any important part in the vegetation. *Ribes aureum*, which is very common in regions III and IV, is much more gregarious in habit. In subxerophytic situations it often forms large patches, the individuals of which, however, are not closely aggregated. It is chiefly remarkable on account of the variation in color and shape of its fruits. Though the bushes can not be told apart, some produce blue-black fruits, while others bear yellow ones. *Ribes cynosbati* is known in but one station in the northern portion of region III.

(2) Shrubs of woodlands, rarely found in thickets, I-IV. The witchhazel, *Hamamelis virginica*, grows rarely in one or two stations along the lower Missouri. *Ribes floridum* and *R. gracile* are probably the two most widely distributed and important bushes in our flora. In the eastern part of the State, thickets of underbrush composed of one or both of these species are found everywhere in woodlands. In the western part of the State they are less abundant, and are most frequently represented by scattered individuals occurring here and there in the edge of thickets or in lowlands. *Ribes gracile* is much the more striking of the two. The bushes are usually 1-1½ meters high and are generally more or less rounded in outline. The stems are very prickly, and in situations where the individuals are aggregated they form fairly impenetrable thickets. *R. floridum*, on the other hand, from its low growth, rarely more than a meter high, and its spreading, slender habit, is much less striking, except perhaps when in full bloom. It is rarely found in definite thickets.

(3) Herbs of woody formations, growing for the most part on wet banks, I-IV. *Circaea lutetiana* is the characteristic inhabitant of wet banks in regions III and IV, extending down along the Missouri to a few localities in I. In region III it is both frequent and abundant. The individuals with their masses of dark green leaves, and slender,

almost inconspicuous inflorescence, occur in dense patches on low, overhanging banks of which they have almost entire control. Along the base of sandy bluffs, in rather exposed, though moist situations, it grows associated with *Phryma leptostachya*, the two forming a dense, homogeneous mass. *Heuchera hispida* is found in some localities in dry, shaded situations; in others it grows on wet banks either shaded or exposed. The plants are invariably solitary, and are conspicuous features of the floral covering, especially when they occur on dry bluff sides where other herbaceous vegetation is lacking.

(4) Immersed aquatics of pools and streams, I-III. The representatives of this group are all members of the Halorhagaceae. Two, *Callitriche palustris* and *Hippuris vulgaris*, are found only at rare stations in the sand-hill region or on its border. The two species of *Myriophyllum*, *M. spicatum* and *M. pinnatum*, are common features of ponds in II and III. *Myriophyllum pinnatum* is confined to shallow pools and sluggish or stagnant streams in regions I and II. Under favorable conditions it takes entire possession of such habitats, fairly choking the stream with a tangled, green mass of stems and dissected leaves.

(5) Hydrophytes of wet meadows, marshes, and spring bogs, I-IV. The three species of *Epilobium* are to be found in almost every fresh, sandy marsh or spring bog in regions III and IV. *E. adenocaulon* and *E. lineare*, moreover, have extended into the edge of II and have been found in similar habitats at a single station near the mouth of the Platte. On spring banks especially, *E. adenocaulon* and *E. coloratum* are striking plants. They have a tendency to grow associated in dense patches, though not infrequently one or the other manifests the same disposition when alone. Their chief importance as amphibious plants does not arise from the conspicuousness of the individuals, but is due to their close aggregation in situations where most of the plants are low and more or less inconspicuous. *Epilobium lineare*, on the contrary, usually grows in wet situations thickly

covered with grasses, through which the individuals are scattered more or less abundantly. *Lythrum alatum* is a common inhabitant of margins of ponds or marshes in II and III. In the lake region of Cherry county, in some lake valleys where there are numerous small pools or marshes, this species may be found forming a complete ring around the smaller ponds and marshy spots. The ring or border is about a meter in thickness, and may be a complete one, surrounding the pond entirely, or only a segment of more or less extent. Where the outline of the pond is irregular, this zone is often interrupted by patches of other amphibious plants, notably *Stachys palustris*. On the margins of small, marshy ponds in II, the species grows in the same manner except that, since the outlines of the ponds are more irregular, the zonal fringe of *Lythrum* is less complete and seldom extends about more than one side of the pond. In regions I and II it is also an inhabitant of wet spots in meadows, where it is a very conspicuous feature throughout its somewhat extended period of flowering. *Penthorum sedoides* is a homely plant of inconspicuous aspect which grows shyly along muddy banks of streams and pools and in ditches in I and II. It is rarely found along sandy banks in III. *Ludwigia polycarpa* and *Isnardia palustris* are found localized in pools and ditches from I to IV. They occupy identical habitats, to which, however, they give a different character. *Ludwigia polycarpa* is erect and grows in muddy situations or in very shallow ponds, where it forms dense, controlling masses. *Isnardia palustris* is procumbent and spreading and forms a carpet over mud in swamps and boggy places. *Ammannia coccinea* plays essentially the same rôle as *Ludwigia polycarpa*, from which, indeed, it is only to be distinguished upon close inspection. *Ludwigia alternifolia* and *Ammannia auriculata* occur sparingly in widely separated stations in region II.

(6) Subruderal species of meadows, roadsides, and low prairies, I-IV. Few plants of our flora are so generally distributed as *Onagra biennis*. In its original habitat, in

meadows or on low prairies or hillsides, the individuals are invariably subsolitary, usually not more than 8-10 being found over a definite area. The species, however, manifests a decided tendency to assume the ruderal habit, and wherever it occurs in waste places or along roadsides the plants endeavor to group themselves more closely. With us the evening primrose is a tall, coarse weed, striking only in twilight, when its large, yellow flowers are open.

(7) Inhabitants of canyons in IV. The sole representative of this group is *Pachylophus caespitosus*, which occurs on the sides of canyons in Scott's Bluff county.

(8) Xerophytes of high barren prairies and sand-hills, I-IV. *Meriolix serrulata* in late May and early June is characteristic of barren slopes and ridges in region II. It is very conspicuous on account of its bright yellow flowers, which give a distinctive appearance to hills for a great distance. This results from the fact that it is scattered almost uniformly over the entire surface, though never occurring in definite masses. On the prairies it grows 3-5 decimeters high. There it is slightly woody at the base, and is very strict, branching only at the base. In region III, where it flowers in July and early August, it is one of the commonest inhabitants of sand-hills and even of blow-outs. Here it is a half shrub, each individual forming a more or less circular, densely branched, woody bunch, about a decimeter in diameter. These bunches gather and hold sand much as do the tufts of bunch-grass. The flowers also are dark yellow, while on the prairies and on the table-lands of IV in the grass formation, where the plants grow erect and are little branched, the flowers are light yellow. Of the three species of *Gaura*, *G. biennis*, *G. coccinea*, and *G. parviflora*, the second is the most widely distributed, though not the most important. Like *Meriolix serrulata*, it occurs scattered over dry hillsides throughout the State. It is never so prominent, since its leafy stems blend with the other vegetation and its deep red flowers are small and not readily visible. On the high table-lands of IV, this species grows

very low, scarcely attaining half the size it has in region II. In their proper habitats *Gaura biennis* and *G. parviflora* are at least subsolitary and rarely attain any considerable height, growing from $\frac{1}{2}$ to $1\frac{1}{2}$ meters. Both are taking on the ruderal habit, however, and along roadsides and in wastes they form thicket-like masses in which the individuals are diffusely branched and attain a height of 2–3 meters. *Oenothera rhombipetala*, while it occurs sparingly over the sandy plains of IV and on the sand-hills and in dry valleys of III, has become a constant inhabitant of cultivated lands that have "gone back." In such places it forms controlling patches, in which little else is to be found. It usually grows about a meter high, though on the sand-hills it rarely attains half that height. In places where it is abundant, it is a most conspicuous portion of the vegetative covering on account of its immense spikes of large, bright yellow flowers. *Megapterium missouriense*, which resembles the foregoing in its large, yellow flowers, is confined almost exclusively to clay or limestone bluffs along the Missouri. *Anogra pallida* resembles *Oenothera rhombipetala* in the patches which it forms, but its flowers are nyctanthous, and it is conspicuous solely on account of its shining, whitish stems and leaves and comparatively large size.

(9) Xerophytes of dry table-lands and foot-hills, IV. Two members of this group, *Chamaenerion angustifolium* and *Sedum stenopetalum*, are confined entirely to high, barren buttes and canyon sides in IV, where they are of sparing occurrence. *Galpinsia hartwegii* and *Gaurella guttulata* are likewise confined to similar xerophytic situations in the Lodge Pole district, where they are rather common. On high, grassy table-lands throughout IV, a beautiful plant in June and July is *Anogra coronopifolia*. Along roadsides and in pastures it covers extensive areas more or less completely and exclusively. Such patches, when the plants are covered with the large violet-purple flowers, are a feature of the landscape.

Loasaceae—Umbelliferae.—This section contains 24 genera and 44 species, distributed among the following 5 families: Loasaceae, 1 genus, 3 species; Cactaceae, 2 genera, 7 species; Umbelliferae, 18 genera, 26 species; Araliaceae, 2 genera, 3 species; Cornaceae, 1 genus, 5 species.

The distribution of the species is indicated by the following table:

	Loas.	Cact.	Umbel.	Aral.	Corn.	Tot.	Pec.
Common to the four regions.....	0	1	4	0	1	6	..
I. Wooded bluff, etc., region.....	1	2	13	3	3	22	4
II. Prairie region.....	0	2	14	0	4	20	3
III. Sand-hill region.....	2	5	16	1	4	28	3
IV. Foot-hill region.....	3	5	12	0	2	22	5

The species of general distribution are: *Cicuta maculata*, *Washingtonia longistylis*, *Peucedanum foeniculaceum*, *Sanicula canadensis*, *Cornus stolonifera*, and *Opuntia polyacantha*.

The following six vegetation-forms are represented:

(2) Shrubs	4
(6) Rosettes	1
(8) Succulents	7
(12) Rootstalk plants	24
(13) Bulb and tuber plants	4
(19) Amphibious plants	2

The habitat-groups are:

1. Woody plants growing in forests or forming thickets, I-IV.	5
2. Shade plants and open woodland plants, I-IV.	9
3. Amphibious plants of pools and springs in III and IV; adventitious in I	2
4. Hydrophilous species of wet meadows and marshy situations, I-IV	4
5. Xerophytes of dry bluffs, prairies, sand-hills, and rocky ridges, I-IV	18
6. Ruderal and introduced species of sporadic occurrence, I-III	5

(1) Woody plants growing in forests or forming thickets, I-III. This group contains only the genus *Cornus*, and includes 4 species. A single one, *C. stolonifera*, is distributed throughout the State. In the woods of the Missouri bluffs, and in parts of region II, it is a common layer in forest formations. Sometimes it forms thickets either on the edge of woodlands or along the banks of streams. In the woodlands of the Missouri district, it is a conspicuous shrub on account of its much-branched habit and dark red twigs. *C. asperifolia*, which is even more common than the foregoing in regions I and II, is a taller shrub with a tree-like habit. It usually grows in rather loose thickets, which constitute a layer of the woody formation. In the canyons of the Niobrara, *C. amomum* plays a similar part. It is lower-growing, however, and forms much denser thickets. *C. candidissima* is scattered here and there in regions I, II, and III, but never occurs in sufficient quantity to be of significance.

(2) Shade plants and open woodland plants, I-IV. Two plants of this group are to be found associated in deep woodlands over the State. One, *Sanicula canadensis*, at certain seasons of the year, takes almost entire possession of the soil in large stretches of woodland, where the individuals frequently stand so thick as to form an almost carpet-like herbaceous layer. Its prominence in the floral covering is due entirely to its aggregation, as the individuals are remarkable neither for their size nor for their flowers. Although often occurring with the foregoing, *Washingtonia longistylis* prefers dark, shady ravines. In such situations only does it attain its maximum size. Here it is to be found in more or less extensive masses, sometimes definite enough to be termed patches. Generally the plants are scattered through the woodland or occur in groups of two or three, which are readily discerned on account of their peculiar deep green foliage. *Washingtonia claytoni*, which is much less frequent, is identical with *W. longistylis* both in habit and in habitat. Likewise *Sanicula marilandica* is distinguished with difficulty from *S. canadensis*, which biologic-

ally it resembles in all respects. In woods where *Sanicula canadensis* does not take complete control of the herbaceous layer, *Deringia canadensis* is usually found associated with it. The two blend so completely that the latter loses but little of its uniformity. When in fruit *Deringia* is somewhat taller than the other and is slightly more prominent on that account. *Heracleum lanatum* is a tall-growing plant which has wandered down from the Hat creek basin into the Niobrara district and is to be found at several stations along the upper Missouri. In the shaded ravines of the upper Missouri and the deep wooded canyons of the Niobrara, *Heracleum lanatum*, on account of its immense leaves and broad umbels of bright white flowers, stands out as a prominent feature of the vegetation. Though it usually occurs single, it is so striking that the floral covering of these spots seems to take its character from the presence of this plant alone. On certain marshy banks it grows more copiously, as many as 8-10 plants occurring together. *Aralia racemosa* is confined to the bluffs of the lower Missouri, where it occurs, not very frequently, on the sides of heavily wooded ravines. *Panax quinquefolia*, which is also confined to a few stations along the Missouri bluffs, is to be found about half way up the sides of steep bluffs in the dense shade. Neither species grows in abundance, but few individuals occurring in any one spot, and, as they are always overtopped by their neighbors, they have little importance in the vegetation. *Aralia nudicaulis* is found upon the steep sides of the Missouri bluffs and in the deep canyons of the Niobrara. The plants are copious, covering the bluff sides completely, and broken only here and there by trees and shrubs.

(3) Amphibious plants of pools and springs in III and IV; adventitious in I. *Berula erecta* occurs either as a narrow border along the margins of cold, clear springs, particularly spring branches, in the marshes where the latter head, or in dense masses in the middle of ponds and pools throughout regions III and IV. It has also found its way into springy situations of similar character along the Mis-

souri. In its usual habitat, *Berula erecta* is an immersed aquatic. But the fact that the leaves have not undergone much structural modification would indicate that this habit has been assumed and that the plant was originally amphibious. Its presence in any hydrophytic formation is very easily discerned during the flowering period by the sharp contrast between its white flowers and its dark green foliage. *Sium cicutifolium*, which resembles *Berula* in most respects, is confined to the lakes and pools of Grant county.

(4) Hydrophilous species of wet meadows and marshy situations, I-IV. In certain portions of the State, especially in regions I and II, *Cicuta maculata* is an inhabitant of wet meadows and swamps, while in the sand-hills, though frequently found in marshy valleys, it grows not uncommonly in the edges of pools and streams. In wet meadows it is subsolitary, but in swampy situations it is invariably gregarious, growing in extensive patches, which, on account of its tall habit and white umbels, give a decided character to the vegetation. It often occurs associated with *Asclepias incarnata*, and the intermingling of the two during the flowering period produces a noticeable effect. *Cicuta bulbifera*, which resembles it much, grows somewhat shyly in the swamps of the Loup district. As regards the part which they play in the floral covering, *Zizia aurea* and *Thaspium barbinode* are scarcely to be distinguished. They are both tall plants of slender growth, with a prominent, yellow inflorescence. Though never forming definite masses, they often occur in sufficient abundance in low meadows to give them a yellow color.

(5) Xerophytes of dry bluffs, prairies, sand-hills, and rocky ridges. Two of the most widely distributed plants of the group are *Opuntia polyacantha* and *Cactus viviparus*. The former occurs throughout the State; the latter is abundant in the edge of II and throughout III and IV. It has likewise made its way into the northwestern corner of I. Considered from the point of view of their typical habitat, these are among the truest of xerophytes. With us, however,

they have had to adapt themselves to less thoroughly xerophytic situations. This is especially true of *Opuntia polyacantha*, which often in the southern portion of II and along the Missouri river in I becomes hydrophilous. *Cactus viviparus*, even with us, is a constant xerophyte. Throughout the sand-hills and foot-hills, the two are to be found associated, not only on the sandy ridges and hillsides, but on sandy stretches, in dry canyons, and ravines. The form and disposition of *Cactus viviparus* is in strict accord with its constancy of habitat. The individuals, though varying not a little in size, are invariably globose and are found in "nests" of 3-15 individuals. *Opuntia polyacantha*, where it is truly xerophilous, often grows in small, dense patches in which the individuals are commonly much branched, the joints being flat and somewhat leaf-like in outline. As an exception to this, the individuals occur scattered or solitary in the sparse vegetation of the sand-hills of the Loup district. In the low, moist situations along streams in II, two forms are found. The one, which is essentially like that of the sand-hills, though much more branched and attaining a height of 5-6 decimeters, grows in masses 3-4 meters in extent. The other form is diminutive and cylindrical. The joints, which are only two or three, are never more than 2-3 centimeters in length. The individuals of this form always occur singly and are scarcely to be distinguished, since the grayish thorns give them a color like that of the sand in which they grow. In the heart of the sand-hill region, *Opuntia humifusa* is much more common than *O. polyacantha*, to which it is similar. Both lend a special character to the sand-hills when in flower, their large, bright yellow flowers being among the most conspicuous features of the landscape. The same is true, but to a less extent, of the smaller and less widely distributed species, *Opuntia fragilis* and *O. rutila*. *Cactus viviparus*, though its red flowers give a characteristic color to many of the sub-sand-hills, has less importance in the sand-hills proper, where the individuals are much sunken in the sand. *Mentzelia deca-*

petala, which is a not uncommon inhabitant of barren bluff tops and bluff sides of the upper Missouri, is much more common westward. Along the Niobrara it is rare, being found only on barren clay bluffs. It is common in xerophytic situations along the Republican and in the foot-hills, though never abundant. Along roadsides and upon abandoned "claims," it becomes subruderal and forms rather definite patches. Both in these situations and in the sparse vegetation of its typical habitat, its tall habit and large cream-colored flowers give it no little prominence. *Mentzelia nuda*, which is common in II and III, is smaller than *M. decapetala*, and the flowers are only half as large, though more numerous. It also differs in that it usually occurs in masses of some extent. A third species, *M. albicaulis*, has been found only upon Scott's Bluff at an elevation of 1,400 meters. The umbellifers are represented in this group by several species, the most widely distributed of which is *Peucedanum foeniculaceum*. This occurs in earliest spring very abundantly upon sandstone hills and to a less extent upon drift-hills throughout I and II. The tops of sandstone hills are sometimes almost carpeted with the spreading, dissected leaves of this plant, and the rather long-stemmed, yellow inflorescences give a decided color to such hills at this season. In regions III and IV, *P. foeniculaceum* is much less common, occurring only at a few stations. This comparative infrequency of *P. foeniculaceum* in the western part of the State is readily accounted for by the fact that a close relative, the western *P. nudicaule*, is here very common. *P. kingii* has been found only in the pass to the northward of Scott's Bluff. Two species of *Cymopterus*, *C. montanus* and *C. acaulis*, which are very much like *Peucedanum* in habit, are confined almost wholly to rocky plains and hills of IV, the former extending a short distance down into the Niobrara district. The same is true of *Musineon tenuifolium* and *M. divaricatum*, which are frequent and often abundant in the Pine Ridge district, where the former is one of the frequent inhabitants of Bad Lands.

(6) Ruderal and introduced species of sporadic occurrence, I-III. The members of this group are *Pastinaca sativa*, *Daucus carota*, *Foeniculum foeniculum*, *Eryngium aquaticum*, and *E. dichotomum*. In general they are confined to regions I and II. *Pastinaca sativa* is also a frequent inhabitant of low meadows in the eastern portion of the Niobrara district. Within ten years *Daucus carota*, once rare in I, has become more and more an abundant weed in pastures along the lower course of the Missouri. During the last six years it has invaded the eastern portion of II to some extent, but it is still rare and confined to a few localities in II.

Heteromerae. — This order comprises in our flora 10 genera and 18 species representing the following 4 families: Ericaceae, with 2 genera and 3 species; Monotropaceae, 2 genera, 2 species; Plantaginaceae, 1 genus, 7 species; Primulaceae, 5 genera, 6 species.

Their distribution in the regions is as follows:

	Eric.	Monot.	Plant.	Prim.	Tot.	Pec.
Common to the four regions	0	0	2	1	3	..
I. Wooded bluff, etc., region	0	1	3	2	6	1
II. Prairie region.....	0	0	7	3	10	3
III. Sand-hill region.....	1	0	3	4	8	1
IV. Foot-hill region.....	2	1	4	3	10	5

The species of general distribution are *Steironema ciliatum*, *Plantago major*, and *Plantago purshii*.

But five vegetation-forms are represented. They are:

(3) Dwarf shrubs	1
(12) Rootstalk plants	10
(16) Monocyclic herbs	4
(19) Amphibious plants	1
(21) Parasites	2

The following habitat-groups may be recognized:

1. Inhabitants of dense, shady forests along the bluffs of the Missouri river, I	1
2. Inhabitants of wooded canyons in III and IV	4

3. Hydrophilous species of wet meadows and the banks of streams, III-IV 2
4. Species growing on low prairies and meadows, I-IV... 3
5. Xerophytes of high prairies and sand-hills, I-IV..... 4
6. Introduced species of lawns, roadsides, and waste places, I-III. 4

(1) Inhabitants of dense shady forests along the bluffs of the Missouri, I. *Monotropa uniflora* is a rare plant along the bluffs of the Missouri. It grows here in the humus and leaf mold in connection with the roots of various trees. It is to be found only in the most secluded spots in the deepest woods.

(2) Inhabitants of wooded canyons in III and IV. The representatives of this section are confined almost wholly to the Hat creek basin. The bearberry, *Arctostaphylos uva ursi*, has been found very sparsely in the eastern edge of the Lodge Pole district and in a single canyon in both the Loup and the Republican districts. *Pterospora andromedea* grows only beneath the scattered pines in the narrower canyons of the Hat creek basin. *Pirola chlorantha* and *P. secunda* are found rarely in similar situations. The latter grows also on Pine Ridge.

(3) Hydrophilous species of wet meadows and banks of streams, III to IV. *Naumburgia thyrsoflora* is confined substantially to the sand-hill region, where it is a frequent plant in marshes and on the edges of pools. In the Niobrara district it has been found as well upon the dry bottoms of shaded ponds. It usually occurs in small groups of a few individuals which are prominent on account of their dense masses of yellow flowers. The shooting star, *Dodecatheon meadia*, which is characteristic of the subalpine region of the Rocky mountains, has found its way down along the Platte into the foot-hills, where it is of rare occurrence.

(4) Inhabitants of low prairies and meadows, I-IV. *Steironema ciliatum*, although it grows throughout the State, is most frequent in low meadows or in the edges of wet

thickets in regions II and III. It is usually found in definite groups of a few individuals, which in favored situations sometimes attain the dignity of patches. It is not infrequently a striking feature of low meadow formations on account of its abundant bright yellow flowers. The related species, *S. quadriflorum*, has been found at a single station along the Republican. *Androsace occidentalis*, though of no significance in the floral covering, is an interesting little plant. It is quite common on the prairies of regions I and II south of the Platte. It forms fairly close patches, though on account of the small size of the plants, which are but 2-6 centimeters high, this fact can be ascertained only on the closest inspection. In many stations it is associated with *Draba caroliniana*.

(5) Xerophytes of high prairies and sand-hills, I-IV. These are all species of the genus *Plantago*. One, *P. purshii*, grows throughout the State, from barren hills of the Missouri and the salt basins of region II to high, rocky plains of IV. Wherever it occurs, this species invariably forms unusually large patches, which, along roadsides, often extend uninterruptedly for several kilometers, and frequently cover an area of more than a square kilometer in the dry valleys of the sand-hills. These patches give a most striking appearance to the situations in which they are found, often betraying the character of the vegetative covering of a hillside or a dry valley at a distance of several kilometers. The species is very variable with respect to the size of the plant. In the salt basins of region II and in prairie-dog towns of III and IV, it is usually a decimeter or so high, with long, spreading leaves. In the dry valleys of the sand-hill region, where it often forms a white, felt-like carpet, the individuals are so reduced as to appear to constitute a distinct species. In the Niobrara country, on roadsides, the plants are often reduced to a centimeter or two in height, and they possess but two or three diminutive leaves and never more than six to eight flowers. Back from the hard-packed roadbed, however, they gradually increase in size until they again become

typical. The reverse is true in the foot-hills, where disturbance of the soil in the lightly traveled roads and trails causes the individuals to grow large, while extending back from the road on the dry, sandy hillsides the plants are much reduced. In the dry valleys of the sand-hills, where great areas are exclusively covered by very low, reduced individuals, wherever in these areas the soil is disturbed by prairie-dogs, the plants are found growing large, with long, dense spikes and numerous, long leaves. *Plantago aristata* is scarcely to be distinguished from *P. purshii* in the part it takes in the floral covering. *P. elongata*, which is confined almost wholly to alkaline situations, seems to exhibit a tendency to become a halophyte.

(6) Introduced species of lawns, roadsides, and waste places, I-III. *Plantago major* grows throughout the State along roadsides, in meadows, and on low prairies. Its spreading, rosette-forming leaves take complete possession of rather large areas, where it crowds out even the most tenacious grasses. *P. lanceolata* is a much less common weed, almost wholly confined to lawns in the eastern portion of the State. *P. rugelii*, though less widely distributed than *P. major*, occupies similiar situations. *Centunculus minimus*, a small, insignificant weed, has found its way into the State in one or two stations.

Gentianales.— With us this suborder comprises 10 genera and 33 species, of which the Oleaceae contains 1 genus and 2 species, Apocynaceae 1 genus and 2 species, Asclepiadaceae 4 genera and 21 species, and Gentianaceae 4 genera and 8 species. The single large genus is *Asclepias* with 12 species.

The regional distribution of the species is shown by the following table:

	Oleac.	Apoc.	Asclep.	Gent.	Tot.	Pec.
Common to the four regions	1	1	4	0	6	..
I. Wooded bluff, etc., region.....	2	2	15	2	21	6
II. Prairie region.....	1	1	11	2	15	1
III. Sand-hill region.....	1	1	13	4	19	3
IV. Foot-hill region.....	1	2	6	2	11	1

The species of general distribution are: *Acerates floridana*,

A. viridiflora, *Asclepias syriaca*, *A. incarnata*, *Apocynum cannabinum*, and *Fraxinus lanceolata*.

The vegetation-forms represented are:

(1) Trees	2
(9) Creepers and climbers	1
(12) Rootstalk plants	23
(13) Bulb and tuber plants	1
(16) Monocyclic herbs	2
(19) Amphibious plants	2

The habitat-groups are five:

1. Trees, inhabitants of forest formations and open woodlands, I-IV
2. Climber, growing on shaded river banks, I
3. Hydrophytes of ponds, marshes, and wet meadows, I-IV
4. Inhabitants of low prairies and of meadows, rarely if ever xerophilous, I-IV.....
5. Xerophytes of high barren hills and ridges, I-IV.....

(1) Trees of forest formations and open woodlands, I-IV. The white ash, *Fraxinus americana*, is found along the lower course of the Missouri, at rare stations, on the bluffs and in wooded portions of the lowland. *Fraxinus lanceolata* is one of the commonest trees in our flora, its distribution being even more general than that of *Acer negundo*. Wherever it occurs in deep woodlands, it is a tree of moderate size with a large expanse of foliage. In such situations the individuals are gregarious, though only a few are found in the same spot. On the edges of forest formations and in meadows and pastures, the trees tend to become solitary or are associated in small numbers with *Acer negundo*. In the canyons of the western portion of the State, notably along the Niobrara and the Republican, this species becomes reduced to a small tree, and a form of it with the twigs and young shoots pubescent makes its appearance, *F. pennsylvanica*. These occur together, forming dense thickets in the lower portion of deep canyons. Sometimes the thickets

extend up the sides, and a few stragglers occasionally reach the top.

(2) Climber, growing on shaded river banks in I. The single representative of this group, *Ampelanus albidus*, has made its way into the extreme southeastern part of the State, where in a few favored stations it climbs in profusion over tall herbs and shrubs.

(3) Hydrophytes of ponds, marshes, and wet meadows, I-IV. The buckbean, *Menyanthes trifoliata*, occurs localized in central Cherry county, where it is a frequent inhabitant of the small ponds in the marshy lake regions. *Asclepias incarnata* is found abundantly in wet meadows and in spring marshes throughout the sand-hill region. In regions I and II it generally occurs in muddy bogs along the muddy banks of streams or ponds, and is very rarely to be found in meadows proper. It is most commonly associated with *Cicuta maculata*. On spring banks the individuals are particularly gregarious. Whenever they occur on the margins of pools or streams, however, they are usually scattered or almost single.

(4) Inhabitants of low prairies and of meadows, rarely if ever xerophilous, I-IV. Four members of this group belong to the genus *Asclepias*. The most widely distributed is *Asclepias syriaca*, which is common on low ground and even grows on hillsides throughout. In many places in the eastern part of the State, it has become a thorough weed, and is the most conspicuous inhabitant of several culture formations. In such situations, though usually scattered, it forms dense patches a meter or more in diameter. It displays this last characteristic on prairies as well, especially when it occurs in company with *A. sullivantii*. The latter is confined entirely to the southeastern portion of the State. The two species are readily distinguished only by the pods, and possess substantially the same importance in the floral covering, though *A. syriaca* is the more abundant. *Asclepias verticillata*, which often occurs with the two preceding, is never a conspicuous member of the formation. In fact, the

low, green plants with their thin whorls of narrow leaves are hardly to be distinguished from the grasses among which they grow, except when the umbels of white flowers make their appearance. *A. tuberosa* resembles the preceding in its manner of growth, several stems arising from the same caudex. But it is a much more important plant of prairie formations, both on account of its taller, more leafy stems and the erect, terminal umbels of bright, orange-red flowers. From its manner of growth it always appears tufted, and these tufts, when abundant, give a brilliant appearance to meadows and prairies during the latter part of June. The species has more or less tendency to take on a ruderal habit, especially in cultivated fields. It is not uncommon in oat and wheat fields, but chiefly invades corn fields, where the individuals are conspicuous objects between the hills. *Apocynum cannabinum*, though regularly an inhabitant of the edges of thickets, not infrequently occurs in dense bush-like masses in low, open meadows or along the banks of streams. *Acerates lanuginosa* is one of the most typically solitary plants of our flora. Though its stations are numerous, never more than a few plants are found in the same place, and these grow singly and widely separated. Along the prairies of the upper Missouri, where it is relatively common, but one or two plants will be found upon a hillside. *Eustoma russellianum* is a characteristic inhabitant of the Platte bottoms. Along the whole course of the Platte, as far east as the edge of region I, it is to be found on the low meadows between the bluffs, where it occurs in large and dense patches. The individuals attain a considerable height, and the bluish leaves and stems, and, above all, the masses of large, deep blue flowers, make these patches very striking and among the most beautiful portions of our floral covering. This species is also to be found in low meadows at some points in the foot-hill region, where it does not attain the same importance. The low, insignificant *Erythraea exaltata*, which is abundant in the mountains to the westward, has been brought down by the Platte river into the edge of the

foot-hill region, where it has established itself in the sands of this stream and of one or two of its tributaries. The gentians are comparatively rare in our flora. Neither *Gentiana puberula* nor *G. andrewsii* are of frequent occurrence. The former is to be found sparsely distributed here and there on the prairie in II; the latter occurs in somewhat indefinite masses in low meadows in the sand-hill region. *G. flavida* grows only at one or two stations along the lower Missouri.

(5) Xerophytes of high, barren hills and ridges, I-IV. The genus *Acerates* belongs almost wholly to this group, there being but a single exception. The most widely distributed species is *Acerates viridiflora*, though the two varieties, *A. viridiflora linearis* and *A. viridiflora ivesii*, are usually more widely distributed than the type. The three, which not infrequently occur associated, are characteristic inhabitants of high, barren hills, from the bluffs of the northern course of the Missouri westward and southward. On barren bluffs of the Missouri the individuals are usually solitary, and, on account of their uniformly green or greenish color, their presence in the floral covering is hardly to be detected. Westward, however, on barren ridges of the sand-hills, they are more or less abundant in the extensive patches of *Rosa arkansana*, in which they commonly constitute the only herbaceous element. *Acerates angustifolia* and *A. floridana*, though usually somewhat taller, are of similar habit and distribution. Two species of milk-weed, *Aselepias arenaria* and *A. speciosa*, are of wide occurrence in the foot-hills and sand-hills, but are sparse and of relatively small importance. *A. latifolia* is entirely confined to xerophytic situations along the course of the Republican river. *Aselepias verticillata pumila* is one of the most interesting of our xerophytes. It is rarely if ever an inhabitant of thoroughly sandy soil, but is found chiefly on the elevated clay or gumbo tablelands in the Ponca district and in region IV, and in the dry valleys of the sand-hills. It usually occurs in patches of a square meter or more and is readily recognized by its abun-

dance of yellowish flowers. In the dry valleys especially, its caudex tends to become woody, and the plant assumes more or less of the character of a half shrub. *Apocynum androsaemifolium* has come down into the Pine Ridge district from the Black Hills. On the other hand *Asclepiodora viridis* is becoming more or less frequent along our southern border.

Polemoniales.—In our flora this suborder comprises a total of 24 genera and 70 species, belonging to 5 families, as follows: Polemoniaceae, 4 genera, 17 species; Hydrophyllaceae, 3 genera, 3 species; Boraginaceae, 9 genera, 24 species; Convolvulaceae, 4 genera, 12 species; Solanaceae, 4 genera, 14 species. The following genera attain some size in our flora: *Cuscuta* with 8 species, *Gilia* with 8 species, and *Phlox* with 9 species.

The distribution of the species is as follows:

	Polemon.	Hydr.	Bor.	Conv.	Sol.	Total.	Pec.
Common to the four regions	0	1	2	1	3	7	..
I. Wooded bluff, etc., region.....	3	2	9	6	8	28	3
II. Prairie region.....	2	2	7	8	9	28	1
III. Sand-hill region.....	3	1	7	7	7	25	3
IV. Foot-hill region.....	15	2	15	5	7	44	23

Seven species are of general distribution. They are: *Solanum triflorum*, *S. rostratum*, *S. nigrum*, *Convolvulus sepium*, *Lithospermum gmelini*, *L. angustifolium*, and *Macrocalyx nyctelea*.

The following vegetation-forms are represented:

(4) Woody climbers	1
(7) Mats	12
(9) Creepers and climbers	2
(12) Rootstalk plants	18
(13) Bulb and tuber plants	1
(15) Dicyclic herbs	5
(16) Monocyclic herbs	19
(19) Amphibious plants	2
(21) Parasites	8

The habitat-groups are seven in number, as follows:

1. Inhabitants of low prairies and meadows, I-IV..... 6
2. Xerophytes of high prairies and sand-hills, I-IV.....11
3. Xerophytes of table-lands and foot-hills, IV.....15
4. Inhabitants of shady woodlands or thickets, I-IV..... 7
5. Parasitic, leafless species, generally found in the midst of luxuriant vegetation, and hence rare in xerophytic situations, I-IV 8
6. Species of diverse habitat, chiefly inhabitants of low meadows, but becoming xerophilous and ruderal, I-IV, 7
7. Introduced weeds of low grounds and waste places, I-IV14

(1) Inhabitants of low prairies and meadows, I-IV.

The puccoon, *Lithospermum angustifolium*, is a characteristic feature of low prairies and plains throughout the State in early spring. The plants themselves are insignificant, but the clusters of bright yellow flowers give the species a great deal of prominence in our prairies. *Lithospermum canescens*, which is smaller and tufted, is of less general distribution. It is of rather common occurrence on low prairies and hillsides along the Missouri and in the eastern edge of region II. *Macrocalyx nyctelea*, which is found everywhere in the eastern half of the State, is comparatively rare in the sand-hills and foot-hills. The fact that it usually grows in very large patches, which crowd out everything else, has probably caused it to assume a ruderal habit in many places. Though originally, perhaps, a member of meadow formations, it is now found in open woodlands, in shaded grounds in cities, and, according to Rydberg, rarely in prairie-dog towns in the sand-hills. *Onosmodium carolinianum* is usually found only in pastures in I and II. This plant owes its prominence in pastures solely to its large size and bushy habit, the flowers being insignificant on account of their greenish color. *Phlox pilosa*, though a typical inhabitant of pastures and meadow land, is very easily driven out, and hence persists rarely in the former, and is becoming each year more and more uncommon in the latter. Ten years ago, grassy low-

lands were often variegated by the bright pink flowers of this species, where now but a few stragglers are to be met with. Its distribution is wholly within the eastern half of region I.

(2) Xerophytes of high prairies and sand-hills, I-IV. These are confined for the most part to the foot-hill and sand-hill regions. One or two occur in region II, however, and a few have found their way into the northern portion of the Missouri district. The species of widest range is the hairy puccoon, *Lithospermum gmelini*, which, though a true sand-hill species, grows frequently on high prairies and plains the State over. It grows commonly in dark green tufts, which with their orange-yellow flowers are scattered rather thickly over the hills. *Ipomoea leptophylla*, the bush morning-glory, grows over large stretches of plain and sand-hill. The plants, though really herbaceous, are veritable bushes, 1-2 meters in height. This plant is especially adapted to xerophytic situations on account of the great depth to which its huge root (2-3 meters long) penetrates. It is remarkable during the flowering period for the numbers of large, purplish flowers which it bears. *Gilia longifolia* occurs at frequent stations throughout the sand-hills and in the edge of the foot-hills. In habit it is usually gregarious, and the clumps of tall, straight stems are very noticeable on account of their terminal clusters of pure white flowers. *Gilia pumila*, which is rather common on dry rocky ridges in the Pine Ridge district, has crept down the Niobrara to a few stations in the sand-hills. *Collomia linearis* is a true xerophyte in the foot-hills and sand-hills, growing in sand-draws or on rocky ridges, but is scarcely to be regarded as xerophilous in sandy situations along the upper Missouri. In the latter stations its presence is almost concealed by the grasses which overtop it. Underneath these, the low, leafy plants, scarcely a decimeter high, form a felted, carpet-like mat. *Phlox douglasii* is commonly associated with *Paronychia jamesii* on sandy hillsides throughout the foot-hills. Here it forms small mats, which are hard to distinguish even

in the sparse vegetation of these hills, since both leaves and flowers are much the same color as the hills. In the western portion of the sand-hill region, this species occurs commonly on sand-hills and sometimes in blow-outs. Here the individuals are always found singly. *Onosmodium molle* is an occasional inhabitant of dry valleys in the sand-hills. *Evolvulus pilosus* is distributed over the entire western portion of the State, where it occurs abundantly in certain localities. The plants are low, somewhat branched, and densely white silky. They tend to form sod-like patches here and there in the floral covering. *Lappula texana*, which is common over dry prairies in III and IV, is becoming almost exclusively ruderal. In addition to being a frequent inhabitant of prairie-dog towns, it is in some places a characteristic inhabitant of roadside wastes. The individuals are low, never exceeding 2-3 decimeters in height, and diffusely branched. In favored situations they form the densest of patches. *Oreocarya suffruticosa* is quite common in the western part of the State, especially in the Bad Lands and in the Wild Cat mountains.

(3) Xerophytes of table-lands and foot-hills, IV. Six species of *Gilia* are found in this group. Together with most of the other members of the group, they are found chiefly on cliffs or buttes or the upper edges of canyons. This is true of *Gilia iberidifolia*, *G. pungens caespitosa*, *G. congesta*, and *G. spicata*. One species, *Gilia gracilis*, has been found only in sand-draws, while still another, *G. pinatifida*, is known for but a single station, the sands of the Platte river at the mouth of Horse creek. Most of these are characteristic mat-forming species, while the others exhibit a decided tendency to assume this habit. *Phacelia heterophylla* is almost invariably associated with *Gilia iberidifolia* on buttes and cliffs throughout the region. Here are found also *Oreocarya sericea* and *O. glomerata*. *Phlox hoodii* and *P. bryoides*, which affect similar situations, are practically confined to the extreme western edge of the State. *Cryptanthe fendleri*, which is to be met with on high plains

and bad lands throughout the region, has also been found in a dry valley in Sheridan county. *Oreocarya fulvocanescens*, a common species on the driest slopes of the Rocky mountains, is to be found in Warbonnet canyon in the Hat creek basin.

(4) Inhabitants of shady woodlands or thickets, I-IV. Three species of *Lappula* belong to this section. One, *L. floribunda*, is an extremely rare plant which has been found growing in region IV in plum thickets along Lawrence Fork. In both habit and habitat it is scarcely to be distinguished from *L. deflexa* or from *L. virginiana*. These are tall plants with spreading branches, which often attain a height of $1\frac{1}{2}$ -2 meters. Though they commonly occur in extensive patches in dense woods, both, especially the former, grow in thickets, where the individuals are scattered and usually somewhat reduced in size. *Lappula virginiana* is abundant throughout the woods of the Missouri and the forest formations of streams in region II. It also finds its way westward along both the Republican and the Niobrara. *L. deflexa*, which occurs chiefly in the Loup and Niobrara districts, grows abundantly in a few of the deep ravines along the upper Missouri. *Mertensia paniculata* and *M. lanceolata*, which are regularly montane, have extended a short distance into region IV. *M. paniculata* grows in the canyons of northern Sheridan county, while *M. lanceolata* is found in Warbonnet canyon and along Lawrence Fork. *Phlox divaricata* and *Hydrophyllum virginicum* are, strictly speaking, plants of the wooded-bluffs and ravines of region I. They are, however, frequent inhabitants of forest formations in the southeastern portion of II. In early spring, *Phlox divaricata* covers not only the bluffs of the Missouri but also those of its smaller tributaries for some distance back. The plants are to be found in the greatest profusion only in such situations, though they sometimes wander down into the ravines. *Hydrophyllum virginicum* is characteristically a plant of damp, shaded ravines. Here, though frequent, it is rarely abundant. The plants appear to grow indifferently in small,

rather loose patches, or singly, scattered here and there in the vegetation.

(5) Parasitic, leafless species, I-IV. This section includes all our species of *Cuscuta*. They are of the widest distribution, only a few which have come in recently being limited to definite portions of the State. From the fact that they grow upon the rankest vegetation, they are almost always to be found along or near water courses. The part which they play in the floral covering is of importance, not only on account of the great damage which they often do to their hosts, but also because of the great conspicuousness which their bright yellow stems frequently give to patches of otherwise insignificant weeds. They generally occur as a more or less definite layer in formations of coarse weeds and in particular in patches of *Salix*, or they intertwine throughout in dense patches of lower herbaceous plants. Of the first type are *Cuscuta cuspidata* and *C. paradoxa*, and sometimes also *C. coryli*. Of the other type, *C. indecora*, *C. arvensis*, and *C. polygonorum* may be mentioned.

(6) Species of diverse habitat, I-IV. These are all species of *Physalis*. As a general rule, they are inhabitants of low meadows. Many, however, have become ruderal, some even typically so. Others, notably in the sand-hills, are also xerophilous. Thus *P. heterophylla*, which grows in low meadows and even in the edge of woodlands in I and II, is frequently an inhabitant of waste places, and is likewise found in xerophytic situations in the sand-hills. In dry valleys in region III, it is especially common on the floor of the valleys and upon the sides of the surrounding sand-hills. Here it grows low and hairy and is often found completely blackened by *Puccinia physalidis*. In thickets and among bushes it takes on another aspect. Particularly in thickets of *Prunus demissa* in dry valleys, it grows very high—usually upwards of a meter, sometimes $1\frac{1}{2}$ meters—rivaling the dwarf plum trees, or rather plum bushes of the thicket, and is glabrous, thin-leaved, and much branched. It is also slender, and in some cases shows an inclination to climb.

Rydberg has proposed to call this form *P. heterophylla umbrosa*.^{*} *Physalis longifolia*, *P. lanceolata*, and *P. virginiana* are typically, at least, inhabitants of low meadows. But *P. lanceolata* has almost entirely forsaken its original habitat and has come to be one of the most common plants of railroad embankments throughout the State. In such situations the dense masses form continuous margins for some distances along either bank. In pastures and meadows this plant is rarely more than two decimeters in height, but on railroad embankments it is two or three times taller and is bush-like. *P. philadelphica* and *P. comata*, which are confined to shady situations on the buttes and cliffs of region IV, exhibit a tendency to become at least subxerophilous.

(7) Introduced weeds of low grounds and waste places, I-IV. Three species, all of the genus *Solanum*, are to be found in wastes throughout the State. The most important of these is *S. rostratum*, which is a bad weed on account of its extremely prickly stems and spiny fruits, and its habit of forming large and dense patches. *Solanum nigrum* and *S. triflorum*, though not so noticeable, are scarcely less frequent. *S. carolinense* is making its way into open woodlands and meadows in regions I and II south of the Platte. *Datura stramonium*, though never abundant, is characteristic of barnyards in I and II, and is sometimes found in extensive patches about the larger cities in places where refuse matter is deposited. *D. tatula* is known in but two stations. The two bind weeds, *Convolvulus sepium* and *C. arvensis*, are becoming so frequent in many localities and are so abundant where present that they are coming to give character to roadsides and neglected grounds quite generally. They spread over abandoned fields to such extent as to choke out a large portion of the ordinary vegetation, and when in flower give them a striking aspect on account of the multitude of white flowers. *Lappula lappula* sometimes usurps considerable areas of meadow and low prairie along the Missouri and in portions of II.

^{*}Contrib. U. S. Nat. Herb. 3: 173. 1896.

Personales. — In our flora this suborder includes 22 genera and 44 species, belonging to 5 families: Scrophulariaceae, 17 genera, 36 species; Orobanchaceae, 2 genera, 4 species; Lentibulariaceae, 1 genus, 2 species; Pedaliaceae, 1 genus, 1 species; and Acanthaceae, 1 genus, 1 species. In our flora the single large genus is *Pentstemon* with 10 species.

	Scroph.	Oro.	Lent.	Ped.	Acan.	Tot.	Pec.
Common to the four regions.....	0	0	0	0	0	0	..
I. Wooded bluff, etc., region.....	18	0	1	1	1	21	4
II. Prairie region.....	13	1	2	0	1	17	5
III. Sand-hill region.....	18	2	1	1	0	22	5
IV. Foot-hill region.....	18	3	2	0	0	23	7

It is worthy of notice that not a single species is common to the four regions.

The following vegetation-forms find representation:

(6) Rosettes	3
(12) Rootstalk plants	22
(16) Monocyclic herbs	4
(17) Floating plants	1
(18) Submerged plants	4
(19) Amphibious plants	5
(20) Parasites	4

The habitat-groups are:

1. Inhabitants of shady woods and copses, I-IV	4
2. Floating or immersed aquatics, I-IV.....	6
3. Hydrophytes of wet meadows, sand-bars, and marshes, I-IV	6
4. Parasites on the roots of herbaceous plants, chiefly in xerophytic situations, II-IV	4
5. Xerophytes of high prairies, sand-hills, and table-lands, I-IV	10
6. Inhabitants of low prairies and meadows, I-IV	9
7. Introduced or naturalized species of meadows and waste places, I-III	4

(1) Inhabitants of woods and copses, I-IV. The

figwort, *Scrophularia marilandica*, grows in forest formations, in open woodlands, and even in meadows in a large portion of the State. The plants are rarely found in groups of more than a few individuals, usually occurring singly, and in favorable situations reaching a height of 2-3 meters. *Mimulus ringens* is not only frequent, but rather abundant along low, wooded banks of streams throughout I and II and in the eastern part of the Niobrara district. The plants usually occur singly, and on account of their small stature might easily be overlooked but for the dark blue, gaping flowers. *Azalia macrophylla* has been found on the lowlands near the mouth of the Platte, while *Gerardia besseyana* is likewise confined to a few stations in the same region.

(2) Floating or immersed aquatics, I-IV. A few years since, *Monniera rotundifolia*, with its round leaves and white flowers floating upon the surface, was a characteristic feature of periodical pools in the southern portion of II. During the past two or three years, the drying up of these ponds has caused this species to disappear from these stations. In the wet valleys of the sand-hills, it appears to be subject to the same conditions, and here exhibits a tendency to grow in the mud more or less terrestrially. *Utricularia vulgaris*, which is a typical inhabitant of deep ponds in I and II, and of lakes and even streams of region III, on rare occasions becomes amphibious. *U. minor* is much less common and appears localized in two or three stations. Both *Veronica americana* and *V. anagallis-aquatica* are common in the swift, sandy streams and spring branches of region III. The former is also found in the foot-hills. They usually grow in dense tufts, characterized by the numerous, bright blue flowers.

(3) Hydrophytes of wet meadows, sand-bars, and marshes, I-III. The sands about the sources of springs and the sandy banks of spring branches throughout the sand-hills and the foot-hills are almost uniformly characterized by *Mimulus jamesii*. Wherever it grows on the barren, wet sand, it is invariably spreading in habit. Along the edges

of shallow streams, however, it often wanders into the water and then becomes upright. In certain springs and pools in the Loup district, it becomes almost submerged. The taller, larger flowered *Mimulus luteus* has made it way into our territory at a single station in the foot-hill region. *Ilysanthes gratioloides* is of some little frequency in regions I to III. In regions I and II it is found as a narrow margin along the banks of shallow ponds, or, when the water is not more than a few millimeters deep, scattered in the pool itself. In the Niobrara district it is found scattered here and there over the wet surface of sand-bars, or growing in small patches in the shallow pools upon them. *Gratiola virginiana*, which appears to be of rather restricted occurrence, grows abundantly only in the wet valleys of the sand-hills about the head of the North Loup. In such situations it forms patches of small extent, which fringe the edges of pools and streams. *Gerardia tenuifolia* is found typically in springy situations and on wet sand-bars in III, rarely in IV. It wanders out upon wet, sandy meadows. It is usually subsolitary in habit, but its numerous, bright purple flowers make it readily noticeable in all situations. *Pentstemon gracilis*, which is ordinarily confined to the near neighborhood of pools or marshy places in III, and to wet meadows or canyon sides in IV, has become almost xerophilous in the Hat creek basin, where it grows on the lower slopes of buttes. The plants occur in groups of about a dozen individuals. These groups are scattered rather sparsely through the thin vegetation, in which it plays a striking part on account of its tall, glaucous stems and shining leaves.

(4) Parasites on the roots of herbaceous plants, II-IV. *Thalesia uniflora* grows in but few stations in II, where it is entirely confined to low prairies. This relative infrequency may be due to the fact that the individuals occur scattered here and there among tall plants, upon which they are parasitic. *Thalesia fasciculata* and *T. fasciculata lutea* are confined to the sand-hills of III and high prairies of IV. In these regions they are found uniformly

in low, almost invisible tufts upon the roots of species of *Artemisia*. *Orobanche ludoviciana*, which affects similar situations in IV, is much more conspicuous on account of its many-flowered, bright yellow stems.

(5) Xerophytes of high prairies, sand-hills, and table-lands, I-IV. With a single exception, the whole of the large genus *Pentstemon* is included in this group. In regions II and III *Pentstemon grandiflorus* is confined almost wholly to dry, sandy situations, though in certain parts of II it grows indifferently on sandstone hills or on drift-hills. In the northern portion of region I, it is restricted to the steep, exposed bluffs and sides of ravines along the Missouri. Few plants play a more striking part in the floral covering of the xerophytic situations where it occurs. In fact a *Pentstemon* hill may often be recognized for a long distance on account of the bright color imparted to it by the clusters of blue-purple flowers. *P. glaber*, which resembles the foregoing very much and is perhaps of equal importance, is much more common westward, occurring at numerous points throughout the foot-hill region. *P. cobaea* is usually found only on the sandstone hills. It is lower-growing than *P. grandiflorus* and never so characteristic. *P. albidus* is very abundant on sandy hillsides of Box Butte county along with *Polygala alba*. On these hills, where the vegetation is very sparse, it is one of the few plants that attain any size. Its usual height is about 2 decimetres, and its white flowers and glaucous leaves set it off sharply among the low, prostrate *Polygalas* and mat-forming species of *Paronychia* and *Phlox* that grow about it. On the same hillsides a few individuals of *P. caeruleus* are also to be found. The latter grows very low, but its bright blue flowers make it readily visible in the white, sandy situations where it grows. *P. albidus* extends into the sand-hill region and even to the edge of region I in the northern part of the State, where it occurs sparsely on high barren limestone bluffs. *P. caeruleus* is of wider distribution in IV, where it occurs on sandy hillsides and buttes throughout and also descends the Niobrara for

some distance into III. The remaining species of *Pentstemon* are extremely localized, for the most part in the western portion of the State. *Castilleja sessiliflora*, which is very common on the dry summits of clay bluffs along the upper Missouri, extends westward and southward over the sand-hills and foot-hills. The individuals occur singly, but it is found in some abundance, growing upon hill after hill, generally associated with *Aragallus lamberti*.

(6) Inhabitants of low prairies and meadows, I-IV. *Gerardia aspera* is, for the most part, to be found only in meadows and low prairies in regions I and II, though it extends some distance west along the Niobrara. Although the individuals occur singly or in groups of 3-4, the bushy stem covered with large, blue-purple flowers gives it some importance. *Veronica peregrina* grows sometimes in small masses along the muddy banks of streams and pools, but ordinarily the plants are scattered more or less thickly through wet, grassy meadows. They are low and insignificant, and are only to be found upon close inspection. *Orthocarpus luteus* is a slender-stemmed, yellow-flowered species which is somewhat common in low or even wet meadows of the Pine Ridge district. *Ruellia ciliosa*, remarkable on account of its beautiful, blue, ephemeral flowers, is a very shy plant, growing in small patches in the southeastern portions of I and II.

(7) Introduced or naturalized species of meadows and waste places, I-III. Two species of *Linaria*, *L. linaria* and *L. canadensis*, are mere escapes from cultivation. *Martynia louisiana*, which is coming into our flora from the South, is more or less common along the Republican. The common eastern weed, *Verbascum thapsus*, extends south of the Platte as far west as region III. It is only abundant in I along the lower Missouri and in a few favored places in II.

Lamiales.—This suborder contains in our flora 18 genera and 44 species. It comprises but two families, *Verbenaceae* with 3 genera and 10 species, and *Labiatae* with 15 genera and 34 species. The only genus of any size is *Verbena*, which with us contains 7 species.

The distribution of the species is as follows:

	Verbenaceae.	Labiatae.	Total.	Pecul.
Common to the four regions	4	5	9	..
I. Wooded bluff, etc., region.....	7	21	28	7
II. Prairie region.....	8	16	24	2
III. Sand-hill region.....	7	20	27	5
IV. Foot-hill region.....	5	12	17	3

The species common to the four regions are *Hedeoma hispida*, *Lycopus americanus*, *Mentha canadensis*, *Monarda fistulosa*, *Phryma leptostachya*, *Salvia lanceolata*, *Verbena bracteosa*, *V. hastata*, and *V. stricta*.

The vegetation-forms represented are but five:

(6) Rosettes	1
(9) Creepers and climbers	2
(12) Rootstalk plants	33
(16) Monocyclic herbs	2
(19) Amphibious plants	1

The habitat-groups are:

1. Shade plants, open woodland plants, and inhabitants of the edges of woods or of thickets along streams, I-IV. 13
2. Inhabitants of wet meadows, sand-bars, edges of streams, and margins of ponds, I-IV 14
3. Xerophytes of high prairies and hillsides, I-IV..... 5
4. Inhabitants of low meadows and pastures, I-IV, and especially of wet valleys in III 7
5. Introduced species of sporadic occurrence, I-III 5

(1) Shade plants, open woodland plants, and inhabitants of thickets, I-IV. Two species, *Monarda fistulosa* and *Phryma leptostachya*, are of the greatest frequency and abundance in forests and woodlands throughout the State. *Phryma leptostachya* is usually to be found only in the deep shade of moist woods, where it often grows in considerable profusion, though otherwise it is seldom important. On wet ledges along the Missouri and along spring banks of the Niobrara it is a common species. *Monarda fistulosa* prefers open woodlands, edges of thickets, or exposed, sparsely

wooded bluffs. In such places it attains a height of 1-1½ meters, grows in fairly large masses, and is a very showy plant on account of its large, pink-purple heads. *Lycopus virginicus* is an insignificant plant of low, dark situations in woodlands or in dense thickets. Two species of *Agastache* *A. scrophularifolia* and *A. anethiodora*, are infrequent. The former is localized on the Missouri bluffs, the latter in Squaw canyon. *A. nepetoides* is a frequent and a prominent plant of deep woodlands along the bluffs of the Missouri and many of the chief streams of region II. Of the two species of *Physostegia*, one, *P. virginiana*, is confined to woodlands in the southeastern portion of the State, while *P. parviflora* occurs at but a single station in the foothill region. *Koellia virginiana*, which is a common plant in the northern portion of the sand-hill region, where it forms considerable patches, occurs sporadically in I and II. *Verbena urticifolia* is associated with *Urtica gracilis* in denser portions of woodlands. It is a tall, graceful plant, usually growing singly. Occasionally it finds its way into meadows and lowlands, where the individuals group themselves in small clusters.

(2) *Hydrophilous species, I-IV.* In general the members of this group form borders along the margins of streams and ponds. This is especially true of species of *Lycopus* and of *Mentha canadensis*. *Lycopus americanus* grows in such situations the State over. *L. lucidus* is practically restricted to the sand-hill region, where it commonly replaces *L. americanus* along sandy banks and margins. Both are low plants, chiefly noticeable from their characteristic position. *Mentha canadensis* resembles these two in size and habit, but is of wider occurrence and of greater abundance. *Scutellaria lateriflora* frequents wet banks and edges of pools from the upper Missouri westward through the sand-hills. In the latter country *S. galericulata* grows in similar situations, and often the two occur together. They are shy plants and are important in hydrophytic vegetation only on account of their bright blue flowers. *Lippia lanceolata* is localized in

wet meadows throughout the territory south of the Platte. It is relatively infrequent, but in favored stations it forms the densest of patches, a hectare or more in extent. *Teucrium occidentale* and *Stachys palustris* grow in marshes and boggy meadows in the sand-hill region for the most part, though a few stations are known for the foot-hills. *Stachys palustris* is most prominent where it occurs in patches along the margin of lakes in the sand-hills.

(4) Xerophytes of high prairies and hillsides, I-IV. *Monarda citriodora* is the most typical member of this group. On level sandy plains of regions III and IV, it covers stretches of country for kilometers, imparting a peculiar, white aspect to the floral covering. *Hedeoma drummondii* is found only upon the exposed summits of the high buttes or upon barren canyon sides in IV. *Salvia pitcheri* is one of the striking elements in the floral covering of prairies in regions I and II during the late summer, when its tall, branched stems are covered with masses of handsome, blue flowers. The individuals are grouped in somewhat definite patches, which are small and widely separated. *Salvia lanceolata* is rapidly becoming a prominent factor in wastes. In many localities its original habitat has been lost sight of entirely, so thoroughly ruderal has it become. *Verbena bipinnatifida*, though occurring only at isolated stations in III-IV, is somewhat characteristic of high, gumbo tablelands and plains. It grows here in large, mat-like patches, brilliant on account of the blue flowers.

(5) Inhabitants of meadows, pastures, and wet valleys, I-IV. Most of the species of the important genus *Verbena*, which has wide representation in our flora, belong to this group. Three species, *V. bracteosa*, *V. hastata*, and *V. stricta*, are of the widest distribution. *Verbena bracteosa* is essentially similar to *V. bipinnatifida* in habit. It has become subruderal in many localities, and carpet-like masses of this plant are frequent along roadsides and in overstocked pastures. *V. stricta* and *V. hastata* are of great prominence in the floral covering. Throughout the State during late

summer, they are the most notable and typical species of prairies and meadows and of both wet and dry valleys. They are almost invariably associated and regularly form the facies of one of our most characteristic pasture formations. The individuals occur copiously, and, when in flower, give a most decided character to the prairie. *Teucrium canadense* grows abundantly in meadows and in the edges of thickets. It is a conspicuous member of meadow formations, both from the aggregation of the individuals and because of its bright, pink-purple flowers. It seems to be mostly confined to regions I and II, being replaced by *T. occidentale* in III. *Hedeoma hispida*, though insignificant as to size, is noticeable in meadows and prairies throughout the State, since it forms extensive carpets, so densely aggregated are the small leafy plants. *Scutellaria parvula* may sometimes be found in wet situations, though generally it prefers prairies and hillsides. The individuals grow in small patches, but are so small and so thoroughly concealed by the taller grasses of the prairie that they are not factors of any consequence in the floral covering.

(6) Naturalized, escaped, or introduced species of sporadic occurrence, I-III. Many cultivated mints, such as *Mentha piperita*, *M. sativa*, *Leonurus cardiaca*, etc., have found their way into meadows and woods along the banks of streams in the eastern part of the State. But two species have become sufficiently introduced to be of much importance. The catmint, *Nepeta cataria*, is to be found in large patches in the deeper woods of the eastern half of the State, and occasionally in wastes. *Prunella vulgaris* has become frequent in meadows, farm yards, and along roadsides, where it forms a dense carpet studded with blue flowers. It was first observed in region II in 1889.

Rubiales — Campanales.—This group contains four families, represented by 14 genera and 31 species, distributed as follows: Caprifoliaceae, 5 genera, 8 species; Rubiaceae, 3 genera, 10 species; Campanulaceae, 3 genera, 10 species;

Cucurbitaceae, 3 genera, 3 species. Galium is the only large genus. It contains 8 species.

The distribution of the species is indicated in the following table:

	Capr.	Rub.	Camp.	Cucurb.	Tot.	Pecul.
Common to the four regions.....	1	2	2	0	5	..
I. Wooded bluff, etc., region.....	7	8	5	2	22	3
II. Prairie region.....	4	5	4	2	15	2
III. Sand-hill region.....	3	7	9	2	21	5
IV. Foot-hill region.....	2	3	4	1	10	1

Lobelia siphilitica, *Legouzia perfoliata*, *Galium aparine*, *G. triflorum*, and *Symphoricarpos occidentalis* occur in each of the four regions:

The vegetation-forms are:

(2) Shrubs	2
(3) Undershubs	4
(4) Climbers and twiners	2
(9) Creepers and climbers	9
(12) Rootstalk plants	13
(15) Dicyclic herbs	2
(16) Monocyclic herbs	2

The species fall into four habitat-groups:

1. Species of forest formations, and open woodlands, more rarely occurring in wet meadows, I-IV 14
2. Hydrophytes of wet meadows and spring marshes, I-IV, 4
3. Xerophytes and subxerophytes of high, rocky hills, ridges, and prairies, I-IV 5
4. Shrubs, typically of forest formations, open woodlands, and thickets, I-IV 8

(1) Species of forest formations and open woodlands, I-IV. Most of our species of *Galium* are ordinarily inhabitants of forest or thickets. From the latter place, however, they have often wandered out upon wet meadows, especially in the sand-hills. In the woods, notably of regions I and II, *Galium aparine* and *G. triflorum* grow in large masses in which the individuals are inextricably intertangled. Such miniature herbaceous jungles are character-

istic of somewhat open ravines in woodlands. Though more or less erect when growing in patches, the plants take on a climbing or recumbent habit where they are less densely aggregated. *Galium circaezans*, which is much shorter, occurs in small tufts scattered here and there through deep woods. Where the herbaceous layer is low and sparse, as is often the case on the wooded bluffs of the Niobrara, the tufts of this species are extremely striking because of their compact, dark green foliage. *Galium trifidum*, though in the Niobrara district almost wholly confined to dark, wet woods of the lowlands, in the heart of the sand-hills is more frequently an inhabitant of wet meadows. In the former situation especially, it is low and scattered and of little prominence. *Campanula americana* appears to find its most favored haunts along the edges of woods. It is found as well in the midst of woody formations, but even here it grows in the more exposed places. It is usually subsolitary, rarely more than 8 or 10 plants occurring together, and in deep canyons of the Niobrara the individuals grow widely separated. Notwithstanding, they are the most conspicuous members of such formations on account of the vivid blue of the flowers. These are borne on a long, strict raceme, which projects far above the general mass of vegetation. The horse gentian, *Triosteum perfoliatum*, with its large leaves, is a familiar plant of the woodlands of the Missouri. In regions II and III, it occurs more rarely, usually in the edge of thickets, where it forms considerable patches. The star cucumber, *Sicyos angulatus*, is distributed sparsely in the deeper woods of the southeastern part of the State, where it is tall-climbing—covering the trees to a very considerable height. *Micrampelis lobata*, the wild cucumber, possesses a much larger geographical area. It grows not only in woodlands, but is especially common along the edges of streams throughout regions I, II, and III. From its dense manner of growth and its climbing powers, *Micrampelis* plays a very important part in woody formations of I and II, and it will be discussed in succeeding chapters.

(2) Hydrophytes of wet meadows and spring marshes, I-IV. With a single exception, this group consists of montane species, which have wandered out upon the foothills, and have found their way into the sand-hill region along water courses. *Lobelia siphilitica*, though it reaches its maximum abundance in the sand-hills, is very equally distributed over the State. In regions I and II, while it occurs along wet stream banks, its favorite haunt is upon wet limestone or sandstone ledges, oftentimes in deep shade. On the sands of the Niobrara and Republican and in wet sand-draws and canyons, it occurs in masses of intense blue, here and there interrupted by a white-flowered individual. With the exception of a short incursion into the sand-hills along the Niobrara, *Galium boreale* is restricted to the foot-hill region, where it is apparently a hydrophyte or subxerophyte at will. The low, diffusely branched, leafy plants are usually aggregated into small but congested patches, characterized by a profusion of minute white flowers. *Campanula rotundifolia* has very nearly the same distributional boundaries. It is somewhat rarer, however, growing in but a few stations outside the Pine Ridge district. *Campanula aparinoides*, which is restricted almost wholly to the sand-hills, is uniformly an inhabitant of very wet places, spring marshes, wet meadows, and the like, in which the delicate trailing stems are conspicuous in grassy spots. *Lobelia spicata* is probably the typical plant of wet valleys in the sand-hills. It grows here in the wettest situations, and forms extensive patches.

(3) Xerophytes and subxerophytes of ridges, sand-hills, and prairies, I-IV. On account of its immense root and creeping stems, *Cucurbita foetidissima* is well adapted to xerophytic situations in the western sand-hills and foothills. From the root, long, creeping stems run in every direction, covering a space several square meters in extent. Such spots are invariably of great prominence in the sparse floral covering. Venus' looking glass, *Legouzia perfoliata*, is common on hilltops and hillsides throughout the State. It is constantly xerophilous only in regions III and IV; in I and

II it is to be found in low prairies, and even along the banks of streams. It is interesting because of its odd appearance, but is important only because of its general distribution. A second species, *Legouzia leptocarpa*, grows in the sub-sand-hills of region II. *Houstonia angustifolia* appears to have come into our flora from the South. Small clusters of it, bright with blue-purple flowers, are not infrequent on high hills of regions I, II, and III, south of the Platte. *Lobelia cardinalis* and *L. inflata*, which are known for one or two stations in III along the southern edge of the State, are likewise invaders from the South.

(4) Shrubs, typically of forests, open woodlands, and thickets, I-IV. The wolfberry, *Symphoricarpos occidentalis*, through the assumption of almost complete ruderal habit, is to be found at the present time in its original habitat for the most part only in regions I and II. Even here, while common in edges of woodlands and borders of thickets, it has become most abundant in pastures and meadows, in some of which it has taken entire possession. The wolfberry, with its dark green and shining leaves, bright flowers, and white berries, has thus come to play a conspicuous part in the floral covering, instead of remaining a mere layer of another formation. In the sand-hills the wolfberry is lower and grows much more sparsely. In the canyons of the foot-hills it is abundant along the lower stretches of canyon sides. The coral berry, *Symphoricarpos symphoricarpos*, is confined chiefly to deep woodlands, though occasionally found in thickets. It is smaller than *S. occidentalis*, but resembles the latter in habit. In the woods of the Missouri it frequently constitutes the second layer of forests for several kilometers. *S. pauciflorus* is limited to the high canyons of Hat creek basin. Elderberry thickets, *Sambucus canadensis*, are characteristic of low ravines and meadows in I and II. While usually found along the edges of woods, they are rather to be regarded as independent. *Lonicera dioica* has followed the wooded bluffs of the Missouri to the mouth of the Niobrara, and even occurs for some distance

along the latter stream. *Cephalanthus occidentalis* and *Viburnum lentago* are confined wholly to the Missouri district.

Asterales.—The Asterales in our flora are represented by Compositae only, of which we have 69 genera and 227 species. The large genera are: *Aster*, 25 species; *Solidago*, 20 species; *Helianthus*, 13 species; *Erigeron*, 12 species; *Artemisia*, 9 species; *Carduus*, 8 species. The regional distribution of the group is as follows:

	Total.	Peculiar.
Common to the four regions	30	..
I. Wooded bluff, etc., region.....	99	12
II. Prairie region	109	16
III. Sand-hill region.....	125	15
IV. Foot-hill region.....	110	32

The species common to the four regions are: *Ambrosia artemisifolia*, *A. psilostachya*, *A. trifida*, *Achillea millefolium*, *Antennaria campestris*, *Artemisia dracunculoides*, *A. gnaphalodes*, *Aster multiflorus*, *A. salicifolius*, *Bidens levis*, *Brauneria pallida*, *Coreopsis tinctoria*, *Dysodia papposa*, *Leptilon canadense*, *Grindelia squarrosa*, *Helenium autumnale*, *Helianthus maximiliani*, *H. rigidus*, *Iva xanthifolia*, *Kuhnia glutinosa*, *Laciniaria punctata*, *Lactuca canadensis*, *L. pulchella*, *L. ludoviciana*, *Ratibida columnaris*, *Lygodesmia juncea*, *Nothocalais cuspidata*, *Rudbeckia hirta*, *Solidago canadensis*, and *S. serotina*.

The vegetation-forms represented are:

(3) Undershrubs	5
(5) Half shrubs	3
(6) Rosettes	14
(7) Mats	8
(12) Rootstalk plants	107
(13) Bulb and tuber plants	7
(15) Dicyclic herbs	16
(16) Monocyclic herbs	46
(19) Amphibious plants	4

The habitat-groups are:

1. Xerophytes of high barren prairies, sand-hills, and table-lands, I-IV 52
2. Xerophytes of table-lands and foot-hills, IV23
3. Inhabitants of low prairies and meadows, I-IV.....51
4. Hydrophytes of wet meadows, marshes, edges of pools, etc., I-IV13
5. Inhabitants of shady woods and thickets, I-IV.....27
6. Halophilous species growing in salt marshes of the foot-hills, IV 1
7. Ruderal or sparingly introduced species, I-IV.....34

(1) Xerophytes of high barren prairies, sand-hills, and table-lands I-IV. Of the three species of *Artemisia* contained in this group, two, *A. canadensis* and *A. frigida*, are exclusively western, while the other, *A. gnaphalodes*, is distributed over the entire State. *A. canadensis*, which is a tall half shrub about 1½ meters in height, grows over extensive areas on the barren plains of IV, and has found its way into similar situations in the Niobrara district. *Artemisia frigida* is distributed over the entire sand-hill region as well as over region IV. It is low-growing, the basal leaves forming dense tufts or mats, which are conspicuous only when they bear the upright flowering stems. This species is usually found associated with *A. canadensis* in the range of the latter species. *Artemisia gnaphalodes*, on account of its white, cottony stems and leaves and its habit of growing in patches, is an easily recognizable feature of high hills and plains throughout the State. In such places it is usually controlling, but in regions I and II it has become ruderal, and constitutes a second layer in tall herbaceous formations. *Aster multiflorus* is the most widely distributed and the most abundant of our species of *Aster*. It presents almost innumerable forms, which adapt themselves to very diverse habitats. Typically, *Aster multiflorus* occurs scattered over large stretches of prairie, sand-hill, or tableland. It is, however, not infrequently an inhabitant of meadows, where it forms somewhat definite patches. The

tendency to mass the individuals is manifested still more along roadsides in I and II. This species is especially interesting as an aianthous plant; the first flowers appear late in May, and the flowering period closes only upon the coming of winter. The high prairies of I and II and the sandy plains of a small portion of the Niobrara district are characterized in late summer and autumn by *Aster sericeus*. An especially noticeable feature of this plant is the uniformity with which it occurs in the vegetation of hill after hill. As a consequence, the entire floral covering of such situations takes its complexion from the silvery stems and leaves and bright purple flowers of this species. *Aster oblongifolius*, which has even more brilliant flowers, possesses very nearly the same distribution, but is rather more restricted within its geographical area. In regions I and II it is usually confined to the summits of exposed rocky bluffs, or stony hills, while in region III it is found only on the ridges between canyons. It is taller-growing than *A. sericeus*, and is gregarious rather than copious. *Machaeranthera sessiliflora*, with its varieties, plays a similar part in the vegetation of the western sand-hills and of the foot-hills. Regions III and IV possess two rather typical species of *Solidago*, *S. missouriensis* and *S. mollis*. *S. missouriensis* usually grows scattered, while *S. mollis* is to be found in more or less definite patches, often in subruderal situations along roadsides or old trails. Wherever either occurs in any abundance, it entirely controls the color effect of the formation. In regions I and II these two species are replaced by *Solidago rigida* and *S. rupestris*. In fact *S. rupestris* and *S. missouriensis* may be regarded as geographical varieties of one species. Though they rarely occur associated, *S. rigida* and *S. rupestris* are entirely interchangeable. In late summer and in the autumn the two substantially dominate the entire floral covering of the prairies. *S. rigida*, which is much taller and hence more conspicuous, usually controls the higher portions of the hills, while *S. rupestris* is more common on the lower hillsides and on low prairies. *Solidago*

nemoralis, which is common on exposed buttes and canyon sides in certain localities in region III, has wandered down upon the bluffs of the Missouri, and is found somewhat rarely in the sub-sand-hills of II. *Helianthus scaberrimus* occurs over the whole State as a tall xerophyte of high hills and plains. *Helianthus petiolaris*, which closely resembles the common sunflower, *H. annuus*, though typically a plant of the sandy prairies in III and IV, is now of most importance in these two regions because of its almost exclusive possession of abandoned "claims," where it forms wastes hardly inferior to those of *H. annuus*. *Helianthus maximiliana*, throughout its wide range, is typically gregarious. On the prairies the rather low, densely canescent plants occur in groups of a dozen or more, which are scattered here and there. Along roadsides, where it is becoming more and more frequent, it becomes fairly social. *Lygodesmia juncea* grows uniformly over large areas of prairie throughout the State. Such stretches often derive their character from the abundance of the bushy stems and pink flowers of this species. It is also one of the commonest inhabitants of the sand-hills, growing on the hills, the most exposed ridges, and in the blow-outs. The taller *L. rostrata* is rather uncommon in sandy pastures and hillsides in the northern half of region III. In the sand-hills of Cherry county, a form referred to *L. juncea* is very common, which, in its long leaves, approaches *L. rostrata* and appears to be intermediate between the two species. Three species of *Hymenopappus*, *H. filifolius*, *H. tenuifolius*, and *H. flavescens*, are hardly to be distinguished from each other as constituents of the floral covering. This is especially true of the first two, which have practically the same distribution. The last, which is comparatively eastern, is confined to the sub-sand-hills of II. The uniformity with which they occur over large areas is characteristic of all three, and their erect stems, with the flat, terminal inflorescence, make them a peculiar feature of the open formations in which they are found. *H. filifolius* is abundant throughout the entire sand-hill region, being found

on almost every sand-hill and in blow-outs. Two xerophilous species of *Carduus* are confined almost wholly to the sand-hills and foot-hills. This is especially true of *Carduus platensis*, which is a typical plant of the sand-hills. *C. undulatus* occurs as well on the prairies of I and II. The former is usually low and isolated, and its cream-colored flowers never acquire the prominence of the red flowers of *C. undulatus*. The latter, moreover, grows in loose patches. *Brauneria pallida* grows throughout the State. In the sand-hills proper it is confined to the dry valleys, and in consequence is extremely constant in habitat. The individuals, though scattered, are nevertheless very prominent on account of their flowers with brown disks and rose-purple rays. *Ratibida columnaris*, though frequent in regions I and II, is rarely abundant. In the extreme western portion of I, however, and in the Niobrara district, it covers long stretches of high prairie in such profusion as to have the appearance of a cultivated plant. In such places the formation is a mass of yellow. With the species, the variety, *R. columnaris pulcherrima*, in which the ray flowers are deep purple, is usually abundant, and in the same patch perfect series of gradations are frequent. Two species of *Euthamia*, *E. caroliniana* and *E. graminifolia*, are confined to the driest and most exposed situations of III and IV, in the floral covering of which they have the same part as species of *Solidago*. *Erigeron pumilus* grows in low, dense tufts on buttes and sandy hillsides throughout region IV. It is to be found with species of *Astragalus* and *Aragallus lamberti* rather than on the sparsely covered hillsides inhabited by *Polygala alba* and *Paronychia jamesii*, and hence escapes notice among its profusely flowering, tall-growing neighbors. *E. bellidiastrum*, a low-growing, much-branched, spreading species, grows on almost every sand-hill throughout region III. Like all typical sand-hill plants it is scattered sparsely, but uniformly, over the hills. *Chrysopsis villosa*, with its several varieties, grows throughout III and IV. It is especially abundant on sandy plains, where it forms dense patches. *Thelesperma trifidum* is a

common inhabitant of high prairies in region IV, where it occurs associated with *Astragalus adsurgens*, *A. mollissimus*, and *Aragallus lamberti*. It is especially noticeable here, since, with the exception of *Erysimum asperum*, it is the only plant of any size which variegates the prevailing blue color given to the formation by the species of *Astragalus*, *Aragallus*, and *Lupinus*. *Thelesperma gracile* is found on the sand-hills in the western portion of region III, where it is neither frequent nor abundant. *Senecio douglasii* forms patches of some size in both the sand-hill and the foot-hill regions. The individuals, which are usually thickly aggregated, are very noticeable on account of their tall, branching habit and the innumerable yellow heads of flowers. The low-growing *Senecio compactus* is nearly identical in range, but is much less common. *Laciniaria punctata* is a serotinal xerophyte of very wide range. Its long spikes of bright purple flowers make it a prominent species in the later aspects of the floral covering. In the heart of the sand-hills, *Laciniaria punctata* and *L. scariosa* are confined to the dry valleys, while *L. squarrosa intermedia* grows on the sides and tops of the sand-hills. In regions I and II, while the latter still preserves this habitat, the two former are found in meadows and pastures as well as upon the high prairies. In early spring *Nothocalais cuspidata* is to be found abundantly on high hills throughout the State, except in the Loup district, where it grows in dry valleys. Its long, grayish leaves and large, yellow flowers make the individuals striking members of the spring vegetation. *Kuhnia glutinosa*, which grows sparsely throughout the State, is most abundant in I and II, where it has become ruderal to a large extent. *Eriocarpum spinulosum*, though typically a xerophyte of the sand-hills, foot-hills, and Bad Lands, is found in abundance in the sub-sand-hills of I and II, to which it gives a distinctively sand-hill character.

(2) Xerophytes of table-lands and foot-hills, IV. This group contains a large number of montane xerophytes which are as yet known for but one or two stations. Among these in the Pine Ridge district are *Artemisia tridentata*, *A.*

longifolia, *Erigeron caespitosus*, *E. concinnus*, and *Antennaria dioica*; in the Lodge Pole district, *Aster adscendens*, *Leucelene ericoides*, *Machaeranthera tanacetifolia*, *Chaenactis douglasii*, and *Pectis angustifolia*. Species of *Chrysothamnus*, *Artemisia filifolia*, and *Gutierrezia sarothrae* are undershrubs or half shrubs of rather common distribution throughout region IV. *Chrysothamnus nauseosus* is apparently confined to the Pine Ridge district, while the variety *Chrysothamnus nauseosus glabratus*, which grows 2 meters or more high, is found in exposed canyons in Scott's Bluff county. *Gutierrezia sarothrae* is distributed over the entire foot-hill region. The low, tufted plants, with their masses of yellow flowers, are characteristic of barren tablelands. In sandy situations, *Artemisia filifolia* is common throughout the same range. *Ptiloria tenuifolia*, which resembles a small *Lygodesmia juncea* in habit, is peculiar to the Bad Lands of the Hat creek basin and of Scott's Bluff county. *Ptilepida acaulis* is a characteristic mat former of hills and buttes throughout the foot-hills. *Eriocarpum grindelioides* is very common on the hills of the Lodge Pole district, especially in the Wild Cat mountains. It is found as well in the Bad Lands of the Hat creek basin.

(3) Inhabitants of low prairies and meadows, I-IV. Like most of the habitat-groups of the Compositae, this group is by no means easy to limit. A certain number of species are typical, low meadow inhabitants, but a large number, while they frequent low prairies and meadows in the eastern portion of the State, in the western portion become more or less xerophilous. Other species tend more or less to become shade plants or open woodland plants, while still others become somewhat hydrophilous. A number, also, are becoming ruderal. A prime cause of this instability and variability of habitat is the excessive development of accessory characters in the composites. Not only in seed production and dissemination, but in internal protective devices, the composites take the first rank among plants. They are thus enabled to invade as well as to retain territory, and be-

come diverse in habitat. The inhabitants of low prairies and meadows are in all cases a more or less difficult group to define, since they are subject to over-abundance of water in some seasons and unwonted dryness in others and are often in the near neighborhood of woody formations which tempt them to some extent. Nevertheless, it is possible to divide this group roughly into four sections: the first composed of low prairie inhabitants which exhibit a tendency to become xerophytes; second, inhabitants of draws in the prairie, tending to spread over low pastures and roadsides and to become ruderal; third, inhabitants of meadows and low prairies in the vicinity of streams and woodlands, tending to become open woodland plants; and, fourth, inhabitants of low prairies, which tend to become hydrophilous. These might have been separated as distinct habitat-groups. But the variability in habitat of the greater number of species is such as to make the attempt to limit them with so much precision unsatisfactory.

(a) Inhabitants of low prairies, tending to become xerophilous. *Antennaria campestris* is one of the most widely distributed, and one of the most characteristic species of this section. In low prairies in regions I and II it is of great abundance, forming interrupted carpet-like patches of some extent. Not only are these patches of considerable size, but they are scattered uniformly over low prairies throughout these regions. It is a prevernal bloomer, and on this account is a prominent constituent of prairies in springtime. Even in region II it tends to become somewhat xerophilous; in the sand-hill region it is a frequent inhabitant of dry valleys, where it is a typical xerophyte. On the high prairies of region IV, though it sometimes occurs in *Stipa* formations, it is more frequently subxerophilous. In such situations the mats cover but small areas, and are very loosely compacted. *Erigeron ramosus* is a frequent and abundant species of prairies in I and II. The individuals occur copiously and uniformly over large tracts of low prairie and low hills. It is an estival bloomer, and in June and July the masses of

white-rayed heads give it a controlling appearance. In the sand-hills *Erigeron ramosus beyrichii* is to be met with here and there in low meadows in the wet valleys. Its general appearance is identical with that of the type. During the vernal period *Senecio plattensis* is one of the most noticeable plants of prairies in I and II. The individuals are somewhat gregarious, occurring copiously over indefinite and somewhat restricted areas. Except when in flower the individuals are insignificant, but the tall stems, bearing large numbers of yellow heads, are prominent features in the spring aspect of prairies. *Mesadenia tuberosa* is a very constant inhabitant of low prairies in I and II. It occurs sparsely, but the tall stems, a meter or more high, crowned with a mass of white heads, are very marked among the low-growing neighbors. *Prenanthes aspera*, a frequent inhabitant of low prairies in I and II, becomes more or less xerophilous upon high sandy hills of the same regions. It extends also into the north-eastern corner of III, where it inhabits meadows. It is a tall-growing species, which is found sparsely over restricted and localized areas. The yarrow, *Achillea millefolium*, is frequent in meadows and low prairies the State over. It is rather diverse in habitat, becoming xerophilous in some localities, and often ruderal as well. In autumn, *Silphium laciniatum* is a characteristic species of low prairies in I and II, which extends also into subxerophilous situations upon hills. While abundant, it is scattered uniformly and almost sparsely. It is a striking feature of the landscape in summer and autumn, on account of the high stems bearing throughout their length large heads of yellow flowers, and the basal tufts of broad, lacinate leaves. In the same regions *Silphium integrifolium* is to be met with in low meadows, usually near streams. *Rudbeckia hirta*, which is becoming common in meadows in I and the eastern portion of II, is one of the most widely distributed inhabitants of wet valleys in III. In the foot-hills it appears to be subxerophilous.

(b) Inhabitants of draws in the prairie, tending to spread over the low pastures and to become ruderal. One

of the characteristic inhabitants of draws and low meadows in I and II is *Vernonia gigantea*. In pastures it soon acquires complete control either of large patches or of the entire pasture. On the prairie, it is usually confined to draws where it is scarcely less controlling. It grows to a considerable height, 1-2 meters, and in summer and autumn the large patches, covered with corymbs of purple heads, are characteristic features. Along roadsides it is becoming a frequent ruderal species. Six species of *Helianthus* are to be met with in similar situations in regions I-III. The species of widest distribution and of chief importance are *H. grosse-serratus* and *H. giganteus*. Both species are to be found in draws, on the margins of ditches, along roadsides and railroad embankments, and banks of streams throughout regions I and II, and in many places in region III. Neither exhibits much tendency to become ruderal, but both have the appearance of weeds in their ordinary situations.

(c) Inhabitants of meadows and low prairies in the vicinity of streams and woodlands, tending to become open woodland plants. The most important species of this section is *Solidago canadensis*, which in late summer and autumn gives a pronounced character to roadsides, meadows, and the edges of woodlands. From the nature of its habitat, the plant is often obliged to become gregarious, though it is in reality social. Its great importance in our flora is due to its wide distribution, to its abundance, and to the predominance which its patches assume on account of the almost solid mass of yellow flowers. *Solidago serotina*, though possessing substantially the same geographical area, has a much smaller number of stations and a less degree of abundance in these stations. It always grows in small masses along the immediate banks of streams, in meadows, or in open woodlands. The individuals are much larger than those of *S. canadensis*, and, though less numerous, attain a high degree of prominence on account of the contrast between their large yellow panicles

and the mass of green foliage in which they are found. *Heliopsis scabra* is typically an inhabitant of grassy banks of streams, where it grows in small patches much after the fashion of some species of *Helianthus*, which it greatly resembles. In region III, where it is sometimes also xerophilous, it is usually to be found more or less scattered through the sparser thickets. Ordinarily, *Artemisia dracunculoides* occurs in large, dense patches throughout lowlands, but it has become in some localities a regular inhabitant of thickets and of open woodlands. *Artemisia biennis*, which is sometimes to be found associated with *A. dracunculoides*, grows on the higher prairies as well, and from these has become ruderal along roadsides.

(d) Inhabitants of low prairies tending to become hydrophilous. The blazing stars, *Laciniaria pycnostachya* and *L. spicata*, are two of the most brilliant flowers of bottoms and low hay lands in late summer. *Laciniaria pycnostachya* is confined to regions I and II, *L. spicata* to III and IV. In the part which they play in the floral covering of meadows, etc., they are exact equivalents. Both have exceedingly tall, slender stems, with narrow leaves, and a dense terminal spike of purple flowers. In some situations, *L. pycnostachya* becomes almost hydrophilous. *Aster salicifolius* and *A. paniculatus* are both common in low meadows throughout the State. The individuals, though tall-growing, are usually found scattered among the rank grasses and sedges, and their presence in the floral covering is scarcely evident except during the serotinal period, when they are in bloom. *Coreopsis palmata*, which is restricted to low, grassy meadows along the course of the Missouri, derives a slight degree of prominence from its deep yellow flowers, which appear in the formation at a time when the prevailing colors are white and blue. Three species of *Crepis*, *C. runcinata*, *C. intermedia*, and *C. glauca*, grow in low meadows along streams or in canyons in the western part of the State. The two latter are restricted to a few localities in the foot-hill region. *C. run-*

cinata extends into the western portion of the sand-hills, where in wet valleys it becomes hydrophilous, and is to be found associated with *Triglochin maritima* and *Plantago eriopoda*.

(4) Hydrophytes of wet meadows, marshes, edges of pools, etc., I-IV. With the exception of a single species, all our representatives of the genus *Bidens* belong to this group. Certain of them, such as *B. connata*, *B. involucrata*, and *B. bipinnata*, are of localized or restricted distribution, and in consequence are of relatively little importance. *Bidens cernua*, which is uniformly low-growing, is found only in region II, where it usually occurs associated with *Typha* in muddy bogs. The heads are rayless, and the plants would be entirely inconspicuous were it not for their dense aggregation. *Bidens trichosperma tenuiloba* and *B. levis* are extremely common in marshes and in the neighborhood of springs and streams throughout the sand-hills and foot-hills. The latter has also begun to invade extremely wet places in regions I and II. Both are characteristic plants in their ordinary habitats, not only on account of the aggregation of the tall-growing individuals, but on account of their conspicuous, yellow-rayed flowers. *Helenium autumnale*, *Eupatorium perfoliatum*, and *E. purpureum* constitute a group which is characteristic of many hydrophytic situations throughout regions III and IV. In such localities, the aggregation of these three species gives a very mottled appearance to the formation, the yellow of the *Helenium* contrasting vividly with the purple of *Eupatorium purpureum* and the white of *E. perfoliatum*. In descending the Missouri into region I, while the two species of *Eupatorium* have kept their ordinary habitat, *Helenium autumnale* has become rather an inhabitant of the edges of pools and of banks of streams. *Boltonia asteroides* is a typical feature of certain flooded lowlands and meadows in region II and of wet hay lands in region III. The plants are tall, a meter or more high, diffusely branched above, and bear innumerable white or pinkish heads, which, on account of the close

aggregation of the individuals, give a striking color to long stretches of bottom land.

(5) Inhabitants of shady woods and thickets, I-IV. Throughout the summer and autumn, the deep woodlands of regions I and II and certain localities in III are filled with a tall, dense, herbaceous layer composed almost wholly of *Rudbeckia laciniata* and *Verbesina alternifolia*. During the period of flowering, this layer is of an almost uniform yellow on account of the long rays of the large yellow heads. *Verbesina alternifolia* is confined entirely to woodlands of the Missouri, with the exception of a few localized stations in II. *Rudbeckia laciniata* is very abundant not only in the woods of I and II, but in meadows and cleared places as well. Wherever they are found together, however, the two are to be regarded as of almost equal value. In the same woods are to be found, rather more rarely, *Helianthus decapetalus* and *Silphium perfoliatum*. Both of these prefer the edges of the woods and are to be found here in patches of small extent. Except when in flower, *Helianthus decapetalus* is never a very prominent member of such formations. *Silphium perfoliatum*, on the contrary, on account of its thick, angled stem and immense, connate leaves, is conspicuous at all times. This is especially true of somewhat considerable patches during the flowering period, when the dark green foliage and the masses of yellow flowers afford a strong contrast. Several species of *Aster* are important members of lower herbaceous layers of woody formations. They are always among the most conspicuous plants not only of their layer, but of the herbaceous portion of the formation as well. This is due chiefly to the uniform blue or blue-purple color of the flowers, but is due to the aggregation of individuals in large patches as well. Especially noticeable on this account are *Aster novae-angliae* and *A. sagittifolius*, though this character is also shown by species of more restricted distribution, such as *A. azureus* and *A. longifolius*. *Mesadenia atriplicifolia*, which is confined to the wooded bluffs of the

Missouri, is very conspicuous in such situations on account of its immense leaves. The individuals, which sometimes reach a height of a few meters, usually occur solitary. *Ratibida pinnata*, which has found its way into a few localities in the southeastern portion of region II, is confined for the most part to the bluffs and ravines of I. It is not very frequent, but wherever found is extremely prominent on account of its tall stems and large flowers. In late summer and throughout autumn, *Eupatorium ageratoides*, with its large clusters of white flowers, is characteristic of deep woodlands and dense thickets throughout regions I, II, and III. The plants, which are ordinarily less than a meter in height, are so diffusely branched and so numerous as to give an uninterrupted white appearance to the herbaceous layer. *Lactuca ludoviciana* and *L. canadensis*, found in nearly every woodland and thicket of any extent throughout the State, are homely plants which rarely form masses at all conspicuous. *Lactuca acuminata*, which is more prominent on account of its large leaves, is confined almost wholly to the southern portion of region I. *Eupatorium altissimum*, which is much taller than *E. ageratoides*, is never so striking nor so abundant. It is, however, a frequent inhabitant of the edges of woods in the southern portion of regions I and II. *Solidago arguta*, which has practically the same range, is frequently found associated with it, though in general the latter prefers deeper parts of the woodland. *Erigeron philadelphicus*, which is characteristic of the base of wooded bluffs along the Missouri, has followed the large rivers westward across the State. In its usual habitat, the tall, gregarious stems with their large, white or pinkish flowers, form considerable patches which are conspicuous features of the vegetation of the bluffs. *Erigeron subtrinervis*, which has much larger, blue flowers, is common only in the canyons of the Hat creek basin, though it has wandered down into occasional stations along the Niobrara. *Arnica cordifolia* is likewise restricted to the Pine Ridge district, in which, as yet, it is neither frequent

nor abundant. It usually occurs in the deep wooded canyons in association with *Erigeron subtrinervis*. *Bidens frondosa* is usually to be found only in the edges of woodlands or in thickets, where it forms rank patches of some size. These are never striking, however, on account of the inconspicuous flowers. *Carduus altissimus* grows in deep woodlands throughout the State. Although it is never more than subsolitary in habit, the tall, strict stems with their terminal, red-purple heads are conspicuous objects in woodlands everywhere.

(6) Halophilous species growing in salt marshes of the foot-hills, IV. The sole representative of this section is *Bahia oppositifolia*, a low, shrubby composite, found only in salt marshes in Scott's Bluff county and in alkaline situations in the Hat creek basin.

(7) Ruderal or sparingly introduced species. The Compositae furnish a remarkably large number of ruderal plants of wide distribution as well as many introduced or escaped species of less frequent occurrence. The latter are almost entirely confined to the southern portions of regions I and II. They include such species as *Tragopogon porrifolius*, *T. pratensis*, *Cichorium intybus*, and *Centaurea cyanus*, which have escaped from gardens, and such as *Anthemis arvensis*, *Crepis tectorum*, *Carduus arvensis*, *Erigeron annuus*, and *Xanthium strumarium*, which are weeds that have come in from the East. Most of the remaining members of this group, such as species of *Ambrosia*, *Helianthus*, *Iva*, *Lactuca*, *Gaertneria*, *Grindelia squarrosa*, and *Dysodia papposa* are either controlling elements of waste formations or are principal members of such formations, and will receive detailed consideration in the next chapter.

CHAPTER V.

THE PLANT FORMATIONS.

The floral covering of the earth is by no means homogeneous throughout. On the contrary, it presents the most profound differences in its constitution with reference to the frequency and abundance of the species, and the size, habit, and habitat of the individuals. Such diversity is the direct result of the coincidence of certain physical and climatological conditions peculiar to more or less restricted areas of the floral covering, and, once established, tends to maintain and to accentuate itself. The floral covering has in consequence become a veritable mosaic, in which the various pieces now stand out sharply, and are now obscure. In other words, the vegetation of the earth's surface is arranged into groups of definite constitution and of more or less definite limits. Such a group is a plant formation. It is necessary to distinguish very carefully between formations and minor groups, facies, and mere patches. A formation is invariably a plant-complex, except in its incipience or decadence. It has to do primarily with the species which compose it, though these are represented in it necessarily by individuals, while a facies or a patch derives its character solely from the individuals of its species. As a matter of fact, this distinction is partly theoretical. In nature both formations and subordinate groups are in stable equilibrium only rarely, and usually for a comparatively short time. All patches are potential, and many patches are incipient formations. Decadent formations are either permanently modified into mere patches, or they pass through a corresponding stage before their disappearance.

Nevertheless, the formation, like the species, should represent a definite concept, and should manifest the greatest possible degree of coordination. One or two recent writers

upon formations, apparently misled by the present taxonomic tendency to distinguish whatever is distinguishable, regardless of phylogenetic coordination and correlation, have distinguished mere patches and portions of formations as formations proper. It might be objected that no two investigators would agree as to the exact conception of a formation, just as two taxonomists would always differ concerning the proper idea of a species. The German phytogeographers, especially Drude, have given a proper degree of definition to the formation. Their understanding of it should, then, be preserved, not merely, nor at all, because of authority, but because it accords best with our present knowledge of phytogeography. Superfine analysis of the floral covering of the earth into a multitude of formations of all possible degrees of value would entirely destroy the worth of the formation as a phytogeographical concept. Just as taxonomy must ultimately modify recent hair-splitting methods which dub every indivisible group a species, in disregard of phylogeny, or descend to a mere science of cataloguing, so phytogeography as the summation of phytobiology, dealing not only with floristic and distribution, but most intimately with morphology, histology, and ecology as well, in its consideration of the floral covering must maintain the proper degree of distinction between formation, facies, formational zones, patches, etc., or it in turn loses its value as an interpretation of the origin of the floral covering and of the workings of physical and biological forces upon the vegetation of the earth, and becomes a mere card catalogue to the terminology of the floral covering.

The plant formation determines not only the constitution of the floral covering, but is also a more or less interpretable expression of those biological forces of which it is a resultant. It is a biological community in which each factor has more or less interrelation with every other factor, a relation determined not merely, nor necessarily, by the fact of association, but also as a result of biological forces induced by physiographical and meteorological phenomena.

To draw a comparison with taxonomy, the formation, like the species, is an obvious summation of the effects of natural forces upon biological functions, and affords at the same time the most available means for the synthesis of the floral covering. Defined accurately, a formation is a piece of the floral covering, the extent of which is determined by a characteristic correlation or association of vegetable organisms, i. e., it is a stretch of land the limits of which are biological and not physiographical. It can rarely have definite limits, therefore, but must be bounded on every side by a more or less extensive belt in which the features of two adjacent formations are confused. As in the case of species, it often becomes necessary to establish arbitrary limits, within which preponderance of characteristic must be adopted as the mark of delimitation. The determination of a formation has one advantage over that of species; a natural barrier or other physiographical feature may sometimes serve as a formational boundary, a method of demarcation rarely available in dealing with species.

With respect to origin, formations are either primitive or recent. The primitive origin of formations must always lie without the domain of exact knowledge. It can only be conjectured by means of the data obtained from phytopaleontology and from the study of recent formations. Formations originate at the present day by one of two principal methods: by nascence or by modification. Formations arise, by the first method, only upon areas destitute of a floral covering. In the second case, they are formed by the elaboration of facies, or of patches, or by the modification of existing formations through the intrusion of foreign elements. Secondary formations, those which make their appearance in harvested or abandoned culture formations, may be of the first sort, stubblefields, or of the second, timber claims.

It is a general principle that the floral covering extends over all portions of the earth's surface capable, under existing conditions, of supporting plant life. Origin by nascence

could never happen if it were not for those changes in the floral covering caused by the rapid disappearance of certain formations. Formations regularly disappear through the agency of fires, floods, mankind, etc., in all of which cases new formations may arise by nascence. The best examples of the latter are to be found on muddy flats caused by the disappearance of water-plant formations, due to the drying up of ponds and streams, or on artificially denuded areas which have been inundated. In such places, the first layer of the nascent formation usually consists of *Botrydium granulatum*, or *Vaucheria sessilis*, or both, with which minute cup fungi, *Humaria* and *Scutellinia*, are not uncommon. After a short period, these give way to *Riccia glauca* (rarely *Marchantia polymorpha*), and various mosses, *Funaria hygrometrica*, etc., which in turn yield to low, appressed, flowering plants, *Portulaca oleracea*, *Lepidium intermedium*, *Amaranthus blitoides*, etc. This carpet-like layer may be entirely replaced by the taller-growing *Chenopodium album*, *Amaranthus retroflexus*, and *Acnida tuberculata*, etc., or it may persist as a layer. The formation may now become stabilized, or a superior layer of *Helianthus annuus*, *Ambrosia trifida*, etc., beneath which the other still persists, may come in. As a general rule each layer vanishes as it becomes subordinate, and the formation comes to be represented by a primary layer alone. Subordinate layers of different constitution from the primitive ones then appear during the succeeding years. In the case of secondary formations, the complete occupation of the ground by the culture formations suppresses their development. As soon as the latter are cut, or their cultivation is abandoned, the secondary formation assumes complete expression in a very short time. The occupation of the ground by the facies of secondary formations is so thorough and the development of the formation so rapid that layers are rarely present.

Two sets of factors are distinguishable in the origination of formations by modification; the one may be termed

natural, the other artificial. Natural factors are either biological or physical; artificial factors are those induced by the presence or agency of man and animals. It need hardly be said that the necessary interdependence of all these and their frequent coexistence render more or less difficult the recognition of their respective effects. Modification by biological forces is obscure. A fuller comprehension of the causation and application of such forces is essential to even a partial elaboration. At the present time, the influence of biological forces is most easily determined in the absence of all others, a condition of affairs which is not of great frequency. Biological forces may transform facies or patches into formations, or they may change the latter by bringing about the intrusion of other facies. The former results with endemic species which have become ruderal. In our flora it is best illustrated by the patches of *Cycloloma atriplicifolium* and *Chenopodium leptophyllum* in the sand-hills. These are invariably incipient formations, and in many situations have become actual formations. Examples of the second process are abundant along the borders of the Otowanie woods, where the waste vegetation of the roadsides is encroaching upon herbaceous layers of the open woodlands. Such a process is very gradual, especially where the biological forces are not reinforced by other forces. Its striking feature is the peculiar dove-tailing of the subordinate layers, which precedes the meeting of the primary layers. The details of such intrusions are given in full under the section dealing with thicket-like waste formations.

The physical forces which effect modification are either meteorological or physiographical. These two forces necessarily operate in unison, and in most cases it is impossible to separate the resultant effect into its exact components. This is especially true when such causative agencies act in the same direction, or when they tend in diametrically opposite directions. In consequence the effect of either force is most easily discernable in the suspension or the over-

shadowing of the other. A rapid change from one extreme to the other, from hydrophytic to xerophytic condition, or the reverse, affords the best example of the influence of meteorological forces. An unusually wet season in the sand-hill region, or an extraordinarily dry one in the Missouri lowlands, furnishes vivid illustrations of the rapidity with which meteorological phenomena modify the floral covering and originate formations. The abnormally wet summer of 1896 afforded several striking instances of such changes. The street-side vegetation of region II in Nebraska consists regularly of various species of *Chenopodium* and *Amaranthus*, of *Dysodia papposa* and *Ambrosia artemisifolia*. During the season just mentioned, as a direct result of excessive precipitation, *Chenopodium* and *Amaranthus* practically disappeared in many situations, and their places were taken by two ordinarily non-abundant grasses, *Syntherisma sanguinalis* and *Panicum proliferum*. In certain lowland wastes of II, *Grindelia squarrosa*, through several successive dry years, had apparently established itself. Yet, through greatly changed meteorological conditions acting during a single summer, *Helianthus annuus* was enabled to almost completely dislodge it. These instances illustrate in a slight degree the bearing of climatology upon formations. It is impossible to estimate fully and accurately the influence of changed meteorological conditions operating through a long period, or of a sudden reversal of such conditions.

Modification of formations by means of physiographical forces is more difficult to determine. It is, however, fairly well illustrated in the canyons of the Niobrara, where the originally sandy soil has become covered with a layer of loam. This richer soil has afforded a path along which the stress of westward tending species might manifest itself. Changed physiographical conditions have destroyed the equilibrium by means of which western species predominated. Formations once distinctly western are being modified by eastern intruders, or are slowly retreating westward,

leaving their place to be usurped by the invaders. An essential difference between meteorological and physiographical modification should be noted in passing. The former acts for a short time; its effects are usually transient and reversible; the latter, once established, persists through long periods of time, and its results suffer reversion only through profound geogenic forces.

Modification of formations due to artificial factors is of several sorts. It may arise through the direct agency of man, as in the case of culture formations, or through the presence of man, as in most waste formations. The prairie-dog town waste is the single example of a formation produced by animal agency which our flora exhibits. The effects of artificial factors are easy of determination, and the mass of details thus acquired belongs elsewhere.

Considered synthetically, formations exhibit types and facies; analytically, they are resolved into layers and zones, or into primary and secondary species. The facies are those elements of the aspect of the formation which give it character, i. e., a facies is an aggregate of individuals of each controlling species of the formation. A formation may possess but a single facies; usually it has several. Hence, a series of facies in general constitute a type of formation. Related types constitute a principal formation. Thus, *Quercus rubra* is a facies of the red oak-hickory formation, which is a type of the principal formation called the river-bluff formation, which, in turn, falls into the general class of forest formations.*

In formations, the control exerted by the facies is vertical or lateral. In the former case, layers make their appearance beneath the facies; in the latter they are absent, or at most rudimentary. Forests are the most perfect examples of layered formations. Not only is the control exercised by the primary layer complete, but the development of subordinate layers reaches its fullest expression also. The number of layers in a formation is variable:

* For different suggestions as to terminology and classification, see Cowley, *Dune Floras of Lake Michigan*, Bot. Gaz., 27:11, Kearney, *Plant Covering of Ocracoke Island*, Contrib. U. S. Nat. Herb., 5:200.

in the deep forests of I and II there may be as many as seven subordinate layers; in many localities this number may be reduced to two. If the parasitic fungi and the climbers and twiners are to be regarded as layers, the number may be further increased. The layers of forest formations may be named from the vegetation-forms present in each. Thus, beneath the primary layer of trees, there are the shrub, undershrub, upper, middle, and lower herbaceous, the toadstool, and the moss-cup-fungus layers. The continuity of layers is rarely perfect, and one or more layers are often absent for considerable stretches. For the sake of convenience, however, the above terms should always be used for the same layer, regardless of its numerical position in the formation. In formations where the control is lateral, formational zones are to be regarded strictly as analogous to layers. The layer, which is biologically a non-layered formation under peculiar conditions, is generally composed of primary and secondary species, which are named simply with respect to the part they take.

Lines of stress produce both zonal disposition and zonal constitution. The two are merely different degrees of expression of the same force. In the first case, the line of stress is comprehensive, exerting its influence in a parallel series of tensions over a considerable portion of the floral covering; it may be termed a primary line of stress. In the second case, the line of stress concerns itself only with the zonal differentiation of a single formation, or of two adjacent formations; it may then be called secondary. In the floral covering, it is impossible to conceive of primary lines of stress without resulting secondary lines, so that the two cases usually coexist; exceptionally, one preponderates to such a degree that the effect of the other becomes insignificant, or inconspicuous. MacMillan* regards zonal formations as due to radial topographical symmetry. This is easily demonstrated in the zonal constitution of water-plant formations of ponds and small lakes, and in the zonal

* MacMillan. On the Formation of Circular Muskeag in Tamarack Swamps. Bull. Torr. Bot. Club, 23:507. 1896.

disposition of alpine and subalpine formations of mountain peaks. The applicability of such a method of causation is not so apparent with respect to the formations along great rivers, extended coast lines, or uninterrupted mountain ranges, where radial symmetry is reduced to merely theoretical existence. In such cases it is necessary to speak of parallel or bilateral topographic symmetry. According to the same author,* formations may be divided into zonal and azonal. These terms are useful as indicating different aspects, but they rarely denote a real distinction. From the nature of the case, nearly all formations are zonal, although zonation, in particular instances, may be confused or obscured by a variety of disturbing forces.

With reference to the biological relations of individuals, formations may be open or closed. In an open formation, the association of species and individuals is of the loosest, and the unity of the formation is easily destroyed. In a closed formation, the interrelations of the members are most intimate and constant, and the unity of the whole is destroyed only with great difficulty. The open formations of our flora are the sand-hill, foot-hill, and the salt marsh formations. Forest, meadow, and culture formations are typical examples of the closed type. Most waste formations are closed, a few are open. The prairie-grass formation may exhibit both aspects.

According to the vegetation-forms and habitat groups, the floral covering of Nebraska exhibits nine general classes of formations: forest, meadow, prairie, sand-hill, foot-hill, salt-marsh, water-plant, culture, and waste formations.

I. The forest formations.—The great plains possess no indigenous arboreal flora. The conditions which are prevalent over them, moreover, are such as to preclude forestation. In consequence, the trees of our flora are floral elements which have been derived from forested regions. Thus considered, the forest formations of the State are composed of two elements, an eastern element and a western

* MacMillan. Observations on the Distribution of Plants along the Shore at Lake of the Woods. Minn. Bot. Studies, 9: 967. 1897.

element. The former has come into our flora along the Missouri river, as an extreme arm of the forests of the Mississippi basin; the latter is characteristic of the foot-hills, where it infrequently has the appearance of being endemic. Of necessity, the eastern floral element predominates in the forest formations of the greater portion of the State. This is especially true if the species common throughout, which are wholly eastern, are taken into consideration. It holds equally well, however, with reference merely to those which have not yet lost the stamp of eastern origin. In its own definitely limited region, the western floral element is alone characteristic of the forests. The two elements, when represented by typical facies, meet but once in the valley of the Niobrara, along which the western element attains its greatest eastern extension, and where, as also in the Republican valley, the eastern element reaches its western limit. Bessey* has already called attention to the fact that this single locality in the Niobrara district affords the only recorded instance of the association of *Juglans nigra* and *Pinus scopulorum*. In the foot-hills and along the upper course of the Niobrara, certain species common throughout the State, which are of eastern origin, though no longer to be regarded as floral elements, constitute woody formations in the canyons, while the ridges and bluffs are covered with pine forests. Even here, however, the pines are constantly intense xerophytes, while the ash, box-elder, etc., are as constantly mesophytic, and the two formations are invariably sharply delimited.

The deciduous-leaved forest formations of Nebraska, since the constituent species are mesophilous, are found in their most typical form only along the large rivers. Their extension is conditioned chiefly upon the presence of water courses, and they occur only in the immediate vicinity of such, being, in fact, practically confined to the valleys of streams. On account of this, the woody formations of such streams are forests only because they manifest the

*Contrib. Bot. Dept. Univ. of Neb., 8: 109. 1894.

constitution and appearance of forests. They are in reality to be regarded as extra-regional patches of the forest formations of the Missouri river. The deciduous-leaved forests, then, are confined to region I and to the southern portion of region II. The deepest woods are found upon the face and along the base of the bluffs of the Missouri from the Nemaha to the Niobrara. Not infrequently they extend several kilometers out upon the lowland, and, where the bluffs are broken by numerous ravines, even a greater distance in the other directions. Along such tributaries as the Nemaha, Weeping Water, and Papillion, a dense woody formation, practically identical with that of the ravines, occurs for a distance of 50-75 kilometers back from their confluence with the main streams. The forests of the Blue and the Little Blue, though less extensive and more interrupted, are of the same character as those of the Missouri. In fact, if the facies were alone to be considered, they should be regarded as belonging to region I. The needle-leaved evergreen forests are confined wholly to the foot-hills and to the broken bluffs and semi-mountainous country along the upper half of the Niobrara. These forests occur in their most characteristic form on the great natural amphitheatre called Pine Ridge, and in the Hat creek basin. Often in the Niobrara district, and regularly in the Lodge Pole, the forest formation gives way to an open woodland.

The ratio of forested area to non-forested area in the State is rather less than 1 to 30. Of this 3 per cent of forest in the floral covering, the pine formation of north-western Nebraska contributes about 1 per cent, the forests of the Missouri district about $1\frac{1}{2}$ per cent, and those of the two Blues, the lower Platte, Republican, and Niobrara, $\frac{1}{2}$ per cent. The most extensive stretches of uninterrupted forest are undoubtedly to be found upon Pine Ridge and in the Hat creek basin, where the pine forests occur without any noticeable break for several kilometers. Along the Missouri, the largest forests rarely exceed a few square kilo-

meters, though such patches are frequently in direct connection through a narrow belt of forest.

It is readily seen from the above that forests play a comparatively unimportant rôle in the floral covering of Nebraska. This is due not only to their lack of abundance, but also to their small extent and interrupted character in the places in which they are found. In fact, the most extensive woody formations of the State deserve the name of forests, not at all on account of their extent, but solely on account of their density and layerage. While their influence upon the floral covering is relatively insignificant, our forests, on account of the great number of eastern species which are found only in them, have a very marked effect upon the flora.

The forests of the State group themselves into four formations, two of which possess distinct types.

1. The river-bluff formation.
 - (1) The red oak-hickory type.
 - (2) The bur oak-elm-walnut type.
2. The pine ridge and pine bluff formation.
3. The springbranch-canyon formation.
 - (1) The linden-cedar-ironwood type.
 - (2) The paper-birch type.
4. The wooded-island formation.

1. THE RIVER-BLUFF FORMATION.—With the exception of the pine formation, this is the most extensive and the most characteristic of all our forest formations. It is typical of the bluffs of the Missouri, though it occurs along the larger streams of region II, and along the lower course of the Republican and of the Niobrara in region III. There are two types of the river-bluff formation: 1, the red oak-hickory type, *Quercus*, *Hicoria*, *Ulmus*, *Fraxinus*, *Juglans*; 2, the bur oak-elm-walnut type, *Quercus macrocarpa*, *Ulmus*, *Juglans*, *Juniperus*. The red oak-hickory type is characteristic of the Missouri as far north as the mouth of the Platte, beyond which it passes gradually into bur oak-elm-walnut type, which persists even beyond the confluence of the Niobrara.

The latter type occurs in region II in the Otowanie woods on Salt creek, and along both the Big Blue and the Little Blue.

(1) The red oak-hickory formation. This formation is constituted by the following facies: *Quercus rubra*, *Hicoria ovata*, *Ulmus americana*, *Fraxinus lanceolata*, and *Juglans nigra*. Its distinctive appearance is given it chiefly by *Quercus rubra* and *Hicoria ovata*. Other species of *Quercus* and *Hicoria*, however, add materially to the characterization of the type in certain localities. Moreover, a large number of eastern trees, of considerable frequency but limited abundance, are striking features of this type of formation. From these facts the constitution of the controlling or primary layer, from which the type derives its character, is both variable and heterogeneous. Not only do the secondary species of this layer disappear very rapidly as one passes northward to the mouth of the Platte, but the two principal facies likewise lose their predominance before the bur oak-elm-walnut type. The same thing may happen in a restricted locality through the suppression of one or more controlling facies and the increase of other facies.

In the lower portions of the Missouri valley, the deep woodlands consist regularly of an extensive nucleus which consists almost solely of the red oak, *Quercus rubra*, and the shell-bark hickory, *Hicoria ovata*. These stand closely together in such places on account of their tall, strict trunks and narrow, compact tops. The foliage masses of the individuals ordinarily touch each other, thus giving continuous shade beneath them. The distance between trunks is usually less than 3 meters, so that, looking through beneath the foliage, they give a crowded appearance to the forest. In this central portion, the bur oak, *Quercus macrocarpa*, the scarlet oak, *Quercus coccinea*, the white oak, *Quercus alba*, the pig nut, *Hicoria glabra*, and the bitter hickory, *Hicoria minima*, are occasional intruders. They have little or no influence upon the facies, since, if they are tall-stemmed, they become merged in it, and, if small trees, as

Hicoria minima, they are masked by it. Around this central mass, the red oak and shell-bark grow more scattered, and elm, ash, and walnut begin to push into the intervals between the individuals. In this zone or area which marks the transition between facies, the individuals of the several facies become more and more intermingled in passing outward, always with a decrease in the number of individuals of the red oak and shell-bark. The elm-ash-walnut facies are then established and become typical of the greater part of the formation. These three facies undergo frequent interruption, not only through occasional clumps of oak and hickory which still persist, but through the incursion of considerable patches of trees which have been unable to invade the red oak-hickory facies. The first effect of this is to impart a very heterogeneous appearance to the entire formation; the second is to destroy the continuity of the primary layer, or to confuse it with the secondary layer. These invaders are numerous. They comprise such trees as the hackberry, *Celtis occidentalis*, the silver maple, *Acer saccharinum*, the Kentucky coffee tree, *Gymnocladus dioica*, etc., which are tall and affect the constitution of the facies, and the hawthorn, *Crataegus mollis*, the prickly ash, *Xanthoxylum americanum*, the redbud, *Cercis canadensis*, the ironwood, *Ostrya virginiana*, etc., which interrupt the primary layer. All these though they may be occasionally represented by scattered individuals, are usually found in extensive masses which may replace the normal facies. The red elm, *Ulmus fulva*, is often associated with its congener, *Ulmus americana*, which it may rarely replace. It is a smaller tree, and for this reason is never found in the deepest woodlands, where the white elm attains an immense height. The honey locust, *Gleditsia triacanthos*, the red cedar, *Juniperus virginiana*, and the buttonwood, *Platanus occidentalis*, are scattered here and there over the densely wooded bluffs. Though comparatively frequent, they are seldom of sufficient abundance to be of any prominence in the constitution of the forests.

The secondary layer of small trees and shrubs is never well-developed in this formation. In the heart of the formation, the species of this layer are few and the individuals of infrequent occurrence. The pawpaw, *Asimina triloba*, the waahoo, *Euonymus atropurpureus*, the Indian cherry, *Rhamnus caroliniana*, the buckeye, *Aesculus glabra*, the bladdernut, *Staphylea trifolia*, and the rough-leaved dogwood, *Cornus asperifolia*, comprise practically all the species represented in the layer. With the exception of the waahoo and the rough-leaved dogwood, which form small clumps, all are solitary or subsolitary. As would be expected, however, this layer finds greater expression in the forest's edge, where the formation begins to lose somewhat of its closed character. Here are to be found a host of small trees and large shrubs, which constitute immense thickets. Through a variety of causes, many of these thickets now have no immediate connection with the formations. All are to be regarded as, originally at least, the secondary layer of the neighboring woodlands. The most common examples of these are thickets of plum, *Prunus americana*, of choke-cherry, *Prunus virginiana*, of service berry, *Amelanchier canadensis*, of sumac, *Rhus glabra*, of hazel, *Corylus americana*, and of the elderberry, *Sambucus canadensis*. But one of these, the service berry thicket, is confined entirely to the red oak-hickory formation. Since, as has already been pointed out, the successively lower layers of a woody formation tend to extend further and further out beyond the primary one, the formation proper is surrounded by what might be regarded as a shrubby zone or subformation, which may be composed almost wholly of a single species, or may be constituted by several different kinds of thickets.

What is practically the secondary, though theoretically the third layer of the formation, is composed of a few species which are of almost constant occurrence throughout. These are the gooseberries, *Ribes gracile* and *R. floridum*, the Indian currant, *Symphoricarpos symphoricarpos*, red raspberry, *Rubus strigosus*, and the black raspberry, *R. occidentalis*.

The most important of these are *Ribes gracile* and *Symphoricarpos symphoricarpos*. They occur throughout the formation, and, except beneath the red oak and the shell-bark facies, where they are somewhat scattered, form a continuous dense, shrubby layer. *Ribes floridum*, which is sometimes associated with *R. gracile*, usually prefers the wooded ravines. Both species of *Rubus* are but rarely found in the heart of the formation; they are chiefly important in preserving the continuity of the layer as it approaches the edge of woodlands.

The rôle played by climbers is an important one. As has already been shown, however, it is usually difficult to refer them to a definite layer in the formation except when they constitute a layer of their own. The catbrier, *Smilax hispida*, is the only climber that dwells regularly in the deeper portions of the woods. It is a high climber, and, while it is by no means to be regarded as a member of the primary layer, its foliage often occupies the same level as the foliage mass of the trees. The other woody climbers, Virginia creeper, *Parthenocissus quinquefolia*, wild grape, *Vitis vulpina*, and poison ivy, *Rhus radicans*, are usually met with only in the forest's edge, or in thickets, where they climb over shrubs and trees alike, forming a dense wall of foliage. The moonseed, *Menispermum canadense*, never climbs high, but sprawls in dense masses over the undershrub layer, especially where the latter runs out beyond the formation proper. The star cucumber, *Sicyos angulatus*, rarely occurs elsewhere than in the red oak-hickory formation, where its tall habit and broad leaves make it a striking climber. The virgin's bower, *Clematis virginiana*, and the wild cucumber, *Micrampelis lobata*, though they occur in the formation as well, are much more conspicuous in thickets, where they sometimes usurp the place of the shrubs as constituents of the principal layer. The wild cucumber, especially, is noted for its habit of growth. It not infrequently roofs over thickets several hectares in extent, converting them into the most closed of patches. The peculiar effect which this has

upon the secondary layers is well illustrated in certain tall thickets of the eastern edge of region II. In those portions roofed over by *Micrampelis lobata*, the secondary herbaceous layers, with the exception of the lowermost, are uniformly lacking; elsewhere, as soon as one passes out from beneath the wild cucumber, the taller herbs are found in abundance.

The upper herbaceous layer is composed of a small number of species, most of which are almost constantly present. Of these but two, cone flower, *Ratibida pinnata*, and giant hyssop, *Agastache scrophularifolia*, both of which, though striking on account of their beautiful flowers, are never important because of lack of abundance, are practically confined to the red oak-hickory formation. The most conspicuous and most abundant constituents of this layer are the tall cone flower, *Rudbeckia laciniata*, and the crown beard, *Verbesina alternifolia*, which, over large stretches of woodland, give a unique appearance to the herbaceous vegetation. In typical situations the individuals of both species are from 2-3 meters high, and stand so close together that they exclude all but a few tenacious grasses. In many places, however, they grow sufficiently scattered to admit of the intrusion of a few stragglers from the middle herbaceous layer. Under such conditions, the latter never even approximates its full expression. The similarity of habit and of flower color in these two species give to the layer in which they occur a homogeneity unequalled in any other layer or formation in our flora. The watercup, *Silphium perfoliatum*, and the sunflower, *Helianthus decapetalus*, are frequently associated with the tall cone flower and the crown beard, without disturbing the usual appearance of the layer. *Helianthus decapetalus* prefers the borders of woods, and thus continues the layer here after the two principal members have disappeared. The wood vervain, *Verbena urticifolia*, and wood thistle, *Carduus altissimus*, which often grow together, never form a close layer, but serve simply to maintain the continuity of the layer in those places which are characterized by

a strongly developed middle herbaceous layer. The wood vervain does, indeed, become aggregated into patches but it never exerts a controlling influence upon subordinate layers. The cow parsnip, *Heracleum lanatum*, which belongs to this layer on account of its height, has but recently followed the Missouri down from the north, and, though most conspicuous, it is not yet sufficiently abundant to be of importance in the formation under consideration.

The middle herbaceous layer is constituted by a large number of species, and presents various aspects. A few species are vernal, and appear in the spring before the layer is more than barely outlined. These are plants of deep woods: may apple, *Podophyllum peltatum*, blue larkspur, *Delphinium urceolatum*, and Solomon's seal, *Polygonatum commutatum*. The fundament of this middle layer is composed almost uniformly of nettle, *Urtica gracilis*, wood nettle, *Urticastrum divaricatum*, touch-me-not, *Impatiens aurea*, and white snakeroot, *Eupatorium ageratoides*. With these are interwoven a number of species, some of which may replace them. Thus, *Impatiens biflora* occasionally replaces *I. aurea*; clearweed, *Adicea pumila*, often occurs associated with the wood nettle; any or all of these may be driven out and replaced by horsemint, *Monarda fistulosa*, or by beggar's lice, *Lappula virginiana*. The usual summer aspect of this layer is a uniform green, when it is composed wholly of *Impatiens* and *Urtica*. This uniformity of ground tone may be interrupted by the intrusion of additional facies, as has just been mentioned, or it may be modified by scattering, blue-flowered stems of the great bellflower, *Campanula americana*, or of false dragonhead, *Physostegia virginiana*, by purple or blue patches of asters, *Aster novae-angliae*, *A. sagittifolius*, and *A. levis*, or by yellow clumps of goldenrod, *Solidago arguta*. The serotinal appearance is characterized by the predominance of *Eupatorium ageratoides*, which gives a uniformly white color to the layer. The pink flea bane, *Erigeron philadelphicus*, is commonly found in the edges of low woods, and rarely if ever occurs in the midst

of the middle layer. *Mesadenia atriplicifolia*, Indian plantain, grows likewise in the more open places. It is to be regarded as a straggler, having little connection other than size with the middle layer. Two climbers, the ground bean, *Apios apios*, and the ground nut, *Falcata pitcheri*, clamber profusely over tall herbs and small shrubs, making a variegated tangle of green foliage and brown, purple, and blue flowers, which is very conspicuous in the sombre color of the layer. Necessarily, the grasses are few. Scattering patches of reed-grass, *Cinna arundinacea*, occur in moist, shady places. Bottle-grass, *Hystrix hystrix*, haunts the steep sides of the wooded bluffs. Two species, constituents of this layer, find their western and northern limit in our flora in the area characterized by the red oak-hickory formation. *Podophyllum peltatum* is confined almost wholly to the immediate vicinity of the Missouri; it extends 20-30 kilometers to the west along the Nemahas. Northward, this western boundary approaches more and more the river, where it coincides, near the mouth of the Platte, with the northern boundary. *Mesadenia atriplicifolia* is restricted to the bluffs and the immediate ravines of the Missouri; its most northern station is at Bellevue.

The lower herbaceous layer presents two pronounced aspects: an early, or vernal aspect, and a later, estival-serotinal aspect. The first is determined by prevernal or vernal species, which grow in the leaf mold or humus, appearing before the layer has attained any definite constitution. These are all low-growing plants of retiring habit, which accounts for the fact that they rarely give definition to the layer. This lack of prominence is more than equalized by their being the only herbaceous plants of the woodlands in early spring-time. A few, blue phlox, *Phlox divaricata*, spring lily, *Erythronium albidum*, and *E. americanum*, and the yellow violet, *Viola scabriuscula*, are social plants, and wherever they occur in abundance, as is usually the case, they cause the herbaceous layer to stand out sharply. *Phlox divaricata* illustrates this best. The low, erect individuals of

this species cover great stretches of ravines and bluffs, giving to the layer a dense blue color, which makes it the most striking feature of the woodland. *Erythronium albidum* and *Viola scabriuscula* play a similar, though less conspicuous rôle; notwithstanding their small size, the aggregation of the dark-foliaged individuals makes a vivid contrast with the prevailing barrenness of the formation in the springtime. Both *Erythronium albidum* and *E. americanum*, when in bloom, give a rare beauty to the stretches of forest in which they occur. No other plant of this group has a part so unique as that of the columbine, *Aquilegia canadensis*, which dots the steep bluffs of the Missouri and of its smaller tributaries with splotches of red and yellow, as far as the Great Bend. The showy orchid, *Orchis spectabilis*, and the yellow moccasin flower, *Cypripedium pubescens*, notwithstanding the beauty of their flowers, are so infrequent as to be of little importance. With us, the distributional boundaries of each lie entirely within the red oak-hickory formation. The same is true of the dainty spring beauty, *Claytonia virginica*; dutchmen's breeches, *Bicuculla cucullaria*; and squirrel corn, *Bicuculla canadensis*. *Sanguinaria canadensis*, bloodroot, and *Caulophyllum thalictroides*, blue cohosh, haunt secluded dells and ravines and are but rarely in evidence in the woods.

The estival-serotinal aspect of the lower herbaceous layer is eminently heterogeneous. The plants which give character to it are most often, if not regularly, the following: black snakeroot, *Sanicula marilandica*, honewort, *Deringia canadensis*, sweet cicely, *Washingtonia longistylis*, avens, *Geum canadense*, clearweed, *Adicea pumila*, and the three-seeded mercury, *Acalypha virginica*. Wherever the middle herbaceous layer is lacking, the facies of the lower layer are *Sanicula*, *Deringia*, *Washingtonia*, and *Geum*; these give to it a uniform green appearance, often broken only by the slightly taller, white-flowered stems of avens. The two plants which are chiefly concerned in preserving the continuity of the lower layer beneath the middle one are *Adicea*

pumila and *Acalypha virginica*; the latter, indeed, is the most abundant and most widely distributed species of this layer. In autumn, its thickly crowded stems with reddened foliage give a characteristic serotinal effect to large areas in the woods. The level of the lower layer is far from being constant. On the one hand, it dips down to the surface of such low plants as *Parietaria pennsylvanica* and *Cystopteris fragilis*; on the other, the plane of demarcation rises to include *Meibomia canescens*, *Phryma leptostachya*, and *Adiantum pedatum*. Two species of bedstraw, *Galium aparine* and *triflorum*, continue the layer in the borders of the wood and in more open ravines, where they form the densest masses of green. It is worthy of note that, while all the members of the vernal aspect of this layer are characterized by beautiful flowers, those of the later aspect, with the exception of species of *Meibomia*, monkey flower, *Mimulus ringens*, and Jack-in-the-pulpit, *Arisaema triphyllum*, have small or insignificant flowers. The species of this layer, whose range is entirely within the limits of the red oak-hickory formation, are *Erythronium americanum*, *Bicuculla canadensis*, *Orchis spectabilis*, *Cypripedium pubescens*, *Geum virginianum*, and *Meibomia paniculata*. In open woodlands and even in deep ravines, blue grass, *Poa pratensis*, has taken possession of large areas. In such places, the blue grass, on account of its dense sod, is exclusive, and the other herbaceous layers are entirely lacking.

(2) The bur oak-elm-walnut formation. This type has much in common with the preceding, into which it grades almost insensibly at one or two places along the Missouri. It is characterized by the disappearance of both red oak and hickory, which are replaced chiefly by facies of bur oak and elm, in which the walnut is often abundant. The hickory disappears in the transition area between the two formations; the red oak, however, persists for some time, a few scattered trees reaching as far as the Great Bend. A large number of the eastern trees of the lower formation have likewise dropped out. Among these, besides the numerous

species of oaks, are *Aesculus glabra*, *Amelanchier canadensis*, *Asimina triloba*, *Betula nigra*, *Cercis canadensis*, *Crataegus mollis*, and *Staphylea trifolia*. *Acer saccharinum*, which early disappears in the Missouri woods of this type, often assumes the importance of a facies along the Big Blue, though it is rare in the Otowanie woods and in the woody formations of the Little Blue. The Otowanie woods, which occupy the upper portion of the greatly depressed Salt creek valley, mark a transition from the first type to the second not dissimilar to the transition area of the Missouri. They are characterized by more than usual heterogeneity. The bitternut, *Hicoria minima*, is so abundant as to almost attain the rank of a facies, while *Quercus rubra* is also not infrequent. *Gymnocladus dioica* and *Crataegus mollis* occur here and there, often in groups of several individuals. Through these different transition areas, arise two extremes of the bur oak-elm-walnut type. The one is typical of the upper Missouri; the other is found in the southern portion of region II. In both the fundament of the formation is regularly the same. Along the Missouri, several species, which are entirely lacking in region II, juniper, *Juniperus virginiana*, linden, *Tilia americana*, ironwood, *Ostrya virginiana*, and prickly ash, *Xanthoxylum americanum*, are more and more abundant northward, especially upon steep, overhanging bluffs. In addition to these, a most peculiar feature of these woods is the dense thickets in their borders, and, in particular, on the crests of the bluffs. These thickets usually arise in the edge of the forest formation and extend as an impenetrable jungle far up the bluffs. On the bluff sides, they are composed chiefly of a dwarfed form of *Quercus macrocarpa*, and western choke-cherry, *Prunus demissa*, which has descended from the Niobrara. Along the base of the bluffs, juneberry, *Amelanchier botryapium*, mingles with them. On the summits, buffalo-berry, *Lepargyrea argentea*, interposes a barrier-like border between woodland and prairie. On the other hand, the thickets found in connection with this type in region II are composed almost wholly of *Prunus ameri-*

cana and *P. virginiana*. In the formation proper, the red elm, *Ulmus fulva*, is a much more important factor than it is along the Missouri.

The undershrub layer and the climbers of the red oak-hickory and of the bur oak-elm-walnut formation are practically identical. The only important exception is *Sicyos angulatus*, which occurs in the second type only in the Otowanie woods. The upper herbaceous layer is essentially the same, though several eastern species, such as *Ratibida pinnata*, and *Agastache scrophularifolia*, entirely disappear. Moreover, *Verbesina alternifolia* and *Helianthus decapetalus*, though abundant in the Otowanie woods and in the transition area of the Missouri, are uniformly absent over the greater part of the formation. The most striking change in this layer is brought about by the increasing abundance of *Heracleum lanatum* in the woods of the upper Missouri. The immense leaves and monstrous white umbels of this plant give a very decided tone to this layer. In the valley of the Little Blue, the upper layer is lacking, and its place is taken by a very well-developed middle layer, whose fundament is identical with that of the same layer in the red oak-hickory formation. This fundament is, indeed, common throughout the middle layer of both formations. The accessory species are, moreover, usually the same. The exceptions are *mesadenia atriplicifolia*, *Hystrix hystrix*, and *Podophyllum peltatum*, which are confined to the Missouri, and *Delphinium urceolatum*, *Physostegia virginiana*, and *Solidago arguta*, which are found in II only in the Otowanie woods. Of the thirteen species which constitute the vernal aspect of the lower herbaceous layer of the red oak-hickory formation, five are peculiar to this formation; five, *Aquilegia canadensis*, *Caulophyllum thalictroides*, *Erythronium americanum*, *Sanguinaria canadensis*, and *Phlox divaricata*, grow northward along the Missouri to the Great Bend; while only three, *Bicuculla cucullaria*, *Erythronium albidum*, and *Viola scabriusecula* occur in the woods of region II. Two species, which have descended the Niobrara, are frequent on shady bluffs in

late spring, and are to be regarded as members of the vernal aspect of the layer. These are the beautiful white violet, *Viola canadensis*, and the mountain strawberry, *Fragaria americana*. The estival-serotinal aspect of this layer, with the exception of those species already cited as peculiar to the lower Missouri, is essentially the same for deep woodlands throughout I and II.

The woody formation of the lowlands of the Niobrara and of the Republican is practically that of the bur oak-elm-walnut type, except for the gradual disappearance of *Juglans nigra* as a facies and the intrusion of a few western species. Westward, the woody formation of the canyons begins to wander out upon the main bluffs, and later, where the bluffs enclose the rivers in narrow gorges, the springbranch-canyon type assumes predominance. The woody formations of the upper courses of these streams will receive attention elsewhere.

2. THE PINE RIDGE AND PINE BLUFF FORMATION.—This is the most extensive of our forest formations. From the Hat creek basin in the extreme northwest corner of the State, it extends eastward, over the Pine Ridge and along the Niobrara, almost to the confluence of the Keya Paha, and southward to the Pumpkinseed and Lawrence Fork, and even to a few stations on the Lodge Pole. Pines are likewise found in isolated canyons in the heart of the Loup district, more than 150 kilometers from the main formation. The range in altitude of this formation is from 700 m. in Valley county to 1,200 m. on Pine Ridge, and 1,616 m. on the Wild Cat plateau.

A single facies, *Pinus scopulorum*, characterizes this formation throughout the entire area covered by it. This facies may, however, present three different aspects. The most common and widely distributed is that of the open woodland, which, with the one exception, is the only condition found in the Niobrara and Lodge Pole districts, where it covers thousands of square kilometers. It is invariably confined to extremely xerophytic situations, exposed bluffs, ridges, etc. Under such circumstances, the individuals are only medium-

sized, attaining a height of scarcely more than 15-20 m. The branches are usually spreading and the trunk is comparatively short and stout, reaching a diameter of $\frac{1}{2}$ -1 m. The trees are dotted here and there in the thin, grassy vegetation, sometimes sparsely, sometimes more thickly. They never become sufficiently aggregated, however, to control the vegetation to any important degree. The only effect they have upon this open grass formation in which they occur results from the killing of the vegetation directly beneath the trees by a dense layer of fallen needles. The typical forest aspect of the formation is found only in the canyons of the Hat creek basin and of Pine Ridge, in Pine canyon in Custer county, and along the Niobrara at the mouth of Plum creek. In these places, the individuals are tall and straight, often attaining a height of thirty meters. In the Niobrara station, the aspect of the formation contains no trees but pines. Elsewhere, large trees of *Juniperus virginiana* are not infrequently intermingled. Wherever the pines occur alone, the ground is covered with a layer of dead needles 10-20 cm. thick. As a consequence, secondary layers, both shrubby and herbaceous, are regularly absent. The only exceptions are the wintergreens, *Pirola chlorantha*, occurring in such situations in Warbonnet canyon, and *P. secunda* on Pine Ridge, and the pine drops, *Pterospora andromedea*, in the narrower canyons of Hat creek.

In the Hat creek basin, the unmixed pine forest occupies only the upper sides of the canyons. Lower down, it is invaded by, or rather it invades, the deciduous-leaved formation of the canyons. Here it is found intermingled with *Fraxinus lanceolata*, *Ostrya virginiana*, *Ulmus americana*, *Populus deltoidea*, and the montane species, mountain maple, *Acer glabrum*, quaking asp, *Populus tremuloides*, and the black birch, *Betula occidentalis*. With the modification of the facies, the secondary layers assume expression. The shrubby layer is represented by *Prunus demissa* and *Amelanchier alnifolia*, which form dense, extraformational thickets, in which *Lepargyrea argentea* is frequent. The undershrub

layer is composed chiefly of species of *Ribes*, *R. oxycanthoides*, *cereum*, *aureum*, and *floridum*, of which *Ribes oxycanthoides* is the most important. *Rhus radicans* grows in abundance, not only throughout the woods, but upon the exposed canyon sides as well, where it is often associated with *Symphoricarpos pauciflorus* and *S. occidentalis*. In the higher places along the edge of the woods are found dense, bushy patches of three-leaved sumac, *Rhus trilobata*. *Parthenocissus quinquefolia* and *Humulus lupulus* clamber over the shrubs and trees in such abundance as to form almost impenetrable jungles. The herbaceous layers are essentially similar to those of the spring branch formation of the Niobrara. In addition to the usual species, a few montane species of forests, *Corallorhiza multiflora*, *C. striata*, *Eriogon subtrinervis*, and of open woodlands, *Arnica cordifolia*, *Calochortus nuttallii*, *C. gunnisonii*, and *Zygadenus elegans*, occur in more or less abundance.

3. THE SPRINGBRANCH-CANYON FORMATION.—This formation finds its most typical expression from Eagle creek on the Niobrara to western Cherry county, and along the Republican from Franklin county to the western boundary of the State. It is also of frequent occurrence along the Loups, the upper course of the North Platte, and in the canyons of Hat creek and White river. While it is characteristic of deep canyons with precipitous sides, in which are found numerous springs, giving rise to a spring branch, it often wanders out upon the bluffs of the river proper. This is especially the case in the narrow gorges through which the Niobrara, Republican, and Loup flow in their middle course. So numerous are these spring branch canyons, which occur along the south side of the Niobrara at intervals of 1-5 kilometers for a distance of more than 250 kilometers, that they give their character to the entire woody vegetation of the stream.

The modifications of the bur oak-elm-walnut formation which have given rise to the spring branch formation of the Republican and the Niobrara, may best be studied along the latter stream, since its woodlands are in direct connection

with those of the Missouri, while the lower course of the Republican lies wholly within another state. The first change takes place by a gradual decrease in the predominance of elm and bur oak, which is noticeable at the mouth of the Niobrara. By the time the stream bends to the west in Knox county, the white elm has disappeared to a very great extent, and the tall, lowland bur oak has given way to a considerable degree to the low, scrubby form of the bluff side. The character of the formation is determined by the rapidly increasing abundance of linden, cedar, and ironwood to the westward. These, with the green ash, *Fraxinus pennsylvanica*, constitute the principal facies of the formation. In a limited portion of the Niobrara district, the spring branch canyons are characterized by an overwhelming predominance of paper-birch, *Betula papyrifera*. For reasons to be discussed later, such canyons have been regarded as constituting a second type. The springbranch-canyon formation, then, may be divided into two types: 1, the linden-cedar-ironwood type, *Tilia*, *Juniperus*, *Ostrya*, *Fraxinus*; 2, the paper-birch type, *Betula*.

(1) The linden-cedar-ironwood formation. The facies of this formation are *Tilia americana*, *Juniperus virginiana*, *Ostrya virginiana*, and *Fraxinus pennsylvanica*. From the peculiarly shut-in nature of spring branch canyons, it usually happens, with the exception of large canyons such as the Long Pine and Plum creek, that only one or two facies are found in the canyon proper. On the bluffs of the main stream, however, all four facies are ordinarily present. A noticeable feature of this formation is the great uniformity of its upper surface, due to the equality in height of the individuals which constitute the facies. This uniformity is only rarely disturbed by taller trees of *Juglans nigra*, or, where the formation may have wandered down upon the bottom-land, by a few towering individuals of *Populus deltoidea*, or of *Ulmus americana*, which are to be regarded as remnants of the lowland woods of the Missouri. In the canyons, integrity of facies is the rule, but on the bluffs of the rivers the

individuals are so intermingled that no single facies stands out distinctly. *Ulmus fulva* and *Acer negundo*, by their frequency, lend still greater heterogeneity to the constitution of the primary layer. *Celtis occidentalis* and *Gymnocladus dioica* are rarer members of this layer; the latter, indeed, is confined to a few stations, while the former is more general, though never abundant, in its distribution. On the steep bluffs of the Keya Paha, *Crataegus macracantha*, which is but a tree-like shrub in the ravines of the Niobrara, is a prominent feature of the primary layer. From the presence of this species, which constitutes the primary layer of the formation, it will be seen that the primary layer of tall-growing trees in the river bluff formation is lacking here. With the exception of *Celtis*, *Juglans*, and *Populus*, which are represented here and there by large trees, the species of the spring branch canyons are all small trees, corresponding in height to the secondary layer of the Missouri formations. Considered as a formation, it is necessary to disregard this absent layer and to consider the upper layer as primary.

In the midst of the formation, the shrubby or secondary layer rarely reaches full expression. In a few localities in the woods of the Niobrara, the kinnikinnick, *Cornus amomum*, and the elderberry, *Sambucus canadensis*, form thickets of considerable extent, but throughout the greater portion of the formation this layer is represented only by scattered individuals of a few species, *Rhamnus lanceolata*, *Malus ioensis*, and *Crataegus macracantha*. Of much more importance are the thickets which, though belonging to the secondary layer, are found only in the edge of the formation, beyond which they often extend for considerable distances. Such thickets are of two sorts, those which grow in subxerophytic situations along the summits of the bluffs, and those which grow at the base. The first sort is most frequently a dense, impenetrable scrub of *Prunus americana* and *P. demissa*, beneath which there are no layers. It may consist, on the other hand, solely of *Lepargyrea argentea*, or all three species may occur in the same thicket. Along the base

of the bluffs and near the stream, the thickets are taller and of a more heterogeneous nature. The most common constituents are species of *Cornus*, *C. asperifolia*, *C. stolonifera*, *C. amonum*, and *Amorpha fruticosa*. With these are often associated *Amelanchier alnifolia*, *Sambucus canadensis*, and *Xanthoxylum americanum*. Beneath such thickets the herbaceous layers are simply a continuation of those of the formation proper. A peculiar feature of certain spring branch canyons, where there is a considerable interval between the bluffs and the stream, is the so-called "brush," which consists of a densely tangled growth, 1½–2 m. high, of *Quercus macrocarpa*, *Prunus demissa*, *P. americana*, *Xanthoxylum americanum*, and *Fraxinus pennsylvanica*.

The undershrubs and climbers are in general those which are common to woody formations throughout the State. Along the Niobrara, *Rhus trilobata*, which is uncommon in the Missouri district, becomes very abundant to the westward. In the same district, ninebark, *Opulaster opulifolius*, and golden currant, *Ribes aurcum*, are abundant from the mouth of the Keya Paha westward.

Of the upper herbaceous layer, which is so fully represented in the woods of regions I–II, only a few species persist. In fact, this layer is almost uniformly lacking in the spring-branch-canyon formation, or it is constituted by a few individuals of *Carduus altissimus* or *Hieracleum lanatum*. In a few places where small remnants of the bur oak-elm-walnut formation occur, several typical inhabitants of this layer are found; *Rudbeckia laciniata*, *Silphium perfoliatum*, and *Verbena urticifolia*. The herbaceous climbers are, as one would expect, *Apios apios* and *Falcata pitcheri*. More rarely, *Polygonum scandens* is seen climbing over shrubs and bushes.

The middle herbaceous layer presents few departures from the middle layer of other forest formations. Its fundament is composed of *Urtica gracilis*, *Adicea pumila*, *Eupatorium ageratoides*, and *Impatiens biflora*, which takes the place of *I. aurea*. The only members of this layer which are at all peculiar to the formation are *Lappula floribunda*, *Erysimum*

cheiranthoides, and the brome-grass, *Bromus ciliatus*. The lower herbaceous layer possesses no prevernal or vernal species, and of course does not present a vernal aspect. A few stations exhibit the estival-serotinal aspect, typical of the other forest formations. In general, however, the appearance of this layer is very different. One of the most characteristic groups of plants in it occurs in moist situations; it is composed of enchanter's nightshade, *Circaea lutetiana*, tear thumb, *Polygonum sagittatum*, sensitive fern, *Onoclea sensibilis*, and *Phryma leptostachya*. From the Keya Paha westward along the Niobrara, mountain bellflower, *Campanula rotundifolia*, becomes more and more frequent in deep, shady, wet canyons. *Scutellaria galericulata*, *S. lateriflora*, and *Lobelia syphilitica* are not uncommon in similar situations. The bluff sides of many of the canyons of Brown, Rock, Keya Paha, and Cherry counties are covered almost exclusively with *Aralia nudicaulis*, *Fragaria americana*, *Viola canadensis*, and *Cystopteris fragilis*. *Elymus virginicus* and *Muhlenbergia racemosa* are the common grasses of this layer on the drier, wooded lowlands, while *Homalocenchrus virginicus* is confined to moist woods and thickets. On particularly steep bluffs, the lower layer is often represented only by the two grasses, *Elymus striatus* and *Oryzopsis micrantha*.

(2) The paper-birch formation. This type might be regarded as an extreme condition of the usual type of spring-branch-canyon formation. The exceedingly restricted area within which it is found, the peculiar predominance of the paper-birch, which grows nowhere else in the State, and the lack of well-developed secondary layers are sufficient reasons for considering it as a distinct type. The paper-birch canyons are confined to a narrow strip of country on either side of the Niobrara, extending for a distance less than 50 kilometers through western Brown and Keya Paha counties and eastern Cherry county. The canyons themselves are invariably narrow and precipitous, and run back but a few kilometers from the river. The facies of the formation is *Betula*

papyrifera; this species alone constitutes more than half of the entire formation. The individuals are tall and strict, and stand out prominently above the other trees, *Juniperus virginiana*, *Ostrya virginiana*, *Fraxinus pennsylvanica*, etc. Their white trunks, likewise, give an especially striking character to this type. Along the upper edges of the canyons occur the usual thickets of *Prunus americana* and *P. demissa*, and a low scrub of *Symphoricarpos occidentalis* and *Ribes aureum*. In a few canyons, *Corylus americana* is not uncommon, and along Hazel creek it forms dense thickets. Secondary woody layers are entirely absent. Far up on the shady sides, *Elymus striatus*, *Heuchera hispida*, *Campanula rotundifolia*, and *Aralia nudicaulis* are found, but never in abundance, the individuals being for the most part solitary. The lower canyon sides and the banks of the streams are covered with a very deep layer of humus and leaf mold, and are strewn with fallen trunks of paper-birch. Over all grows a uniformly dense carpet of mosses, *Funaria*, *Mnium*, *Bryum*, and *Hypnum*, which constitutes the sole layer of the deeper, wetter portions of these canyons. Scarcely less characteristic than this dark green, mossy layer is the well-developed layer of large, fleshy fungi, *Lactarius*, *Clarkeinda*, *Helvella*, *Geoglossum*, and *Peziza*, and of small cup fungi, *Sepultaria*, *Barlaea*, *Humaria*, etc.

4. THE WOODED ISLAND FORMATION.—The wooded islands which exhibit this formation are sand-bars which have become forested. They must be carefully distinguished from those islands which have been cut off from the wooded mainland, and which possess nearly the same floral covering. Theoretically, the two may become confused by the appearance of typical forest species, when the sand-bar reaches an advanced condition of forestation. As a matter of fact, the sand-bars of the Missouri and the Niobrara, where this formation is found, are so shifting in nature that they rarely persist for a time sufficient to bring about so great a transformation in their floral covering. As a direct consequence of their short duration, then, the woods which cover sand-

bars must be composed of rapid-growing trees. In addition, the trees must be those that grow well in very wet situations. Of the arborescent species of our flora, *Salix* and *Populus* are best adapted to such conditions, and, in fact, *Salix cordata* and *Populus deltoidea* are the prevailing facies throughout this formation. Rarely, *Salix nigra* may assume the importance of a facies. Usually it is merely an accessory species.

The peculiarly circumscribed character of wooded islands influences the occurrence of the facies so that three sorts of islands may be distinguished according to the constitution of the primary layer. In the lower stretches of the Missouri, the cottonwood, *Populus deltoidea*, is the sole facies, while between the Great Bend and the mouth of the Niobrara, diamond willow, *Salix cordata*, has exclusive control of most of the islands. On the wooded sand-bars of the lower Niobrara, and here and there in the Missouri, the two facies are of almost equal rank, though frequently the cottonwood is superior in height, and the willow excels in number. In fact, the individuals of *Populus* are regularly larger throughout the formation; they often attain a height of 20–30 meters and a diameter of 1–1½ meters. The tops are broad and spreading, and the trunks are in consequence somewhat widely separated, notwithstanding which the branches of adjacent trees often touch each other. *Salix cordata* is rarely 15 meters high, and its diameter is usually from ½ to ¾ meter. The individuals are tall and slender, and they stand comparatively close together, ordinarily forming a denser shade than does *Populus deltoidea*.

The secondary woody layers are almost entirely lacking in the wooded island formation. The border of the formation at the water's edge is usually fringed with sand-bar willow, *Salix fluviatilis*, and *amorpha*, *Amorpha fruticosa*. *Sambucus canadensis* is found here more rarely. Occasionally a few straggling plum trees, *Prunus americana*, wander in. In open places, the box-elder, *Acer negundo*, is often seen represented by a few individuals. Back in the formation

proper, *Celastrus scandens* climbs over the tree trunks, and occasional thickets of dogwood, *Cornus asperifolia*, or patches of gooseberry, *Ribes gracile*, appear. On the sand-bars of the Niobrara, *Cornus asperifolia* is almost entirely replaced by the red osier, *Cornus stolonifera*, and kinnikinnick, *C. amonum*. The herbaceous layers are likewise but poorly developed. Wet, wooded islands are covered almost exclusively by a swampy vegetation in which *Cicuta maculata*, *Scirpus atrovirens*, *Asclepias incarnata*, and *Lythrum alatum* are prominent species. Those of the Niobrara with a dry, sandy soil are carpeted with a dense tangle of *Apios apios* and *Falcata pitcheri*, into which *Acuan illinoensis* and *Cassia chamaecrista* have come in abundance. The wooded islands of the Missouri are covered for the most part with a loose, grassy covering of *Elymus virginicus*, *Muhlenbergia racemosa*, and *Poa pratensis*, in which occur a few common species such as *Urtica gracilis*, *Adicea pumila*, *Verbena urticifolia*, etc.

II. The meadow formations.—Meadows are essentially mesophilous formations. They are found throughout the State along river courses and about lakes. They are most frequent in region I, and they decrease gradually in size and frequency to the westward. Exceptions to this general rule are afforded by the extensive hay flats of southern Holt, Rock, and Brown counties, which cover thousands of hectares, and the large hay meadows of Box Butte and Grant counties. Meadow formations are intermediate in position between amphibious formations, or woody formations, and prairie formations. In character they are very distinct from either. They are typically closed formations, in which the principal members are long-stemmed sod-formers. Bunch-grasses are almost invariably absent.

5. THE LONG-STEMMED GRASS FORMATION.—All the meadows of our flora are aspects of a single formation which may be called the long-stemmed grass formation. The facies are *Elymus canadensis*, *Stipa spartea*, *Agropyron pseudorepens*, *Panicum virgatum*, *Andropogon provincialis*, and *Spartina*

cynosuroides. In addition to these, *Muhlenbergia racemosa* is sometimes of sufficient importance to rank as a facies; the same is true of *Sporobolus airoides* in meadows in the foothills. According to different conditions of soil and moisture, this single type presents three aspects, which are of considerable constancy for their typical habitats. The single facies, *Spartina cynosuroides*, constitutes the exclusive covering of large stretches of slough and ravine. *Stipa spartea*, porcupine grass, has complete sway over extensive tracts of prairie-like meadows. *Elymus canadensis*, *Panicum virgatum*, *Agropyron pseudorepens*, and *Andropogon provincialis* are the most frequent facies in low meadows of the ordinary type. Oftentimes, all six facies are associated in the same meadow, and meadows in widely separated localities exhibit various combinations of facies. In extensive meadows, interruption of the facies is rare, but in smaller areas, which suffer invasion from both prairie and woodland, a considerable number of secondary species, grasses and other plants, make their appearance. The common secondary grasses are *Bouteloua curtipendula*, *B. oligostachya*, *Andropogon scoparius*, and *Chrysopogon avenaceus*. In the older portion of the State, introduced or cultivated grasses, such as *Phleum pratense*, *Agrostis vulgaris*, and *Poa pratensis*, have become abundant in meadows. Several xerophytic grasses, *Calamovilfa longifolia*, *Andropogon hallii*, and *Eragrostis trichodes*, not infrequently wander down into the sandy meadows of the sand-hill region. *Agrostis hiemalis* and *Sporobolus heterolepis* are only occasional inhabitants of meadows. A single sedge, *Carex vulpinoidea*, is sufficiently common in I and II to be of importance in this formation. In meadows where *Stipa spartea* is the controlling grass, various species of *Equisetum*, *E. levigatum*, *arvense*, and *robustum*, are commonly of great abundance. Tall-growing, secondary species with conspicuous flowers are not numerous. They are in general exceedingly characteristic, however. The most important are *Phlox pilosa*, *Laciniaria pycnostachya*, *L. spicata*, *Solidago canadensis*, *Silphium*

integrifolium, *Aster salicifolius*, *Zizia aurea*, *Thalictrum purpurascens*, and *Baptisia leucantha*. Certain secondary species, while somewhat common in meadows, are really intruders from low prairies; common examples of such are *Delphinium carolinianum*, *Sisyrinchium bermudiana*, *Asclepias syriaca*, *Senecio lugens*, *S. plattensis*, *Anemone canadensis*, etc. On the other hand, *Boltonia asteroides*, *Lythrum alatum*, and others have come in from wet meadows and marshes. Owing to the dense aggregation of the individuals of the facies in the meadow formation, a secondary layer is usually absent or is represented by a few scattering plants of *Tradescantia virginica*, *Gyrostachys cernua*, or of *Viola*. In some localities, however, *Viola obliqua* and *V. pedatifida* cover the ground with a dense carpet of blue beneath a facies of *Spartina cynosuroides*. *Steironema ciliatum* is often associated with them. *Fragaria illinoensis* frequently performs a similar rôle, and, more rarely, *Collomia linearis* also.

III. The prairie formations.—The prairies constitute by far the greater portion of region II; they occur throughout the western edge of I and in III north of the Niobrara river. They are of great importance only in II, which owes its character to the prevalence of prairie formations. Prairies are regularly little diversified, and in consequence possess much the same constitution throughout their geographical area. They are to be regarded in general as mesophytic; on high, barren ridges, they are often almost typically xerophytic. According to the predominance of mesophytic, or subxerophytic conditions, two sorts of prairies, high prairies and low prairies, may be distinguished. The latter have much in common with meadows and pastures; the former bear no small resemblance to the sand-hills in certain respects.

The floral covering of the prairies corresponds to their physiography, and is essentially homogeneous. In many localities there is a noticeable difference between the vegetation of low prairies and that of high prairies. The former, moreover, are characterized by a more or less closed type, the latter by the open type of formation. The same facies occur

in both situations, however, and the change in aspect proceeds entirely from a difference in secondary species. With reference to the constitution of the soil, prairie formations may be divided into two sorts: the one characteristic of loamy prairies, and extending over the greater portion of II; the other confined to argillaceous soil, "gumbo" hills and plateaux, in the northern portion of the Niobrara district, throughout the Ponca district, and in many localities in region III and the transition areas between II and III, and III and IV. From the prevailing grasses, the former may be termed the prairie-grass formation, the latter the buffalo-grass formation.

6. THE PRAIRIE-GRASS FORMATION.—With the exception of high, barren prairies, where xerophytic conditions necessitate the assumption of the bunch habit, the principal grasses of this formation are sod-formers, and the typical appearance of the prairie-grass formation is that of a turf. The facies are *Sporobolus asperifolius*, *Koeleria cristata*, *Eatonia obtusata*, and *Panicum scribnerianum*, all of which are ordinarily present throughout the varying changes in aspect. In different localities, facies of adjacent formations wander in, and bring about more or less modification in the constitution of the formation. Such places are, of course, to be regarded as transitional areas between formations. *Stipa spartea* and *Panicum virgatum* have come in in this manner from the meadow formation, *Aristida purpurea* from the beard-grass formation, and *Bulbilis dactyloides* from the buffalo-grass formation. All these, though assuming the importance of a facies only in or near the transition area, occur in varying abundance here and there in the prairie-grass formation. *Bouteloua curtipendula* and *B. oligostachya* are important secondary species of great frequency here, as in all the grass formations of our flora. *Andropogon furcatus* and *A. scoparius*, which are characteristic of certain other formations, are of comparatively little abundance and of considerable frequency. *Agropyron pseudorepens*, which in usual situations is more or less of a sod-former, when it

occurs on low prairies, as is frequently the case, is a bunch-grass. The other secondary species, *Festuca ovina*, *Eragrostis pectinacea*, *Sporobolus asper*, *S. vaginiflorus*, *Agrostis hiemalis*, and *Schedonnardus paniculatus* are frequent, but only occasionally occur in sufficient abundance to give them importance.

The prairie-grass formation presents two aspects, a vernal and an estival-serotinal aspect. In the former, the prairies present a fundament consisting of grasses, which is variegated by a considerable number of prevernal and vernal bloomers. Some of these, on account of their small size and inconspicuous flowers, play an insignificant part; of these are *Draba caroliniana*, *Androsace occidentalis*, and *Scutellaria parvula*. Others, notwithstanding this fact, are conspicuous by reason of aggregation, *Antennaria campestris*, or through their bright yellow flower-clusters, *Peucedanum foeniculaeum* and *Carex pennsylvanica*. The most important species of this aspect are *Astragalus crassicaarpus*, *Baptisia bracteata*, and *Anemone caroliniana*, which are to be found on every hill and hillside characterized by this prairie formation. *Comandra umbellata* is often found associated with them. On low prairies, the vernal species are *Allium mutabile*, *Callirhoe alcaeoides*, *C. involucrata*, *Lithospermum angustifolium*, and *Viola pedatifida*. The estival-serotinal aspect takes its character from a large number of species, among which amorphas, goldenrods, verbenas, and prairie clovers play the principal part. In the late stages, these yield place to asters and blazing stars. Outside of the grasses, the most characteristic plants of the prairies are *Amorpha canescens*, *Psoralea floribunda*, *Solidago rigida*, *canadensis*, *rupestris*, *speciosa*, *rigidiuscula*, *Kuhnistera candida*, *purpurea*, *Verbena stricta*, and *V. hastata*. Of nearly equal importance are the serotinal species, *Laciniaria scariosa*, *punctata*, *squarrosa*, *Aster multiflorus*, *sericeus*, and *Vernonia gigantea*. These are all copious or gregarious plants of the greatest frequency. A host of species, which occur throughout the formation, manifest equal abundance

and diminished frequency, while a considerable number possess equal frequency and less abundance. Among the first are *Glycyrrhiza lepidota*, *Pentstemon grandiflorus*, *P. cobaea*, *Lygodesmia juncea*, *Artemisia gnaphalodes*, *Erigeron ramosus*, *Psoralea argophylla*, *Kuhnia glutinosa*, etc.; of the latter, *Linum sulcatum*, *Meriolix serrulata*, *Lespedeza capitata sericea*, *Hedeoma hispida*, *Asclepias pumila*, *syriaca*, *Helianthus scaberrimus*, *Silphium laciniatum*, *Brauneria pallida*. The widely distributed species of scattered or single habit are *Potentilla arguta*, *Leptoglottis uncinata*, *Gerardia purpurea*, *Prenanthes asper*, *Mesadenia tuberosa*, *Carduus undulatus*, and *Achillea millefolium*. The sub-sand-hills of the Little Blue, which are covered with an open condition of the prairie-grass formation, possess a considerable number of sand-hill xerophytes. *Eriocarpum spinulosum*, *Hymenopappus flavescens*, *Yucca glauca*, *Cactus viviparus*, *Opuntia polyacantha*, *Evolvulus pilosus*, and *Talinum teretifolium* are all common, giving a transitional character to the floral covering of these hills.

The dry valleys of the sand hills possess a floral covering essentially similar to that of the prairies, although they usually contain more sand-hill inhabitants. The origin of the vegetation of dry valleys is obscure. It is probably to be considered as arising from the colonization of favorable habitats by prairie species.

7. THE BUFFALO-GRASS FORMATION.—The buffalo-grass was, until recently, supposed to have once covered the greater portion of Nebraska; its disappearance has, as a matter of sentiment, been connected with that of the buffalo. That such a supposition is entirely erroneous is beyond a doubt. The patches of buffalo-grass, which are found scattered here and there over the State, are to be regarded as intrusions rather than stragglers left by a retreating species. The buffalo-grass formation is found in our flora chiefly on the "gumbo" plains and ridges north of the Niobrara and in a few dry valleys in the Loup district, throughout the Republican district, and in the transition areas on either side of re-

gion III. It is the most typically closed of all our plains formations. Buffalo-grass, *Bulbilis dactyloides*, and grama grass are the sole facies. The dense mats of the former are peculiarly exclusive. Other grasses are never abundant, and are to be found only in the intervals between the mats of buffalo-grass. *Bouteloua curtipendula* and *B. oligostachya* are the most common of these. *Aristida purpurea*, *Agropyron pseudorepens*, *Distichlis spicata stricta*, and *Koeleria cristata*, all of little frequency, are the remaining grasses. Secondary species, other than grasses, are likewise of limited occurrence. *Asclepias pumila* and *Verbena bipinnatifida* are characteristic of these formations. *Amorpha canescens*, *Kuhnistera candida*, and *Solidago missouriensis* are all common; *Yucca glauca*, *Ipomoea leptophylla*, *Psoralea esculenta*, and *Parosela aurea* infrequent.

The buffalo-grass formation is of two types: the *Bulbilis* type and the *Bouteloua* type. The geographical area of the former is large but greatly interrupted, and while the facies manifests great abundance, its frequency is not comparable to that of *Bouteloua oligostachya* or *Andropogon scoparius*. The dense mats of buffalo-grass render this formation fairly exclusive except where it is interrupted. The number of secondary species is small. They are, for the most part, reduced facies of adjacent formations, *Aristida purpurea*, *Agropyron pseudorepens*, *Distichlis spicata stricta*, *Koeleria cristata*, and the ubiquitous *Bouteloua*. The ground tone of the formation is given to it by the buffalo-grass. *Asclepias pumila* and *Verbena bipinnatifida*, though characteristic of this formation, have little effect upon it. *Amorpha canescens*, *Kuhnistera candida*, and *Solidago missouriensis* are common in this as in the prairie-grass formation. The fullest development of this formation is found in the Dakotas and in eastern Montana whence it extends southward through Nebraska and Kansas. The *Bulbilis* type prevails for the most part upon argillaceous table-lands. On the other hand, the *Bouteloua* type is found over sandy stretches and is characteristic of the transition area between the prairies and the

sand-hills. The facies is *Bouteloua oligostachya* replaced in some situations by *B. curtipendula*. The former is scarcely less exclusive than *Bulbilis* in typical situations where it comprises 92–98 per cent of the vegetation. In the transition area between regions II and III it admits a few secondary species, such as *Solidago mollis*, *Lygodesmia juncea*, and *Plantago purshii*. On the bottom of long, dry canyons, *B. curtipendula* often prevails. In such situations it is sometimes the sole constituent of the vegetation.

IV. The sand-hill formations.—The sand-hills and sandy ridges of region III, and the sub-sand-hills of the northeastern portion of the State, are covered with well-marked formations of xerophilous plants. The vegetation of the sand-hills is sparse. Nowhere, except in occasional patches of *Psoralea lanceolata* on a hillside, or of *Cycloloma atriplicifolium* on the top of a ridge in the eastern edge of the region, do the individuals grow densely, or even closely together. On the hills and ridges, on the hillsides, and in the “passes” between the valleys, the individual plants or tufts of plants are commonly from 2–10 dm. apart, and the sand is everywhere to be seen. In blow-outs and sand-draws and on sandy canyon sides, it is not uncommon to see an area 50 meters square in which the individual plants may be numbered on one’s fingers. The sand-hills and sandy ridges throughout the region present an open formation which shows almost no change in any part. In their report on the flora of the sand-hill region of Sheridan and Cherry counties,* Smith and Pound say: “The species peculiar to the sand-hills and blow-outs * * are common to the entire region, from the point where we entered the sand-hills east of Alliance to the sand-hills near Neligh in Antelope county.” The localities mentioned are more than 360 kilometers distant. Of course, on the western edge of the region, many foot-hill species, as *Phlox douglasii*, for instance, are to be met with commonly on the sand-hills, and, on the eastern edge, some xerophytes of region II have become associates of the sand-hill species. So

* Bot. Surv. Neb. 2:8. 1892

also in one place one set of sand-hill plants, for instance, the xerophilous bushes and undershrubs, may predominate; in another place, *Yucca glauca* or *Chrysopsis villosa* may be most abundant. But, in general, the most noticeable character of sand-hill vegetation, after one has become accustomed to the great variety of species which the sparse vegetation of each hill affords, is its extreme monotony. This is due to the predominance of bunch-grasses, which are the controlling element in the covering of the hills, hillsides, sandy ridges, and sandy table-lands of the watersheds. The principal formation of the sand-hills, then, is the bunch-grass formation, a grass formation of exposed hills and ridges of pure sand. The bunch-grasses acquire their controlling importance from the fact that they are able, when established on a sand-hill, to hold their place notwithstanding the shiftings of the dry sand. They not only hold sand with the roots, but the large tufts or bunches accumulate more sand, and the bunch is often to be found holding out after the surrounding sand has blown away so as to leave the bases of the culms several centimeters above the level of the sand. These bunches, which are the most characteristic feature of the sand-hills, enable a large number of other species to occupy the intervals sparsely. But in many large areas, where the bunch-grass has no foothold, or where the shiftings of the sand have at length dried it out and caused the hills to become barren, different conditions prevail. These are well described by Rydberg*: "Wherever the sand is not held together by the roots of plants or by moisture, or is not otherwise protected, it is little by little carried away by the wind. If a spot on a dry hill becomes bare, the loose sand is blown away, a small hollow is made, the surrounding grass dies from drought, the dry sand, no longer held together by the roots, slides down into the hollow and in its turn is borne away, and thus the hollow becomes larger and larger. Such blow-outs were seen 100 meters in diameter and 15 to 20 meters deep." In these blow-outs, which are a characteris-

*Contrib. U. S. Nat. Herb. 3:134. 1895.

tic mark of the sand-hills and occupy a large part of the area of hill after hill, the bunch-grass is uniformly wanting. But a small number of grasses are especially adapted to these localities and are uniformly to be found in such blow-outs, where they are the chief and commonly the only vegetation. One of them, indeed, is confined to blow-outs or to situations of such character. The others are of somewhat wider range. These grasses mark a second formation which may be called the blow-out formation. Still a third set of conditions is to be found in sand-draws and on sandy canyon sides, where the sand is slipping and sliding away rather than blowing. Here neither the bunch-grasses nor the blow-out grasses are to be found, but a different sort of vegetation becomes controlling, and leads a somewhat precarious existence in the slippery, treacherous sand. This third sand-hill formation may be called the sand-draw formation. The sand-hill formations, then, are three:

8. The bunch-grass formation.

(1) The bluestem type.

(2) The beard-grass type.

9. The blow-out formation.

10. The sand-draw formation.

8. THE BUNCH-GRASS FORMATION.—This is the prevailing and the characteristic formation of the sand-hill region. It covers hill after hill and ridge after ridge over areas of great extent. In fact, the greater portion of the Loup district is one vast extent of bunch-grass, with oases, as it were, where the dry valleys or wet valleys between the hills admit of prairie or meadow formations. As has been said, its most noticeable feature is extreme monotony. Not only has every hill the same species as every other hill, but they occur in the same manner and have the same relation, and in consequence one hill, as a rule, has the same appearance as another. It is only when, for some reason, the facies changes suddenly, as on the eastern edge of region III, or on the broad, level tops of watersheds, that there is relief from the monotony of bunch after bunch of blue culms with yellowish leaves

and dry, brownish spikes. Many of the secondary species have flowers of no little beauty, and in other situations they would relieve the landscape. But here, since they can not be massed, but grow sparsely in the intervals between the bunches, they have no effect at a considerable distance. The only species that gives any character to the hills, besides the bunch-grasses, is *Yucca glauca*. The individual plants, loaded with large, cream-colored flowers, are very abundant where they occur, and, as they attain a considerable height, they fairly outrank the grasses in the aspect of the formation. But *Yucca*, though common, is not to be found on every hill, and does not extend over the whole region.

Not only does the bunch-grass formation extend over the entire sand-hill region, but it is to be met with as well in the sub-sand-hills of the northeastern portion of region II and the extreme northern portion of I. The formation presents two well-marked types. The one type prevails over the whole of the Loup district upon the high, shifting hills of pure sand, marked by blow-outs. The other is to be met with on the sub-sand-hills and the lower, more stable sand-hills of the edge of region III, especially those rising immediately back of the Niobrara. These hills, which have no blow-outs, exhibit a somewhat different set of conditions, and the aspect and constitution of the formation is much altered. These types might be called the sand-hill type and the sub-sand-hill type, but it seems better to refer to them as the bluestem type and the beard-grass type, from their characteristic grasses.

(1) The bluestem formation. The first type prevails over the whole of the Loup district, and over the true sand-hills with blow-outs in every part of the sand-hill region. It is characterized by species of *Andropogon*, almost always *A. scoparius*, associated with *Calamovilfa longifolia* and *Stipa comata*. *Andropogon scoparius*, which is *the* bunch-grass, is the prevailing and the typical species. But in Holt county and Antelope county, and here and there in other localities, *A. hallii* largely replaces it on the tops of the hills,

and *Calamovilfa longifolia* on the sides. In places also on the edge of region II, *Andropogon furcatus*, forsaking its usual habitats, becomes a bunch-grass of the sides of sand-hills, and replaces *A. scoparius*. With the exception of these localities, *A. scoparius* is the predominant member of the formation throughout its area. Not less abundant, but less important in the formation, is *Stipa comata*. The thin tufts of this species do not gather sand, and it does not form bunches in the sense in which *Andropogon* forms them, but in number of individuals it sometimes exceeds the latter. *Calamovilfa longifolia*, which is also a blow-out grass, is more common than *Stipa* in the eastern sand-hills, and is an exceedingly frequent species in the sand-hills along the Middle Loup and the Dismal, but in the sand-hills of Sheridan county and Cherry county it is less often met with. *Andropogon hallii*, a tall, coarse bunch-grass, grows on the tops of the sand-hills throughout. In the greater part of the region, while larger and more conspicuous than *A. scoparius*, it is much inferior to the latter in importance in the formation. But in some places, as on high sand-hills in Antelope county, for example, it replaces the ordinary bunch-grass almost wholly. *Andropogon hallii* and *Calamovilfa longifolia* are somewhat later than their two associates, so that, in localities where they are abundant, the formation has two aspects, one in June and July, when *Andropogon scoparius* and *Stipa comata* are at their maximum, the other in the last days of July and in the first part of August, when the *Stipa* has dried up and *A. hallii* and *Calamovilfa* are at their best. The sand-hill vegetation commonly dries up about this time, so that the two aspects are not very well marked, nor are they essentially different in appearance. The four species mentioned, *Andropogon scoparius*, *A. hallii*, *Calamovilfa longifolia*, and *Stipa comata*, are the most important in the formation. They are the staple of the sand-hill vegetation, and, as has been said, it is to their constant and uniform appearance that the monotonous aspect of the hills is due. Of the blow-out grasses, *Eragrostis trichodes* and

Oryzopsis cuspidata are frequent associates of the bunch-grass on hilltops. *Eragrostis trichodes*, a true bunch-grass, is one of the commonest of the grasses of secondary importance on the hills. It occurs throughout the region. *Oryzopsis cuspidata* is scarcely less common in Sheridan county and western Cherry county, but it is principally a blow-out grass. *Muhlenbergia pungens*, one of the chief blow-out grasses, is to be found occasionally in small hollows in the sand in the bunch-grass area. *Bouteloua hirsuta* occurs in numerous but widely separated localities as an occasional inhabitant of this formation. It grows here and there sparsely, in small, bunch-like mats, not more than a decimeter in diameter. *Aristida purpurea* and *A. basiramea*, which are of the first importance in another type of the formation, are rarely found as constituents of the *Andropogon* type. In the heart of the sand-hills they appear only in isolated stations and are not abundant. Other species of grass occasionally met with in this formation are *Stipa spartea*, *S. viridula*, and *Cenchrus tribuloides*. All of these are of trifling importance on the sand-hills and are confined to a few stations. *Sporobolus cryptandrus* is occasionally met with in this formation in the heart of the sand-hills. A sedge, *Cyperus schweinitzii*, which has something of the appearance of a low bunch-grass, though the individuals grow singly, is a very common associate of the bunch-grasses throughout the region, but it is of more importance on the sub-sand-hills.

Next in importance to the bunch-grasses in this formation are the xerophilous bushes, undershrubs, and half shrubs. After the bunch-grasses, they make up the bulk of the vegetation, and in some cases they supersede the latter as controlling elements in patches or even areas of some extent. The commonest of these is the sand-cherry, *Prunus besseyi*. The short twigs of this species, bearing glossy green leaves and bright red fruits, are to be seen rising out of the sand in more or less definite patches on every hill. It is a peculiar circumstance that almost all the fruits in the

heart of the sand-hill region become affected by *Exoascus pruni*, so that in a stretch of many kilometers of sand-hills scarcely a fruit is to be seen that is not distorted and turned black by the parasite. The sand-cherry, while extremely abundant, is not in any way controlling. Nor are *Kuhnistera villosa* and *Amorpha canescens*, two species of abundance in the bunch-grass formation, ever to be found usurping the headship over any portion of the soil. They grow uniformly but sparsely, perhaps a dozen or more individuals on each hill, throughout the region. On the lower sides of the hills, which bound the larger valleys, they are much more abundant. Passing down into the dry valleys they are found assuming the important rôle taken by them in the constitution of prairie formations. *Ceanothus ovatus*, which is probably the most common of the larger woody plants in this formation, is most abundant on the sand-hills in the neighborhood of the Middle Loup and the Dismal. *Meriolix serrulata*, which, on the prairies, is a rootstalk plant, in this formation is a half shrub. Its low, woody, diffusely branched, and spreading stems are to be found in large numbers on every hill. As the woody stem with the persistent dead branches of former seasons makes a sort of net-work which accumulates and holds sand, this species forms small bunches similar to those made by the bunch-grasses, but much smaller. On this account it is enabled to acquire a strong foothold and to become one of the chief secondary species in the formation. *Yucca glauca* has also the means of forming bunches by accumulating sand in the dead leaves at the base of the stem, and, because of this and of its exceedingly long and well-developed root, it is enabled to rival *Andropogon* on many of the hills. In the western portion of the sand-hill region, it is to be met with on almost every hill, commonly in a subordinate position, growing sparsely over the top and the sides, but not infrequently entirely replacing the bunch-grass and taking control of the whole area for a considerable distance. Each individual forms its own bunch, and these

bunches often compare with those of *Andropogon* for size and compactness. In the intervals the ordinary secondary species of the formation grow sparingly, as where *Andropogon* prevails. The latter is substantially or entirely wanting in such areas. *Rosa arkansana* and *R. woodsii* are also common constituents of the formation in the central and western sand-hills. There seems to be no little difficulty in limiting the latter on account of its extreme variability.* These roses sometimes assume a position of importance in the formation. This is especially true on the broad tops of the "divides" on the watersheds, where *R. arkansana* prevails. Here the roses are often the controlling plants for long distances, the bunch-grasses giving away completely. In such places, the secondary species are *Acerates viridiflora linearis*, *A. viridiflora ivesii*, and *Asclepias arenaria*. As soon as the edge of the divide is reached, and, indeed, as soon as the flat surface of the top begins to be broken up, the bunch-grass resumes sway. It is only where the level stretches afford, for a brief space, conditions different from those prevailing on the shifting hillsides and hilltops that the roses are enabled to take a firm hold. *Ceanothus ovatus* is said to play a somewhat similar rôle in like situations in portions of the central sand-hills.

The number of secondary species which occur regularly and uniformly in the formation wherever it is met with over the whole of the sand-hill region is remarkable. Besides the species already named, *Tradescantia virginica*, *Eriogonum annuum*, *Chrysopsis villosa*, *Hymenopappus filifolius*, *Eriocarpum spinulosum*, *Laciniaria squarrosa intermedia*, *Psoralea lanceolata*, *Carduus plattensis*, *Helianthus scaberrimus*, *Argemone intermedia*, *Phaca longifolia*, *Acerates viridiflora*, with *A. viridiflora linearis* and *A. viridiflora ivesii*, *Opuntia humifusa*, *Lygodesmia juncea*, *Oenothera rhombipetala*, *Erigeron bellidiastrum*, *Euphorbia petaloidea*, *E. geyeri*, and *Lathyrus ornatus flavescens*, at least, are to be found on every sand-hill where this formation prevails. The order in

*Rydberg Contrib. U. S. Nat. Herb. 3²:157. 1895.

which they are named approximately accords with their relative abundance and importance. In a large part of the sand-hill region, but not extending over the whole, *Cycloloma atriplicifolium*, *Froelichia floridana*, *Rumex venosus*, *Croton texensis*, *Corispermum hyssopifolium*, *Amaranthus torreyi*, *Acerates angustifolia*, *A. lanuginosa*, *Euphorbia hexagona*, and *Cactus viviparus* are of no less abundant occurrence in the formation. In the western portion of the Loup district, *Rumex venosus* is to be found uniformly distributed over the hills in great abundance. *Froelichia floridana*, which becomes very important in hills of the other type, grows singly on the tops of the hills in the *Andropogon* formation, the individuals attaining an unusual height. *Cycloloma atriplicifolium* attains great importance on the eastern edge of region III, where, on the hills dominated by *Andropogon hallii* and *Calamovilfa longifolia*, it takes exclusive possession of large areas. In the remainder of the region it is less important, occurring in small patches here and there in the formation. Of the species first mentioned, those occurring abundantly wherever the formation extends, several, either because they grow in tufts from a perennial root or on account of their basal persistent tufts of dead leaves, are able to accumulate sand and to form more or less perfect bunches. *Chrysopsis villosa* is a notable example of the one class, *Eriogonum annuum* of the other, though the latter, sending up numerous stems in a tuft, combines both methods. These species, in consequence, are of especial importance. They also acquire importance from the possession of an exceedingly long root, which character is shared by the greater number of the more important secondary species enumerated. In addition to the species mentioned, the following are of regular and abundant occurrence in the formation in Sherman county and western Cherry county: *Asclepias arenaria*, *A. speciosa*, *Opuntia fragilis*, *Linum rigidum*. In Cherry county, *Thelesperma gracile* becomes no less abundant on every hill. In the region of the Middle Loup and the Dismal, the following species are more or less common: *Malvastrum*

coccineum, *Psoralea campestris*, *Opuntia polyacantha*, *Senecio compactus*, *S. douglasii*, *Lygodesmia rostrata*, and *Lithospermum gmelini*. On the edge of region IV, *Phlox douglasii*, *Comandra pallida*, and sometimes *Pentstemon albidus* and *P. caeruleus* invade this formation. None of them become at all abundant except *Phlox douglasii*. That species is an ordinary and abundant one in Sheridan county and western Cherry county. It grows here in small tufts which hold sand and enable it to form miniature bunches. *Talinum teretifolium* is a frequent secondary species of the formation in many localities.

(2) The beard-grass formation. This formation replaces the bluestem formation over the sandy plains and prairies of the Niobrara district and the sub-sand-hill portion of region II. It is really a transition type between the grass formation of the high prairies of I and II, and the bluestem formation of the sand-hills proper, but on account of its peculiar character it can not be considered as belonging strictly to either one. The intermediate nature of this formation is evident, not only in its position and in its constituent species, but in the special features of the formation itself. The prairies of the eastern portion of the State are characterized by a vegetative covering, the fundament of which is a somewhat close sod composed of several grasses. The sand-hills of the Loup district are controlled throughout by grasses which grow in bunches, one or more meters apart. On the clay bluff tops of Cedar and Dixon counties, where the beard-grass formation may be first distinguished, the individuals, though tufted, are sufficiently aggregated to form a loose sod. On the sub-sand-hills of Knox and Antelope counties, the bunches are somewhat separated, and along the Niobrara they come to stand at a distance of 2-5 dm. The formation, however, never becomes so typically open as the bluestem formation. In the sub-sand-hills of the southern portion of region II, the individuals, as they become more and more separated, rarely assume the tufted habit, but form a very loose, sod-like covering.

The facies of the beard-grass formation are the purple beard-grass, *Aristida purpurea*, beard-grass, *A. basiramea*, and cusp grass, *Sporobolus cuspidatus*. In the upper Missouri district, porcupine grass, *Stipa spartea*, is usually present as a facies, which disappears in Holt county, apparently not connecting with the corresponding facies, *Stipa comata*, of the bluestem formation. The aspect of this formation in its eastern portion is determined by *Stipa spartea*, *Aristida purpurea*, and *Sporobolus cuspidatus*. The first grass grows much taller than the other two, and is distributed evenly throughout its habitat; the two latter are typically bunch-grasses, the tufts of which are of especial importance in the appearance of the formation. *Stipa spartea* loses its rank in the lower portion of the Niobrara district, and the number of the facies is reduced to two. In Brown county, *Aristida purpurea* rapidly loses its predominance, and is replaced from Plum creek westward by *A. basiramea*, which forms smaller and less widely separated tufts. *Andropogon scoparius*, typical of the bluestem formation of the sand-hills, occurs scatteringly from Dixon county westward. In this formation, it becomes abundant only in Brown, Keya Paha, and Cherry counties, where, oddly enough, it is usually found in somewhat argillaceous situations. The larger bluestems, *Andropogon furcatus* and *A. hallii*, find their eastern limit in Holt county. From Turkey creek westward they become more and more frequent on ridges and hillsides, until at length they constitute facies in the bluestem formation. The three species of *Bouteloua*, *B. curtispindula*, *B. hirsuta*, and *B. oligostachya*, though in some localities even more abundant than the beard-grass and cusp-grass, are hardly to be regarded as more than important secondary species. The same is true of the typical sand-hill inhabitant, *Calamovilfa longifolia*, and of the buffalo-grass, *Bulbilis dactyloides*. The former, while it forms conspicuous patches of some extent, is interrupted in its distribution; the latter, though never very abundant, is frequent in clayey or somewhat clayey situations. *Eragrostis trichodes*, though lack-

ing in this formation east of Holt county, is very abundant on low, sandy plains along the Niobrara, where, especially in subruderal situations, it grows in dense tufts. *E. pectinacea*, which is more frequent in higher locations, is most often ruderal; it is a common grass in strips of fallow land. *Panicum scribnerianum*, *Koeleria cristata*, and *Eatonia obtusata* are important accessory species in the eastern aspect of the beard-grass formation. *Panicum scribnerianum* drops out when the sand-hills are reached, and *Koeleria* and *Eatonia*, though they still persist, are greatly reduced in abundance. *Muhlenbergia pungens*, which resembles *Bouteloua* in its habit of forming low, dense mats, grows localized in widely separated stations west of Eagle creek. *Sieglingia purpurea* and *Aristida oligantha* are likewise of somewhat restricted occurrence; the one is not infrequent in sand-draws of the western portion of the area of the formation; the other, though an abundant ruderal plant in the argillaceous soil of prairie-dog towns, occurs but rarely in the sandy lowlands. A few species, *Agropyron pseudorepens*, *Chrysopogon avenaceus*, and *Panicum virgatum* are typically residents of meadows in the lowland. Here and there, however, they encroach more or less upon the low, sandy plain.

Along the upper Missouri and occasionally along the lower Niobrara, the beard-grass formation of the hills seems to be almost controlled by *Ceanothus ovatus* and *C. americanus*, which grow in great abundance on the bluffs back of the river. On similar hills, though rarely, if ever, on the same, *Yucca glauca* is a familiar shrub. Very oddly, it is more abundant on the hills of the upper Missouri than on the sandy plains to the westward. The lead plant, *Amorpha canescens*, which is characteristic of high prairies in I and II, is also common in the present formation; it is, however, less conspicuous and less abundant. The smaller-leaved *A. nana* is found only in this formation. On the hills of Cedar county it forms extensive patches similar to those of *A. canescens*. The prairie-rose, *Rosa arkansana*, while frequent along the Missouri, becomes more and more rare to the westward. The

typical dwarf shrub of the sandy plains and sand-hills is *Prunus besseyi*, which fairly carpets shallow swales in the undulating plains covered by this formation.

On account of the open nature of the beard-grass formation, layers are undeveloped. But with reference to secondary species alone, it is possible to distinguish two artificial layers of advantage for comparison. The upper layer consists of plants two-thirds of a meter to a meter or more in height, which, though usually sub-solitary, are sometimes gregarious, and, with one or two exceptions, are never tufted. The lower layer is composed of low, tufted, or densely gregarious species, less than one-half meter in height. The most typical and most abundant constituents of the upper layer are western species, *Helianthus petiolaris*, *Ipomoea leptophylla*, *Oenothera rhombipetala*, *Eriogonum annuum*, *Artemisia canadensis*, *Froelichia floridana*, *Cycloloma atriplicifolium*, and *Senecio douglasii*. The others, *Onosmodium carolinianum*, *Carduus undulatus*, *Hymenopappus filifolius*, *Allionia linearis*, *Potentilla arguta*, *Silphium laciniatum*, *Artemisia gnaphalodes*, *A. dracunculoides*, *Helianthus scaberrius*, *Gilia longiflora*, and *Mentzelia nuda*, with the exception of the last two, occur more or less commonly over the prairies of region II. The lower layer might be divided into two, the one represented by such taller-growing plants as *Meriolix serrulata*, *Psoralea digitata*, *Argemone intermedia*, and the like; the other by the low or prostrate forms, *Pulsatilla hirsutissima*, *Malvastrum coccineum*, and *Euphorbia geyeri*. The characteristic appearance of this layer is derived almost entirely from species of the first sort, which manifest a striking equality of height. Of the common sand-hill species of the layer, but a few, *Aragallus lamberti*, *Plantago purshii*, *Opuntia polyacantha*, *O. humifusa*, and *Cactus viviparus*, are of the low-growing type. The others are uniformly much taller; *Meriolix serrulata*, *Eriocarpum spinulosum*, *Kuhnistera villosa*, *K. candida*, *K. purpurea*, *Psoralea lanceolata*, *P. digitata*, *Chrysopsis villosa*, *Lotus americanus*, *Solidago missouriensis*, *Cyperus schweinitzii*, and *Linum rigidum*.

Of the less important members of the lower layer, *Lappula texana*, *Artemisia frigida*, *Malvastrum coccineum*, *Lesquerella ludoviciana*, *Parosela aurea*, *Euphorbia petaloidea*, *Talinum teretifolium*, and *Euthamia graminifolia* are western species. A few, *Comandra umbellata*, *Gaura coccinea*, *Polygala alba*, *Aster multiflorus*, and *Tradescantia virginica*, are species which are found generally throughout our flora.

9. THE BLOW-OUT FORMATION.—The physical conditions which prevail in blow-outs have been described. These large, crater-like areas, often taking up a whole side of a large hill, are usually not less than 50 meters in diameter, but not infrequently become 100 or even 200 meters across, and have been seen as large as 400 meters across. But very few species can inhabit these arid and shifting pits. Four or five grasses are especially adapted to them, however, and two are almost wholly confined to these areas. The blow-out grasses are *Redfieldia flexuosa*, *Muhlenbergia pungens*, *Eragrostis trichodes*, *Oryzopsis cuspidata*, *Calamovilfa longifolia*, and *Stipa comata*. *Munroa squarrosa*, which is the chief grass of sand-draws, is rarely found locally in blow-outs. Of these seven grasses, the first two, *Redfieldia flexuosa* and *Muhlenbergia pungens*, are habitually and almost exclusively blow-out inhabitants. *Oryzopsis cuspidata* and *Eragrostis trichodes* are for the most part confined to the blow-outs also. *Stipa comata* and *Calamovilfa longifolia* are constituents of the bunch-grass formation, but both, especially the latter, are able to invade blow-outs.

Not only is the vegetation of a blow-out, such as it is, made up almost entirely of the grasses mentioned, and chiefly of *Redfieldia* and *Muhlenbergia*, but it is solely on account of the presence of the latter, and to a less degree of *Eragrostis trichodes* and *Calamovilfa longifolia*, that any vegetation whatever is to be found in such unfavorable spots. They bind the sand together with their roots and retain it so as to enable other species to gain a foothold. The two species which thrive best in these localities and which are almost entirely confined to them have each been called "blow-out grass."

In the greater part of the sand-hill region, *Redfieldia flexuosa* is the more abundant and controls the blow-out vegetation, though the two are often associated. But in some localities, and especially in the Republican district, it is replaced by *Muhlenbergia pungens*.

There is seldom anything to be seen in a recent blow-out but *Redfieldia*. Often a blow-out 50 or 100 meters in diameter will contain no other vegetation than a few tufts of *Redfieldia*. Generally one tuft will be seen at the lowest point of the crater, and two or three more scattered over the lower portion. In Cherry county, a recent blow-out usually contains not to exceed five or six tufts of *Redfieldia*, and, in their near vicinity, two or three scattered individuals of *Lathyrus ornatus flavescens*. Then a few individuals of *Muhlenbergia pungens* will appear high up on the treacherous sides. *Oryzopsis cuspidata* will soon after be found in a few tufts on the lower sides and bottom, and a few individuals of *Eragrostis trichodes*, *Stipa comata*, or *Calamovilfa longifolia* will closely follow. By this time, the *Redfieldia* has prepared the way for other species. When an old tuft of *Redfieldia* is pulled up, one drags with it a large network of roots spreading over a considerable area and holding firmly large quantities of sand. The influence of a few tufts of *Redfieldia*, when well established, therefore, is much more extensive than a glance at the barren area out of which they spring would indicate. By the time that the other grasses have sprung up in the blow-out, if a large one, it may contain 15 or 20 tufts or individuals scattered over its surface. The vegetation is always extremely sparse, but at this stage opportunity is afforded for a few of the regular associates of the bunch-grass formation to get a foothold. The bunch-grasses themselves never get into the blow-outs. But seven species of those already enumerated as ordinary sand-hill inhabitants habitually invade blow-outs after the blow-out grasses have obtained control. These are: *Tradescantia virginica*, *Eriogonum annuum*, *Meriolix serrulata*, *Lathyrus ornatus flavescens*, *Phaca longifolia*, *Euphorbia petaloidea*,

and *Hymenopappus filifolius*. Besides these, *Lygodesmia juncea*, *Psoralea lanceolata*, and *Linum rigidum* are occasionally met with. In some localities, *Pentstemon haydenii* is to be found in the edge of blow-outs. This comparatively limited list comprises all the species that are ever to be found in the formation. From its very nature, depending entirely upon the blow-out grasses, whose roots alone are able to give opportunity for other vegetation, and admitting only a few secondary species which are especially adapted to arid and shifting sands, the formation is a closed one. It varies but little throughout the region, the only changes being induced by the substitution of *Muhlenbergia pungens* for *Redfieldia flexuosa* in some localities or districts and of *Calamovilfa longifolia* for both in localities in Antelope county. In the Loup district there is almost no change in the secondary species in any part. But it is probable that, when the formation is closely examined in those parts of the sand-hill region outside of Nebraska, other changes of facies and even other types will be found.

The origin and development of the vegetative covering in these curious spots have been indicated. The decadence of the formation is no less interesting. The conquest of a blow-out by the roots of *Redfieldia* and its associates is a slow process, and, for several seasons, a large one will contain little else than a small but increasing number of tufts of the grasses. As from time to time the latter become more abundant and bind the sand more firmly, more and more of the secondary species come in, and they become more and more abundant. At length, after this process has gone on gradually for many seasons, the whole area of the blow-out has been recovered. At this point, the bluestems of the bunch-grass formation, which hitherto have been unable to enter, quickly take a foothold, the blow-out grasses disappear before them, and the change from blow-out to hillside is complete. The first to disappear, as it is the first to enter, is *Redfieldia*. Hence, that grass is only to be found in what are readily recognizable as blow-outs. Other blow-out grasses linger for a

longer period after the blow-out has been recovered, and hence appear as associates of the bunch-grass formation. But in the end they, too, yield and retire to begin their work anew in some other blow-out.

10. THE SAND-DRAW FORMATION. Though a sand-draw has much in common with a blow-out in external appearance, the conditions prevailing in it are very different, and the vegetation is quite distinct. The only real similarity is in the extreme dryness and exposure to which the vegetation is subjected, and the resulting scarcity and excessively sparse distribution of the individual inhabitants. The sand-draws and the sandy, sliding, dry canyon sides are inhabited by fewer species than the blow-outs, and the vegetation is of an entirely different character. Here species are required that are able to hold out against sudden washing away in case of rain and sudden slipping away of the sides on which they grow. Accordingly, the sand-draw species are not characterized by their ability to bind shifting sand and to hold it against the wind, but by growing more or less buried in the sand. The grasses are not controlling here, and take but a subordinate or occasional part. The regular and habitual inhabitants of these situations are but two, the closely related *Polanisia trachysperma* and *Cristatella jamesii*. These two species, which appear very much alike, are almost entirely confined to such areas, and when found elsewhere are in sandy situations of the same essential character. They constitute the bulk of what little vegetation there is in the sliding sand on the sides of dry canyons in the sand-hill region, and in sand-draws in the sand-hill region and in parts of the foot-hill region. In the foot-hill region, the butte and Bad Land inhabitants invade dry, sandy canyon sides and supercede these species, but in region III they are often the sole inhabitants of such situations, and are always controlling there. The two are very commonly associated in the same sand-draw, but *Polanisia* is of wider distribution, though in many localities in region III *Cristatella* alone is to be found. The principal grass of these situations is *Munroa*

squarrosa, which, however, is by no means constant. In the Niobrara district, *Eragrostis major* is the commonest and most abundant sand-draw grass, and, after it, *Siegingia purpurea*. In one locality, *Paspalum setaceum* has also been met with. None of these grasses are either regular or characteristic sand-draw inhabitants, nor are any of the plants that appear in this locality or that as secondary species. The most frequent of the latter are *Euphorbia petaloidea* and *E. hexagona* in region III, and *E. montana* in region IV. Many of the inhabitants of sandy plains or of sandy hillsides in IV also come into sand-draws, as, for example, *Collomia linearis* and *Gilia gracilis*. But these come in late, just as sand-hill species of the bluestem formation at length get into blow-outs. The typical sand-draw in III is characterized solely by *Polanisia* and *Cristatella*, either in association or singly, and one or both of these is almost sure to make up most of its vegetation. They are especially adapted to such areas, and hence they have somewhat the same importance that *Redfieldia flexuosa* and *Muhlenbergia pungens* have in blow-outs.

After a time, as the sand-draw species have made it possible for an increasing number of species to creep in from the surrounding formations, the sand-draw loses its character and begins to be a part of the sandy prairie or sand-hill, or a mere waste. At this stage, or even somewhat earlier, the sand-draw species gradually disappear, and, in some types, *Psoralea lanceolata*, *Meriolix serrulata*, *Chrysopsis villosa*, *Argemone intermedia*, and the like, in others, *Euphorbia petaloidea*, *E. geyeri*, *E. montana*, *E. hexagona*, and like species, in others *Ipomoea leptophylla*, or, in still others, ruderal or subruderal species of *Gaertneria*, *Ambrosia*, and *Artemisia* become established, and the draw becomes completely assimilated to sand-hill, or sandy plain, or becomes a mere waste. These areas deserve careful study in other portions of the region without our limits. Such study should reveal other types and additional characteristic species. In our limits the sand-draw can not be assimilated to any of the sand-hill or foot-hill formations, since its peculiar and controlling veg-

etation is distinct in character, in mode of growth, and in behavior. At the same time, the extremely limited number of peculiar sand-draw inhabitants and the sameness of sand-draw vegetation throughout that portion of the region in our limits make it doubtful how these areas should be considered.

V. The foot-hill formations.—Several of the prairie and meadow formations are to be met with in region IV, but the foot-hill region presents physical conditions so different from those prevailing elsewhere in the State that its characteristic formations are more marked and more individual than those of any other of our regions. Only a small portion of the region lies within our limits, and some of the most characteristic formations are not to be treated adequately without comparing and discussing data from localities remote from our territory. On this account it will often be necessary to treat such formations somewhat summarily in the present chapter, and to require but one type or but one facies to do duty for what, the region over, is an important formation.

In our limits the foot-hill region shows three formations peculiar to it. The first and most characteristic prevails over barren table-lands and the almost denuded Bad Lands. In these situations the staple of the sparse vegetation is furnished by undershrubs and half shrubs, such as species of *Artemisia*, the greasewood, and the white sage. The buttes and cliffs, the rocky hills and ridges, and sandy hillsides are sparsely occupied by another formation, which is only less characteristic of the region than the former. Here the vegetation is entirely or almost entirely composed of mats and rosettes, such as *Paronychia jamesii*, *Arenaria hookeri*, and the mat-forming species of *Polemoniaceae*. Finally, the high prairies, as they are called, and the level, sandy plains in the eastern portion of the region are dominated by a grass formation not unlike the prairie formations in that the grasses furnish a thin and meager sod, or sod-like covering, in which many secondary species find a home. These three principal formations may be called the undershrub formation of table-lands and Bad Lands, the mat and rosette formation

of buttes and hills, and the foot-hill grass formation of high prairies and level, sandy plains. Each exhibits several types.

Foot-hill formations:

11. The undershrub formation.

(1) The sage-brush type.

(2) The greasewood-whitesage type.

12. The mat and rosette formation.

(1) The mat formation of buttes and cliffs.

(2) The rosette formation of sandy hillsides.

13. The grass formation.

(1) The *Stipa* type.

(2) The *Agropyron* type.

(3) The peppergrass-cactus type.

11. THE UNDERSHRUB FORMATION OF TABLE-LANDS AND BAD LANDS.—This formation does not reach its maximum in our limits. In other parts of the foot-hill region it is of the greatest importance, dominating large areas, and giving character to extensive districts. With us it is chiefly in the Bad Lands that the formation becomes important, and the type that prevails over the barren table-lands to the westward is only partially developed. *Artemisia tridentata*, the well-known sage-brush, is the staple and controlling element of the vegetation in the heart of the region. Not far to the west of us, on high barren plains of Colorado, *Sarcobatus vermiculatus*, *Chrysothamnus nauseosus*, and *Gutierrezia sarothrae* cover the plains for many kilometers. These species attain no such importance in our limits. With us, while collectively they are controlling over the barren plains and the denuded Bad Lands, no one of the undershrubs or half shrubs of the formation becomes as important as it does to the westward.

The formation exhibits two types. The high, barren plains, the edges of which are closely pressed by the grass formations and are invaded by secondary species of the latter, are sparingly covered much in the same way as the more characteristic plains to the west. On the other hand, in the denuded Bad Lands, in which excessive erosion renders the surface so unstable as to prevent vegetation from gaining much foot-

hold, the undershrubs are restricted in influence, and only two of them regularly take part in the floral covering. These might be termed the table-land type and the Bad Land type. We have preferred to name them, from their chief constituents, the sage-brush type and the greasewood-whitesage type.

(1) The sage-brush formation. This is named the sage-brush formation because, to the westward, species of *Artemisia*, chiefly *A. tridentata*, constitute the bulk of its controlling elements. In our limits, *A. tridentata*, *A. frigida*, *A. filifolia*, *A. cana*, and *A. canadensis* may be found on the high plains and barren table-lands of the foot-hill region. But *Chrysothamnus nauseosus*, *Eurotia lanata*, and *Gutierrezia sarothrae*, singly or collectively, make up the principal facies in this State. The secondary species are few and unimportant. The individual undershrubs, while they strike the eye as the only constituents of the floral covering, and hence appear to form a low thicket a meter to a meter and a half in height, are sparsely disposed, and the intervals are almost destitute of vegetation. A few isolated mats of *Bouteloua* and occasional stragglers of *Pectis* are about all that are to be found. On the eastern edge of the region, some species from the sandy plains, sand-hills, and even from the dry prairies invade the formation to a slight extent.

The *Artemisia filifolia* formation. A very pronounced formation of the sage-brush type maintains almost exclusive possession of extensive sandy areas in the table-lands of the foot-hill region. It occurs invariably upon level stretches characterized by the *Stipa* formation, which it replaces over broad, sandy belts. Its presence is conditioned chiefly upon the arenaceous character of the soil, and its typical habitat is undulating sandy hills, into which the monotonous table-lands rise here and there. Not infrequently, the same formation characterizes a well-marked zone, corresponding usually to the mesa between the lowlands and table-lands along the North Platte in Scott's Bluff, Cheyenne, and Deuel counties. *Artemisia filifolia* constitutes the sole facies. It grows in dark green bunches, 3-5 decimeters wide,

and very high. In the typical aspect of the formation, these bunches stand less than a meter apart; at the edge of the zone dominated by the formation the bunches become separated by the intervals of several meters. The deep green tufts of *Artemisia filifolia* are so strikingly prominent, especially during the late summer, when other vegetation is dried up, that a large strip along the edge of the surrounding *Stipa* formation appears to belong to the *Artemisia filifolia* formation, so conspicuous are the scattered bunches of the latter. With the exception of this very narrow transition zone between the two formations, the *Artemisia filifolia* formation is sharply defined. The belts characterized by it, which often attain a length of 25-30 kilometers and a width of 2-5 kilometers, are readily discernable at a considerable distance. *Artemisia frigida* is a frequent secondary species which never acquires the value of a facies on account of its small degree of abundance. Its bunches are never so large as those of *A. filifolia*, and its glaucous color causes it to merge into the prevailing serotinal color of the secondary species of the formation. The bunches are usually isolated, growing at an interval of 2-3 or more meters. Sometimes, however, *A. frigida* manifests a ruderal tendency, and, in such places, it not infrequently takes complete possession of old trails and paths, giving them a very striking color. These extremely narrow zones of a uniformly blue-gray color may be followed as far as the eye can reach, as they wind over the table-lands. The characteristic turf-builder of the formation is *Carex stenophylla*, called nigger's wool, on account of its densely tangled, black roots, which are a striking feature of eroding hilltops. It grows in minute, bright green tufts, which are frequently aggregated into false mats, 2-10 decimeters in extent. *Stipa comata*, *Bouteloua oligostachya*, and *Calamovilfa longifolia* are uniformly non-abundant and of little importance. The typical secondary species are those that have come in from the sand-hills to the eastward. The most important are *Psoralea lanceolata*, *Chrysopsis villosa*, *Helianthus petiolaris*, and *Lathyrus decaphyllus*. Other sec-

ondary species are *Thelesperma trifidum*, *T. gracile*, *Kuhnistera candida*, *K. purpurea*, *Opuntia humifusa*, *Cactus viviparus*, and *Cyperus schweinitzii*.

(2) The greasewood-white sage formation. The exceedingly loose and unstable soil of the Bad Lands, due to continuous erosion of canyon sides and buttes, together with comparatively slight precipitation and great heat in summer, renders the vegetation of these plains extremely meager. After a rain, deep channels are formed suddenly in the surface. The sides of these channels rapidly crumble away, or, as rapidly, the channel deepens into a gulch or a canyon. The surface is unstable and very rough, and vegetation, at best very sparse, is not infrequently wholly lacking. Rydberg in his itinerary thus describes one of these districts. "There was a piece of land, several sections* in extent, all made up of canyon after canyon winding down, and separated from one another by narrow, steep ridges. Not a green spot was seen." The formation which prevails here has been named from the two undershrubs which are the characteristic and constant inhabitants of these areas. The greasewood, *Sarcobatus vermiculatus*, a spinescent shrub, from half a meter to about a meter in height, with smooth, white bark, is a striking object in the almost denuded alkaline stretches, where alone it is to be met with in this state. It occurs only in alkaline Bad Lands in the foot-hill region. The white sage, *Eurotia lanata*, is more common, and it occurs as well on barren table-lands in the Lodge Pole district. So far as there is a controlling vegetation in the Bad Lands, these species are controlling. A number of secondary species, most of which take part in other formations, are to be found on the edges of Bad Lands. Other species are to be met with in the interior here and there in dry canyons, barren gulches, and like comparatively favorable spots. *Ptiloria tenuifolia* is the most characteristic of the secondary species in Bad Lands of the Lodge Pole district. In barren gulches one will often come upon *Astragalus multiflorus*,

* That is, the government survey section=2.59 sq. kilometers.

and, in dry canyons, *Cryptanthe fendleri*. *Calamovilfa longifolia*, whose power of binding the soil must prove valuable here, is the only grass reported as occurring in the Bad Lands in this state. In the Dakotas, some of the bunch-grasses, such as *Oryzopsis cuspidata*, *Andropogon scoparius*, etc., are reported as well.* But grasses are rare and only occasional in the formation. In addition to the species mentioned, *Carduus undulatus*, *Aster multiflorus*, *Gutierrezia sarothrae*, *Chrysothamnus nauseosus*, *Musineon tenuifolium*, *Mentzelia decapetala*, *Pachylophus caespitosus*, *Lesquerella argentea*, and *Eriogonum jamesii* have been observed, either on the edges or in favorable spots. This brief list comprises all the species which, in our limits, have been met with in these sterile areas. The vegetation itself is no less meager than the list of species that take part in it. In the Dakotas, where the bulk of the Bad Lands lies, much is yet to be done in the way of gathering complete data. It will only be when these have been collated with those taken in our own state, and with more complete observations to the west of us in Colorado and Wyoming, that fuller discussion of this formation will be possible.

12. THE MAT AND ROSETTE FORMATION OF BUTTES, CLIFFS, AND HILLS.—In our limits, this is the chief of foot-hill formations. On buttes and cliffs, on rocky hills and rocky ridges, and on sandy hillsides, the controlling, and almost sole vegetation is of the mat or rosette type. In these situations the vegetation is sparse, though by no means to the same extent as in those previously considered. At times a considerable number of secondary species come in and occupy the intervals between the mat-forming species more or less completely. Probably in all cases the soil is visible, however, and on sandy hillsides this is especially true. In such situations there is little, if any, more density in the floral covering than on a typical sand-hill. The inhabitants of these elevations are all low, tufted perennials, and in this respect there is great uniformity in the floral covering.

* Williams: Grasses and Forage Plants of the Dakotas, 34. 1897.

But there is none of the monotony of the bunch-grass formations, and the fact that the prevailing species are not grasses, and that many of them possess profuse and striking flowers, gives the formation in most cases an agreeable aspect. Two types may be distinguished. The first prevails on the buttes and cliffs, and is to be distinguished chiefly in degree from that which prevails on rocky ridges and stony hillsides. The second prevails over sandy hillsides in the eastern edge of the region, where it is well set off. The chief constituents of the first in both situations are mats. The most striking members of the second are rosettes. The two types may, therefore, be called (1) the mat formation of buttes and cliffs, including also the mat formation of rocky ridges and stony hills, and (2) the rosette formation of sandy hillsides.

(1) The mat formation of buttes and cliffs. The floral covering of buttes and cliffs, while entirely of one type, varies considerably in respect to the constituent species. Thus, on Scott's Bluff, are found *Arenaria hookeri*, *Gilia spicata*, *Phacelia heterophylla*, *Orophaca caespitosa*, *Eriocarpum nuttallii*, *Stenotus armerioides*, *Pieradenia acaulis*, *Eriogonum cernuum*, *Townsendia exscapa*; and *Arenaria hookeri*, *Gilia pungens caespitosa*, *G. iberidifolia*, *Phlox hoodii*, *Eriogonum flavum*, *E. multiceps*, and *E. cernuum*, *Musineon tenuifolium*, *Orophaca sericea*, *Homalobus caespitosus*, and *H. montanus* are characteristic and prevailing on cliffs and foot-hills of the Lodge Pole district. Another not uncommon species in these situations is *Pachylophus caespitosus*. *Oreocarya fulvocanescens* is a cliff inhabitant, while *Orophaca sericea* inhabits the edges of rocky bluffs throughout the region. In the Lodge Pole district, *Gilia iberidifolia*, *G. congesta*, and *Phlox hoodii* are characteristic of chalk rocks of the cliffs. In the Pine Ridge district, according to Woods,* the most conspicuous members of this formation are *Phacelia heterophylla* and *Gilia iberidifolia*. With these on buttes in the Hat creek basin,

*Bot. Surv. Nebr., 2: 32. 1893.

are *Eriogonum flavum*, *Sedum stenopetalum*, *Picradenia acaulis*, and *Eriocarpum nuttallii*. Two woody plants, *Berberis aquifolium* and *Symphoricarpos pauciflorus*, are to be met with on the buttes or upper canyon sides of the Hat creek basin. Where they occur, they are somewhat dominant in small areas, but, as in the case of xerophilous bushes of the bunch-grass formation, these areas are of secondary importance only.

The secondary species are almost all plants that have wandered in from other xerophytic habitats. Thus, *Erigeron pumilus*, *Meriolix serrulata*, *Malvastrum coccineum*, and *Gaura coccinea* from the high prairies, *Phaca longifolia*, *Hymenopappus filifolius*, and *Chrysopsis villosa* from sandy hillsides or sand-hills, and *Stipa comata* and *Agropyron pseudorepens* from both, are to be seen more or less commonly in the Pine Ridge district, scattered here and there in the typical mat-like vegetation of the buttes. In the Lodge Pole district, *Hedeoma drummondii*, *Rumex venosus*, *Aragallus lamberti*, *Eurotia lanata*, and *Psoralea lanceolata* occur, all readily accounted for. On the summit of Court House Rock, Smith* found *Oryzopsis cuspidata*, *Agropyron pseudorepens*, *Aristida purpurea*, *Bouteloua oligostachya*, *B. curtipendula*, *Muhlenbergia pungens*, and *Sporobolus cuspidatus* growing among the characteristic species of the formation. All of these are common members of other formations in the vicinity, and their presence is not to be wondered at. But the two species of *Bouteloua*, which not uncommonly form small mats in the formation prevailing over sandy hillsides, have a certain fitness here. They are the only grasses whose occurrence in the formation is in some degree regular, though they are not at all abundant in it, and are of secondary importance only.

As the physical conditions prevailing on rocky ridges and high, stony hills in region IV are only different from those of the buttes and cliffs in degree, so the difference in the mat formation and its constituents in the two situations is chiefly

*Rep. Nebr. St. Bd. Agr., 1859:10. 1890.

one of degree. In the Lodge Pole district the characteristic and dominant species of rocky ridges and high, stony hillsides are *Phlox bryoides*, *P. hoodii*, *Arenaria hookeri*, *Eriogonum flavum*, *Lesquerella alpina*, *Townsendia exscapa*, and *Viola nuttallii*. *Cheilanthes lanuginosa* grows on the exposed rocks. In the Pine Ridge district, *Gilia pumila*, *Arenaria hookeri*, and *Eriogonum flavum* are of chief importance, together with *Homalobus caespitosus*, which, in high, rocky situations, forms dense, caespitose masses. On Pine Ridge, *Loeflingia texana* occurs also. With these species many are to be found which come in from the surrounding formations and occupy a favorable spot here and there. Among those commonly met with are *Euphorbia montana*, *Opuntia humifusa*, *O. polyacantha*, and *Thermopsis rhombifolia*.

Cercocarpus parvifolius, an undershrub 1-2 meters high, is an interesting woody plant of these situations. This species is often so abundant on rocky hills of Banner county as to give them, when the shrubs are in fruit, a peculiar grayish color. Its rôle in the formation is not much different from that of the two woody plants of the buttes in the Hat creek basin, though it assumes more importance on account of its abundance.

2. The rosette formation of sandy hillsides. An interesting type of the foot-hill mat and rosette formation is to be seen on sandy hillsides in the eastern portion of the region. The hills over which it prevails are not unlike the true sand-hills, being almost pure sand, and very sparsely covered with vegetation. But they have no blow-outs, and the bunch-grasses, characteristic of the true sand-hills, are wholly absent. Instead of the latter, the dominant and often the only vegetation is furnished by mat and rosette forming species, which occur uniformly, but very meagerly, over the surface; so meagerly, in fact, that the hill takes its color from the sand and not from the vegetation. Between the mats or tufts, a few species of other types occur sparingly. Although the mats are well represented in this formation,

the most abundant and conspicuous plants are rosettes, which lie half buried in the sand, or with the sand accumulated or banked up about the basal tuft of leaves, whence low stems arise, covered with flowers. The formation has been given its name from this predominance of rosettes. Nevertheless, it is of the same essential character as the preceding, the physical differences of situation being ample to account for the difference. In eastern Box Butte county, where this formation is very well developed, hill after hill will be seen covered sparingly with *Polygala alba*, *Pentstemon albidus*, *Pentstemon caeruleus*, *Phlox douglasii*, *Paronychia jamesii*, *Orophaca sericea*, and *Oreocarya suffruticosa*. The most important and the most abundant of these are *Polygala alba* and *Paronychia jamesii*. The former grows over loosely defined areas, a tuft or bunch here and one there, sometimes entirely or almost entirely alone. The latter grows in rather large mats, either on the same hills or on small sandy elevations, with few or no associates. More commonly, both are to be met with, and with them small mats or tufts of *Phlox douglasii*, numerous individuals of *Pentstemon albidus*, half buried in the sand, and a few sprawling individuals of *P. caeruleus*. The latter with *Polygala alba* and *Phlox douglasii* forms the most noticeable portion of the vegetation of every hill. Few grasses are to be met with. The most frequent are small, circular mats of grama grass, or even of buffalo-grass, a few centimeters in diameter, and a few individuals of *Stipa comata*. Sometimes *Rumex venosus* comes up sparingly from the sandy plain beneath. But in general the aspect of every part of every hill is solely due to four of the controlling species mentioned. Three of these, *Polygala alba*, *Phlox douglasii*, and *Pentstemon albidus*, having white flowers, are not to be noticed at a distance on the sandy hillside. But the deep blue flowers of *Pentstemon caeruleus*, borne on low, almost prostrate stems, stand out in marked contrast to their surroundings. On some hillsides, prostrate, spreading individuals of *Orophaca sericea*, almost buried in the sand, are the chief

vegetation. These form dense oblong patches, 5-10 decimeters in length, which are closely interwoven and are banked up on all sides with sand. On such hills the sand is usually very shifting, and, in consequence, *Polygala alba* and *Phlox douglasii* are almost the only other inhabitants.

In other parts of the Lodge Pole district, *Gilia spicata* and *Pachylophus caespitosus* take part in the rosette formation. In the Pine Ridge district *Arenaria hookeri* is associated with *Paronychia jamesii*, and *Pentstemon glaber* supersedes *P. albidus* in the Hat creek basin. Otherwise, the floral covering of these situations is substantially the same throughout the region, except as now the *Pentstemons*, now *Polygala alba*, now *Orophaca sericea*, or now the *Phlox* and the two mats prevail on individual hills.

13. THE GRASS FORMATION OF HIGH PRAIRIES AND LEVEL, SANDY PLAINS.—The foot-hill grass formation has much in common with the prairie formations of region II. As one looks at high, rolling prairies in region IV, covered with *Stipa comata*, from a distance, the carpet of *Stipa*, variegated with the profusely flowering astragali, lupines, and psoraleas, which abound in it, appears to be a piece out of the familiar prairie of the eastern portion of the State. But even in this type, which most closely resembles the ordinary prairies, on closer inspection the carpet is found to be thin and patchy, while, on the sandy plains, the covering is seldom sufficiently dense to hide the sand, even at a distance, and is still more patchy and intermittent. Unlike the typical foot-hill formations just considered, this formation is emphatically a grass formation. It is controlled by two grasses, which not only furnish the bulk of the vegetation and give the aspect to the landscape, but sometimes take exclusive possession of extensive areas, though more commonly they admit a number of secondary species. These two grasses are *Stipa comata*, growing here in a thin sod, and *Argopyron spicatum*. The two are associated as a rule, but one or the other is commonly overwhelmingly predominant, and they rarely meet on equal terms. Each of these grasses

gives character to a type of the formation. The high, rolling prairies, which are more thickly carpeted and are similar to the prairies of region II, are controlled by *Stipa comata*. The level, sandy or gumbo stretches, where the covering is comparatively thin and in patches, are dominated by *Agropyron pseudorepens*. On the dry hillsides, which occupy a middle position, as it were, between these situations, these two grasses are more equally distributed, the *Stipa* apparently predominating on the higher ground, the *Agropyron* on lower or waste ground.* In this middle type there are some species to be met with that are not ordinary inhabitants of either of the extremes. But in general it is only a merger of the two in a situation which has some of the physical characteristics suitable to each. It seems best, therefore, to distinguish but two types. These have been named from their characteristic grasses, (1) the *Stipa* formation of high prairies, (2) the *Agropyron* formation of level, sandy plains. A third type of the formation, of widely different nature, may also be distinguished. In this type the fundament is grama grass or buffalo-grass. But other species acquire no less importance in it than the grasses, and from them it has been named the peppergrass-cactus formation.

(1) The *Stipa* formation of high prairies. This is the type prevailing, with some modifications, over high, rolling prairies throughout the region. Next to the low meadow formation, which prevails in low meadows along streams, it is the chief grass formation of the region. It covers large areas of rolling table-lands and of sides of ridges, as, for instance, the southern slope of Pine Ridge. As has been said, the prevailing grass is *Stipa comata*. Here the behavior of this species is very different from its custom in the sand-hill region, and even from its behavior on the sandy hillsides of region IV, as an intruder in the mat and rosette formation. So far from growing as a bunch-grass, it forms a sod, though a thin one, in which the secondary species occur, much as in *Stipa spartea* meadows of the

*Smith & Pound, Bot. Surv. Nebr., 2:9. 1893.

eastern part of the State. Sometimes the *Stipa* has exclusive possession of tracts of wide extent. More often it has only the chief place, many species being associated with it. Of the grasses that share these situations with the *Stipa*, *Koeleria cristata* is first in importance and in abundance. It is to be found abundantly in *Stipa* sod throughout the region, and in spring it is perhaps the chief grass of the formation. *Agropyron pseudorepens* and *A. spicatum* are the only other grasses of regular occurrence. *Bouteloua oligostachya* and *Bulbilis dactyloides* are met with in small mats here and there, but they are not frequent as in the *Agropyron* type.

The secondary species of the *Stipa* formation are important and conspicuous. In eastern Box Butte county, in late June and July, this formation makes one of the most beautiful of our prairie landscapes. The comparatively dense stretches of *Stipa*, just coming into fruit so that the glistening, white awns bend before the wind in long waves, of themselves are a sight to be remembered. But even more striking is the blue color imparted to the hillsides and low, rolling elevations by the copious and uniform distribution throughout the *Stipa* sod of *Lupinus plattensis*, *Astragalus mollissimus*, *A. adsurgens*, *Aragallus lamberti*, and *Psoralea argophylla*. In many places *Tradescantia virginica*, here displaying large clusters of deep blue flowers, is to be seen with the foregoing species, abundantly and uniformly distributed over loosely defined areas. The effect of this reiteration of blue is very beautiful. The *Lupine* is somewhat darker, and the *Aragallus* a little lighter than the average color of the formation, but the difference is scarcely noticed. On closer view, one sees *Erysimum asperum* and *Thelesperma trifidum*, whose profuse, yellow flowers contrast strongly with the prevailing blue, and, as one reaches the lower ground, where *Agropyron* becomes more abundant, long stretches are copiously inhabited by *Malvastrum coccineum* or *Anogra coronopifolia*. Here red and purple largely replace the blue of the high hillsides, though the latter is well represented. On the high ground, three blue-flowered species occur, which

are common but less conspicuous than those named. *Psoralea digitata*, *P. tenuiflora*, and *P. esculenta* occur uniformly and copiously, but not so much so as *Lupinus plattenis* and *Astragalus mollissimus*, which are the most abundant of the secondary species on every hand. *Pentstemon albidus* and *Erigeron pumilus*, usually in association, are frequent in restricted areas here and there. The former, which is low, few flowered, and almost prostrate on the sandy hillsides, here grows erect, and is covered with large, whitish flowers. *Cactus viviparus* is to be seen isolated in small, bare spots on the hilltops. Later in the summer, as the *Stipa* becomes hard and dry, and the flowering period of the secondary species has passed, these prairies have a parched aspect, not much relieved by the abundance of blazing star, *Laciniaria punctata*, and numerous individuals of *Aster canescens* and *A. incanopilosus*. A little earlier, *Allionia linearis* and *A. hirsuta*, are to be found on the higher ground, where they are especially common along a road or a trail. Further to the westward, *Psoralea collina* covers the hillsides in profusion, often as almost the sole secondary species present. In the Pine Ridge district, *Potentilla hippiana*, *Thermopsis rhombifolia*, and *Senecio douglasii* are to be added to the list of secondary species, and, in some localities, *Pulsatilla hirsutissima*. The latter harmonizes well with its fellows in the formation on account of its bluish flowers. In the Hat creek basin, *Lupinus argenteus argophyllus* is to be met with, and, in the southern portion of the Lodge Pole district, *Lupinus argenteus decumbens*, *L. pusillus*, and *Psoralea hypogaea*. In some localities, also, *Anogra albicaulis*, *Gaurella guttulata*, and *Zygadenus nuttallii* are reported. None of these take a part of any importance.

(2) The Agropyron formation of level, sandy and gumbo plains. This formation is much more open than the preceding. On low hillsides where the two merge, the sod is more or less thick and is comparable to that of the high prairies; but on the level stretches it is sparse and usually in patches, interspersed with bare, sandy

areas of more or less extent. Sometimes the grass will form patches of sod of some extent, in which other species are admitted. At other times the grass will grow sparsely and almost in bunches, with a few secondary species in the intervals. Elsewhere, in one place this species and in another that will form large patches, in which the grass is either absent or subordinate. There is none of the uniformity here which prevails on the high prairies. As has been said, the controlling grass of this formation, and the controlling species over most of the area, is *Agropyron spicatum*. In places, as was observed by Bessey on flat gumbo stretches near Chadron, the vegetation for long distances is composed exclusively of *Agropyron*. But this is rare. More commonly, somewhat exclusive patches of *Agropyron* are interspersed with patches of this species or that, or with barren areas, inhabited by a mixed population of a few individuals of many species. Other grasses of the formation are *Festuca octoflora* and *F. ovina*, which occur on sparsely covered patches of sand, *Koeleria cristata*, *Elymus elymoides*, and *Bulbilis dactyloides*, which, as well as *Bouteloua oligostachya*, in some places form patches of some size. The two latter are to be met with chiefly where the *Agropyron* formation approaches the buffalo-grass formation of the "range." The most important of the species which form large patches of more or less exclusive character are *Monarda citriodora*, *Hedeoma drummondii*, *Malvastrum coccineum*, *Plantago purshii*, and *Rumex venosus*. On the less sandy situations near the hills, *Malvastrum coccineum* is almost controlling. Here the *Agropyron* grows in small patches or fringes, with large patches of *Malvastrum* interspersed. Where the sand prevails and the vegetation is more sparse, the *Malvastrum* is copiously distributed over a somewhat definite area, less densely and exclusively. On the well-covered areas, *Hedeoma drummondii* grows in patches of several meters in extent, either exclusively or in the thin sod of *Agropyron*. *Monarda citriodora* covers long stretches in level, sandy situations.

almost exclusively, often with *Stipa comata* as well as *Agropyron spicatum* for an associate. On the sandy plains to the west of the sand-hill region, as for example in parts of Sheridan and Box Butte counties, it is especially characteristic. It is scarcely less characteristic on the dry, flat, sandy stretches in McPherson county, which are an extension of the former into region III. *Rumex venosus* occurs abundantly, but not densely, over similar stretches, interspersed with patches of grass, or with a few tufts of grass here and there in the area of the *Rumex*. *Plantago purshii* forms like patches on higher, sandy plains, either interspersed among tufts or in a thin sod of *Agropyron*, or exclusive in areas not occupied by the grass. It will be seen that there is no uniform or characteristic appearance here, as in the other types of the foot-hill grass formation. The greater or less predominance of *Agropyron* is often all that two level, sandy stretches have in common.

Astragalus microlobus does not form exclusive patches like the species just enumerated, but, on level plains of the less sandy type, it is often copiously distributed over definite areas sprawling in the *Agropyron* sod, or taking up more or less thoroughly the waste ground along a road or trail. It would be impossible to enumerate the species that invade this open formation from the sand-hills on one side or from the foot-hills on the other side. In the more thickly sodded situations one may meet with *Antennaria campestris*, *Legouzia perfoliata*, *Linum rigidum*, *Collomia linearis*, *Allium reticulatum*, and *Gaura coccinea*. In the sparsely covered, more sandy places, *Abronia fragrans*, *Lesquerella ludoviciana*, *Argemone intermedia*, and *Meriolix serrulata* are a few of the more common species. Further west, Rydberg reports *Erigeron concinnus*, *Galpinsia hartwegii*, and *Eriogonum corymbosum* as most common, after *Rumex venosus*, on sandy plains covered by the *Agropyron* formation. In the Hat creek basin, *Calamagrostis neglecta* is associated with *Agropyron spicatum* in the well-

sodded situations. On the more sandy stretches, along with *Rumex venosus*, *Oryzopsis cuspidata* and *Polygala alba* have also been noted.

(3) The peppergrass-cactus formation. This type is included in the grass formation because its fundament, whether practically continuous or greatly interrupted, consists almost entirely of *Bouteloua oligostachya* and *Bulbilis dactyloides*. In certain aspects, both species are present in nearly equal abundance; in others, *Bouteloua* alone is important, *Bulbilis* being represented by small, infrequent mats. During the short growing-period in the intensely xerophytic geographical area of this formation, the two facies assume a certain degree of prominence. This is especially true during their flowering period. From the middle of June throughout the remainder of the year, both *Bouteloua* and *Bulbilis* practically disappear from the aspect of the formation, their small, dried tufts being concealed by taller species. This aspect of the formation is most striking after the first part of July, when the peppergrass assumes its characteristic appearance. At this time, the upper half of the plant is multiramose to such an extent that the tops of adjacent plants touch, the leaves dry up and fall, and the whole plant, especially the long racemes, becomes straw-colored. From the overwhelming abundance of *Lepidium*, this color is communicated to the ground-tone of the entire formation, and, except for slight interruptions, is continuous for many kilometers. On closer view, this is seen to be interrupted by patches of *Opuntia polyacantha*. These patches are from $\frac{1}{3}$ –1 meter in extent, and there is a varying interval of 2–10 meters between bunches. At a distance of a few hectometers, therefore, the yellow-brown color of the formation is broken by the darker, greener patches of *Opuntia*. But the green of the plant-body is so greatly modified by the numerous, long, straw-colored spines, that at a distance of scarcely more than a kilometer the darker bunches of *Opuntia* are lost in the prevailing color of the formation.

Secondary species have little or no importance in the peppergrass-cactus formation. Where it is contiguous to either the *Stipa* or the *Agropyron* formation, *Stipa comata* or *Agropyron spicatum* appears in it in considerable quantity. The latter quickly vanishes, however, and the former only persists sparsely. The most abundant secondary species are those characteristic of incipient roadside wastes, *Grindelia squarrosa*, *Malvastrum coccineum*, and *Salsola tragus*, or those which have come in great abundance into abandoned trails, *Gutierrezia sarothrae* and *Artemisia frigida*. *Opuntia humifusa* and *O. fragilis* are frequent, though rarely abundant. The same is true of the remaining secondary species, such as *Thelesperma trifidum*, *Lupinus plattensis*, *Psoralea collina*, *Allionia linearis*, *Cactus viviparus*, *Erigeron pumilus*, and *Oreocarya suffruticosa*.

The peppergrass-cactus formation extends over vast stretches of mesa and table-land, especially in the Lodge Pole district north of the North Platte river, where it holds undisputed possession of a belt 8-20 kilometers wide and 75-100 kilometers long. In the Bad Lands of Scott's Bluff county it is characteristic of the flat tops of peaks and buttes. It has also been observed covering long stretches of similar character in Montana. In certain portions of the sand-hill region, in its western and northwestern edges, a modified form of this formation has been observed. Here, the fundament is *Bouteloua oligostachya*, but the latter is soon obscured by a veritable forest of peppergrass. No other species than *Lepidium intermedium* may be observed in such stretches for great distances. Rarely, *Solidago mollis*, *Eriocarpum spinulosum*, or *Chrysopsis villosa*, or even other ordinary sand-hill species, may be seen in small bunches. *Opuntia polyacantha* does not occur.

VI. The salt marsh formations.—The salt basins of Lancaster county and the alkaline marshes of region IV are inhabited by a halophytic formation which is very uniform in constitution and aspect in the two localities, widely separated as they are. Salty or alkaline meadows, which are to

be found here and there throughout the State, are of the same type. In these meadows, *Distichlis spicata stricta* is always the controlling, and is often the sole inhabitant. *Agropyron pseudorepens* is often associated with it, either in patches, or sparsely here and there in the *Distichlis* sod. In the salt marshes, *Distichlis spicata stricta* is likewise an invariable and controlling inhabitant. But here it occupies only the level fields about the marsh or basin, and yields to other halophytes in the intensely saline or alkaline soil of the basin itself.

14. THE SALT GRASS-ORACHE FORMATION.—In the typical salt basins of Lancaster county there is a certain zonal arrangement, in consequence, chiefly, of the diminution in the amount of salt in the soil in passing from the salt springs of the interior to the salty meadows about the basin, where the salt has been deposited by successive overflows, year after year. In small, salt water ponds in the bottom of the basin, *Ruppia occidentalis* is to be met with. Such ponds, however, are not common in the basins in Lancaster county. In wet spots on the floor of the basin, in the saltiest of soil, often growing through a crust of salt, the sole inhabitant is *Salicornia herbacea*. This plant grows abundantly along and in the moist channels or depressions of the bottom of the basin and in the muddy portion about the salt springs. But the individuals, numerous as they are, do not completely cover any portion of the soil. The vegetation is so sparse as to have no effect whatever upon the general aspect of the basin, which appears as a great, white, bare spot. On the dry, upper portion, and on the salty soil about the basin, species of *Atriplex*, chiefly *A. hastata* and *A. argentea*, grow in dense patches. With them, *Dondia depressa* is scarcely less abundant, either in patches of its own or distributed copiously with *Atriplex*. *Corispermum hyssopifolium* occurs here also, where the situation is subruderal. Out of and beyond the basin, the salty meadows are covered by salt grass, *Distichlis spicata stricta*. *Agropyron pseudorepens* often occurs associated with it, and where a road runs

through the fields, or the soil is otherwise disturbed, huge patches of *Atriplex* occur, and the sod is invaded by *Grindelia squarrosa* and *Ambrosia artemisifolia*. *Polygonum ramosissimum* is also a frequent invader of these spots, and frequently occurs with the species of *Atriplex* and with *Dondia depressa*. Finally, the sides of the outlet of the basin are covered with *Panicum walteri*.

Such is the vegetation of the salt basins of region II. The salt marshes and alkaline lowlands of the western part of the State are more simple in their vegetation. In eastern Box Butte county one generally finds *Distichlis spicata stricta* occupying the alkaline lowland exclusively, or with *Agropyron pseudorepens*, while the bottoms of dried-up ponds are completely taken up by *Polygonum ramosissimum*. Where the ponds have not dried up, they contain *Ruppia occidentalis*. The salt marshes of Deuel and Scott's Bluff counties resemble those of region II on a small scale. But the *Salicornia* is absent, and the dry, salty bottom is sparsely occupied by *Dondia depressa*, while in the upper portion the rôle of *Atriplex hastata* and *A. argentea* in region II is taken by *Bahia oppositifolia* and *Chenopodium incanum* in some cases, or by *Monolepis nuttalliana* in others.

Ruppia occidentalis is the only flowering plant which is ever to be found in the salty ponds and springs of the salt basins. But *Enteromorpha intestinalis* grows in saline ponds throughout the State, and *E. compressa* occurs with it in salt springs in the salt basins of region II. In the latter, *Beggiatoa alba*, *B. arachnoidea*, *Spirulina subsalsa*, and *Lamproedia litoralis* are also abundant and characteristic, and in the principal basins near Lincoln certain diatoms, not found elsewhere in the State, *Amphora salina*, *Amphiprora pulchra*, *Synedra tenuissima*, *Nitzschia sigmoidea*, and *Biddulphia laevis*, are very common.

VII. The water plant formations.—According to the constitution of the soil and the character of the surface waters, the water plant formations of our flora are of two kinds. The one, glacial, grows in clear, cold, limpid waters, which

possess a sandy bed, or on sands permeated by such waters. It is characteristic of montane or submontane regions, and, in Nebraska, is confined to the foot-hills and the sand-hills. The other, fluvial, is found in closed or stagnant pools and ponds, in sluggish streams with muddy bottoms, or in alluvial marshes. This sort of formation is restricted almost entirely to the lowlands of regions I and II. In consequence of these peculiarities of constitution, our water plant formations present a great diversity of types, which may be arranged in five principal formations.

15. The marsh formation :

- (1) The reedgrass-rush type.
- (2) The water hemlock type.
- (3) The smartweed type.
- (4) The false loosestrife type.

16. The wet meadow formation :

- (1) The rush meadow type.
- (2) The fern meadow type.
- (3) The sedge meadow type.

17. The pond and stream formation :

- (1) The pond-weed type.
- (2) The pond-lily type.
- (3) The water crowfoot type.
- (4) The stonewort type.

18. The sand-bar formation.

19. The spring and spring branch formation :

- (1) The spring marsh type.
- (2) The spring branch type.

15. THE MARSH FORMATION.—The four types of this formation are constant only when each is subject to certain typical conditions. In other words, they exhibit numerous gradations through the suppression of proper facies or the intrusion of other facies. Such intermediate conditions are to be regarded, however, as due to the mingling and confusion of two distinct types, which are striving for control under circumstances more or less different from those of their typical habitats. From this it follows that, while certain

secondary species may occur in several types, interchange of facies takes place only rarely, if ever. Certain species of very general distribution are, of course, common in marshes everywhere. Thus, *Eleocharis palustris* is found in the four types of marsh, while *Oxygraphis cymbalaria* is lacking only in the false loosestrife formation.

(1) The reedgrass-rush formation. This type of marsh is confined practically to regions I and II, where it occurs on the flood lands of the principal streams. The facies are *Phragmites phragmites*, *Scirpus lacustris*, *S. fluviatilis*, *Typha latifolia*, *Alisma plantago-aquatica*, and *Sagittaria latifolia*. *Sparganium eurycarpum* is likewise a common member which may occasionally assume the importance of a facies. A peculiar feature of marshes of this type is the readiness with which the individual facies may become isolated, or localized, notwithstanding their coherency in marshes of considerable extent. Thus, this formation is often represented in marshy places, or marshy pools of small extent, throughout I and II by one or two facies, sometimes *Scirpus lacustris* or *Typha latifolia* alone, sometimes *Typha* and *Sparganium*, or *Sagittaria* and *Sparganium*, etc.

The most typical examples of the reedgrass-rush marsh occur along the Missouri river. These are characteristically closed formations, in which layers are often developed to a considerable extent. When such conditions prevail, the primary layer is composed invariably of either *Phragmites phragmites*, or *Scirpus fluviatilis*, or both. The secondary layer is constituted by *Phalaris arundinacea* and species of *Scirpus*, *S. lacustris*, *atrovirens*, and *americanus*. These grow invariably in dense clumps scattered here and there over the marsh; along the edge, *Scirpus lacustris* usually forms a thick border. Between these clumps of grass and rush, the marsh is thickly covered with *Sagittaria*, *Alisma*, *Sparganium*, and *Typha*. In the muddy edges of the marsh, *Carex lurida* often grows thickly. It usually extends some distance into the marsh proper upon little

hummocks of earth. *Calamagrostis canadensis* grows sparingly in shallow pools, or it may be found back along the marshy banks of small streams. *Eleocharis palustris* forms a dense carpet, extending from the shore throughout the swamps, except where the water becomes too deep for it. This carpet is interrupted by frequent yellow patches of *Ranunculus delphinifolius*, or of *Oxygraphis cymbalaria*, and occasionally by a few large individuals of *Ranunculus pennsylvanicus*. *Monniera rotundifolia* is a common floating aquatic of pools in swamps and of isolated ponds characterized by facies of this formation. It occurs in ponds in the sand-hills, however, and can not be regarded as peculiar to this formation. In the western stations of the formation along the Niobrara, *Cicuta maculata* and *Lythrum alatum* come in to a limited extent.

(2) The water hemlock formation. This type is found for the most part in the sub-sand-hills and in the sand-hills proper. It is, however, to be found upon an alluvial rather than upon a sandy substratum, growing in wet meadows or ravines. The facies are water hemlock, *Cicuta maculata*, swamp milkweed, *Asclepias incarnata*, loosestrife, *Lythrum alatum*, and *Scirpus atrovirens*. With these are often associated *Spartina cynosuroides* and *Phalaris arundinacea*, so that the appearance of the whole formation is that of a uniformly green fundement, dotted with the white flowers of *Cicuta* and the pink ones of *Asclepias*. In addition to these, *Berula erecta*, *Stachys palustris*, *Teucrium occidentale*, and *Alisma plantago-aquatica* are frequent secondary species. Low-growing plants, such as *Oxygraphis cymbalaria* and *Mimulus jamesii*, are of comparatively rare occurrence on account of the peculiar density of the upper layer, which is as a rule the sole layer of the formation.

(3) The smartweed formation. This formation is of wide distribution, occurring in wet ravines and canyons throughout our flora. It is never of large extent, rarely covering more than a few hectares of surface. The facies are entirely species of *Polygonum*, *P. lapathifolium*, *incarna-*

tum, and punctatum, and they give a characteristically close and uniform appearance to the formation. On account of the dense aggregation of individuals, layers are completely lacking, and very few plants intrude to disturb the facies. In the Loup district, *Polygonum emersum* and *P. hartwrightii* are occasional secondary species of this formation; in such cases, however, they have simply wandered in from the marginal formation of pools and lakes. Other species of *Polygonum*, *P. persicaria*, and *P. hydro-piperoides*, are likewise somewhat frequent constituents. The former is usually represented only by a few scattering individuals, the latter by extensive patches. In general, the smartweed swamps present two aspects. In the one, *P. lapathifolium* and *P. incarnatum* are the facies, in the other, *P. punctatum* with which *P. hydro-piperoides* is most often associated. A third aspect is that sometimes present in swampy meadows and waste places, where the ruderal *Polygonum pennsylvanicum* takes exclusive possession of large, marshy areas.

(4) The false loosestrife formation. Broad, shallow ditches, especially those along railroad embankments of the southern portions of regions I and II, are often filled with a dense growth of *Ludwigia polycarpa*, *Ammannia coccinea*, and *Penthorum sedoides*. In the edges of such pools and ditches, and extending out upon the muddy banks, *Eleocharis palustris* forms a thick carpet. Secondary species are rare. *Roripa palustris* and *Mentha canadensis* are occasionally seen on the marshy margins, and *Spirodela polyrhiza* is rather common upon the surface of the water. This formation is important solely because it is the only typical ditch formation in our flora. The great majority of ditches and shallow pools are ordinarily characterized by facies, or patches, from the reedgrass-rush formation, *Sagittaria*, *Sparganium*, etc., or by formations of algae, *Vaucheria*, *Spirogyra*.

16. THE WET MEADOW FORMATION.—Wet meadows are intermediate in nature and in position between marshes

and meadows proper. In consequence, they are of uncommon occurrence in I and II, where marshes pass abruptly or very quickly into meadows. In the lake region of the sand-hills, and throughout the springy canyons of III and IV, the transition from marsh to meadow takes place through long stretches of wet, sandy meadow land. The latter, indeed, often extends from canyon side to stream bank. From their subpaludose character, wet meadows are typically covered with rushes, *Scirpus* and *Juncus*; grasses are little abundant or entirely lacking. The few wet meadows of I and II contain little else than sedges. A third type of this formation occurs in the canyons of the Niobrara and Loup districts. It owes its character to the presence of ferns.

(1) The rush meadow formation. This type of wet meadow is frequent in the sub-sand-hills of the northern portion of II, throughout III, and in parts of IV. The facies are *Juncus tenuis*, *J. nodosus*, *Scirpus atrovirens*, and *S. americanus*. In the sub-sand-hills, *J. tenuis* and *Scirpus atrovirens* are the facies most frequently associated. With them, especially in the wetter portions, *Panicularia nervata* frequently approaches the rank of a facies. In more sandy meadows to the westward, *J. nodosus* and *J. torreyi* are prevailing, usually in company with *Eleocharis palustris*, and more rarely, *Catabrosa aquatica*. *Oxygraphis cymbalaria*, of course, occurs everywhere in large carpet-like areas throughout wet meadows. A great many species, *Mentha canadensis*, *Lythrum alatum*, *Lycopus americana*, *Steironema ciliatum*, etc., though more or less frequent, are never sufficiently abundant to be of real importance.

(2) The fern meadow formation. These peculiar meadows are confined to wet valleys and canyons of the Loup and Niobrara and the valleys of our principal rivers. They consist almost exclusively of the two facies, *Dryopteris thelypteris* and *Onoclea sensibilis*. Accessory species are uncommon. *Epilobium lineare*, *Hypericum virginicum*, *H.*

majus, *Galium trifidum*, and *Campanula aparinoides* are represented by a few scattered individuals only.

(3) The sedge meadow formation. Extensive wet sedge meadows are of rare occurrence in Nebraska. A few species only, *Carex striata*, *C. stricta*, and *C. filiformis lanuginosa*, occur in such formations. With the exception of *Spartina cynosuroides*, accessory species are almost wholly lacking. This formation is found only along the Missouri and the main streams of II.

17. THE POND AND STREAM FORMATION.—The general conditions which control the distribution of aquatic plants in our flora have already been treated of in chapter III. In conformity with these facts there may be distinguished four types of aquatic formations. One is a formation of submerged aquatics characteristic of sluggish streams and muddy pools throughout the State; it consists of species of *Potamogeton*, *Myriophyllum*, *Zannichellia*, etc. The second consists of floating plants confined to pools and small lakes; *Nymphaea*, *Castalia*, and *Nelumbo* are the important and almost the sole plants of this formation. The third type is found in the cold, sandy streams and spring branches of sand-hills and foot-hills; *Batrachium*, *Berula*, *Roripa*, *Veronica*, and *Cardamine* are characteristic of this formation. The fourth formation is found in stagnant, sandy pools of sand-hills and of sub-sand-hills; it is constituted solely by *Potamogeton*, *Naias*, and *Chara*. *Spirodela polyrhiza*, *Lemna minor*, and *L. trisulca* occur everywhere in the first two formations, and rarely in the third and fourth. *Utricularia vulgaris* is likewise frequent in ponds of the first and second type. *Philotria canadensis*, which is apparently endemic in the clear streams of the Niobrara district, is rapidly becoming naturalized in the muddy streams and pools of I and II.

(1) The pond-weed formation. This is the most widely distributed aquatic formation of our flora. Represented by one or more of its facies, it is found in streams and ponds everywhere in I and II, and frequently in III. The

facies are *Potamogeton natans*, *amplifolius*, *foliosus*, *Myriophyllum spicatum*, *Zannichellia palustris*, and *Ceratophyllum demersum*. Secondary species, other than those common to aquatic formations, are rare. *Potamogeton spirillus*, *diversifolius*, and *zosterifolius* comprise practically all of them.

(2) The pond-lily formation. The ponds characterized by this formation are of two sorts: those in which the facies is *Nymphaea advena*, and those in which the facies are *Castalia tuberosa* and *Nelumbo lutea*. The former type is found in small ponds in the sand-hills and especially in the sub-sand-hills. *Utricularia vulgaris* is frequently associated with *Nymphaea* in them, but is never found in the other type. The second type occurs abundantly in the southeastern corner of the State in the edge of the wooded bluff region. It grows usually in large ponds, and exhibits a well-defined zonation. The ordinary lowland sedge and grass formation passes into a zone of *Spartina cynosuroides*, 3-10 meters wide, found just at the edge of the pond. This is followed by a zone 3-10 meters in width of *Scirpus fluviatilis*, and *Typha latifolia*, extending out to a depth of 3-6 decimeters. This gives place to a broad zone of *Nelumbo lutea* 10-50 meters wide. The latter extends to the nucleus of the formation which is made up of a dense mass of *Castalia tuberosa* and species of *Potamogeton*, which form a close, green carpet in the center of the pond. Occasionally, the latter and the *Nelumbo* zone are interrupted by extremely dense patches of *Typha*, or by large, looser groups of *Scirpus lacustris*. *Polygonum amphibium* occurs here and there in the deeper parts of the pond. In the prairie region this type is often reduced to the single facies, *Castalia tuberosa*, and secondary species are altogether absent. In its most complete expression, the *Castalia* and *Nelumbo* formations entirely cover ponds or lakes almost a kilometer in diameter. These are confined to the neighborhood of the Missouri or its immediate tributaries.

(3) The water crowfoot formation. The facies of

this type is *Batrachium trichophyllum*. It is found as a secondary species throughout the pond-weed formation of I and II, and infrequently also in the pond-lily formation. It is of chief importance only in the swift, sandy streams of III and IV. Several species are associated with *Batrachium*; some of them occasionally assume the appearance of a facies, though none are sufficiently constant throughout the formation to have permanent rank as such. The most common of these are *Roripa nasturtium*, *Cardamine hirsuta*, *Veronica americana*, and *V. anagallis-aquatica*. These were originally amphibious, but have become, in this formation at least, immersed aquatics. *Mimulus jamesii*, which is regularly an inhabitant of wet, sandy soil, exhibits a similar tendency in the spring branches along the Niobrara. *Dulichium arundinaceum* is a peculiar sedge, which is more or less common in similar streams.

(4) The stonewort formation. Pools and small lakes in the wet valleys of the Loup district possess a characteristic vegetation in which *Chara* is the principal constituent. Four species, *Chara contraria*, *C. foetida longibracteata*, *C. fragilis*, and *C. coronata*, are found in this formation. The other plants present are *Naias flexilis* and different species of *Potamogeton*, *P. pectinatus*, *P. heterophyllum graminifolius*, *P. pusillus*, etc.

18. THE SAND-BAR FORMATION.—This formation is in many respects one of the most unique of our flora. Notwithstanding the hydrophytic conditions which such a situation presents, it is almost constantly an open formation. In this respect it differs from sandy, wet meadows, with which it has much in common so far as constituents are concerned. Typical sand-bar formations are found in the Niobrara, Republican, and Loup rivers, and in the North Platte. The sand-bars of the lower Platte and of the Missouri are generally more or less alluvial, or they present xerophytic conditions and are totally different. The vegetation of a sand-bar derives its peculiar character from the prevailing rushes and galingales. The most constant and characteristic are the rushes, *Juncus*

bufonius, balticus, nodosus, torreyi, and, more rarely, *J. tenuis*. Scarcely less typical is arrow-grass, *Triglochin maritima*, which, though an inhabitant of wet meadows in the sand-hills proper, is confined almost entirely to sand-bars in the Niobrara district. Species of *Cyperus*, while not so abundant as the rushes, are of the widest occurrence over sand-bars. *Cyperus inflexus* and *C. strigosus* are the most abundant. *C. erythrorhizos*, *C. diandrus*, and *C. rivularis* are to be found, however, on every sand-bar of any considerable extent. *Hemicarpha micrantha* and *Scirpus americanus*, which are more or less frequent, contribute also to the rush-like nature of the formation. The secondary species of sand-bars are exceedingly diverse. In fact, one may expect to find any hydrophyte of adjacent formations upon them. Such species, though numerous, are never abundant. *Rumex maritimus* alone is of sufficient frequency to be important. *Diplachne fascicularis* is likewise frequent, but is usually represented by scattered individuals. The same is true of *Gerardia tenuifolia*. The bulk of secondary species consists of *sagittaria latifolia*, *Alisma plantago-aquatica*, *Polygonum incarnatum*, *Cicuta maculata*, *Mentha canadensis*, *Lycopus americanus*, *L. lucidus*, *Scutellaria lateriflora*, etc., which are to be regarded as intruders from other formations.

19. THE SPRING AND SPRING BRANCH FORMATION.—This formation is confined to sandy situations, which are more or less shaded, and in which the soil is constantly saturated or covered with the waters of cold springs or spring branches. Such conditions are most frequent in III and IV, and formations of this character are very common in these two regions. They occur rarely in the sub-sand-hills of the southern part of II. In region I, an almost typical example is found along the base of the Missouri bluffs at Bellevue. This locality is, of course, entirely outside of the geographical area of spring and spring branch formations, and has no connection with it other than that of accidental distribution. The real home of these formations is in the sand-hills. In the canyons of the Republican, the Loups, and the Niobrara, the hydrophy-

tic vegetation is exclusively of this nature. The spring-branch-canyon country along the southern bank of the Niobrara is especially remarkable for the presence of such vegetation. In the foot-hills, such formations are restricted chiefly to the submontane streams.

Spring and spring branch formations fall into two fairly constant types, though the fact that both regularly occur in the same narrow canyon leads to a considerable intermingling of secondary species. One type is characteristic of the sandy marshes about the sources of springs, and is usually to be found at the head of the main or of side canyons. The other type is riparian, growing along the wet, sandy margins of the spring branches, or even in the edge of the water. The former may be termed the spring marsh formation, the latter the spring brook formation.

(1) The spring marsh type. In many localities, this formation grows in thickets or woodlands and might be regarded as a layer. Its typically hydrophytic character and the fact that it often has no connection with woody formations justify its consideration as a distinct formation. The facies, all of which are almost invariably present, are the touch-me-not, *Impatiens biflora*, and the willow herbs, *Epilobium adenocaulon* and *E. lineare*. *Impatiens biflora* usually constitutes the nucleus of the formation. The tall-growing, densely aggregated individuals form a mass rarely interrupted by other plants. The smaller *Epilobium adenocaulon* grows in abundance about this central mass; scattered plants of *E. lineare* are intermingled in it. Frequently, the formation is of a more open nature, and the *Impatiens* facies is interrupted not only by *Epilobium adenocaulon* and *E. lineare*, but also by *Rumex britannica*, *Helenium autumnale*, and *Cicuta maculata*. In such case, a secondary layer makes its appearance. In the closed aspect of the formation, this layer is extraformational, i. e., it occurs only about the margin of the formation. The constitution of this layer varies from one locality to another. The principal species, however, are of fairly constant occurrence. The most frequent of these

are *Mimulus jamesii* and *Berula erecta*. In addition, *Onoclea sensibilis*, *Polygonum sagittatum*, and *Campanula aparinoides* are found in nearly every spring marsh; the first forms an especially dense layer in shaded marshes. *Cuscuta gronovii*, which is very injurious to the facies of this formation, may be regarded as belonging to this layer. *Polygonum punctatum* is occasionally an important constituent of the secondary layer, though not infrequently extraformational. The other secondary species, most of which are uncommon, are *Cinna arundinacea*, *Lobelia spicata*, *Ranunculus recurvatus*, *Scutellaria lateriflora*, and *S. galericulata*; these also occur sparingly in the second type. A peculiar modification of the spring marsh formation is found here and there along both the Niobrara and the Keya Paha. In it *Impatiens biflora* is almost entirely or wholly replaced by *Helenium autumnale*. *Epilobium adenocaulon* is of greatly diminished abundance, and its place is taken by several species of *Bidens*, *B. trichosperma tenuiloba*, *levis*, *frondosa*, *connata*, and, rarely, *involutrata*.

(2) The spring brook type. This formation usually occupies but a narrow strip along the margins of spring brooks. This strip may broaden occasionally, where a spring in the canyon side forms a small marsh along the banks of the stream. The facies are rarely so well marked as in the preceding; they are *Eupatorium purpureum*, *E. perfoliatum*, *Homalocenchrus oryzoides*, and, more rarely, *Zizania aquatica*. The continuity of the facies is usually incomplete, and the spaces are occupied by lower-growing species, *Mentha canadensis*, *Lycopus lucidus*, and *L. americanus*. These, with *Lobelia syphilitica*, grow in patches or dense borders, and are the only abundant secondary species. *Epilobium adenocaulon* is a frequent intruder from the preceding formation; the individuals are usually scattered and are of little importance. *Sagittaria latifolia*, *Galium trifidum*, *Gerardia tenuifolia*, *Habenaria hyperborea*, and *Cyperus rivularis* are frequent, scattered species of this formation.

VIII. The culture formations.—The culture formations, or

those due directly and solely to cultivation by man, occupy a large and increasing area in the State. Cultivated fields are necessarily most numerous and valuable in regions I and II. A great part of region III, chiefly in the Loup district, is wholly unsuited to cultivation, and large stretches in regions III and IV are chiefly serviceable to mankind for grazing land. Of late, irrigation has been resorted to extensively in region IV, as it long had been in that portion of the region to the west of us, and in parts of region III it is now largely made use of. In this way, the area of land under cultivation in those regions will probably be increased greatly. But in recent years considerable areas, in which cultivation had been attempted in region IV and in the western portion of region III, have been abandoned, and have lapsed into wastes.

The woody culture formations of the State are attaining some importance. Under the influence of the timber culture laws, and of the spirit that finds expression in "Arbor Day," tree-planting has gone on steadily for many years, so that in regions I and II many fine groves have had time to grow up. The groves planted under the timber culture acts have been for the most part of cottonwood, and large cottonwood groves are of common occurrence in the eastern and central portions of the State. But in the sand-hill region, in many a wet valley occupied under the statutes relating to timber culture, "claims" planted with cottonwoods may be seen which have been neglected and suffered to become wastes. Orchards are becoming very frequent, and are increasing in number and productiveness in many parts of the State. In region I, which includes the oldest settled portions of the State, many orchards are of long standing, and the larger and more productive orchards are generally in this region. Even region III, however, has some of no mean importance. In many parts of region II orchards of considerable value are to be met with, and in time, when those more recently planted have grown up, the prairie region will exhibit a surprisingly large number.

The "corn field" is the chief culture formation in Nebraska. The Indian corn, *Zea mays*, is the staple product, not only of Nebraska, but of the neighboring states to the east and south. Whole stretches are planted to it annually, and as the fertile soil of the prairie has not, as a rule, required rotation of crops to be resorted to, the same fields year after year are sown with maize. In late summer and autumn, the immense cornfields, one joining to the next without visible mark of separation for long distances, are the most noticeable feature of the landscape in all but the western portions of the State. Fields of "small grain" are less abundant. The Dakotas, to the north of us, have been called one vast wheat field, but in Nebraska, with few exceptions, wheat is not grown over large tracts or to any great extent. In regions I and II, however, the small grain fields are numerous, though not to be compared to the corn fields in size or in number. In recent years, alfalfa, *Medicago sativa*, has come to be cultivated extensively for forage, and in region III extensive fields of this plant are now of common occurrence. In the Elkhorn and Platte districts of region II, the sugar beet is also cultivated to some extent. Large tracts are devoted to raising hemp in two localities in region II.

IX. The waste formations.—Most of these are, in a sense, culture formations, since they are the result of disturbance of the soil by man. In fact, with the exception of the prairie-dog town wastes, caused by the burrowing of prairie-dogs, which are in all respects similar to ordinary wastes, all waste formations are due directly or indirectly to human agency.

Many weeds are habitual members of the ordinary culture formations. Some are sown along with the seed and in this way become frequent, as, for example, the dandelion and the chickweed in lawns. Such plants are becoming frequent with the increasing number of lawns in the cities and towns in regions I and II, and are migrating and invading waste situations of all sorts. Other weeds invade cultivated fields and gardens and flourish there. The largest number take possession of waste ground in and about cities and towns, aban-

doned fields, roadsides and "trails," overstocked pastures, railroad embankments and cuts, "broken" prairie, etc., and develop in these situations formations of no little complexity. Most of these waste plants are annuals, and are enabled to get possession of areas where breaking of the soil or grazing has driven out the native perennial occupants, by reason of enormous seed-production and of devices for dissemination. Some of them, however, are perennial, such as *Grindelia squarrosa*. The greater part are invaders from other floras, and constitute the flora adventitia, which includes naturalized species, introduced species of sporadic occurrence, and species which escape from gardens and grow here and there in ruderal and sub-ruderal situations.

Of the weeds which take part in waste formations we may distinguish two sorts: (1) invaders from other floras which have become thoroughly established and naturalized for a long time, and (2) native species that have become weeds. In the former category may be mentioned, first, species which have come from Europe or other distant regions and have gradually followed in the wake of civilization and cultivation or of travel. Many of these, which are common in the eastern United States, are only just reaching our borders, and few of them have gone further than regions I and II, except sporadically along lines of railroad. The more important of this class are *Arctium lappa*, *Carduus arvensis*, *Datura stramonium*, *Lappula lappula*, *Melilotus alba*, *Abutilon abutilon*, *Brassica nigra*, *Chenopodium album*, *C. hybridum*, *Polygonum aviculare*, *Rumex crispus*, *R. acetosella*, *Amaranthus retroflexus*, *Panicum crus-galli*, *Syntherisma sanguinalis*, *Chaetochloa glauca*, *C. viridis*, and *Eragrostis major*, all of which are completely established. After these are to be placed species native of adjacent regions to the eastward, which have become completely naturalized and long-established in regions I and II and in parts of region III. The most important of these are *Leptilon canadense*, *Iva ciliata*, *Xanthium canadense*, *Plantago major*, *P. rugelii*, *Convolvulus sepium*, *Lepidium virginicum*, *Phytolacca decandra*,

Amaranthus graecizans, *Polygonum pennsylvanicum*, and *Cenchrus tribuloides*. The progress of many of these over the western portion of region II into region III, and even into the edge of region IV, may still be witnessed. Finally, we must note *Solanum rostratum*, which has come in from the region to the west of us, and has spread over and has become established in regions III, II, and I successively, and in many states to the eastward, since it was first seen by the writers. *Salsola tragus*, introduced into the Dakotas from Russia, has become established in all parts of the State with remarkable rapidity.

The most important of the species native of our territory or of the regions in which it falls, which have become thoroughly ruderal, are *Grindelia squarrosa*, *Ambrosia psilostachya*, *Helianthus annuus*, *H. petiolaris*, *Dysodia papposa*, *Lactuca pulchella*, *Euphorbia marginata*, *Amaranthus blitoides*, and *Sporobolus vaginiflorus*. In addition to these, many native species are rapidly becoming ruderal, and some have become almost as well established as ruderal plants as in their original situations. Among species of this sort may be mentioned *Cleome serrulata*, *Argemone intermedia*, *Mentzelia decapetala*, *Cycloloma atriplicifolium*, *Chenopodium leptophyllum*, *C. incanum*, *Atriplex hastata*, and *Froelichia floridana*.

Waste formations are chiefly developed in regions I and II, where man has been at work longest and most constantly. In region III, the abandonment of "claims" in recent years has also given rise to wastes; but these are largely *sui generis* and entirely different from the characteristic wastes of the eastern portion of the State, although along railroad lines the ordinary wastes of region II have begun to penetrate extensively, and in localities near to the railroads abandoned fields are generally taken up by the sunflower. In region IV, except on abandoned "claims," waste formations are rare or wanting, bare areas falling prey to the ordinary species of sandy hillsides, dry canyons, and Bad Lands.

The waste formations of the State are four. Three of them

are closed wastes, in which a certain number of species take almost complete control. The fourth is an open formation, admitting many intruders of all sorts, and is of very irregular constitution. The first is composed primarily of erect, tall-growing species, which form a sort of herbaceous forest, growing to a considerable height, often more than 3 meters, and admitting several subordinate layers. This may be called the thicket-like waste formation. The second is composed of lower, much-branched, bush-like species, forming dense patches, which may not inaptly be compared to brush in clearings in their effect on other species. Here also there is commonly one subordinate layer, and sometimes there are two. This has been termed the brush-like waste formation. The third is made up of species which grow prostrate and spreading, sometimes creeping, and choke out other vegetation, forming a dense carpet or even a sod. In these wastes, while several species commonly take part, there can be but one layer. But the species taking part in this formation often form a layer in portions of other wastes. This formation has been called the carpet-like waste formation. Finally, we have also the open waste formation of roadsides, over stocked pastures, railroad cuts, and like situations, of which there are several types, agreeing only in their general character.

20. THE THICKET-LIKE WASTE FORMATION.—The “sunflower patch” or sunflower waste, which well represents one type of this formation, is the characteristic waste formation of region II. On broken prairie, on waste ground in and around cities and towns and along roadsides, *Helianthus annuus* forms huge patches, often covering many hectares, in which the individuals are commonly 2–3 meters, and sometimes 4–5 meters in height. The sunflowers, with their tall stalks and large, spreading leaves, control the conditions of growth in these areas almost as absolutely as the woody plants in a thicket. Even after the leaves have fallen, the dead stalks exert no small influence, as may be observed when the snow is melting in spring, when the snow remains in the

sunflower patches many days after it has disappeared from the prairie. In situations where the sunflowers have not attained the mastery, they grow slender and densely crowded, not more than a meter to a meter and a half high, and admit little else. But in the ordinary sunflower wastes, where the sunflowers grow year after year, they grow tall and tree-like, and admit several subordinate layers. In wastes of this sort, where the sunflowers occupy 5-10 hectares or even more, there is often a second layer of *Ambrosia artemisifolia* extending over the greater part of the waste. The latter grows very tall in these wastes, usually about 2 meters, or even more. On the edges, *Xanthium canadense*, *Acnida tuberculata*, or *Chenopodium album*, if near cultivated lands, or *Grindelia squarrosa* and *Artemisia gnaphalodes*, if on broken prairie, are the second layer. Both in the area occupied by the second layer and in other portions of the waste, *Polygonum pennsylvanicum* is frequently to be found as a third layer. The grass of sunflower wastes is chiefly *Panicum capillare*. This grass covers the soil in almost every large patch, and is the lowest layer. Sometimes *Chaetochloa glauca* or *Eragrostis major* takes its place, principally in urban or suburban wastes. An interesting example of the sunflower waste may be seen where the sunflowers invade a long-stemmed grass meadow. For a strip about 100 meters wide back from the roadside the sunflowers have full control and grow densely, the individuals about 4 meters high. The second layer is well developed, consisting of *Ambrosia artemisifolia*, growing 1½-2 meters high. Subordinate to that is *Polygonum pennsylvanicum*, and, as the lowest layer, *Panicum capillare*. Near the road, these species have exclusive possession. *Andropogon furcatus* is the controlling species in the interior of the meadow. There is a wide strip between the two, in which the sunflowers grow lower and the *Andropogon* is mingled with them on about equal terms. Here, *Solidago rigida*, *Artemisia gnaphalodes*, and stragglers of *Silphium laciniatum* are to be found, along with *Ambrosia artemisifolia*, all apparently struggling to grow to

unusual heights. Below them, many of the secondary species of the meadow may be found growing here and there as a third layer, and *Panicum capillare* is only sparsely represented.

The extensive *Ambrosia trifida* wastes, which are to be found in low grounds along roadsides and along streams in ground flooded over in spring, *Abutilon abutilon* wastes, and *Iva xanthifolia* wastes are to be referred to the same type as sunflower wastes. All of these differ from sunflower wastes only in the constitution of the primary layer and in harboring fewer secondary species. The *Ambrosia trifida* wastes, which are the most extensive and the most important after the sunflower wastes, are almost exactly like the latter, the individuals growing 2-3 meters high, and very dense. *Iva xanthifolia* wastes of considerable extent may be seen in Custer county, on the edge of the sand-hill region. The individuals are $1\frac{1}{2}$ to 2 meters high, or sometimes $2\frac{1}{2}$ meters, and form a dense thicket, in which *Chenopodium album* is commonly the second layer.

The most important example of another type of thicket-like waste is furnished by the large patches of ragweed, *Ambrosia artemisifolia*, which are to be found about dwellings and in exhausted pastures near towns and villages, about railway stations, and in like situations where the soil has not been disturbed sufficiently, or where for other causes the sunflowers do not come in. Such wastes are often to be seen occupying an area 100 meters or even 200 meters square. It is not uncommon to see the ragweed struggling with *Grindelia squarrosa* for the possession of an exhausted pasture, or of waste ground about the outskirts of a town. The ragweed grows very dense, and admits but few other species in its own layer. It reaches a height of about a meter or a meter and a half. In clayey soil, *Dysodia papposa* is usually the second layer; on low ground, *Polygonum pennsylvanicum*. The usual grass of these wastes is *Chaetochloa glauca*, but *Eragrostis major* is also common about cities and towns, and the latter is invariably the grass of all thicket-like wastes

in the Platte district. Where *Ambrosia* and *Grindelia* are struggling for the mastery, there is often a *Grindelia*-*Ambrosia*-*Dysodia* waste, with *Chaetochloa glauca* the prevailing grass. The gumweed occupies the unbroken ground and holds it firmly. In the remainder, it will be found mingled more or less equally with the ragweed, with large patches of *Dysodia* throughout the whole area. Such wastes may often be seen several hectares in extent.

The butterweed, *Leptilon canadense*, usually forms wastes of the same type. Before the butterweed has become well established, as in many incipient butterweed wastes in abandoned fields in the western edge of region III, it does not grow densely, and the waste is an open one. But the butterweed wastes in region II are very similar to ragweed wastes, and individuals of *Ambrosia artemisifolia* may often be seen on their edges. The butterweed usually takes possession of old "hog lots," though abandoned plowed land is often covered with it. In these situations it grows densely, a meter to nearly two meters high, with *Panicum capillare* or *Chaetochloa glauca* as the secondary species. Sometimes *Chenopodium album* will be found intruding as a second layer, and *Portulaca oleracea* and other prostrate forms will replace the grasses. The wastes formed by *Iva ciliata* in low, waste ground about the salt basins in region II also belong to this type. Here the *Iva* forms dense patches of great extent, covering all the waste ground with a mass of individuals varying from one to one and a half or even two meters in height. Few other species are admitted, but *Eragrostis major* has been seen forming a rather close, but patchy carpet in such wastes, and, when they occur along roadsides, the peppergrass is a frequent intruder as a second layer. The extensive *Xanthium canadense* wastes to be found in railroad yards in the cities are of this type. In these wastes, the cocklebur grows densely over the whole area, reaching a greater height than usual. *Panicum capillare* or *Chaetochloa glauca*, or both in patches, form a dense carpet beneath.

21. THE BRUSH-LIKE WASTE FORMATION.—In wastes of

this character the predominant species grow in a bushy, spreading fashion, and in consequence are not so densely aggregated, so that the formation is somewhat less closed than the preceding. The most striking example is furnished by the *Cycloloma* wastes, which have already been described sufficiently. The *Chenopodium leptophyllum* wastes, which are to be found covering tracts a kilometer or more in length, where the soil has been disturbed, in regions III and IV, belong to the same type. The extensive wastes formed by *Cleome serrulata* about ranches in region III, along the Platte in region II, and even in abandoned spots along the Missouri bottoms, are also of this type. All of these wastes agree in being controlled by one species of bushy, spreading growth, which admits few or no secondary species.

Acnida tuberculata forms wastes illustrating another type of this formation. It is almost invariably associated with *Amaranthus retroflexus*, and both frequently occur in association with *Chenopodium album*. The three are distributed about equally in a loose primary layer. *Rumex crispus* is a frequent weed of this layer in urban wastes, and where this formation springs up as a secondary one in high stubble fields in August and September, *Xanthium canadense* is a common member. Peppergrass, *Lepidium intermedium*, is an abundant weed of this formation in cities and towns, where it forms a dense fringe about the edges, and a second layer here and there in patches in the interior. In most cases the second layer is formed by low, prostrate species, such as *Amaranthus blitoides*. Where *Acnida tuberculata* and *Amaranthus retroflexus* dominate the waste, *Amaranthus blitoides* commonly has complete possession of the subordinate layer. The *Atriplex hastata* wastes and *Chenopodium album* wastes are of the same type.

The *Polygonum* stubble fields, which are so conspicuous in late summer and autumn, are to be referred to the same type as the *Acnida* wastes. They replace the latter in low fields, the higher fields being taken up by *Acnida* and *Amaranthus retroflexus*. Stubble fields on low ground com-

monly contain little else than *Polygonum pennsylvanicum* and *Panicum crus-galli*, the latter growing as a true second layer in the dense masses of *Polygonum*. About the edges, and here and there in sparsely covered spots, one may find *Acnida tuberculata*, *Xanthium canadense*, *Euphorbia glyptosperma*, and *Bidens frondosa*, and in such spots the grass is usually *Chaetochloa glauca*, which also grows in the higher stubble fields. The grass associated with *Polygonum* in sandy stubble fields is usually *Cenchrus tribuloides*.

Another type of the brush-like waste formation is to be seen in the areas about cities used for depositing refuse matter. In large tracts of this sort about Lincoln and Omaha, the controlling plant is *Datura stramonium*, which grows in rather dense patches, attaining a height of a meter to a meter and a half, covering substantially the whole waste area. Owing to the nature of the situation, few secondary species are to be found. *Brassica nigra* may often be observed growing abundantly with *Datura stramonium*, and attaining an equal height.

22. THE CARPET-LIKE WASTE FORMATION.—The carpet-like wastes are made up of prostrate or creeping species, which form a carpet or even a sod, or of low-growing, erect species, which grow densely aggregated. The best example is furnished by *Polygonum aviculare*, which forms a sod-like covering in urban wastes and along roadsides. In the same waste one often sees patches of *Amaranthus blitoides*, *Portulaca oleracea*, or *Euphorbia maculata*, and each of these species may be found covering waste places to the exclusion of all others here and there. Commonly, however, all of them, or a large number of them, are associated. When associated the individuals rarely mingle, but each species forms small patches, and the patches unite to cover the whole area of the waste. *Lepidium intermedium* and *Bursa bursa-pastoris* are frequent intruders in such wastes, sometimes growing in small patches, at other times scattered here and there in the patches of the prostrate forms. The grass of these wastes in regions I and II has come to be *Syntherisma san-*

guinalis, not without a struggle, however. In dry years, other grasses rapidly come in and replace it. Where the ground is low, *Plantago major* and *P. rugelii*, which grow low and close to the surface, form more or less definite patches. In such situations, *Polygonum aviculare* is commonly the prevailing species. Where the soil is clayey, *Sporobolus vaginiflorus* is the prevailing waste grass, and *Dysodia papposa* grows with it in extensive patches, in which the individuals grow low and very dense. In such spots and in over-stocked pastures, *Dysodia* may be found taking up areas 100-200 meters square almost exclusively. *Sporobolus vaginiflorus* and *Dysodia papposa* are the characteristic plants of clayey soil which has become waste. On sandy soil, *Cenchrus tribuloides* controls. This is particularly noticeable in waste lands on the Platte bottoms, where there are dense patches of sand-bur several kilometers long. Within the last two or three years, *Malva rotundifolia* has begun to take possession of waste ground in towns and cities throughout I and parts of II. It has been observed forming large urban wastes as far west as Broken Bow within the last year. The *Malva rotundifolia* wastes are of the same general character as the other carpet-like wastes, and this species often forms a patch in waste areas where *Polygonum aviculare*, *Amaranthus blitoides*, and *Plantago rugelii* occur also in large patches. Waste places in cities and towns are sometimes occupied entirely by grasses, usually *Chaetochloa glauca* with *Eragrostis major* on the edges. *Syntherisma sanguinalis* or *Panicum crus-galli*, or both, may often be found in more or less abundance scattered through the *Chaetochloa* patch. In shaded or damp places *Syntherisma sanguinalis* sometimes replaces *Chaetochloa* entirely, and in street-side wastes *Panicum proliferum*, replaced at times in dry seasons by *Hordeum jubatum*, usually prevails. Exclusive patches of *Panicum proliferum* are very common in waste places in the larger cities along paved streets. *Eragrostis purshii* often grows over neglected brick sidewalks and unused brick pavements in large patches.

23. THE OPEN WASTE FORMATION.—Open wastes are not characterized by any controlling species or type of vegetation. They are areas in which a large number of ruderal species flourish and dispute for the mastery. A few straggling individuals of the species already mentioned as characteristic of the closed waste formations will generally be found. But a different sort of plants takes the principal part. These species grow copiously over the surface, but, as a rule, not densely, and admit many others in their own layer, so that the vegetative covering is very heterogeneous. This is especially true in those situations where the vegetation is sparse, such as railroad cuts.

An important type of this formation is to be seen in rural, over-stocked pastures, where *Euphorbia marginata*, *Grindelia squarrosa*, or *Solanum rostratum*, or even the three in conjunction have obtained control. These species commonly grow in great profusion, but not densely, and the prostrate species of *Euphorbia* and the erect *E. glyptosperma* are to be found with them in abundance. Stragglers of *Dysodia*, *Acnida*, and *Polygonum*, according to the nature of the ground and soil, occur also. Sometimes *Euphorbia marginata*, *Grindelia*, or *Solanum* will show a tendency to grow densely and form a close patch, but the usual habit is otherwise, even where they are associated. This type of waste is to be met with only where the soil has not been broken. The broken ground is quickly taken up by the thicket-like or brush-like wastes. But where the prairie-grasses have been eaten off or worn off in pastures, and more or less replaced by annual, waste grasses, the pasture is soon invaded by the open waste species and dominated by them. The *Vernonia* and *Vernonia-Verbena* formations of exhausted pastures in the southeastern portion of the State are to be referred to this type also. In low pastures, *Vernonia gigantea* and *Verbena stricta*, singly or in combination with each other, and sometimes with *Verbena hastata* as well, enter in great numbers and quickly become dominant, since they are not eaten on account of their bitter juices. These species are very densely

copious, and *Vernonia* exerts an additional influence on the vegetation because of its tall growth. These species are to be classed as subruderal, and the formation is subruderal. But it has the general nature of other open waste formations, and especially resembles those controlled by *Euphorbia marginata* and *Grindelia squarrosa*.

Another type of open waste is to be seen in railroad cuts and on clayey railroad embankments, where the vegetation is sparse. Here one of the principal elements is made up of species of *Physalis*. *Euphorbia maculata* and *E. glyptosperma*, *Chaetochloa glauca*, and, in sandy cuts, *Cenchrus tribuloides* occur also. Stragglers of *Acnida*, dwarf, spindling sunflowers, a few individuals of *Polygonum pennsylvanicum*, small patches of *P. ramosissimum*, and a motley gathering of individuals from the formation prevailing on the hillside above are to be seen here and there where the side of the cut offers an opportunity. In other places, *Melilotus alba* becomes one of the chief species, growing very high and bushy and more or less aggregated, and covering the bottom of the whole cut.

Along the roadsides there is a complex mixture of all our ruderal species. Sometimes the sunflowers or the ragweed take control and form thicket-like wastes. But commonly *Cassia chamaecrista* in sandy soil, *Dysodia papposa* in clayey soil, and elsewhere *Chaetochloa glauca*, *Panicum capillare*, and *Hordeum jubatum*, in distinct patches, are most abundant. Most of these patches are incipient brush-like or carpet-like wastes. The open waste will show instead species of *Lactuca*, *Allionia nictaginea*, *Polygonum ramosissimum*, *Lepidium intermedium*, the subruderal *Aster multiflorus*, *Rumex crispus*, *R. salicifolius*, *Plantago major*, *P. rugelii*, and, in parts of region I, *Phytolacca decandra*, mingled in a haphazard fashion with a few of the more persistent of the original inhabitants of the soil, such as bunches of bluestem, patches of *Agropyron pseudorepens*, and an occasional straggler of *Kuhnistera* or of *Rosa arkansana*. *Grindelia squarrosa* is a common member of these

wastes, and at times obtains some control over them. But in general they yield after a time to sunflower or ragweed wastes, as the area becomes larger and more thoroughly waste.

The most interesting of our open waste formations is the prairie-dog town waste, to be found in prairie-dog towns in regions III and IV and in some places in region II. Where the sod of the prairie or of the floor of a dry valley has been disturbed by the burrowings of the prairie-dogs and the dirt thrown up by them, an opportunity is offered for many ruderal and subruderal species to come in. These "towns" are of all sizes, from small ones 200 meters square to large ones of many kilometers in length. The plants which take possession of these situations vary with the locality, since the ordinary ruderal species of the eastern part of the State are not at hand, or are only beginning to come in along the lines of railroad. The most widely distributed and most characteristic inhabitant of these wastes is *Solanum triflorum*.* In the foot-hill region, the prairie-dog town species are *Solanum triflorum*, *Cryptanthe crassisepala*, and *Chenopodium incanum*, and Rydberg found the same species in these wastes in the central sand-hills. In the dry valleys in Cherry county, *Plantago purshii* is the chief inhabitant of such spots. In the Niobrara district, the principal inhabitants of prairie-dog town wastes are *Schedonnardus paniculatus*, *Chenopodium incanum*, and also *Euphorbia marginata*, *Verbena bipinnatifida*, and *Malvastrum coccineum*, which have come in from the surrounding vegetation. Along the Platte in region II, *Schedonnardus paniculatus* is most common in such spots, though *Solanum triflorum* and *Plantago purshii* occur frequently.

What may be called subruderal formations are closely related to the open wastes. These are either decadent prairie and meadow formations or incipient ruderal formations. Here a number of species, not typically ruderal, enter areas in which the original vegetation is being driven out by reason

*See Rydberg, Contrib. U. S. Nat. Herb. III. 3:141, note.

of pasturing or of the wear of roads and trails, and play the part of ruderal plants. Pastures in which the original vegetation is only partially affected, and edges of fields, prairie roads, etc., in region II, and roadsides and trails in regions III and IV are the commonest examples of sub-ruderal formations. *Aster multiflorus*, *Andropogon furcatus*, and *Agropyron pseudorepens* are always to be found in such spots, and the former is even to be met with in the street-side vegetation of towns and cities. Many other species have the same habit, as has been pointed out in the preceding chapter. These areas are soon occupied by open waste formations, and in time by closed waste formations, as they become more thoroughly waste.

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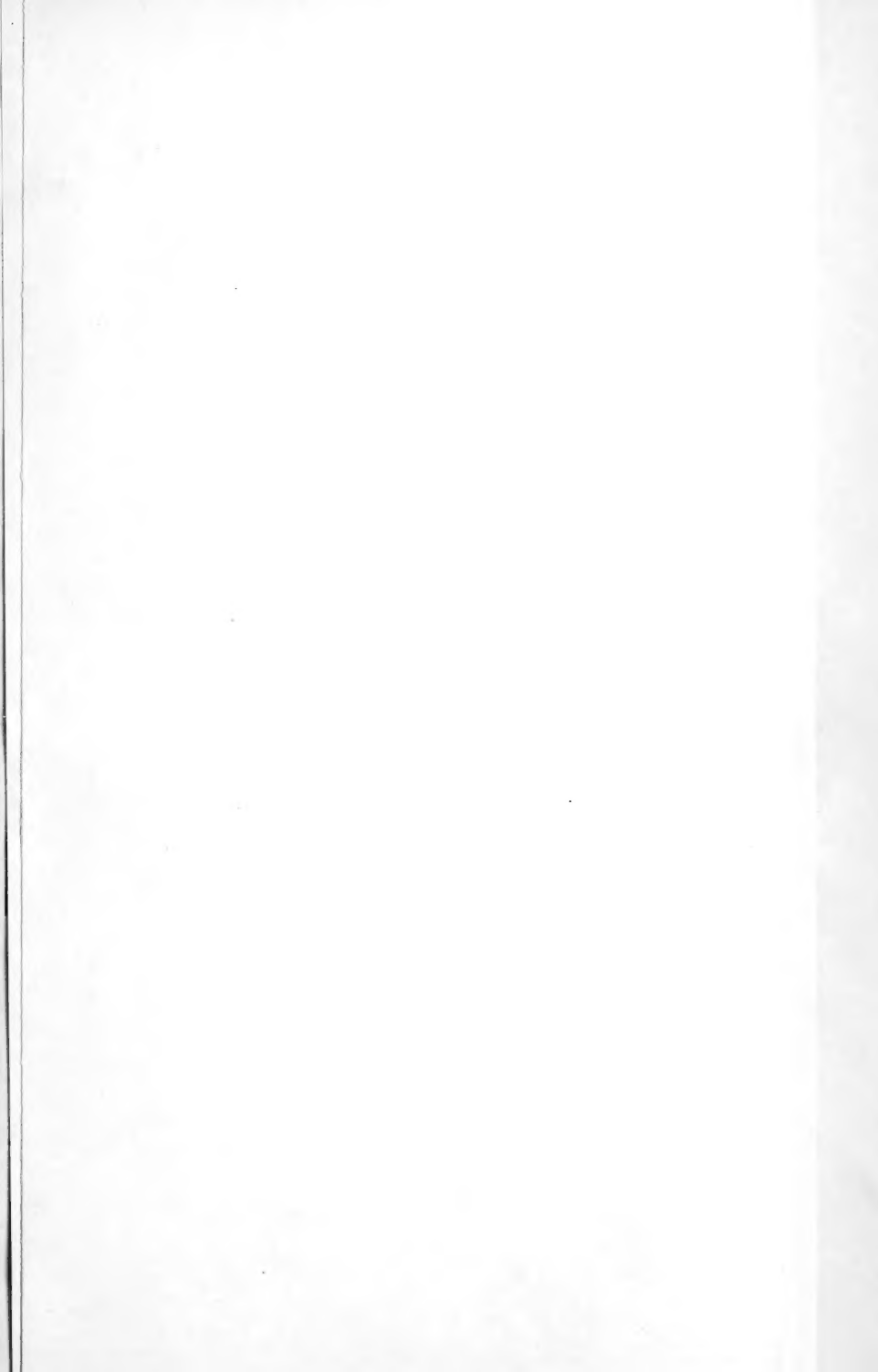
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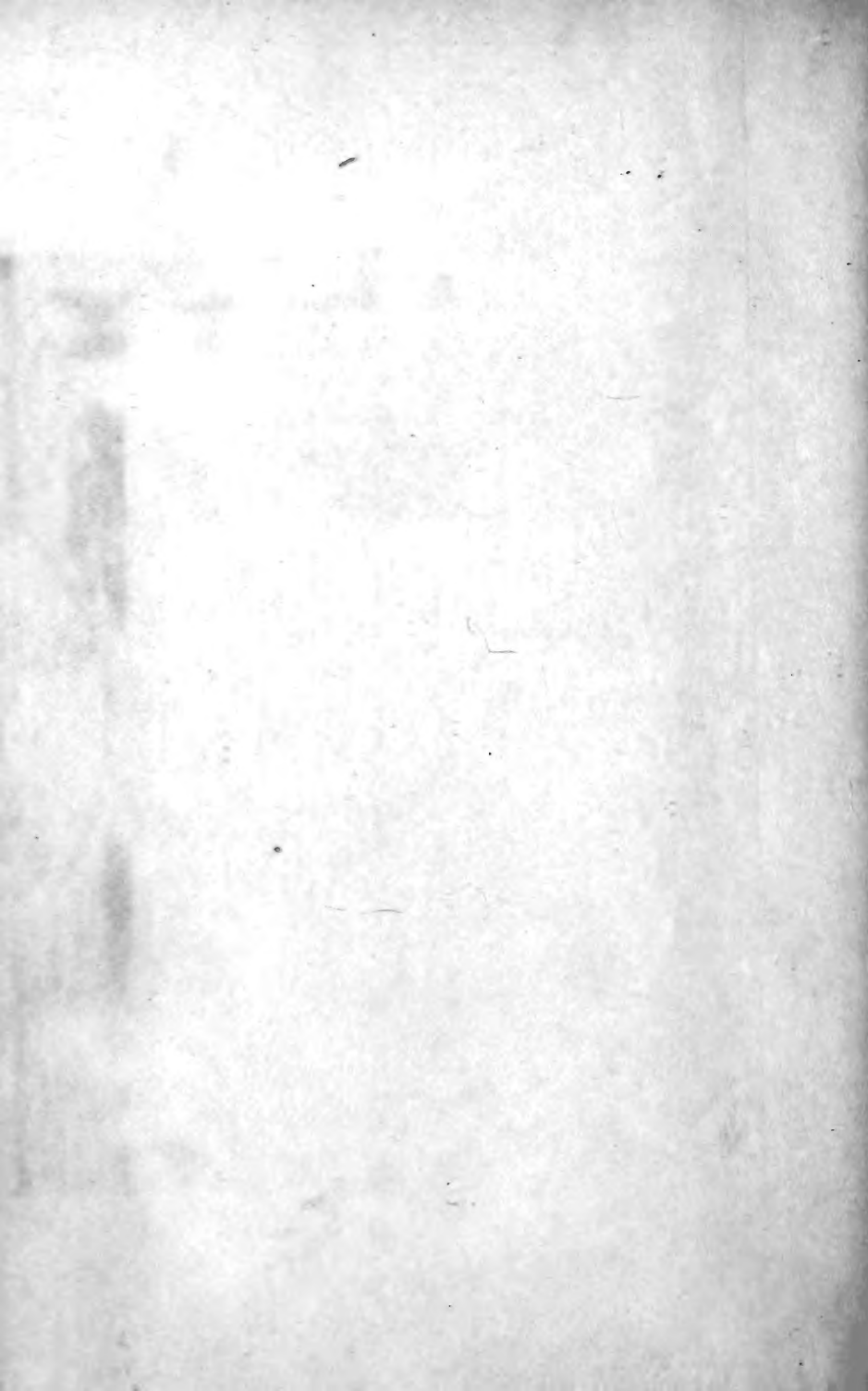
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EXPLANATION OF MAPS.

- I. Topographical Map.
 - II. Political Map, with boundaries of regions and districts.
 - I. Wooded-bluff and meadow-land region.
 - II. Prairie region.
 - III. Sand-hill region.
 - IV. Foot-hill region.
 - III. Map showing river systems with regions and districts indicated.
 - IV. Map of the Prairie province.
 - I. Prairie region.
 - II. Sand-hill region.
 - III. Foot-hill region.
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